Daniel Neuhoff, Sang Mok Sohn, Charles Ssekyewa, Niels Halberg, Ilse. A. Rasmussen and John Hermansen (Editors)

Organic is Life Knowledge for Tomorrow

Volume 1 Organic Crop Production

Proceedings of the Third Scientific Conference of the International Society of Organic Agriculture Research (ISOFAR), held at the 17th IFOAM Organic World Congress in Cooperation with the International Federation of Organic Agriculture Movements (IFOAM) and the Korean Organizing Committee (KOC)

28. September – 1. October 2011 in Namyangju, Korea

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The 3rd Scientific Conference of the International Society of Organic Agriculture Research (ISOFAR) was held from 28. September to 1. October 2011 in Namyangju, Republic of Korea, in the frame of the 17th Organic World Congress of the International Federation of Organic Agriculture Movements (IFOAM), organised by the Korean Organizing Committee (KOC).

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Preface

The Third International Scientific Conference of ISOFAR was held from 28 September to 1 October 2011 in the frame of the 17th IFOAM Organic World Congress (OWC) in Gyeonggi Paldang, Republic of Korea. The practical implementation of the OWC was managed by the Korean Organizing Committee, while ISOFAR was responsible for the scientific part of the conference, the so-called 'research track'.

Interest is deepening in agricultural practices that promote environmentally sound agriculture, well-grounded on scientific knowledge and facts. Scientists working on the organic research track are aware that the cradle of their daily work is based on the numerous practical approaches and the experiences gained under diverse site conditions and given obstacles to clear. Trial and error are part of the daily life of researchers as well as of practitioners. Thus, the value of this scientific conference can be measured in the stimulus it provides to the individual researcher and farmer, especially the young ones, knowing that future progress will depend on them. Furthermore, the value of this conference lies in the opportunity offered to us to discuss possible strategies how to overcome future restrictions Organic Agriculture will be confronted with under the individual site conditions in different regions.

It's a pleasure for me to express my gratitude to those who made this conference possible and to those preparing the proceedings. I want to thank our benefactors for their efforts and our institutional hosts in Korea for providing the conference venue and for supporting all the conference activities. On behalf of the participants of the Third Scientific Conference of ISOFAR, I gratefully recognize the diversity of contributions which reflect the broad spectrum of Organic Agriculture worldwide.

I'm especially indebted to the editors of the proceedings for their diligent and tireless efforts in preparing and polishing the submitted manuscripts. These proceedings can be regarded as an anticipatory window opened to a promising future to come. In general, editors share a common experience: after all their hard work and the given functional relationship between the quality of the submitted papers and editors' general well-being, they will not deal with a legacy of 'again another international conference proceedings booklet – grey literature, nothing else', but conference proceedings that are cherished as not less than a milestone for the further evolution of Organic Agriculture based on science. This aim could further be fulfilled by publishing of many of the four page contributions reviewed for the proceedings as extended versions in ISOFAR's new scientific journal 'Organic Agriculture' or at least by submitting them to other international highly ranked journals.

May these proceedings that comprehensively represent the current state of the art in Organic Agriculture Research find a good reception among its readers and encourage further research activities that contribute to a more complete understanding of what is required for a successful use of unique approaches and techniques in Organic Agriculture in order to expand organic production worldwide.

Ulrich Köpke

President ISOFAR

Dear Reader,

The present two volumes of the Proceedings of the Third Scientific Conference of ISOFAR, carried out during the OWC in Korea in autumn 2011, are noticeably thinner compared to the previous conference. It would certainly be a mistake to draw premature conclusions on an alleged drawback of organic agricultural research. The decrease of paper submissions is a simple result of a lower participation of European researchers, who traditionally have a strong position within the international research community. From a total of 400 submitted papers finally some 250 were selected for oral (150) or poster presentation (100) and subsequent publication.

Volume 1 of the proceedings covers various aspects of soil fertility and nutrient management as well as a considerable range of topics on organic crop production. The majority of the papers deal with specific aspects of crop productivity with a strong emphasis on organic fertilization and crop protection rather than on systemic approaches. No need to say that these facts also reflect the world-wide diversity of self-conceptions on Organic agriculture. From a pure agronomic point of view problem oriented research approaches a more than reasonable, in particular in countries with a high population density. Strategically, however, it should not be forgotten that the largest capital of Organic Agriculture are still the consumers and their permanent readiness to purchase organic products with an expected superior overall quality.

Accordingly volume 2 begins with papers on consumer research including also other important topics such as marketing, certification and organic food quality. Since smallholders play a key role for food security and poverty eradication especially in Asia and Africa, joint sessions of ISOFAR and IFOAM will be dedicated to this important topic. The final part of the second volume is dedicated to agro-ecological research as well as to specific aspects of research methodology and knowledge dissemination. The editors are very grateful to the authors for their valuable contributions, as well as to the innumerable reviewers, who significantly improved the final quality of the papers

ISOFAR is greatly indebted to the Korean Organizing Committee (KOC), which spared no efforts to design an attractive overall programme for the Organic World Congress. In particular we would like to express our sincere gratitude to Mrs. Jennifer Chang (KOC). Thanks to her excellent competence and her tireless helpfulness, the cooperation between the partners turned out to be delightful. All that glitters is not gold. Therefore we offer our sincere apologies to all, who have suffered under inefficient communication or technical problems during the preparation of this conference.

It is our sincere hope that the proceedings of the Third Scientific Conference of ISOFAR in Korea in 2011 will be a useful source of information not only for the organic research community but also a valuable incentive for the whole organic movement.

On behalf of the Editors

Daniel Neuhoff, Sang Mok Sohn and Niels Halberg

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Soil fertility and nutrient management

Evaluation of the potential of feather meal as organic fertilizer in production of *Amaranthus caudatus*

AdeOluwa, O.O.[1] & Adeogun, O.O.

Key words: Feather meal, Amaranth caudatus, organic fertilizers

Abstract

This study investigated responses of Amaranthus caudatus (a leafy vegetable) to Feather meal and All-purpose organic fertilizers.

The experiment replicated four times was conducted in a screen house with a randomized complete block design. The treatments used were feather meal, All-purpose organic fertilizer, mineral fertilizer (NPK 15-15-15) and Control (no soil additive). All the treatments (except control of no soil additive) were applied at 100 kg N/ ha. The treatment means were analyzed using Analysis of Variance (ANOVA) and the means were compared using standard error of means (SEM).

The results of this investigation (at P<0.05) revealed that feather meal had better performance (11.25 t / ha) than the control (no soil additive) and All-purpose organic fertilizer but lower than NPK 15-15-15 (16.2 t / ha) on fresh weight of amaranth plants at the main planting. However, regression equation of yield revealed that the feather meal had better potential than the mineral fertilizer NPK 15-15-15. Thus feather meal could be a good organic fertilizer in raising leafy vegetables.

Introduction

One of the major limitations to adoption of organic crop production practices in many developing countries is the availability of inputs conformable to organic production practices. Organic fertilizers are part of those inputs. Large scale organic crop production often requires some external fertilizer inputs to augment nutrient recycling within the farming system. A lot of organic materials are generated globally as wastes that could be used as fertilizers for crop production. Poultry feather generated annually in Nigeria alone is estimated at 75,000 t / year (FAO, 2008). There is a need to consider the potentials of feather meal as a fertilizer because it is easily available to farmers.

Feather meal has been reported to be a good source of nitrogen for the growing crops and has been found to contribute to earlier and larger peppers (Gaskell, 2001). It has a potential to improve soil fertility resulting in better crop and higher yield. Each year, tropical soils finite capacity to grow food and fibre has progressively decreased. This is largely because of the decline in soil fertility (Parr *et al.*, 1989; Ayoub, 1991; Adeoye *et* 2005). Though feather meal contains about 12 nitrogen but effectiveness of its mineralization of composed nutrients to meet up with nutrient demand of some aggressive crops like most leafy vegetables needs to be investigated.
Since efficiency of a fertilizer material would depend on the ability of the fertilizer to supply adequate nutrients for plant growth at specific stages of development, there is

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a need to investigate the potentials of feather meal as a fertilizer for leafy vegetables' production. Thus, this paper reports assessment of feather meal's potential as an organic fertilizer for producing *Amaranthus caudatus*.

Materials and methods

The experimental site was located at the Department of Agronomy, University of Ibadan, Nigeria. The experiment replicated four times was conducted in the screen house in a randomized completely block design. Sixteen 2 kg-pots were filled each with 2 mm sieved and properly leached river sand. Planting was done twice; one main and the other residual (without further treatments' application). Experimental soil was very low in N (0.03 g / kg), P (7 mg / kg) and K (0.1 cmol / kg).

The treatments used were feather meal, while All purpose Organic Fertilizer (NPK 9-3-4), mineral fertilizer (NPK 15-15-15) and Control (no soil additive) were used as control treatments. All the treatments (except control) were applied on dry matter basis at the rate of 100 kg N/ ha. While the organic sources was applied a week before planting, the inorganic was applied a day to planting. *Amaranthus caudatus* seeds were broadcast and thinned to five. Leaching of nutrients from the potted plants were prevented.

Plant fresh and dry yield were determined two weeks after planting and was done weekly till the 5^{th} week after planting. The treatment means were analyzed using Analysis of Variance (ANOVA) and the means were compared using standard error of means ($P< 0.05$). Regression of plant weight per week against 5 weeks of planting was done with Microsoft Excel program.

Results

At the main planting (5 weeks after planting), the feather meal resulted in a significantly ($P<0.05$) lower fresh and dry yields than NPK (15-15-15) but better than other treatments used. However, at the residual planting, there was no significant difference between NPK and feather meal and both were significantly better than other treatments (Figure 1)**.**

Table 1 showing the results of regression of the fresh weight of *A. caudatus* at the main planting with time revealed that all treatments used had highly significant ($P<0.01$) value of correlation (r). Feather meal had the highest projected weight of 19.79 g/plant at five weeks after planting, though its observed weight was less than that of NPK mineral fertilizer. Consequently, the feather meal resulted **in** the highest difference between projected and observed yield.

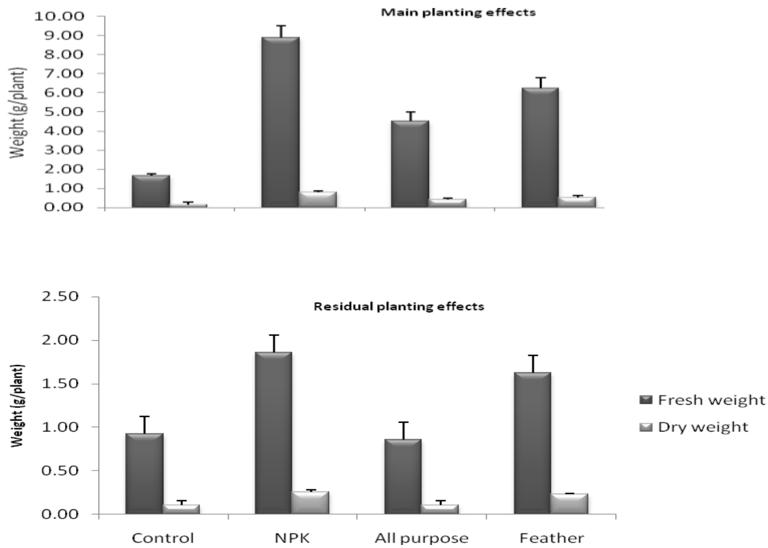

Figure 1: Comparative effects of treatments on fresh weight of A. caudatus at 5 weeks of two successive plantings,bar = standard error at $P<0.05$

Table 1: Regression of amaranth fresh weight (g) over period of 5 weeks as influenced by fertilizer application

Treatments	Observed fresh weight (g/plant) @ 5WAP	*r	Regression n = 4	Projected fresh weight (g/plant) @ 5WAP	Difference between projected and observed
Control	1.68	1.00	$y = 0.1774x^2 - 0.3472x + 0.2214$	2.92	1.24
NPK	8.9	1.00	$y = 1.1181x^2 - 2.7274x + 1.8381$	16.15	7.25
All purpose	4.5	1.00	$y = 0.5386x^2 - 1.218x + 0.7526$	8.13	3.63
Feather Meal	6.23	1.00	$y = 0.5996x^2 - 0.8979x + 0.3113$	19.79	13.56

* Significant for $P<0.001$

Discussion

The focus of this report was to assess the potential of feather meal as an organic fertilizer for producing *A. caudatus*.Yield of 6.23 g / plant (equivalent to 11.25 t/ha) from the feather meal was much lower than that observed 8.9 g / plant (equivalent to 16.2 t/ha) from NPK as well as 20 t/ha on a sandy soil of poor fertility status reported by Norman (1992). However, performance of feather meal was better than other treatments used in this experiment (excluding NPK). The difference in yield could be because the soil used was properly leached of nutrients as against the one reported by Norman (1992). Improved rating of the feather meal treatment at the residual planting is a positive indication that the treatment could improve soil productivity in raising a leafy vegetable like *A. caudatus*.

The feather meal had better projected yield than other treatments used in this study. However, the observed yield was lower than that of the NPK. It is possible that production process of feather meal could have accelerated earlier release of its nutrients (Mikkelsen & Hartz, 2008) and resulted into volatilization of a nutrient like nitrogen from the very porous sandy soil. Since nitrogen is very essential for leaf production, its loss could have led to the reduction in crop yield from the feather meal treatment. Thus, it is possible that the yield of feather meal as a fertilizer could improve under better soil conditions.

Conclusions

Although feather meal fertilizer resulted in lower fresh weight yield of *A. caudatus* in this investigation, the positive residual and regressed expected potentials of the fertilizer are indicators of its likely improved performance under better soil conditions. Thus, further investigation of the fertilizer on farmers' field is suggested.

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Indigenous knowledge systems and use of plant resources in managing the fertility of cultivated soil in the Philippines

Pangga, G.[1] & Dimaano, A.[2]

Key words: Indigenous knowledge, soil fertility, plant residues, organic practice

Abstract

A field study was conducted to document the indigenous knowledge systems in rice-based farming communities of Southern Luzon Philippines. The use of lesser-known plant resources (Gliricidia sepium, Macaranga tanarius, Barringtonia racemosa, Schizostachyum lumampao) in the restoration of soil quality and improvement of plant health were studied. In a separate study a long-term field experiment was conducted on a low-fertility clayey soil (Aquandic Epiaqualf) at the IRRI-U.P Los Baños Experiment Station in Laguna, Philippines. Results showed that soil resilience capacity to recover from pest infestation was observed on treatments with added plant residues. After 9 rice croppings, G. sepium and M. tanarius significantly have improved the rice grain yields by providing healthy plants comparable to those plants applied with inorganic fertilizers. These findings may explain farmers' ingenious practices on soil nutrient and pest management. Results such as these can be an option for the future as it guarantees yields, reduces costs, environment-friendly and its contribution to the sustainability of agriculture.

Introduction

Agriculture in the Philippines has developed from more or less extensive subsistence farming to intensive agricultural production that is highly dependent on pesticides and chemical fertilizers. The sustainability of agricultural production systems depends on the ability of the environment to continuously render its ecological services. Alternative agricultural practices and the ultimate goal of a long-term sustainable agriculture depend largely upon the addition of organic amendments to soil leading to the improvement of soil quality (Parr *et al.* 1992). Organic production practices must improve the natural resources of an operation, including the soil and water quality.

Materials and methods

A study was conducted to document the indigenous and organic farming practices in rice-based communities of Southern Luzon Philippines. The study aimed to increase capability of farmers, organic practitioners, and other stakeholders in solving constraints on soil productivity that will provide better soil and plant health. The study was intended to increase farmers' responsiveness on the weakening balances of the agro-ecosystem due to intensive agriculture. The methodology employed in this study includes physical observations and questionnaire surveys that consisted of open-ended and close-ended questions. Results were disseminated to a wider audience of

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[2] As Above

stakeholder through learning and information exchange activities. A long-term field experiment was conducted to evaluate the response of rice crop to the incorporation of plant residues on a low-fertility clayey soil Maahas Series (*Aquandic Epiaqualf*) at the IRRI-U.P Los Baños Experiment Station in Laguna, Philippines. The treatments used are the following: straws of 3 rice varieties (IR 36, 54 and 72), *G. sepium*, *M. tanarius*, and farmers' recommended rate (mineral fertilizer at 90-30-30 and 120-30-30 for Wet and Dry Season, respectively). A control treatment, where no residue was added into the plot, was also included with other treatments.

Field experiment was prepared with 28 plots measuring 6m x 6m with a total area of 0.175 ha. Treatments were arranged in a Randomized Complete Block Design (RCBD) and replicated 4 times. Data were analyzed by the analysis of variance using the NEVA program. Separation of treatment means were achieved using Duncan's Multiple Range Test (DMRT).

Results and Discussion

Indigenous knowledge on organic farming practices that represent successful ways by which people have dealt with poor quality soil were documented. The incorporation of rice straws into lowland paddy soil and the use of straw as mulch harvested from first rice crop for use to the second crop i.e. *Brassica chinensis*, were known to be part of farm management systems. Hargrove *et al.* (1991) reported that decomposition rates were significantly faster when residues were incorporated into soil than they were maintained in the surface. Among the plant resources documented,' Kakawate' (*G. sepium* Leguminosae), is popularly known to farmers for its nutrient composition and pesticidal property. The advantages of *G. sepium* as soil ameliorant were presented in the reports of Badayos and Pangga (2002) and Dela Cruz (2003). "Putat", Filipino name for *Barringtonia racemosa*, is a good soil stabilizer and commonly planted along rice dikes and paddies, on stream banks and other upland areas that are actively eroded. Burger (1972) reported that this shrub is commonly planted to rehabilitate coastal strand vegetation and lowland woodland. "Buho" Filipino name for *Schizostachyum lumampao*, is endemic to the Philippines and local farmers planted this bamboo to conserve the soil near water tributaries. *Heliconia* spp. is an exotic plant that can easily adapt to a wide range of soil and climatic environment. They were used as hedgerows in undulating and sloping catchment areas. Because of their prolific growth habits, they favorably contribute to soil conservation.

- There was a wide range in the initial total N concentration between treatments (Table 1). Plant materials with high N concentration are considered to be of high resource quality to microorganisms and they decompose and release N quickly (Rao 1995). The concentration of digestible organic matter (DOM), acid detergent fiber (ADF), cellulose and lignin also varied in plant residues. Plants are subjected to a number of environmental conditions which may affect the final composition, structure and digestibility at maturity (Pearce 1985). Table 2 presents the effect of added rice straws, *G. sepium* and *M. tanarius* on rice grain yield. Plant resources affected rice yield and were evident on the 4^{th} and succeeding croppings. Juo and Kang (1989) have highlighted the importance of plant residues for long-term fertility maintenance and reported that retention of these organic materials resulted in higher soil organic matter and crop yield compared to treatments from which no residues were added. Results such as these may explain that there is often a close association between the level of N input and rice yield, but the relationship may vary considerably from year to year depending on the variability of the climatic factors and pest occurence.

Table 1. Total N and organic constituents (%) of plant materials and straw from different rice varieties.

Plant Material	Total Nitrogen	DOM[1]	ADF[2]	Cellulose	Lignin	Soluble Phenolics
G. sepium	4.06[A]	55.0	22.2	13.6	8.6	2.1
M. tanarius	2.84	41.3	30.1	19.6	10.6	-
IR-8	0.69 defg	48.9 bcd	50.3	47.1	3.2	3.9
IR-36	0.87 bc	51.5 b	50.2	47.2	3.0	4.3
IR-54	0.52 hi	47.2 de	52.7	49.8	2.9	4.1
IR-72	0.69 defg	49.6 bcd	48.9	46.1	2.8	4.7
PSBRc18	0.65 efgh	45.9 efg	50.0	47.0	3.0	4.6
IR67962-84-2-2	0.94 b	48.5 cde	56.8	52.5	4.3	1.4
Intan	0.48 i	43.3 gh	63.8	59.8	4.0	4.1
Khao Seetha	0.93 b	50.8 bc	52.7	49.2	3.5	1.6
Soc Nau	1.13 a	55.0 a	50.0	45.9	4.1	1.9
Suakoko 8	0.94 b	49.1 bcd	55.5	50.5	5.0	3.3
K. Rondo Marong	0.64 fgh	44.0 fgh	60.2	55.4	4.8	2.0
Ketan Lombok	0.67 efg	43.1 h	61.6	56.5	5.1	1.9
Ribon	0.58 ghi	46.0 ef	56.5	52.0	4.5	5.4
Rodjolele	0.51 hi	46.1 ef	57.5	53.5	4.0	3.8

[A] Numbers within a column followed by the same letter are not significantly different according to DMRT at P≤0.05. [1]Digestible organic matter [2]Acid detergent fibre

Table 2. Rice grain yield at different crop/plant material and different cropping season.

	Rice Grain Yield (tons/ha)								
Treatments	WS 2003[2]	WS 2004[2]	WS 2005	DS 2006	WS 2006	DS 2007	WS 2007	DS 2008	WS 2008
IR36	3.65 ab[1]	3.11 bc	3.40 c	3.31 b	3.78 ab	3.75 bc	2.99 ab	4.26 a	2.35 b
IR54	3.80 a	2.53 d	3.19 c	3.27 b	3.41 bc	3.34 d	2.84 b	4.08 ab	2.41 b
IR72	3.70 ab	3.30 b	3.30 c	3.52 ab	3.54 abc	3.50 cd	3.09 ab	4.14 ab	2.20 b
G. sepium	4.01 a	3.17 bc	4.27 b	3.68 ab	4.04 a	3.97 ab	3.33 a	4.45 a	3.31 a
M. tanarius	3.97 a	3.04 c	3.97 b	4.07 a	3.94 ab	3.57 cd	3.11 ab	4.40 a	2.71 b
Recomm. Rate	3.60 ab	3.59 a	5.08 a	4.09 a	4.11 a	4.27 a	3.24 ab	4.35 a	2.39 b
No residue-	3.31 c	1.89 e	2.68 d	2.52 c	3.08 c	2.76 e	2.30 c	3.71 c	1.50 c

[1] Numbers within a column followed by the same letter are not significantly different according to DMRT at P≤ at 0.05.

[2] Damaged by rats and birds; WS – wet season; DS – dry season

Conclusions

Many concerns have been expressed about the sustainability of rice production systems. The intensification of production must not be undertaken through ecologically destructive approaches, in which the traditional/indigenous farming principles may apply. The appropriateness and adoption of these indigenous practices and soil management systems will depend largely on their profitability and value to farmers. The future of the small-holder rice farmer will be determined by their ability to maintain an economic operation while simultaneously sustaining the farms production potential.

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Application of oil palm waste-based organic fertilizer in three crop cycles of sweet corn: effects on yield, soil properties and carbon stock

Rosenani, A.B.1, Kala, D.R.2, Ahmad, S.H.3, Fauziah, C. I.4, Radziah, O5 & Anizan Isahak[6]

Key words: organic fertilizer, soil chemical properties, soil carbon stock, sweet corn.

Abstract

Composting of oil palm wastes is becoming popular in the last decade as an alternative method of waste disposal. Thus, a study was conducted to investigate the use of an organic fertilizer formulated from oil palm waste compost and chicken manure for sweet corn cultivation The treatments in this study were recommended rates of N, P and K chemical fertilizers (CF) and 4 rates of oil palm waste-based organic fertilizer (OPWOF), i.e. 100, 150, 200 and 300% N equivalent (equav.) of recommended rate of chemical fertilizer with five replicates laid out in randomized complete block design with plot size 4.0 m x 6.0 m. Three crop cycles were completed and the crops were harvested at 75 days after sowing. Composite soil samples were taken from 0-15 cm depth after each harvest for chemical properties and core samples were taken after the third crop for bulk density and C stock measurements. Due to poor weather the first crop yield for all treatments were very low. However, in the second and third crop cycles, the cob and total DM yield of the crops with 300% N equiv. rate of OPWOF were comparable to the crop that received chemical fertilizers. Application of OPWOF had increased significantly the soil pH, and total N and organic C contents of the topsoil compared to the CF. The cation exchange capacity and, exchangeable bases, and C stock in soil with 300% N equiv. OPWOF application were significantly higher than the soil with CF at harvest of the third crop.

Introduction

Malaysia is one of the top producers of palm oil in the world and in 2009, the total area under oil palm cultivation is about 4.69 million hectares (Malaysian Palm Oil Board 2009). Recently in Malaysia, there has been a great interest in converting oil palm wastes into organic fertilizer through composting. Converting these organic wastes

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into organic fertilizers is a ‘win-win’ strategy, i.e. besides the direct reduction of GHG emissions associated with waste disposal, it also increase soil organic C. Organic farming which subscribes to the principles of sustainable agriculture is rapidly expanding worldwide that relies on ecosystem management rather than external agriculture inputs. Studies have shown that organic fertilizer improves soil fertility over time by improving soil physical properties and increase biological activity in (Petersen & Wistinghausen 1999). Researchers found that oil palm waste compost increased soil fertility by increasing available phosphorus, % base saturation and cation exchange capacity (Aisueni & Omoti 2001). However, there is still lack of use of oil palm wastes-based organic fertilizers in organic farming probably due to lack of research and understanding on the nutrient availability and crop performance of the fertilizers and their effects on properties of highly weathered acidic tropical soils. A field study was conducted to determine the effects of an oil palm waste-based organic fertilizer (OPWOF) on sweet corn yield, nitrogen mineralization, humification rate, carbon dynamics and soil chemical properties in 0-15cm soil depth in three crop cycles. However this paper presents results relating to dry matter yield and soil chemical properties only.

Materials and methods

A field experiment with sweet corn crop (Manis madu variety) was established in the University Putra Malaysia farm from March 2008 to August 2009 with clayey topsoil (0-15cm), pH_{water} 5.7, 1.37% organic C, 0.161% total N and 6.86 cmol (+) kg^{-1} CEC. Oil palm waste organic fertilizer (OPWOF) was produced by a mixture of oil palm waste compost and chicken manure at 70:30 ratio (w/w). The OPWOF had the following characteristics: pH_{water} of 7.8, 1.97% total N, C/N ratio 9.5, 1.67% P, 2.50% K, 7.1% Ca and 1.12% Mg. The treatments involved were T1: recommended rates of N, P and K chemical fertilizers (CF), T2: 100%, T3: 150%, T4: 200%, and T5: 300% N equivalent (equiv.) of recommended (rec.) rate of OPWOF; with five replicates and laid-out in a randomized complete block design (RCBD) with plot size 4.0m x 6.0m. OPWOF was applied 5 days before sowing and N, P and K fertilizers in treatment CF were applied in the forms of urea, triple super phosphate (TSP) and muriate of potash (MOP) at 200:90:90 kg ha^{-1}, respectively, in each crop cycle. The chemical fertilizers were applied in a split application, once at sowing and the other half at silking. Weeding was done manually and no pesticide was applied. The crop was harvested at 75 days after sowing. Total dry matter weight and dry matter weights of cobs and stover (stalk and leaves) were determined. At harvest, one composite soil sample were taken from 3 points per plot at 0-15 cm depth for soil chemical analysis: pH 1:2.5 (w/v), total C (Leco C Analyzer), total N using Kjedahl method (Bremner & Mulvaney 1982) and cation exchange capacity and exchangeable bases (ammonium acetate buffered at pH7 method). Calcium and Mg were determined by atomic absorption spectro-photometry while K was determined by flame photometry. After harvest of the third crop, soil cores were taken from 0-15 cm soil depth for determination of bulk density in order to calculate total C carbon stock (Mg C ha^{-1}).

Results

The crop performance of the 1st crop cycle was very poor due to bad weather thus not presented. However, there was an increasing trend in the cob and total dry matter weight of sweet corn in the 2nd and 3rd crop cycles (Tab.1). The OPWOF produced the same cob and dry matter yield as chemical fertilization only at the rate of 300% N equiv. Table 2 shows the effect of OPWOF on soil chemical properties in the three crop cycles. There were no significant effect of the OPWOF on the total N and organic C concentrations in the topsoil at harvest of the 1st crop. However, there were improvement in soil chemical properties in general in the 2nd and 3rd crop cycle with OPWOF application compared to CF. Application of OPWOF increased significantly soil C stock compared to CF in the 0-15cm soil depth at harvest of the 3rd crop (Figure 1).

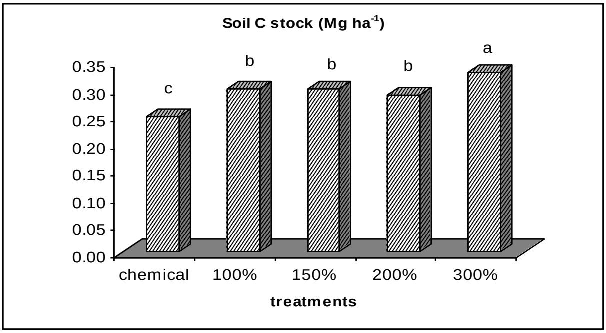

Figure 1: Soil carbon stock (Mg ha-1) in 0-15 cm soil depth as influenced by OPWOF and chemical fertilizer after 3 crop cycles of sweet corn. Bars with identical letters are not significantly different at the 0.05 level of probability, as determined by a DMRT test.

Discussion

Application rate of OPWOF lower than 300% N equiv. of CF was not able to produce crop growth and yield comparable to chemical fertilizers. Obviously, the nutrients derived from the lower rates of OPWOF were not released fast enough to be available for the plant uptake. Thus, the optimum rate for application of OPWOF was 300% N equiv. which produced sufficient amounts of available nutrients for plant uptake. However, OPWOF was able to sustain soil organic C and other soil properties compared to CF. According to Roe (1998), increase of soil organic C continually supplied with composts can result in improvement of soil quality indicators that facilitate nutrient availability and uptake. Application of OPWOF, even at the lower rates was shown to increase soil C stock compared to CF.

Conclusions

It is concluded that the application of OPWOF at 300% N equiv. of CF may be used in an organic production of sweet corn. Repeated application of OPWOF increased soil C stock and sustained soil chemical properties.

Tab 1: Stover, cob and total dry matter weight (t ha-1) of sweet corn in 2nd and 3rd crop cycle as influenced by OPWOF and chemical fertilizer.

Treatment	Stover	Cob	Total DMW
2nd crop cycle			
Chemical	2.00b	1.30a	3.30ab
100% OPWOF	1.30b	1.20a	2.50ab
150%OPWOF	1.56b	1.35a	2.91ab
200%OPWOF	1.41b	1.11a	2.43 b
300%OPWOF	2.51a	1.12a	3.63 a
3rd crop cycle			
Chemical	1.33a	5.22 a	5.57 a
100% OPWOF	1.02a	2.89 b	3.91 b
150%OPWOF	1.21a	3.23ab	4.44ab
200%OPWOF	1.01a	2.79 b	3.80 b
300%OPWOF	1.65a	4.56 a	5.61a

Means in columns with identical letters are not significantly different at the 0.05 level of probability.

Tab. 2: Effect of OPWOF and chemical fertilizer on soil chemical properties (0-15cm soil depth) in 3 crop cycles of sweet corn.

Treatment	Total N%	Total C%	pH	CEC*	Ex K	Ex Mg	Ex Ca
1st crop cycle							
Chemical	0.133a	1.36a	5.36c	7.79 c	0.60 b	0.96 b	4.32a
100% OPWOF	0.138a	1.44a	6.15b	7.90 c	0.68 b	1.08 b	3.95a
150%OPWOF	0.136a	1.69a	6.34b	7.97 c	0.74ab	1.45ab	4.23a
200%OPWOF	0.152a	1.63a	6.67a	8.76 a	0.98ab	1.60 a	4.68a
300%OPWOF	0.159a	1.67a	6.73a	8.58ab	1.11 a	1.76 a	4.77a
2nd crop cycle							
Chemical	0.126 c	1.07b	5.44c	7.58a	0.63c	0.99 c	4.16a
100% OPWOF	0.143ab	1.38a	6.22b	7.36a	0.64c	1.11 c	4.20a
150%OPWOF	0.135bc	1.43a	6.36b	7.57a	0.80b	1.62 b	4.45a
200%OPWOF	0.158ab	1.62a	6.64a	8.43a	1.03a	1.81ab	4.85a
300%OPWOF	0.162 a	1.61a	6.69a	8.03a	1.23a	1.96 a	4.65a
3rd crop cycle							
Chemical	0.156 c	1.29 c	5.02 c	7.55 c	0.50 c	0.74 b	3.16 c
100% OPWOF	0.176ab	1.64ab	6.19ab	8.83 b	0.64bc	0.92ab	3.57bc
150%OPWOF	0.171bc	1.58 b	6.07 b	9.04ab	0.63bc	0.93ab	3.94 b
200%OPWOF	0.190 a	1.51 b	6.41 a	9.36ab	0.91ab	1.09 a	4.61ab
300%OPWOF	0.163bc	1.74 a	5.96 b	9.86 a	1.07a	0.99ab	4.95 a

Means in columns with identical letters are not significantly different at the 0.05 level of probability, Cation exchange capacity (cmol (+) kg^{-1}),Ex - Exchangeable bases (K,Mg,Ca) - (cmol (+) kg^{-1})

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Si fertilization as integral part in sustainable agriculture and organic farming

Matichenkov V.[1]

Key words: Silicon fertilizer, yield, soil fertility, field test

Abstract

Restoration or formation of high soil fertility and optimization of plant nutrition by nonsynthetic materials are ones of the necessary steps to transfer conventional agriculture into organic agriculture. Large scale field demonstration tests (150 sites with total area more than 3000 hectare) were conducted on North Queensland, Australia, which showed that the application of Si fertilizer Natural Silica (certified for organic farming) increased yield by 5 to 50% for sugarcane, hay, potato, corn, banana, and tropical fruits. Using Si fertilizers with high level of active Si makes possible to reduce the traditional mineral fertilizer rates by 20 to 30% and pesticide using by 40 to 70% without negative impact on crop production. The soil analysis showed improved soil fertility level one year after Si fertilization. The application of Si fertilizers or Si soil amendments is very important and should be included into cultivation system for both conventional and organic agriculture.

Introduction

One of important aspects necessary to provide sustainable agriculture, especially organic farming, is related to the protection of cultivated soil against chemical, physiological, and biological degradation. The conventional agriculture usually leads to soil degradation. To transfer conventional agriculture to organic, high level of soil fertility should be formed.

Silicon is a constituent of many plants, but its role and functions in plant biology remain poorly understood (Liang 1999). Beginning in 1840, numerous laboratory, greenhouse and field experiments have shown beneficial effects of silicon fertilizers for rice, corn, wheat, barley, sugar cane, and other crops (Snyder et al., 2006). Si fertilizers benefit plant growth through their impacts on soil and plant. Firstly, Si reinforces plant protection against insect and fungal attacks and unfavorable climatic conditions (Datnoff et al., 1997). Secondly, Si applied to soil improves physical and chemical soil properties and maintains nutrients in plant-available forms (Matichenkov and Ammosova, 1996).

Although Si has not always been listed among the generally essential elements for higher plants, there have been reports of direct effect of Si supply on plant defense system (Liang 1999). Several mechanisms by which Si affects plant defense system were suggested (Biel et al., 2008): 1) Si provides mechanical plant protection via accumulation in epidermal tissue and formation of a thick layer, which protects plants against fungi and insect attacks (Ma and Takahashi, 2002); 2) Si provides physiological protection related to optimizing root formation and enhancing

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photosynthesis (Snyder et al., 2006); 3) Chemical protection by Si is realized due to the interaction between monosilicic acid and some contaminants such as heavy metals, Mn, and Al in plant tissue (Matichenkov & Bocharnikova, 2001). Soluble forms of Si are supposed to be able to play a role in additional catalytic synthesis of specific and non-specific stress hormones and antioxidants (Biel et al., 2008). However, the lack of the specialists and poor understanding of the mechanisms of direct and indirect effects of active Si forms on soil, plant, and microorganisms impede wide practical implication of Si fertilizers and Si soil amendments. The best way to increase the attention to this type of fertilizers is demonstration of their efficiency on a large scale.

The main aim of this study was to demonstrate the importance of Si fertilization for agricultural productivity and soil fertility on a large scale.

Materials and methods

Natural Silica (NS) (Synergy Fertilizers Pty Ltd, North Queensland, Australia) from an open mine near Mt Garnet in North Queensalnd, a natural mineral high in plant-available Si, was used in this study. This material is officially certified for organic farming. The chemical composition of the material is present in Table 1.

Table 1. Selected chemical properties of Si-rich material

pH	Adsorption capacity, kg t-1 of NS		CaO	MgO	Fe_2O_3	P_2O_5	Al_2O_3	SiO_2
	P	NH_3	--%------------------------------					
6-7	4.3-4.5	20-24	3-4	1-2	5-7	0.15	3-4	80-82

The laboratory investigation has shown that this material has very high content of active or plant-available Si (Matichenkov, 2008). Water-soluble Si ranged from 80 to 100 mg kg^{-1} of Si as monosilicic acid. The parameter named active Si (Bocharnikova et al., 2010) was about 2000 mg kg^{-1} of Si. The preliminary greenhouse and field tests have demonstrated high efficiency of this source of plant-available Si (Matichenkov, 2008; Bocharnikova et al., 2010).

Field tests were conducted on 150 commercial fields located from Mossman to Bundaberg (North Queensland, Australia) during 2008-2010 on sugarcane, hay, potato, banana, corn, and tropical fruits. Each field trial had at least 3 control plots with minimum size 20 hectares were treated with standard mineral fertilizers (control) and at least 3 plots treated with standard mineral fertilizers plus NS (treated). The plots with no fertilization were not used, because all tests were conducted on the commercial fields. By this means each experiment had minimum 6 plots. The design of 10 field trials included control plots (100% standard fertilization), treated plots (100% standard fertilization + NS 1 t ha^{-1}), and advanced treated plots (70% from standard fertilization + NS 1 t ha^{-1}). The design of 2 field trials included control plots (100% standard fertilization), treated plots (100% standard fertilization + NS 1 t ha^{-1}), advanced treated plots I (75% from standard fertilization + NS 1 t ha^{-1}), and advanced treated plots II (50% from standard fertilization + NS 1 t ha^{-1}). Each plot had the area at least 1 ha for fruits and at least 10 ha for sugarcane, potato, banana, maize or hay. The total area of field trials was about 3000 ha. Soil samples were collected each 3 mo. from each plot and analyzed in the Si-Soil Technologies Laboratory. The crop quality was evaluated by farmers. The volume of pesticide application was managed by farmers as well.

Results

In general, NS increased the crop production by 5 to 40% (on average 12.5%) for sugarcane with increasing of ccs as well, by 10 to 30% (on average 13.4%) for potato, by 15 to 25% (on average 17.8%) for banana and tropical fruits, and by 25 to 50% (on average 28%) for hay (Table 2). If farmer reduced the application of the traditional fertilizers, the application of Si fertilizer allowed prevention of reducing yield. It is importnat that farmers reported about reduced pesticide application by 40 to 70% on Si-treated plots.

Table 2. Selected data of the effect of Natural Silica on available soil macronutrients and yield (C- control, T- treated).

Region, crop tested and area (ha)	Mineral N (ppm)		P (Colwell) (ppm)		Exchangeable K (ppm)		Mean yield (t ha-1)	
	C	T	C	T	C	T	C	T
Burdekin 1, sugar cane, 40 ha	8.6	9.2	3	6	8	8	69	75
Burdekin 2, sugar cane, 20 ha	7.6	12	37	59	86	126	73	88
Table Land, Passion fruit, 2 ha (yield, kg per tree)	25	21	50	54	41	50	35	54
Tableland, banana, 20 ha	25	20	27	30	282	240	3.4	3.8
Table Land, potato, 20 ha	16	20	66	57	75	78	25.4	28.7
Ingham, sugar cane, 20 ha	1.4	4.8	20	29	47	45	41	70
Kaban, hay, 10 ha	27.4	3.5	35	43	24	48	1.03	1.24
Innisfail, banana, 20 ha	0.6	6.5	18	21	19	25	4.3	4.8
MillaMilla, hay, 20 ha	185	42.0	181	131	93	89	0.84	1.03
LSD_{05}	1.3	1.5	1.5	2.4	3.2	3.0	1.2	1.5

Discussion

The field tests of NS have demonstrated the positive effect on soil properties and yield of crop. The NS application optimized the contents of plant-available P, N, and K in soil. An increase in plant-available P could be explained by the exchange reactions between Ca-, Al-, and Fe- phosphates and monosilicic acid, which result in transferring plant-unavailable P into a plant-available form (Matichenkov and Ammosova, 1996; Matichenkov 2008). The improved nitrogen and potassium status by NS can be explained by high adsorption capacity of NS and increased microbial activity in the treated soil (Biel et al., 2008; Matichenkov 2008).

Si fertilizers give possibility to reduce traditional fertilizer application rate as well as pesticide application. By this means, Si fertilizers could provide gradual transition of conventional to organic agriculture without a reduction in crop production. Simultaneously, the application of Si fertilizers initiates the restoration of a soil fertility level. Consequently, the application of those Si fertilizers, which are classified for using in organic farming and possess high content of active Si, should be included into organic agriculture management.

Outlook

Large scale field demonstration tests have shown that the application of Si fertilizers increased the yield of corn, potato, banana, sugarcane, hay, and tropical fruits by 5 to 50% and gave possibility to reduce the application rate of traditional fertilizers and pesticides without negative impact on the crop production. Si fertilizers provided improved soil fertility. The obtained results have demonstrated that Si fertilizers with high level of active Si play a remarkable role in developing sustainable agriculture and should be included as an integral part in organic farming system.

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Comparison of variable liming strategies in organic farming systems using online pH-measurements

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Key words: variable liming strategies, online-sensor, soil pH variability

Abstract

In organic farming, soil pH is one of the most important soil characteristics affecting nutrient availability, soil microbial activity and plant growth. Using the soil pH mapping sensor system Veris MSP, detailed information on in-field variability of soil pH can be obtained enabling spatial variable lime application. Scenario calculations for an organically managed field in Germany reveal that compared with the standard farm practice (i.e. uniform liming rate) variable lime application does not lead to higher costs while soil pH is optimized in different field zones resulting in increased crop productivity. Using two different lime qualities increases liming costs moderately but gives farmers the chance to increase pH quickly in extreme low pH areas.

Introduction

As soil pH decreases over time, application of lime is the standard farm practice readjusting soil pH, in order to ensure optimal plant growth. In Germany fertilizer recommendation schemes for lime application in mainstream as well as in organic farming, are based on soil pH measured in manually collected soil samples (one representative sample per field) taking soil texture and organic matter content into consideration (VDLUFA 2000). Thereby the mainly used limes in organic farming are of medium quality (50 % reactivity) in Germany.

According to Bianchini & Mallarino (2002), spatial soil pH variability of more than two pH units can occure within short distances in a field. Up to now this variability is disregarded in German standard farm practice due to time constraints and analysis costs for manual soil sampling. To cover this spatial variability a high density of soil pH measurements is required. A sensor platform (Veris MSP, Veris Technologies Inc., Salina, KS, USA) for on-the-go soil pH and electrical conductivity (EC) mapping has been developed which can provide a vast number of pH samples (Adamchuk *et al.* 1999). Based on this high resolution data different pH zones in the field can be identified (Olfs *et al.* 2010).

As soil pH has a significant influence on nutrient availability and uptake (e.g. nitrogen, phosphor), soil microbial activity (especially mineralisation and nitrogen-fixation by rhizobia bacteria) and soil structure (Thomas 2006), detailed information about pH variability in fields is of high relevance, especially in organic farming. Additionally a lime application with a fast-acting but more expensive lime type could be processed more precisely and efficiently. Based on high resolution pH data from an organically managed field, two liming strategies (variable, variable with two lime qualities) were

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compared with the standard farm practice (i.e. uniform application rate) using scenario calculations.

Materials and methods

To compare different liming strategies, a 13 hectare field on an organic farm in north-west Germany close to Osnabrueck (59°19'14'' N; 8°09'28'' E) has been mapped with the Veris MSP. The soil type is characterized as Plaggic Cambisol according to FAO (2006). Soil texture in most parts of the field is classified as sandy clay loam.

The Veris MSP is featured with an automatic sampling unit for online pH measurements: A sampler shoe is forced into the soil taking a soil core in a depth of 8 – 10 cm. In specified time intervals the shoe is automatically raised against two antimony pH electrodes and the average pH value is recorded together with its geo-referenced position. The next measurement cycle starts with rinsing the electrodes with demineralised water while simultaneously a new sample is collected. For this field trial, a sampling density of 34 pH samples per hectare at a speed of 8 – 10 km/h and spacing of 15 m between passes were realised.

Due to the fact that this online pH measurement is not identical with the lab procedure in Germany (e.g. electrode type, extraction conditions), reference samples need to be taken manually from zones with low, medium and high Veris MSP pH values. Each reference sample consists of 15 individual soil cores, taken in the middle of these zones (radius = 10 m). The pH analysis was done by following the German standard procedure (calcium chloride 0.01 mol/l; soil + extraction solution = 1 + 2.5; glaselectrode). Based on these lab pH values, a linear function was calculated to convert each online pH value into a standardised pH so that the German liming recommendation scheme can be applied. These standardised pH values were interpolated using kriging according to Webster & Oliver (2007) to generate the pH map of the field by using the open source GIS software "OpenJUMP" (Kielhorn & Trautz 2009). Thereafter the entire field was divided into grid cells (11 x 11 m). Taking into account the standardised pH, soil texture (sandy clay loam) and soil organic matter content of 4 %, the lime application rate (t CaO/ha) was calculated for each grid cell.

Using scenario calculations, three liming strategies were developed. For the "standard farm practice" strategy (SFP) lime requirements were calculated for each grid cell based on the average field pH of 5.9, while the "variable application rate" strategy (VAR) takes the different standardised pH values into consideration. For both strategies a medium lime quality (45 % calcium oxide; reactivity 50 %) was utilized. In the strategy "VAR+" different lime qualities were used: A high reactive lime quality (55 % calcium oxide; 80 % reactivity) in places where pH is lower than the average pH of 5.9 and the standard lime quality with 50 % reactivity for the remaining grid cells.

Results and discussion

Online pH measurement for the study site reveals differences in the standardised pH of 0.7 pH units (pH 5.5 – 6.2). Zones with low pH values (5.5 – 5.7) at the northern and south-western part of the field can be distinguished from two areas in the south and northwest with higher pH (6.1 – 6.2; Fig. 1). Based on the German lime recommendation scheme and the pH variability within the field the required lime amounts differ between 2.6 – 5.8 t calcium oxide per hectare. Comparing this VAR strategy with the SFP strategy (4.2 t per hectare) illustrates that about 4.3 hectare of this 13 hectare field will not receive enough lime to increase the soil pH to the required level. On the other hand 4.7 hectare will be oversupplied with lime leading to soil pH above the recommended level (Fig. 2), i.e. 70 % of the total area the average liming rate is not adequate. The total amount of lime applied on this field is the same for these two strategies. Therefore liming costs are identical. However, it can be expected that the VAR strategy has a positive impact especially on nutrient availability and induces more homogeneous growing conditions for crops. Pierce & Warncke (2000) demonstrated in field trials using variable liming rates on two fields in Michigan (USA) that soybean yields declined when soil pH is inappropriate.

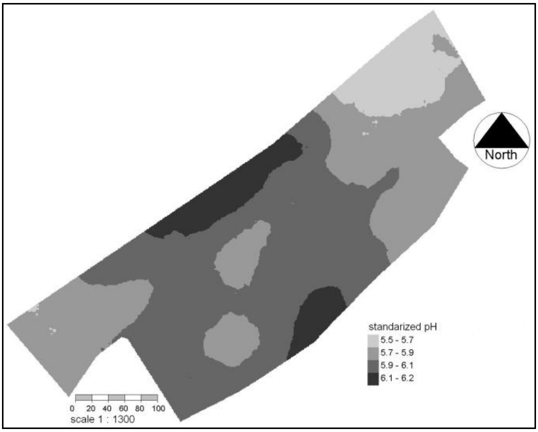

Figure 1: Kriging interpolated standardised pH map of the 13 ha field

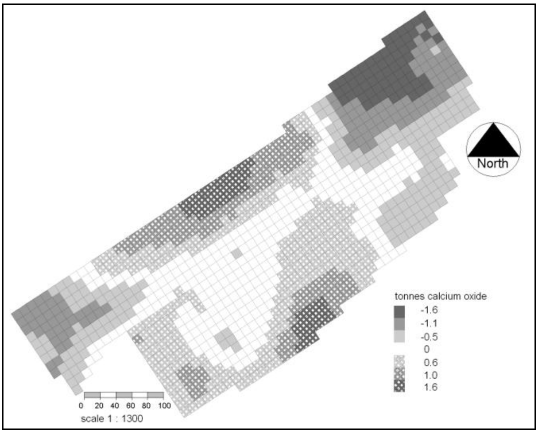

Figure 2: Differences in lime application rate for each grid cell (tons calcium oxide) when using SFP instead of VAR liming strategy of the 13 ha field

The VAR+ strategy causes higher total liming costs of about 25 – 30 % due to more expensive lime plus the required second lime application. This is necessary as at present, no techniques are available to apply two lime types simultaneously. The efficiency of such a strategy depends on the effects an immediate pH increase will have on crop growth. The VAR+ strategy for this study site is profitable if it leads to a yield increase of 0.2 tons per hectare based on a price of 40 € per ton for organic milling wheat. Comprehensive economical calculations of variable rate liming in Indiana (USA) according to Bongiovanni & Lowenberg-Deboer (2000) reveal increased annual returns in corn and soybean production.

Conclusions

The Veris MSP sensor collects reliable spatial soil pH data which can be used for variable lime applications after a recalibration based on lab analysed soil samples. Such a variable lime application strategy offers the opportunity to apply lime more precisely according to the different pH zones in the field. Increased nutrient availability and higher yields can be expected. In comparison to standard uniform lime application a variable application with a moderate reactive lime quality does not increase costs but leads to optimized pH values in different field zones. The additional use of a high reactive lime quality in extreme low pH areas increases liming costs slightly, but will result in a more rapidly adjustment of soil pH. Field trials to evaluate these different liming strategies and to calculate the costs for Veris MSP measurement are ongoing.

Acknowledgments

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Relation between soil structural field parameters and soil physical laboratory measurements

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Key words: Soil structure, Soil fertility, Field method, Spade diagnose

Abstract

Visual observations of soil structure in the field offer the potential to provide semi-quantitative information for use in specification and monitoring.

At 24 test sites in Germany soil samples for laboratory analysis were taken. Parallel to this sampling the field analyses of the soil structure with the methods of DIN 19682 (2007) which describe the field method of the packing density (PD) and the DIEZ method (Diez & Weigelt, 1997) were conducted.

In this study the field methods and its single parameters were compared with laboratory measurements of dry bulk density, air capacity, saturated hydraulic conductivity, actual bulk density and pre-compression stress at -6kPa matrix potential.

A spearman correlation showed a significance relation of aggregate arrangement and structural soil type with dry bulk density, air capacity, saturated hydraulic conductivity and actual bulk density. The calculated and aggregated mark of the DIN or the DIEZ method was significantly related to dry bulk density and the saturated hydraulic conductivity. The results showed that with the mark of the PD or DIEZ method it is feasible to obtain a semi-quantitative status of soil physical properties in the field and that all parameters are important to comprehensively assess the soil physical status.

Introduction

When crops show visual signs of growth retardation a whole range of causes are possible. Apart from the incidence of diseases, lack of nutriens , water stress or soil structural effects could be the reason. In organic agriculture it is not possible to mitigate such effects with mineral fertilizer or pesticides, however, the best fertilizer management will not work if roots are not able to access water or nutrients. The function of soils as buffer for water, air and nutrients depends highly on its structure.

Soil physical analyzes are notoriously work, time and money intensive and normally completely unpractical for farmers. Thus different field methods for a semi-quantitative evaluation of soil structural conditions have been suggested, however, most of these methods are based on the use of a spade or a pocket knife and have some sort of assessment scheme. Two methods to asses soil structural properties in the field are the measurement of the packing density (PD), (DIN 19682-10, 2007) and the method of DIEZ (Diez & Weigelt, 1997). If and how strong the field observations could reflect laboratory measurements is the objective of this study.

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Materials and methods

The dataset for this study is based on samples from 24 test sites located all over Germany. A wide spectrum of soil texture classes (clay, silt, loam, sand - clay content from 2% to 32%; sand contend from 3% to 93%) is included. At each site disturbed and undisturbed samples were collected from the topsoil (17-23 cm) and the subsoil layer (32-38 cm). Parallel to the collection of the samples, the field measurement of the packing density (PD) and the DIEZ level was conducted. All fields were sown with winter cereals (wheat or rye).

Determination of packing density (PD) and the DIEZ-method

The level of the PD and the DIEZ method is assessed visual and haptical in the field. It is based on digging out a soil sample with a spade and gentle manipulation by hand or pocket knife followed by a visual assessment of the soil profile. Both parameters integrated marks, which combine various soil structural properties affected by the degree of compaction. The macroscopic properties are combined to the PD and the Diez level:

- P1 Root distribution in the different soil horizons (PD + Diez)
- P2 Proportion of biogenic macropores (root and earthworms channels) (PD + Diez)
- P3 Penetration resistance with a pocket knife (PD)
- P4 Aggregate size (PD + Diez (indirect))
- P5 Aggregate arrangement as an indication of the properties of the aggregate space (PD)
- P6 Soil structure type (Diez)
- P7 Cohesion of the soil structure assessed with the falling test (PD)

The single properties could be graded with marks. In this case we use the marks 1 (very positive) to 5 (very negative) with 0.5 steps with regard to plant growing conditions. At each test site we took 4 replications.

Soil physical laboratory measurements

At each site two different types of soil cores with five replications for the lab analysis were taken. For each variation we sampled a volume of 220cm³ for the measurement of the pre-compression stress in an all-automatic oedometer (Bradford and Gupta, 1986) and 8 replications of soil cores with a volume of 250cm³ for the measurement of dry bulk density, air capacity and saturated hydraulic conductivity. For other analysis like texture or aggregate density we took disturbed samples as well.

The following values are in the focus of this paper:

- A1 Logarithm of pre-compression stress [kPa] (Bradford and Gupta, 1986, Casagrande, 1936)
- A2 Dry bulk density (DBD) [g cm^{-3}] (DIN ISO 11272, 2001)
- A3 Air capacity [Vol%] (DIN ISO 11274, 2001)
- A4 Saturated hydraulic conductivity [cm d^{-1}] (DIN 19683-9, 1998)
- A5 Actual bulk density of soil [g cm^{-3}] (calcul.: = DBD + 0,009 * clay %) (AG Bodenkunde, 2005)

Results and Discussion

Table 1 presents the correlation between the structural field parameters and the soil physical and mechanical data from the measurements. Even though the biological parameters P1 (roots) and P2 (macro-pores) are included with high weight in field observations nearly no relation was found. In contrast to the biological parameters the structural parameters penetration resistance (P3), aggregate arrangement (P5) and soil structure type (P6) showed significant relations to the laboratory data. This result concurs with the observation of Mueller et al. (2009), who found that “biological features like earthworm or root numbers were less reliable indicators of soil structure than aggregate characteristics”. Additionally, Horn et al (2007) report that it is possible to make conclusions from penetration resistance (penetrometer) to the pre-compression stress of a soil.

Table 1: R² - Correlation Matrix (Spearman; Bonferoni corrected) of the single structural field parameters and the overall mark of packing density (PD) and DIEZ method and the soil physical laboratory analyses over all test sites

	Single parameter							Overall mark	
	P1	P2	P3	P4	P5	P6	P7	**Diez**	**PD**
A1	0,38	0,33	**0,54**	0,31	0,46	0,41	0,42	0,47	0,45
A2	0,38	**0,49**	**0,50**	0,53	**0,73**	**0,53**	0,40	**0,59**	**0,51**
A3	-0,35	-0,05	-0,46	**-0,60**	**-0,74**	**-0,50**	**-0,73**	-0,36	-0,45
A4	-0,34	-0,34	**-0,53**	-0,48	**-0,68**	**-0,57**	**-0,66**	**-0,51**	**-0,52**
A5	**0,56**	0,40	**0,62**	**0,75**	**0,75**	**0,73**	**0,69**	**0,68**	**0,68**

n = 48; Fad values = significant at 0.05 level.
A1 = Pre-compression stress, A2 = Dry bulk density (DBD), A3 = Air capacity, A4 = Saturated hydraulic conductivity, A5 = Actual bulk density; P1 = Root distribution, P2 = Biogenic macro-pores, P3 = Penetration resistance, P4 = Aggregate size, P5 = Aggregate arrangement, P6 = Soil structure type, P7 = Cohesion of the soil structure (falling test)

Air capacities below 5 to 8 Vol%, which have been postulated by Lebert et al. (2004) as minimum requirements for plant growth, could be found at PD/DIEZ -level ≥3.5. The low correlation with the air capacity (A3) is caused by the fact that different PD/DIEZ-levels belong to similar air capacities. This could be due to the fact sandy characteristics of the soils used as well as the fact that compact soils show stable macro-pores though the ecological parameters (yield, infiltration) are not always affected.

The results showed that with the PD or DIEZ method we were able to indicate semi-quantitative information on status of soil physical properties, which are parameters of important soil functions like water and air porosity and the root resistance, however, it was not sufficient to only focus on one a single parameter like penetration resistance.

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Practicing soil fertility from a practice theory perspective

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Key words: organic farming, practice theory, materiality, site of the social

Abstract

This article considers the relevance and contribution of practice theory (PT) for describing the social practices of organic farming. Particular to this theory is the "site of the social," the social practices, or the mesh of arrangements of embodied routine, repeatable behaviors and actions of individuals, that are expressed in specific interrelations with artifacts (e.g. machines) and natural entities (e.g. plants, animals, rocks) as well as their specific physicality. PT integrates various perspectives - "mind" and body", "subjectivism" and "objectivism" -, to help interpret social practices. Based on an outline of relevant characteristics of the theory, we refer to selected social practices of organic farmers in order to make explicit the added value of practice theory and to explore a deeper understanding of the complexity of organic farming.

Introduction

Organic farming is discussed as a complex approach to practicing agriculture. It is not simply a rearrangement or slight adaptation of techniques. Farmers are also confronted with new structural conditions, which provide guidelines for production and marketing, organization, industries or consumer demands. Conversion to organic entails changing the entire agri-food-system and therefore the social practices that constitute social life. On the farm this includes the technical, social, and market – issues (e.g. farm economy and labor) - , as well as conceptualizing interrelationships with nature. The farming practice can be seen as one in which novel artefacts and natural products, each with a specific physicality, enter and leave the farm, lead to modifed embodied practices, new forms of reflections, values, emotions, language and discourses. Social practices gain new significance or are changed within socio-economic and technical networks, the family, local community and society as a whole. These bundles of social practice arrangements are interpreted as the site where the social takes place, always connected within a specific space-time-context. From this perspective, organic can be seen as a far-reaching innovation process which demands a specific theoretical perspective in order to describe and interpret the interplay between human, artefacts, organisms (nature) and socialized structures. The aim of this paper is to explore a deeper understanding of the practical and social rationale of organic farming through the lens of practice theory (PT), to the specific case of managing organic soil fertility. In doing so, we seek to illustrate how PT helps make some characteristics of organic farming more explicit.

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Theoretical framework and methods

The strength of PT lies in its ability to draw attention to a detailed analysis of the development, routinization and change of social practices (Brand 2011, 24). A social practice is described as a nexus of verbal and nonverbal activities, where different actors and actants participate (Schatzki 1997). Behavior and acting follow implicit as well as explicit rules. Social practices are interpreted as partly routined – though for Schatzki also evolving, repeatable and repeated embodied activities, which are carried out by different actors and actants within a site and time specific context (Reckwitz 2000 p. 542; Schatzki, 2010, personal communication).

The central contribution of the theory involves its power to overcome the separation between social theoretical objectivism (e.g. structuralism) and subjectivism (e.g. phenomenology, theory of rational choice), “mind” and “body” (Bourdieu 1979, Giddens 1979). One specific insight of practice theory relative to other cultural approaches is the idea that objects characterizing and creating practice also create the social (Hörning 2001; Wieser 2004; Shove et al. 2007; Schatzki 2010). To put something “into practice” requires not only a human being but a hybrid network of individuals, objects, and meanings, which is capable of dealing with social practice as a shared common interaction (Shove et al. 2007, Schatzki 2010 p. 133). That is, materiality creates social life (ibid, 125). Human coexistence is inherently tied not just to practices but also to physical, biological and chemical entities (artifacts, organisms) and how these are arranged (Schatzki 2010 p. 130). Hence, these entities are accepted as relatively independent actants in the relational practices of “Doing Culture” (Latour 1987, 2002).

From this perspective non-living and living objects (both are actants) – i.e. artefacts and organisms -, with their specific physical, biological, chemical materiality, become agents of activity in an interplay with human actors. The entirety of this web is situated within socio-historic time space (Schatzki 2010 p. 130). Materiality affects nature, processes, techniques, people, and organisations along this actor chain. With this ontological perspective Schatzki identifies the inseparability of the social, nature, and materiality, and calls into question the human – nature dichotomy. He recognizes that “*any thing, property, or event can be at once both social and material-natural*”; “*any material entity...is also at once a social entity*” (2010 p. 133). This web of material, social and natural is expressed in different orders, or what Schatzki also calls the practice-arrangement nexuses.

PT interprets individual behavior and action as a consequence of individual choices and perspectives, impacted by socialized structures. Normative structural orders, e.g. organization, law, research bodies, or the media (Reichardt 2007, p. 54), are interwoven with individual characteristics, e.g. with certain know-how, reflexivity, mental patterns and emotional activities (Reckwitz 2003 p. 11). These webs are visible in sets of trained and routinized bodily performances, in behaviour and in discourses. Together these social practices express the site of the social. Social practices constitute social life - the culture and the nature of social existence (Schatzki 2002 p. XI). Culture becomes visible in an embodied human activity around a socially shared practical understanding (Schatzki et al. 2001 p. 2).

Our methodological approach is to follow the trajectories of an organic farmer in the way he / she practices „soil fertility“. First we offer a brief definition of soil fertility, how it is described from an organic perspective, their artefacts and materiality (industrial and natural), and how soil fertility is pre-formed by structural conditions (e.g. laws, certification, etc.). Then we introduce the elements of PT with reference to soil fertility and describe how they are expressed as a practice-arrangement-nexus, which includes the practices itself, the social network, as well as the related discourse on soil fertility. To make the practices visible we refer to well know organic farm practices.

Results

Soil fertility is defined as the capacity of a soil to provide crops with optimal living conditions. Fertile soils are characterised by their resilience to droughts, heavy rains and soil erosion; a capacity to self-regulate / suppress soil-borne diseases through their biodiversity and large biomass of microorganisms; high storage capacity for relevant plant nutrients and ability to make these available for plant growth due to a high organic matter content; a conducive pH level; the presence of specific clay minerals; a high load bearing capacity; and a broad spectrum of habitats for various organisms. Already, then, the term „soil fertility“ contains a material arrangement of soil as an inseparable unit.

Structural „pre-arrangements“ for „doing soil fertility“ in organic agriculture are the limitation of mineral fertilizer use, life stock units per ha, and the wide exclusion of pesticides and herbicides. This framework is prescribed by organic standards, monitored by private certification bodies - accredited by governmental organisations, and finally influenced by interest groups from various perspectives. Mental, ethical, ecological, social and economic values beyond these institutionalised norms, rules and laws are described by the IFOAM principles. These structural arrangements have broad implications for the social practices, types of knowledge, discourses about soils, and the reflexivity of the farmer. Specific farmer journals, the selling points of fertilisers and pesticides, the related social network, communication channels etc., are of no further relevance if a farmer starts practicing this definition of soil fertility. Techniques for spraying and distributing fertiliser become obsolete, embodied practices change, and the concept of „plant protection“ creates new practices. With these changes, the smell of pesticides and burned plant leaves in a landscape disappear and the size of a field changes. All becomes features of a new site of the social expressed in the social practices, e.g. planting a hedge together with environmental groups, etc.

To draw a first conclusion – the structures beyond the organic understanding of soil fertility are socialised in the farmers’ practices. They considerably alter the site of the social through changing practices that range from dropping the practice of buying inputs at their selling point, pesticide and mineral fertilizer storage and preparation, to practices with legumes and compost, in a landscape with modified forms, functions, colors, higher plant diversity, immigration of animals, techniques, smells etc. The entities mentioned also demonstrate that the practice-arrangement nexuses of soil fertility are connected and overlap with the concept of plant protection, herb (weed) management, agro-ecological landscape planning etc.

Applying the above concepts, how can we now understand „embodied, routined and repeated practices of doing soil fertility“? We already concluded that structures, norms and rules are socialised in farmers’ practices. One embodied practice, which is part of doing soil fertility, is the routined and yearly use of a spade for performing soil diagnosis. Spade diagnosis is a social practice. It takes place in the field, mostly during the growing season, and in the presence of other farmers, advisors, students or consumers. The material site arrangement is created by several physically different artefacts with characteristic materialities: soils, plants with their roots, pink coloured nitrogen fixing bacteria, dark earthworm channels indicating bacteria colonization, a knife for separating soil aggregates from the roots etc. Additionally, there exists a knowledge, terminology and language to interpret the complexity of soil-plant-climate-interactions. For the farmer and other participants standing together around the horizontally proped up spade on two iron bearings, the discourse is about crop rotation, root systems, plant varieties, tillage systems, green manure, microorganisms, farm yard manure, soil aggregates etc., referring to different time-space levels, all retained in a written protocol, the latter developed by a participatory interdisciplinary research team. How to dig with the spade and how to talk about soils are practices which are learned over several years, and thereby become embodied and routined. The result of the spade diagnosis has consequences for crop rotation, organic and mineral fertilizer management or soil tillage strategies. It affects farmers' emotions, values and motivations, i.e., his / her connectedness with soil and plants. It is the farmer who undertakes the whole analysis. The site of the social is the practice in the „laboratory of nature", i.e. in the field. In contrast to the spade diagnosis, the social practice of a chemical soil analysis for estimating the mineral fertilizer use encompasses the solitary farmer taking small soil samples each year, sending these to a chemical laboratory for soil analysis. Based on the written results and recommendations he / she practices a certain mineral fertilizer regime.

Conclusions

PT offers a sensitive approach to producing a broader, holistic description of organic agriculture by making the systemic character explicit, highlighting the interweaving of structures, individuals and materiality, and in reducing the distance between human, artifacts, and nature. This view makes especially explicit what the transition to organic agriculture means, encompassing all its social, material, environmental and economic implications. Consequently, the PT perspective speaks to those who ask for a deeper understanding of this agri-food-system as a cultural practice and the complexity beyond.

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Developing novel farming systems: effective use of nutrients from cover crops in intensive Organic Farming

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Key words: cover crops, organic farming, system development, alfalfa, ecosystem services.

Abstract

On-farm nitrogen fixation is a driving force in organic agriculture. The efficiency with which this nitrogen is used can be increased by using alfalfa or grass-clover crops directly as fertilizer on other fields: cut-and-carry fertilizers. In two crops in two years, the use of several types of alfalfa and grass-clover as fertilizer is compared with the use of poultry manure and slurry. The nitrogen use efficiency at crop level is comparable or better for the cut-and-carry fertilizers as compared to the animal manures. The relative P and K content of these fertilizers comes closer to the crop demand than that of the poultry manure. Crop yields are comparable or better when using the alfalfa or grass-clover as fertilizer. It is concluded that the cut-and-carry fertilizers are a serious alternative for manure as part of an overall farm soil fertility strategy.

Introduction

The objective of this study was to address the issue of developing intensive cropping systems that facilitate more effective use of on-farm N-fixation. This was achieved by developing innovative “cut-and-carry” cropping systems based on perennial grass clover or alfalfa crops. Including these forage crops in arable cropping systems will enhance soil quality in general. In this manner nutrients accumulated by these deep-rooted crops can be used as soil amendment rather than being sold and shipped off the farm as forage. This is very desirable because the revenues from these crops are rather limited whereas the on-farm nutrient use efficiency with these crops, that feature very high dry matter and nutrient accumulation, can be appreciable.

Materials and methods

The experiments were located on a organic farm in the centre of the Netherlands (52^{o}39’08 N ; 5^{o}48’07 E; 3 m below sea level) on a well drained clay soil with 2.6% of organic matter, 280 mg P kg^{-1} (P-Al) and 46 mg K kg^{-1}.

During 2009 the use of freshly (1st cut of season) grass clover, alfalfa, and silaged alfalfa were compared with application of chicken manure as a nutrient source for fall-grown spinach. Alfalfa was cut in pieces of about 3 cm. All materials were being

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applied manually five weeks before the sowing of spinach and shallow (8 cm) incorporated. An additional treatment was included to evaluate the effect of applying materials later by incorporating alfalfa at ten days before sowing as well. Actual N application rates amounted to 0, 165, 200, 202, 267 and 271 kg N /ha for the control, late application of alfalfa, silaged alfalfa, chicken manure, grass clover, and alfalfa, respectively. There were four replicates of each treatment in a randomized field lay-out.

In 2010 the experiment was repeated in a potato crop using slightly adapted treatments. The treatments, again in four replicates, were zero application, freshly cut alfalfa, alfalfa silage early application, alfalfa silage late application, poultry manure and a mixture of cattle slurry with vinasse. Poultry and cattle slurry originated from organic sources, vinasse from sugar beet production. Alfalfa early application was realized when planting the potato seeds; the other applications took place three weeks later when the ridges were build. The N application rates were 125 kg for the alfalfa treatments and the poultry manure treatment, and 93 kg for the mixture of cattle slurry and vinasse.

Results

Regarding N-availability, it was observed that after soil incorporation the subsequent mineralization of plant material was very rapid and within 5 weeks between 27% (silaged alfalfa) and 38% (fresh partly-dried alfalfa) was readily available while for chicken manure this number staggered at 17%.

Fresh yield of spinach was the highest with the use of fresh cut grass clover and alfalfa, applied 5 weeks before sowing of the spinach (Fig. 1). Yield increased with soil mineral-N values at sowing time with maximum yields occurring at around 175 kg N/ha. Compared with chicken manure, use of alfalfa and grass clover applied 5 weeks before sowing increased N production efficiency by 32-44%. However, delaying application to 10 days before sowing did not result in an appreciable improvement of N production efficiency. Mineral removal rates amounted to 67-126 kg N, 13-17 kg P and 122-233 kg K per hectare.

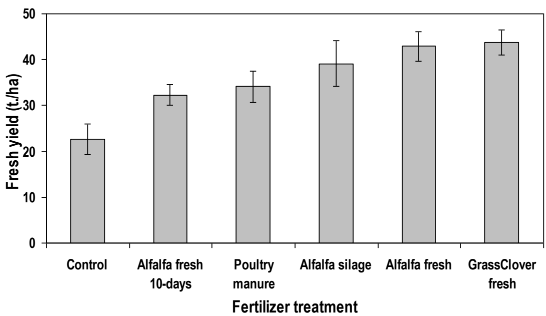

Figure 1: Fresh yield of spinach in different fertilizer treatments

The P and K content of the forage crops closely matched actual crop demands of spinach resulting in only relatively slightly positive nutrient balances (Table 1).

The P surplus of the poultry manure is very high. To assess the effects of treatments on crop performance we also calculated the apparent nitrogen recovery (ANR). This index calculates the additional nitrogen yield in comparison with the non-fertilized control per unit nitrogen present in the nutrient source.

Tab. 1: Mineral balance of phosphate and potassium and ANR for spinach in 2009.

	P*		K*		ANR*	
Spinach	(kg ha-1)		(kg ha-1)		(%)	
Control	-7	e	-31	c	-	
Alfalfa fresh 10 days	36	b	70	a	21	ab
Alfalfa silage	21	c	36	bc	23	a
Poultry manure	141	a	61	ab	15	b
Grass clover fresh	20	c	89	a	22	ab
Alfalfa 36 days	14	d	59	b	22	ab

*Significant for P < 5% after ANOVA

When the ridges were build in the 2010 potato experiment, soil N_{min} in the early alfalfa silage plots was on average 38 kg ha^{-1} higher than on the other plots. The marketable yield of the potatoes was in all treatments higher than in the control and the alfalfa treatments had the highest yields, but differences between the fertilized treatments were statistically insignificant. Nitrogen removal rates varied from 64 to 92 kg ha^{-1} .

The P content of forage crops closely matched actual crop demands of potatoes resulting in only relatively slightly positive nutrient balances (Table 2). For K all treatments except the Slurry/Vinasse show negative balances. The ANR is lower for the poultry manure.

Tab. 2 Mineral balance of phosphate and potassium and ANR for potato in 2010.

	P*	K*	ANR**	
Potato	(kg ha-1)	(kg ha-1)	(%)	
Control	-16	-139	-	
Alfalfa fresh	11	-83	20	b
Alfalfa silage early	2	-68	22	b
Alfalfa silage	3	-58	20	b
Poultry manure	132	-28	11	a
Slurry/vinasse	-10	26	18	b

* P and K based on measured input and default P and K content.

**Significant for P < 5% after ANOVA

Discussion and conclusions

The nitrogen out of alfalfa and grass-clover has a comparable or better ANR then nitrogen out of poultry manure or slurry/vinasse. At crop level the P balance was much better using alfalfa or grass-clover in both crops. Use of chicken manure resulted in a hyper-accumulation of phosphorus of 132 - 141 kg P ha^{-1}. The K balances are more ambivalent. This shows that cut-and-carry fertilizers such as fresh or silage alfalfa and grass-clover have a high potential as nitrogen fertilizer, meanwhile substantially reducing the risk of unbalanced P and K applications.

At farm level, the use of cut-and-carry fertilizers has consequences for the mineral balance. If a manure input from outside the farm is replaced by a farm-grown fertilizer, less phosphorous and potassium are brought into the farm to compensate the output of minerals by sold products. On the other hand, by selling a forage crop a lot of nutrients are sold and normally this will be compensated by purchasing manure. The overall effect on the mineral balance of introducing cut-and-carry fertilizers in a farming system will strongly depend on the starting situation and the choices made by the farmer. An economic evaluation study indicated that the cut-and-carry fertilizers are of interest with prices above 12 € per ton of cattle slurry (€3.50 kgN^{-1}).

Conclusions

It is concluded that a cut-and-carry fertilizer system facilitates an effective use of perennial leguminous forage crops for sustaining inherent soil fertility. Based on studies in spinach and potato it appears that use of freshly cut or silage materials from such crops will result in comparable yields while reducing the dependence of arable farms on external animal manures by more effectively closing nutrient cycles. It is expected that, with pending and more restrictive regulations for the use of animal manures and phosphates in the Netherlands, the cost of organic nutrient sources such as cattle slurry will increase. This will render the use of cut-and-carry fertilizer crops more cost-effective. Using this strategy will further reduce the fertilization cost of forage-based systems while minimizing the potential risk of nutrient depletion associated with exclusive use of green manure crops or hyper-accumulation of phosphate due to excessive use of chicken manure.

Acknowledgments

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High root biomass for cereal crops increases carbon sequestration in organic arable systems

Chirinda, N.[1], Olesen, J.E.[1] & Porter, J.R.[2]

Key words: Carbon sequestration; Root biomass

Abstract

In agroecosystems, soil organic carbon (C) inputs come from applied manures, plant roots and retained shoot residues. Several reasons, associated with root measurements, limit current knowledge on root C input.This study aimed at evaluating root responses to nutrient management and fertility building measures (e.g. catch crops). We made use of one inorganic fertilizer-based and two organic systems in an 11-year-old field experiment on sandy loam soil. At anthesis, soil cores (5 cm dia.) were sampled from 0-30 cm depth within and between rows of winter wheat and spring barley. Roots were separated from soil and washed with tap water, the dry matter (DM) biomass was determined. Dry matter biomass was also measured in shoots.The spring barley root DM was at least 30% higher in the organic compared to the inorganic fertilizer-based system. The organic system that included catch crops had 17% higher spring barley root DM than where catch crops were absent. In the inorganic fertilizer-based system, the biomass shoot-to-root ratio for spring barley was twice that in the comparable organic system. High root DM biomass in organic compared to the inorganic fertilizer-based systems, implies higher C sequestration in the former, especially considering the slow decomposition rate of root residues.

Introduction

In agro-ecosystems, soil C inputs are mainly from applied manures, organic material released from growing roots (i.e. root exudates, lysates, mucilages, sloughed cells), plant shoot and root residues. Basically, the organic material released from growing roots are mainly easily decomposible in soil, which is unlike root residues that are more lignified and have lower biodegradability (Rasse *et al.* 2005). The SOC stocks reflect the balance between C input and C mineralization (Wong *et al.* 2010). Therefore, notwithstanding the mineralization of organic material, cropping systems with different C inputs influence soil C content differently. In particular, high-input crop production systems fertilized with inorganic fertilizer tend to have high shoot biomass and large quantities of crop residues. On the other hand, due to presence of more resilient C, applied animal manure could enhance C sequestration in low-input organic systems. Whereas C input from manure and shoot residues have been extensively studied, root contributions to soil C have been estimated from root biomass towards the end of the growing season (Hulugalle *et al*. 2010). However, the scarcity of literature on root C input is partly due to the costs associated with most current methodologies (Izzi *et al*. 2008). Consequently, the knowledge gap causes increased uncertainty in assessing the potential for C sequestration within arable systems. This is despite the fact that an accurate assessment of plant rooting is essential for

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understanding the role of roots in soil C storage and ecosystem functioning. In addition, a combination of higher chemical resistance of root molecular structures to decomposition and physico-chemical protection through interactions with soil minerals doubles the residence time of root-derived C over shoot C (Rasse *et al.* 2005). Notwithstanding limited literature on root studies, we are not aware of studies that compared root C inputs between organic and inorganic fertilizer-based systems; which was the main objective of the current study.

Materials and methods

Field site

This study used plots in a crop rotation experiment initiated in 1997 at Foulum in western Denmark (Olesen et al. 2000). The soil is a Typic Hapludult, sandy loam.

Experimental structure

The experiment has a factorial design comprising three factors and two replicate blocks (Olesen et al. 2000). The present study used organic crop rotations (O4) fertilized with manure; with and without undersown catch crops (CC) in the cereal and pulse crops in addition to an inorganic fertilizer-based (C4) crop rotation (Table 1).

Table 1: Structure of the three selected four-year crop rotations

Rotation course	O4/+M/+CC	O4/+M/−CC	C4/+IF/−CC
1	s. barley^{CC}	s. barley	s. barley
2	Faba bean^{CC}	Faba bean	Faba bean
3	Potato	Potato	Potato
4	w. wheat^{CC}	w. wheat	w. wheat

spring (s), winter (w), catch crop (cc), Manure (M), inorganic fertilizer (IF)

Results presented here are from samples collected in 2007/08 from soils under winter wheat and spring barley. The catch crops in the organic cropping systems were either pure stands of perennial ryegrass or various mixtures of perennial ryegrass, chicory and clover species (Olesen *et al*. 2009).

Management

Winter wheat and spring barley had inter-row distances of ca. 12.5 cm, and sown at rates of ca.181 and 170 kg ha^{-1}, respectively. On average crops in the C4 rotation received approximately 109 kg total N ha^{-1} y^{-1} while organic rotations received pig slurry at rates corresponding to 70 kg total N ha^{-1} y^{-1}. Weeds in O4 and C4 systems were controlled mechanically and chemically, respectively.

Plant measurements

At anthesis, above-ground plant material sampled from areas of 1 m^2 areas was dried in an oven set at 80^{o}C for 18 h. Three separate soil cores (5 cm dia.) were collected from within and between crop rows (0−30 cm depth; where 90% of cereal roots are found). Soil cores from similar sampling positions were pooled. The roots were washed with tap water to remove mineral matter and collected on a sieve with a mesh size of 0.425 mm. The collected roots and debris were placed in a tray where live roots were separated from dead organic matter based on colour and physical appearance as described by Gregory (2006). The live roots were then dried in an oven at 70°C for 48 h. Upon removal from the oven, root dry matter was recorded before a portion was weighed, oven-dried again and placed in a muffle furnace set at 650°C for 5 h. This was done to determine root ash content. (Chirinda et al. 2011a). Shoot and ash-free root DM biomass were used to determine DM biomass shoot-to-root (S/R) ratios. It is important to highlight that at cereal anthesis catch crops had just begun to germinate hence their roots were an insignificant part of measured biomass.

Statistical analyses

A mixed model was used to test the response of different plant attributes to cropping system. Differences of Least Squares Means were used to compare treatment means.

Results

Results in Table 2 indicate that root DM biomass for winter wheat showed a tendency ($P = 0.07$) to be lower in C4/+IF/−CC compared to the organic O4/+M/−CC system. For spring barley, the difference in root DM biomass between the C4/+IF/−CC and the O4/+M/−CC system was significant ($P < 0.001$).

Table 2: Cereal shoot and root biomass (g DM m^{-2}) and biomass shoot-to-root (S/R) ratios

System	Shoot	Root	S/R
winter wheat			
C4/+IF/−CC	1121[a]	206[a]	5.4[a]
O4/+M/−CC	870[a]	292[a]	3.0[a]
O4/+M/+CC	976[a]	250[a]	3.9[a]
spring barley			
C4/+IF/−CC	576[a]	154[a]	3.7[a]
O4/+M/−CC	375[b]	201[b]	1.9[b]
O4/+M/+CC	565[a]	236[c]	2.4[b]

Values with different letters for same crop and column are significantly different (P<0.05)

The organic rotation that included manure and catch crops had higher ($P < 0.01$) root DM biomass for spring barley compared to where catch crops were excluded. The biomass S/R ratio for the inorganic fertilizer-based system was significantly higher for spring barley ($P < 0.001$) and marginally higher for winter wheat ($P = 0.06$) than in the comparable organic system. The organic system that included manure and catch crops had marginally higher ($P = 0.06$) spring barley biomass S/R ratios than the organic system were catch crops were excluded.

Discussion

High nutrient availability in the inorganic fertilizer-based system probably led to the generally higher cereal shoot biomass compared to the organic systems. Besides, the low shoot biomass in organic systems may have been due to poor synchrony between crop nutrient demand and supply. Significantly higher spring barley root DM biomass for the O4/+M/−CC compared to the C4/+IF/−CC indicate a potential for enhanced root C input in organic compared to inorganic fertilizer-based systems. Similar tendencies for winter wheat, though not statistically significant, support this finding. This suggests that in low input systems root exploration of soil to meet plant nutrient demands and overcome the low nutrient availability leads to higher root biomass compared to high-input systems. Therefore, root C inputs from cereals grown in organic fertilizer-based systems are higher than those grown in inorganic fertilizer-based systems. Considering the longer residence time of root C (Rasse *et al.* 2005), low-input organic systems may therefore have substantial below-ground contributions to C sequestration. Moreover, in a recent study, Kong and Six (2010) observed that the relative contribution to stable soil organic matter of root C compared to shoot C was greater in the organic than conventional system.

The differences in cereal biomass S/R ratios in manure and inorganic fertilizer-based systems result from a high shoot biomass and low root biomass in the latter. These findings corroborate with the hypothesis that plants establish different biomass S/R functional equilibriums in response to soil and climatic conditions (Bolinder *et al.* 2002). This implies that, in agro-ecosystem under different management regimes, estimating root biomass from fixed biomass S/R ratio values may further increase uncertainties in estimation of below-ground C inputs and lead to biases when comparing different cultivation systems. The findings reported in the current study were corroborated by those from a follow-up study conducted at the same site in 2010 (Chirinda *et al*. 2011b).

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Carbon levels in agricultural soils under organic and non-organic management – a Meta analysis

Gattinger, A.[1], Häni, M., Fliessbach, A., Müller, A., Mäder, P., Stolze, M. & Niggli U.

Key words: Soil carbon, organic farming, meta-analysis

Abstract

An evidence-based, global evaluation of the scientific literature on soil organic carbon (SOC) contents, stocks (= masses) and sequestration rates in organically and non-organically managed soils was conducted by a meta-analysis. Only peer-reviewed studies of pair-wise farming system comparisons (organic vs. non-organic management) reporting SOC data were considered. Until now 45 publications encompassing 2477 single samples are integrated into the data matrix and the literature search and further evaluation is still ongoing. The average duration of management of all included studies is 16.7 years and the average soil depth is 22.5 cm. Until now no relevant studies from Africa and Central and South America have been found. A simple comparison of the data sets by analysis of variance (ANOVA) reveals that organically managed soils contain higher SOC concentrations and stocks (org: 37.4 t C ha^{-1} and non-org: 26.7 t C ha^{-1}) than soils managed conventionally. Also meta-analysis of SOC contents and stocks revealed the same result as determined by ANOVA and explorative statistics. These results, however, are preliminary and further attempts are made to get more data for a reliable meta-analysis of SOC stocks as only 12 publications contain these data which is crucial for the assessment of carbon storage in soil.

Introduction

Farming practices are known to exert strong control over soil organic carbon (SOC) content because they affect both input and turnover rates of soil organic matter (SOM). Whether particular practices lead to either an increase or a decrease in SOM content has implications for environmental policy, in particular with respect to soil C sequestration. Measures that offset some of the anthropogenic CO_2 emissions could mitigate global warming (Lal 2004). Soil carbon sequestration is a key measure in agriculture and may counterbalance large proportions of agriculturally induced emissions of methane and nitrous oxide (UNFCCC 2008). Improving and maintaining soil organic matter is a core principle in organic agriculture. Humus management is not only essential for plant nutrition and to maintain the long term built-up soil fertility, it also has a significant climate benefit as with humus accumulation the most important greenhouse gas CO_2 is sequestered in soil. CO_2 emissions are also spared through the avoidance of synthetic nitrogen fertilizer. By cultivation of perennial clover grass in organic crop rotation systems and application of organic fertilizer like manure and compost a potential humus loss caused by soil cultivation and removal of crop residues is not only balanced but even overcompensated. Whether this practice does lead to a SOC built-up in organic farming practices in the long term and whether the

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corresponding SOC levels are higher under organic than under non-organic management are the key questions of this study.

Materials and methods

In 2010 a literature review on soil organic carbon (SOC) contents, stocks and sequestration rates in organically managed soils was initiated. Only studies based on pair-wise comparisons (under similar site conditions) for organic and non-organic farming practices were considered for evaluation in which depth and time of soil sampling and experiment duration were equal for both. A farming system was defined as “organic” according to the original authors` classification. Farming systems defined by the original authors as conventional, integrated or no-till were all classified as “non-organic” in the current literature review. Various computerized information resources were searched for published studies. Because of poor data sources from developing (southern) countries recognized experts of that field of research were contacted to contribute further ideas on resource identification and invited to share relevant publications or data. This literature review followed the following five steps: 1) literature search, 2) literature review/evaluation, 3) If positive (i.e. containing a pair wise comparison of ORG vs. non-ORG): integration into data matrix and parameterization 4) Descriptive and explorative statistics with *SPSS* software, 5) Meta analysis with *Comprehensive Meta Analysis* software

A meta-analysis is the statistical procedure for combining data from multiple studies and allows a quantitative proof of the hypothesis (Dickerson and Berlin, 1992). This is a significant advantage over a narrative review were a quantitative proof of a given phenomenon cannot be made. A meta-analysis is an ideal tool to assess an entire knowledge area, to determine a reliable, average main effect size and to identify research gaps. In contrast to conventional statistical procedures, a meta-analysis takes the sample sizes and significance levels of single data sets into account for the calculation of the main effect size. and recommendations applied in most countries.

Results

Until now 45 publications are integrated into the data matrix. Among these are 37 peer-reviewed paper from scientific journals and 8 are (peer-reviewed) conference proceedings/book chapters/dissertations. These 45 publications are all based on pair wise system comparisons. These are from 44 field research projects consisting of: i) 21 long-term plot experiments, ii) 5 field trials and iii) 18 farm comparisons. These 45 publications based on 44 field research projects encompass 280 data sets (lowest data aggregation level: general statistics) based on 2477 samples (meta-analysis). The average duration of management of all included studies is 16.7 years with the oldest ones being found in Europe. Until now no relevant studies from Africa and South America have been found. The sampling depths of the different SOC studies varied between 8 and 60 cm. Most of the samplings however were performed down to 20 cm and the average recorded soil depth was 22.5 cm.

A simple comparison of the data sets (N = 280) by analysis of variance (ANOVA) reveals that organically managed soils contain higher SOC contents (= concentrations as expressed in mass percents) than conventional soils. The same is true for the SOC stocks (= absolute masses; N = 118), even though fewer studies contained data of bulk densities necessary to calculate SOC stocks (Fig. 1). In soils under organic management the SOC stocks were 37.4 t C ha^{-1} in average, in comparison to 26.7 t C ha^{-1} under non-organic management. Also meta-analysis of SOC contents and stocks revealed the same result as determined by ANOVA and explorative statistics. Meta-analysis revealed that soils under organic management showed significantly higher SOC contents than those managed non-organically (N = 2477) (Forest plot of meta-analysis not shown) and that soils under organic management showed significantly higher SOC stocks than those managed non-organically (Forest plot of meta-analysis not shown). These results, however, are preliminary and further attempts are made to get more data for a reliable meta-analysis of SOC stocks as the sample number is well below the total of 2477 for SOC contents with only 12 publications containing data on stocks.

Especially grassland soils showed higher SOC concentrations in comparison to arable land or horticulture. A somewhat clear tendency has been demonstrated with the multiple analyzis of variance where the factors influencing SOC contents are ranked. It turned out that climate has the strongest impact on soil organic carbon contents followed by land use (arable, grassland, horticulture) and the management system (ORG, non-ORG).

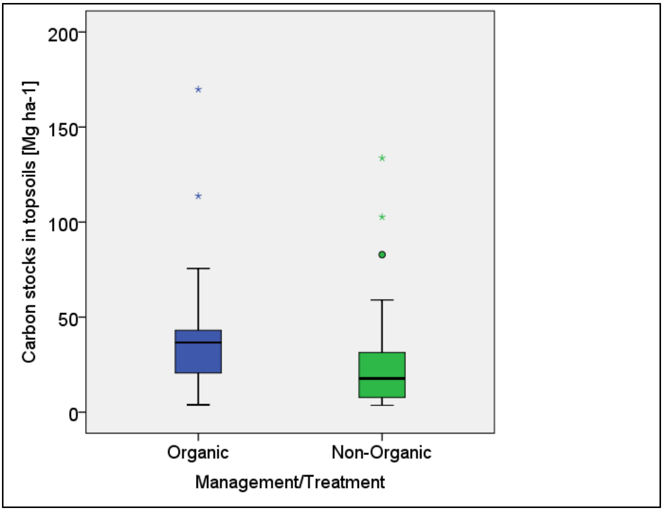

Figure 1: SOC stocks (in Mg ha^{-1}) in soils under organic (n = 47) and non-organic (n = 71) treatment. SOC stocks were significantly different at *P* = 0.05.

Discussion and conclusions

The core work of the comprehensive literature review, i.e. the integration of more than 40 scientific publications into a meaningful data matrix is completed. Quantitative evaluation of this comprehensive data set reveals strong scientific evidence for higher SOC contents in soils under organic farming which is also in accordance with the findings of Leifeld & Fuhrer (2010). Their evaluation of 32 peer-reviewed papers and 68 data sets revealed that after conversion, SOC contents in organic systems increased annually by 2.2% on average, whereas in conventional systems SOC did not change significantly. There is a lack of SOC data for developing countries: no data from Africa and Latin America at the moment from farm system comparisons. There is also only limited data on SOC stocks which is crucial for determining carbon storage in soil.

The majority of the reviewed publications reported SOC concentrations rather than stocks. The great majority of these studies were originally designed to define the influence of agricultural management practices on various agronomic criteria and as a result many long-term trials neither reported SOC stocks nor soil bulk density. If the latter one would be reported SOC stocks could be calculated. SOC concentration, however, is a key indicator for soil fertility but for assessing the sequestration potential the mass of CO_2 or C stored in a given soil is required, i.e. SOC stock = t C ha^{-1}. Hence, C sequestration rates for organic farming practices cannot reliably assessed at the moment.

Another problem is the shallow soil sampling. The median of the sampled soil depths of the farm system comparisons is 22.5 cm. This soil depth covers more or less the entire cultivation horizon of agricultural soils but a substantial part of SOC will not be considered (P. Smith, personnel communication). Fliessbach et al. (1999) showed that in farming systems of the DOK trial in Switzerland containing two years of deep rooting grass-clover leys, 64% of the total SOC stocks are deposited in the horizons 20-80 cm soil depth. As in many parts of the world organic farming systems are relying on the soil fertility build-up of deep rooting grass-legume mixtures and on the incorporation of plant residues by deep-digging earthworms, it is quite likely that the currently available data sets underestimate the SOC stocks in organically managed soils. This is particularly significant in the view that in deeper soil horizons SOC seems to be more stabilized. Radiocarbon analyses of microbial short-chain phospholipid fatty acids (PLFA) from different soil depths showed that the PLFAs in surface soils were derived largely from fresh plant residues whereas the radiocarbon values of PLFAs at 30–45 cm soil depth suggest the contribution of more stabilized soil organic matter (Rethemeyer et al., 2005).

Further attempts will be made for getting more reliable data on soil carbon stocks considering deeper soil horizons and also the time points when system comparisons were started.

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Effect of grass-clover on the ecosystem services soil structure maintenance and water regulation

Van Eekeren, N. [1], Bokhorst, J. [2], Brussaard, L.[2] & Koopmans, C.[1]

Key words: grass clover, roots, earthworms, organic farming, ecosystem services

Abstract

White clover has a lower root biomass and a higher abundance of earthworms than grass. This might have an impact on the ecosystem services soil structure maintenance and water regulation when white clover is introduced in the grassland on organic dairy farms. We investigated the root biomass, the abundance of earthworms and a selection of soil physical parameters in white clover, grass-clover, and grass with and without N fertilizer. The treatment with clover-only had a lower root biomass, a lower C/N-ratio of the roots, a higher abundance of earthworms, a higher number of earthworm burrows, a lower penetration resistance at the 20-30 cm soil layer and a lower proportion of crumbs in the soil, than the other treatments. This confirms the literature that pure clover stimulates the ecosystem services of water regulation, but is less conducive to soil structure maintenance. However, the grass-clover mixture did not differ significantly from the grass treatments, but differed from pure clover in a higher percentage of soil crumbs. We infer that, when clover is introduced in grassland on organic dairy farms to fix atmospheric N_2, the mixture of grass and clover maintains the positive impact of grass roots on soil structure but only may show a positive effect of clover-only on water regulation with a higher clover percentage in the dry matter.

Introduction

In sustainable grassland the focus is on ecosystem services like soil structure maintenance and water regulation, because of the perennial nature of the crop with no regular cultivation coupled with the compaction from animal trampling and tractor usage. For these ecosystem services, roots and soil biota play an important role. When sustainable grassland systems are developed it is important to know which effect management measures have on roots, soil biota and the functioning of the soil-plant system. One of the management measures on organic dairy farms is the introduction of white clover (*Trifolium repens*) with its ability to fix atmospheric N_2 in symbiosis with *Rhizobium* bacteria. However, it is well documented that the root density of white clover is considerably lower than that of grass (Robinson and Jacques, 1958). Since the organic material released by living or decomposing roots stabilizes aggregates directly or indirectly by providing nutrients to micro-organisms,

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the lower root density could have a direct impact on soil structure maintenance. Robinson and Jacques (1958) measured a lower percentage of stable soil aggregates in white clover than in perennial ryegrass. On the other hand, Sears (1950) found a higher earthworm biomass in a grass-clover mixture than in grass-only swards. Earthworms are known for their positive effect on soil structure and water regulation through their burrowing activity and earthworm burrows characteristics (Clements *et al*., 1991). Mytton *et al*. (1993) found higher drainage rates in white clover than in perennial ryegrass. Altogether this would suggest that with the introduction of white clover in grassland, soil structure maintenance could deteriorate, while water regulation would improve. In the present field study, we measured the root biomass, the abundance of earthworms and a selection of soil physical parameters in white clover-only, a grass-clover mixture, and grass-only with and without N fertilizer. Our objectives were (1) to measure the effect of the treatments on the root biomass and abundance of earthworms, and (2) to explore the relevance of changes for the ecosystem services soil structure maintenance and water regulation.

Methods

Sampling site and experimental design

The experiment was established in spring 2004 on a free-draining sandy loam soil (7.2-7.5 % clay (< 2 μm)) in the east of the Netherlands (52º26´N, 6º08´E). Four treatments were established in a completely randomized block design of six blocks: Grass with N fertilizer (GN1), Grass without N fertilizer (GN0), Grass-clover without N fertilizer (GCN0) and Clover without N fertilizer (CN0). In order to get approximately the same quantity and quality (C/N ratio) in the above- and below-ground biomass in GN1 and GCN0, inorganic fertilizer (calcium ammonium nitrate 27%) was applied on GN1 at a rate of 150 kg N ha^{-1}. The percentage clover dry matter in 2005 was on average 26% for GCN0 and 75% for CN0.

Soil sampling and analysis

On 16 December 2005, two growing seasons after the start of the experiment, soil samples were taken. Three soil cores (0-10 cm, ø 8.5 cm) per plot were taken to determine the root biomass. Only the 0-10 cm soil layer was measured since from other experiments is known that 75% of root biomass is concentrated in this layer (Van Eekeren *et al*., 2010). After washing the roots for soil, the roots were oven-dried at 70 °C and the dry matter, ash content and total N of the roots was measured.

Earthworms were sampled in two blocks (20x20x20 cm) per plot. The earthworms in the blocks were hand-sorted counted and weighed. Before the blocks were sorted for earthworms, in one block per plot the earthworm burrows were counted on horizontal surfaces (20x20 cm) exposed at 10 cm and 20 cm depth.

Penetration resistance was measured with a penetrometer (Eijkelkamp, Giesbeek, The Netherlands) with a cone diameter of 2 cm^2 and a 60° apex angle. Soil structure was determined in 1 block (20x20x20 cm) per plot. The soil was divided by visual observation into crumbs, sub-angular blocky and angular blocky elements.

Statistical analysis

The treatment effects on the measured parameters were tested using one-way ANOV, using the GENSTAT statistical software (8^{th} Edition, Hemel Hempstead, UK)

Results

CN0 had significantly lower grass root biomass and significantly higher clover root biomass than the other treatments (Table 1). The C/N ratio in the total root biomass was lowest for CN0 and highest for GN0. GN1 and GCN0 were intermediate. Earthworm abundance was significantly higher in CN0 than in the other treatments

(Table 1). Earthworm numbers and biomass were negatively correlated with the C/N ratio of the root biomass (r=-0.59, P=0.002 and r=-0.52, P=0.01, respectively). The number of earthworm burrows at 10 cm depth was significantly higher in CN0 than in the other treatments. At 20 cm depth, the number of earthworm burrows was highest in the two treatments with clover (GCN0 and CN0), but it was not significant different from GN1. The number of burrows at 10 cm and 20 cm depth was positively correlated with the earthworm biomass (r=+0.50, P=0.012 and r=+0.49, P=0.015, respectively). The penetration resistance in all soil layers was lower in clover-only (CN0) than in the grass-only with N fertilizer (GN1), but this was only statistically significant in the soil layer at 20-30 cm depth. The penetration resistance at 20-30 cm was negatively correlated with earthworm biomass (r=-0.47, P=0.02).The proportion of crumbs was significantly higher in GN0 than CN0 (Table 1). GN1 and GCN0 took an intermediate position. The CN0 had the highest proportion of angular blocky elements. The proportion of crumbs was negatively correlated with clover root biomass (r=-0.53, P=0.008), but no significant correlation was present with grass or total root biomass.

Table 1. Root, earthworm and soil physical parameters in grass with added N fertilizer (GN1), grass without N fertilizer (GN0), grass-clover without N fertilizer (GCN0) and clover without N fertilizer (CN0).

Parameter	Unit	Treatments				
		GN1	GN0	GCN0	CN0	P-value
Root biomass 0-10 cm						
Grass	G AFDM m-2	169a	217a	177a	12b	<0.001
Clover	G AFDM m-2	0c	1c	16b	62a	<0.001
Total	G AFDM m-2	169a	218a	193a	73b	<0.001
Total N	G N m-2	4.0a	4.1a	4.5a	2.6b	0.043
C/N		21.0b	26.3a	21.3b	14.2c	<0.001
Earthworms						
Total number	N m-2	322b	326b	359b	480a	0.002
Total biomass	G m-2	82b	76b	110ab	135a	0.009
Earthworm burrows						
10 cm depth	N m-2	58b	67b	138b	225a	0.002
20 cm depth	N m-2	50ab	8b	113a	121a	0.023
Penetration resistance						
0-10 cm	mPa	1.48	1.44	1.46	1.39	0.776
10-20 cm	mPa	1.46	1.45	1.40	1.34	0.368
20-30 cm	mPa	2.51a	2.39ab	2.45ab	2.13b	0.036
Soil structure 0-10 cm						
Crumb	%	39bc	53a	50ab	32c	0.006
Sub-angular	%	13	9	12	5	0.094
Angular	%	47b	38b	38b	62a	0.009

Values followed by the same letter within a row are not statistically different at the 5% error level for the main treatment effect.

Discussion and conclusions

In line with other research (Robinson and Jacques, 1958), the root biomass in clover-only was less than in grass-only. However, the mixture of grass and clover had the same root biomass as grass-only. Although the soil structure was only correlated with clover root biomass and not with grass or total root biomass, the soil structure followed the same pattern; the soil structure in clover-only was less developed than in grass-only and the grass-clover mixture. Since the grass root mass and the soil structure in the grass-clover mixture were comparable with the grass-only treatments, we suggest that the soil structure of clover mixed with grass is maintained at the same level. Further research on soil aggregate stability is needed for confirmation. The earthworm biomass was higher (70%) in clover-only (CN0) than in grass-only (GN1 and GN0), with the mixture of grass and clover in an intermediate position. Sears (1950) found a higher earthworm biomass in a grass-clover mixture than in grass-only swards. Thus, introduction of clover in a grass sward results in higher earthworm population densities. The negative relationship between the C/N-ratio of the root biomass and the total abundance of earthworms, suggests that the quality of the litter rather than the quantity played a prominent role in the higher abundance of earthworms. Water regulation as an ecosystem service in grasslands is greatly influenced by earthworms and their burrows (Clements *et al*., 1991; Edwards and Shipitalo, 1998). In our experiment, the numbers of earthworm burrows at 10 and 20 cm depth were highest in clover-only. Furthermore, clover-only showed the lowest penetration resistance at 20-30 cm, suggesting improved water infiltration. These data are consistent with results of Mytton *et al*. (1993), who found that white clover-only drained more rapidly than grass-only. For both drainage and soil moisture characteristics, Mytton *et al*. (1993) found that a grass-clover the mixture (> 50% clover in the DM) took an intermediate position between the monocultures of grass and clover. In our research, the mixture of grass-clover (GCN0), with 26% clover in the DM, showed a higher number of earthworm burrows and a lower penetration resistance than grass-only with fertilization (GN1), but differences were not significant. This suggests that a positive effect of clover on water infiltration was not apparent in our grass-clover mixture. With a higher clover percentage in the dry matter this might be different.

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Soil organic carbon and soil biological characteristics of organic and conventional cropping systems with a long-term located monitoring in China

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Key words: organic agriculture, soil organic carbon, soil biological characteristics

Abstract

In this study, long-term located technique has been adopted in monitoring soil organic carbon and biological characteristics of organic and conventional cropping system, in order to estimate potential of soil carbon sequestration under organic management and to further develop organic agriculture in china. After successive 8 years monitoring, results showed that there was more content of soil organic carbon (SOC) , soil microbial biomass carbon and higher soil enzyme activity in organic system than that in conventional system, with a significant difference. Organic cultivation was more favourable for carbon accumulation and biological activation in soil compared to conventional cultivation.

Introduction

Soil organic carbon pool (SOCP) plays an important role in global carbon circulation. Carbon content of SOCP is approximately two or three times that of the atmosphere or above-ground biomass carbon pool (Lal R. 2004). It is generally accepted that slight change in SOCP will bring CO_2 concentration fluctuation in the atmosphere to a great extent. Massive consumption of fossil energy is the most obvious feature of modern conventional agriculture, which has destroyed ecological environment seriously. Meanwhile, the widespread use of chemical fertilizer and plant protection product and insufficient input of organic fertilizer enhance mineralization of soil organic matter. All of these leads to the increase of soil greenhouse gas emission and the reduction of carbon stock in soil. Soil carbon sequestration is actually the process of carbon accumulation in SOC. Soil microbes, together with soil enzyme, master circulation of the whole soil organic carbon (Dou S. 2010). These soil properties vary with different management. It is known that organic cultivation can positively improve soil fertility and biological activity. Chinese organic agriculture began in the 1990s, some soil characteristics comparative studies between organic and conventional system have been developed. However, long-term located monitoring adopted in this type of study is rarely reported in China. Therefore, this technique has been taken in the study in order to explore evolution law of soil characteristics under different cropping system. Furthermore, it will provide evidence to estimate potential of soil carbon sequestration and emission reduction in Chinese organic agriculture.

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Materials and Methods

The research facility was set in Nanjing Planck Organic Farm as the representative in China. It has subtropical monsoon climate, with an average temperature of 15.5℃, and rainfall of 1037mL annually. The conventional farmland near the organic farm was chosen as comparison at the same time to ensure identical soil genetic layers and soil genesis condition in different cropping system. The area of the transition zone between organic and conventional plots is large enough to avoid interference. This study began in 2003. Three plots in conversion to organic (ZH), three organic plots(OR), and nearby two conventional plots (CN) were chosen by GPS technique as sampling spots at the beginning of this study (Table1). The plots of OR and ZH acquired organic certification in 2002 and 2006 respectively. Area of each plot is approximately 0.5 ha.

Soil samples were collected from 8 plots twice annually in spring and autumn. Eight to ten sampling spots were chosen as tessellation. Surface impurity was removed before sampling. Compound sample was selected by quartation from the 0-20 cm soil layer, leaving one or two kilogram. One part of the fresh soil sample was maintained in 4℃ and sieved to 2 mm for soil biological analysis (no more than a week). The rest was made into air-dry sample, and then sieved to analyze soil physical and chemical properties. Organic carbon was analyzed by standard methods (Bao, S. 2000). Activity of soil urease, acid phosphatase and catalase were tested in use of the methods reported by Lin, X. (2010). Microbial biomass was determined by modified chloroform fumigation method. The data of different systems showed in figures and tables as follows was the average of each plots. Significance test of difference among different three systems was calculated at the level of 0.01 and 0.05.

Table 1. Introduction of different systems in this long-term study

	Latitude and longitude of each anchor point in 8 plots	Management	Crops in these plots
OR	31°35′10″N 119°03′55″E	commercial organic fertilizer (certified by organic) and none chemical inputs	cole, cabbage, radish, carrot, letuce, tomato, greengrocery, and cucumber by rotation method
	31°35′10″N 119°03′58″E		
	31°35′12″N 119°04′01″E		
ZH	31°35′24″N 119°04′01″E	as above	as above
	31°35′25″N 119°04′03″E		
	31°35′29″N 119°04′04″E		
CN	31°35′45″N 119°04′07″E	compost farmyard-manure, mineral fertilizer and chemical inputs	as above
	31°35′44″N 119°03′59″E		

Results

- Soil Organic Carbon
- As is shown in Fig.1, there was larger accumulation of *SOC* content in OR than conventional system. This indicator of two organic systems decreased from 2006 to 2008 and then increased after 2008. Although it increased in CN, there was no significant difference among these results. The reason for the change was the facilities in the organic farm were destroyed by blizzard in the winter of 2007, and organic cultivation and organic fertilizer input was recovered in organic systems one year later. However, there was no destruction in conventional system because of its open-air cultivation.

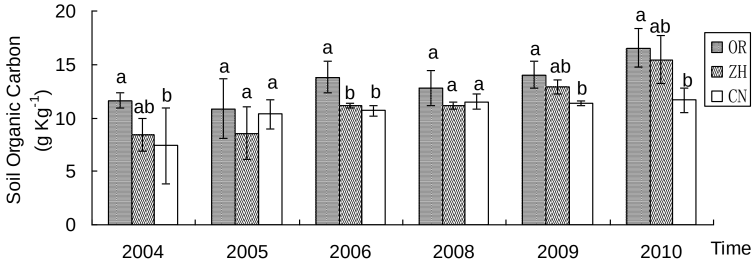

Fig.1 Changes of soil organic carbon in different cropping systems. (Different small letters show significant difference at 0.05 level among three systems in the same cropping year.)

- Soil Biological Characteristics
- Results in Fig. 2 showed that soil microbial biomass maintained growth trend in OR and ZH. However, it increased in CN from 2004 to 2006 and then declined. As was shown in Table2, soil enzyme activity was higher in organic system than that in CN, with a very significant difference ($p<0.01$) in 2010. It was obvious that soil from OR had the largest amount of microbial biomass and highest enzyme activity of three systems during the cropping years.

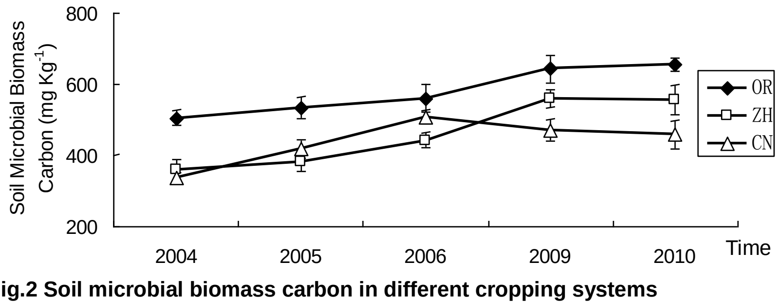

Fig.2 Soil microbial biomass carbon in different cropping systems

Discussion and Conclusion

It was obvious that soil biological activities increased in organic system gradually as organic cropping years increasing. There was more potential of soil organic carbon accumulation in organic system than that in conventional system. The difference of soil properties between organic and conventional system increased year by year compared to the beginning of the monitoring study, while it decreased in organic systems with different organic cropping history. We supposed that soil fertilization under organic management was more favourable for carbon accumulation in soil. In addition, soil biological characteristic improved without exception from 2006 to 2008 in organic system compared to the changes of soil organic carbon. It was no doubt that soil biological activity in organic system maintained growth trend by short-term external change. Soil organisms in organic systems played a more positive role in soil carbon accumulation than that in conventional system.

Table 2: Activity of soil urease, acid phosphatase and catalase in different cropping systems.

		2004	2006	2008	2010
Urease (NH_3-N, mg Kg-1)	OR	0.32aA	0.34aA	0.38aA	0.41aA
	ZH	0.21bA	0.25bA	0.29bAB	0.33aA
	CN	0.21bA	0.26bA	0.25bB	0.19bB
Acid Phosphatase (mg p-Nitrophenol mg-1h-1)	OR	12.57aA	16.48aA	18.73aA	23.13aA
	ZH	12.08aA	14.78aAB	16.05bA	20.03bB
	CN	11.87aA	12.65bB	12.38cB	11.23cC
Catalase (mL $KMnO_4$ g-1h-1)	OR	6.20aA	7.29aA	7.31aA	7.62aA
	ZH	4.53bA	6.28abAB	6.39abA	6.77aAB
	CN	5.28abA	5.13bB	5.21bA	5.23bB

Different capital and small letters show significant difference at 0.01 and 0.05 levels among three systems in the same cropping year.

Carbon sequestration content of soil organic carbon in organic system exceeded that in conventional system through successive cropping years. Therefore, organic agriculture is inevitable requirement of low-carbon economy nowadays in the background of global climate change. Further efforts will be made on long-term located monitoring in the future to construct soil organic carbon accumulation model. Furthermore, the increase of soil carbon sequestration potential by developing organic agriculture will be estimated according to the model and future situation.

Acknowledgments

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Nutrient balances in different patterns of organic farming in Egypt

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Key words: Nutrient balances; Organic farming in Egypt;

Abstract

The agricultural area managed by organic farming systems in Egypt is rapidly increasing. However, few studies evaluated the effect of different soil fertility management strategies and organic fertilizers additions on soil fertility and farm nutrient balances. Since Egyptian agricultural soils lie in the arid region it is generally characterized by low organic matter content. It is hypothesized that the incorporation of animal manure and compost is a determining factor for balancing the nutrient export. In this study, nutrient budgets were determined in three organic farms in addition to conventional farm for comparison, including total of twelve different crops. The organically managed farms were different in soil types, farm size and organic fertilization strategy. Frequently collected soil samples were analyzed for total and available N-P-K. Inputs represented by the applied organic fertilizers and outputs (Nutrient removal by crop and loss) were also analyzed for total N-P-K content. In general the total N-P-K content was not significantly changed, while organically managed farms increased the soil available nutrients content compared to conventional farms. Results of the field observations showed that organic amendments induced the use of inherent soil fertility and shifted up the plant uptake of nitrogen and phosphorus. In addition to the effect of inputs type, the soil type and the grown crops also played a major role in farm nutrient balance.

Introduction

One of the debatable issues in today's agriculture is whether organic farming can feed the growing world population (Badgley et al. 2007, Connor 2008). There is no clear answer for this question; however, it is clear that the use of intensive chemicals and energy inputs in agriculture has played a major role in climate change and GHG emissions (UNCTAD 2010). This fact, along with increased consumer demand and premium prices, has organic farming rapidly growing in developing countries (Willer at al. 2009). Organic farming in Egypt occupies around 17,000 hectares and has the potential for rapid growth. One of the main obstructions that hinder the expansion of organic farming in the arid or semi arid regions is the low soil organic matter content and the rapid decomposition rate of soil organic matter. Therefore, organic amendments are crucial for sustaining organic production. Further obstacles for OF in Egypt are the increasing food demand and the limited soil resources. Thus organic growers in Egypt are required to keep the high production rate by using large organic

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inputs additions. Unfortunately, few studies have questioned the nutrient balances and the sustainability of organic farming soil fertility management systems in Egypt. This study hypothesized that manure and other nutrient rich amendments are essential for OF in Egypt to achieve balanced cropping system and to compensate nutrient depletion from soil. For that purpose nitrogen, phosphorus and potassium inputs and outputs were carefully monitored at different farms characterized by different soil conditions and different crops and organic inputs in order to test the N-P-K balance

Materials and methods

This study is based on observation data for N-P-K in soils, inputs and removed by plants from some field sites. The study started early October 2008 (table1). To report the N-P-K balances, two organic farms Sakaran, 20 feddans, Basunia 25 feddans and one conventional farm of similar size (control) for comparison were selected in Fayuom governorate (90 km southwest of Cairo), where more than 50% of the organic farms are located. The selected farms represent the Fluvents soil type, (Old Nile alluvial soils). The size of the selected farms in Fayoum was medium as most of the average organic farms are in Fayuom. The cultivated crops in Sakaran are Suger beet, (two years old) and Lemon grass, (two years old) as a representation of the medicinal herbs. The cropping pattern of Basunia is field crops and mixed vegetables, at the start of the sampling process the crops in the field were Green Beans, Sugar beet and Clover. Meddle of Dec. Green beans is been harvested and replaced with wheat. The conventional farm was cultivated by wheat, onion, and garlic.
One Large farm Al Hoda, (400 feddans) was also studied in Ismaillia Governorate (120 km eastern north of Cairo) with bsamments soil type to represent those organic farms in the new reclaimed land and produce mixed vegetables,(salad onions, green beans, potatoes, baby corn) beside Mango, grapes and citrus.

Sampling procedure

The nutrients released from organic fertilizers and soil nutrient status were evaluated through frequent soil sampling before cultivation, after organic matter application and before planting, every fifteen to twenty days during the growth season and until the harvest. Each sampling event and for each crop, three complex soil samples were randomly collected from specific marked spots (Table 1) and 10 cm away from plantation. Using a farrett auger, samples were taken from the 0 – 30 cm depth (root depth). Shovel was used in case of sandy soils to the same depth. Soon after sampling, Sub samples were stored by chilling to +2^{o}C to restrict the mineralization for mineral- N determination. Three replicates of composite soil samples were collected from the top 30 cm, each composite sample were collected from five points samples, then identified with a tag. Prior to fertilization or amendments application, represented samples were collected from all organic or mineral additions to determine mineral-N, total- N, Total phosphorus and potassium. The application rate kg ha^{-1} was recorded in order to calculate the N – P – K inputs. Nutrient inputs are shown in table 1.

Soil, organic material and plant chemical analysis

In order to determine available nitrogen 40g of moist soil sample was extracted by shaking with 200 ml of 2M KCl for 1h, mineral-N was determined in 50 ml of the filtrate by the steam distillation using micro-Kjeldahl distillation or as described by (D. L. Rowell, 1994). Total N was determined in 2 g sample by a micro-Kjeldahl method. Soil available potassium was determined by shaking 10 g air-dry soil with 50 ml of HCl and ammonium fluoride mixture known as Bray solution for 30 min and according to (Page

1982). The potassium was then measured in the filtrate using a flame photometer (Model PFP7, Jenway Ltd, UK). Available phosphorus was determined in 5g air-dry sample by extraction with 100 ml of sodium bicarbonate solution and shaking for 30 min at 20^{o}C. Phosphorus was determined in the extracts using spectrophotometer and according to (Watanabe and Olsen, 1965). For the measurements of soil total phosphorus and potassium content, 1 g of air dried soils was digested by 3 ml of concentrated Nitric acid in Folin-Wu digestion tube (CLS790025, Sigma-Aldrich) in a heating block for 1h at 150^{o}C then 4 mL of $HClO_4$ was added and temperature raised to 240^{o} C for an additional hour otherwise as described by (Blancher *et al.* 1965). P and K were determined in the supernatant by ICP-MS at the labs of desert research centre, Cairo, Egypt and according to (Fassel *et al.* 1974). Samples of fertilizers, organic inputs and harvested plants were analyzed for N-P-K content using the same principals.

Table 1: study sites and crops characteristics.

Governorate Farm	Crop	Date of plantation D/M/Y	Harvest date D/M/Y	Duration Days	Harvested F.W ton F.W ha^{-1}	Total D.M Yield ton FW ha^{-1}	Inputs
Ismailia /Al- Hoda	Potato	15/10/2008	25/02/2009	147	19.7	5.6	FYM, rock phosphate enriched compost, cow manure, orthocalse, Compost extracts
	Bean	10/10/2008	11/03/2009	152	9.2	6.3	
	Dry Onion	10/11/2008	01/03/2009	111	16.2	3.1	
	Green Onion	28/09/2008	15/01/2009	109	15.0	2.8	
Fayoum /Basunia	Clover	16/09/2008	01/05/2009	227	60.5	6.9	Chicken manure, Kinate,sheap manure, FYM, Rockphosphate
	Sugar beet	26/09/2008	24/03/2009	179	42.3	4.7	
	Wheat	01/12/2008	01/04/2009	121	22.2	3.8	
Fayoum /Sakaran	Lemon grass	15/10/2006	23/03/2009	890	3.8	1.5	Ash, Farm compost, green manure
	Sugar beet	22/11/2008	24/03/2009	121	22.6	3.4	
Fayoum /Control, Conventional	Garlic	28/11/2008	25/03/2009	117	28.1	7.1	Superphosphate, K_2SO_4, Amm.nitrate, Urea, EDTA-micronutrients
	Onion	08/12/2008	24/03/2009	106	47.2	5.7	
	Wheat	11/12/2008	01/04/2009	111	12.9	9.6	

Results

The results revealed that soil total N-P-K content was not significantly affected at the end of the season. The change was more pronounced in case of sandy soils at

Ismailia governorate. Ismailia soil showed decrease in soil total-N content after crop harvest. This decrease was highly significant in case of potato crop, but in general total N and K content was lowered at the end of the growing season. On the other hand Ismailia sandy soil showed the only significant increase in the total-P content. The same trend was observed in the clay soils, non significant decrease in total N and K and an increase in soil total-P. Available nutrients followed different trend, the soil available N-P-K of the control farm (conventional farming system) was significantly reduced by the end of the season for almost all crops. While, available soil N was also reduced under organic farming system except for leguminous crops, the change in soil available P and K for organic farms did not follow a specific trend and was more affected by the specific crops, inputs and soil type. Soil available P was significantly increased in case of bean and dry onion in Ismailia and wheat, lemon grass and sugar beet in El-basionia and Sakaran consequently. The effect of farming system (organic vs conventional) on the nutrient uptake (removal) by plants was significantly pronounced in case of N and P compared to K (figure1). Organically grown crops showed a superior N and P uptake when compared with conventionally grown crops.

Discussions

The change in the sandy soils total N-P-K content is attributed to its initial low content of nutrients compared to clay soils in El-Fayoum governorate. The fact that clay soil total N-P-K was much greater than added inputs represented a statistical difficulty for calculating nutrient loss. Our original model for calculating nutrient loss based on nutrient balance was for N for instance as follows:

N-loss = (Soil total-N before cultivation+ Inputs-N) – (Soil total-N at harvest+ N removal by crop)

Hence any minor errors and variations between replicates in nutrient content are magnified when compared to inputs or removal by plants. A better procedure is to calculate the nutrient balance on longer term in order to have comparable values. The results showed in table 1, and temporal soil available nutrients data (none shown data) suggests that high inputs of organic matter and manure in organic farming is actually mobilizing sensible part of the soil. The higher uptake efficiency of organic crops can also be partially interpreted by the effect of organic matter on lowering the soil pH, a better synchronization between plant growth and input timing and higher nutrient losses in case of inorganic fertilizer inputs.

Conclusions

Calculating farm nutrient balances is essential for examining the sustainability of the farming system. This study showed that organic farming and organic inputs enhances the use of inherent soil fertility. Mean while high P content in manures and organic inputs combined with low P removal by plants could lead to phosphorus accumulation in soils under organic farming systems. This study strongly recommends the establishment of long term experiments to study nutrient balances.

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For complete references, please contact the author

Nutrient balance in agroforestry systems of organic cacao (*Theobroma cacao*) in Waslala, Nicaragua

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Keywords: Agroforestry system, organic cocoa, Theobroma cacao, nutrients balances, organic fertilizers, Nicaragua.

Abstract

Using the NUTMON model, we produced a partial and total nutrient balance (NPK) for a sample of small-scale producers of organic cocoa in Waslala, Nicaragua. We identified the primary (crops) and secondary (animal component) production units; however, nutrient balances were focused on organic cocoa production, which represents nearly 50% of family income in the area. We established 3 groups of farms based on site conditions and compared nutrient balances across groups. Total balances were N =- 3.0 P = 1.6 K = -5.0 (Group 1), N = -9.3 P = 0.5 K = -9.8 (Group 2), and N = -5.7 P = 0.5 K = -10.6 (Group 3), in the case of partial balance was N =-0.2 P = 0.6 K = -5.7 (Group 1), N = -4.2 P = -0.4 K = -9.3 (Group 2), and N = -5.1 P = -0, 5 K = -10.8 (Group 3). Differences between total and partial balances resulted from the use of formulas that included different variables. Potassium balances were consistently negative, evidencing high extraction of this element without subsequent reinstatement. In addition, over 80% of farmers applied organic fertilizer to their crops (kg ha -1 year -1 of 1.3 to 8.3 N, 0.2 to 1 , 5 for P and 0.7 to 4.0 for K). We conclude that partial balances are useful for agricultural systems characterized by infertile soils and low external input. The interaction between primary and secondary production units defined positive and negative nutrient balances, emphasizing the necessity to strengthen strategies that lead to high productivity.

Introduction

Cocoa is one of the most important agricultural commodities in international trade, and as such it is an indispensable source of foreign exchange for many countries. In Central America cocoa production represents less than 1% of world production. Nevertheless, it is of great importance for indigenous rural households, where it constitutes a relevant socio-cultural element and an income source.

Latin America comprises 14 cocoa producing countries, out of a total of 24 worldwide, including Nicaragua with a total of 15 thousand tons per year (ICCO 2006, International Federation of Organic Movements (IFOAM) (2006). Certificated organic production that meets quality standards has the incentive of selling above market prices, approximately $ 3700.00 per tonne vs. $ 3400.00 in conventional markets. Organic cocoa production in Nicaragua is carried out by a small-scale farmers of marginalized areas, who follow a forestry production model that provides an

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opportunity to reforest and preserve forests and biodiversity through the combination of cocoa plantations with tree species, a strategy that reduces soil erosion and nutrient loss (Gaitan 2005).The analysis of resource management and nutrient cycles in organic cocoa production systems will provide a solid basis to argue the sustainability of such systems.

Therefore, the main objective of the study was to analyze the nutrient balance of organic cocoa agro-forestry systems (*Theobroma cacao*) in Waslala, Nicaragua in order to determine their fertility status. Accordingly, the specific objectives were:

• Characterize the components and management of organic cacao agroforestry systems.

• Characterize the processing, composition and application of organic fertilizers used in organic cacao agro-forestry systems.

• Determine the nutrient balance (NPK) in cacao agro-forestry systems using the NUTMON software

Materials and methods

The study was conducted in the tropical rainforest of the municipality of Waslala, located in the North Atlantic Autonomous Region (RAAN) of Nicaragua,13 ° 20 ° North Latitude and 85 ° 22 ° West Longitude. The area is characterized by average temperature of 24.1 oC, an annual rainfall of 2750 mm and a relative humidity of 84% (Grebe 2003). Soils are generally Ultisols and Alfisols (Grebe 2003).

Characterization of the production systems

Organic farms were characterized by location, height (m), topography, shade tree species in the cacao plantation, plantation age, productivity, and management (use of organic fertilizers). Subsequently, we classified in three groups according to these characteristics. We applied the Nutrient Monitoring System for tropical farming suggested by FAO (2003) for the analysis of nutrient balance in small-scale farms. Additionally, we carried out a structured survey to address farm management and identify the primary and secondary production units that characterized the three groups. Moreover, we generated a nutrient balance based on dry matter (harvested crop residues, organic fertilizer and manure) and its percentage of NPK.

Organic fertilizers

We analyzed organic fertilizers taking composite samples of each type of fertilizer used in the farms. The sampling was done by collecting two kilograms of homogenized sub-samples from different composting sites. Additionally, an interview was applied to identify composting ingredients, timing and preparation methods.

Elaboration of nutrient balance (total and parcial)

Based on the data collected from the monitoring surveys on input and output flows, structured interviews, literature, and laboratory analysis (Bationo et al 1998), we calculated nutrient balance using the NUTMON model (Vlaming *et al.* 2003) , which was modified to calculate nutrient balance in organic cocoa systems of America.

Total Balance and partial balances were calculated for each plot. Partial balance displayed information representing a gate balance with information provided directly by the producer regarding harvested crop, outputs and use of fertilizers as inputs. On the other hand, total balance calculations took into account flows difficult to measure in the field (inputs such as: nitrogen biological fixation, atmospheric rain nutrient deposition and outputs such as: denitrification and leaching), which were calculated with the use of formulas. Balances (total and partial) are the result of the sum of inputs minus the sum of outputs.

Results

Characterization of production systems

Studied farms, located between 217 and 693 masl, were characterized by a relatively uniform slope (30-35%) and infertile Ultisols with low base charge (Lathwell y Grove 1986). Average farm size was 11.9 ha. The main crops were cocoa (*Theobroma cacao*), corn (*Zea maize*), beans (*Phaseolus vulgaris*), which accounted for 37% of farm income along with a variety of pastures.

Primary and secondary production units

Primary production units were composed by pasture (100% of producers have pasture), corn (*Zea mays*), beans (*P. vulgaris*) (80%), coffee SAF (*Coffea arabica*) (43%), and minor crops such as malanga, cassava, sugar cane and rice These units along with organic cocoa SAF presented a scenario of diversified subsistence agriculture .. This type of farming is based on the existence of multiple crops managed differently. However, (Giller 1991) due to the limited availability of resources such as manpower and nutrients, crop management is highly interdependent within the system. Secondary production units are characterized by cattle, pigs, and chickens. These are generally small units with less than 3 pigs (69.6% of farms), 10 cows and 20 chickens. Animals are generally fed by farm by-products (crop residues, bananas) and part of maize crops, in the case of poultry farms.

Primary production unit: the cacao

Cocoa tree plots presented adult individuals (average age 19) with low productivity, which may require a process of regeneration and rejuvenation. Cacao trees had an average height of nearly 4 m, planting densities that varied from 310 to 980 trees per hectare, and an average density of 658 trees / ha (intensively managed farms had an average 1100 cacao trees / ha, planted at 3 x 3 m). The mean percentage of shade in cocoa farms was 77%, while recommended values oscillate in a 20- 40% range (Enríquez 1985; Gramacho *et al.* 1992; Arévalo *et al.* 2004)

Organic fertilizers

The use of fertilizers is a common practice among producers. Approximately 74% of interviewed farmers applied compost (88.5%) and biofermenter (65%).
The regional "Waslala compost" is a widely used recipe prepared with black soil (mountain), ashes, cocoa husks, banana stalk and cow dung. Cow dung is applied in large quantities, (7 kg), followed by ash, cocoa husk and chopped stalks (0.9 to 2.1 kg). With these average ingredient amounts growers apply 208.6 ± 191.2 kg of compost per hectare, which results in kg ha -1 year -1 from 1.3 to 8.3 N, 0.2 to 1.5 for P and 0.7 to 4.0 for K.
Organic fertilizer increases productivity and improves cocoa foliage, which justifies its widespread application despite being a laborious and time-consuming activity, especially when transportation is required. Studies carried out in Dominican Republic evidenced that cocoa yields are significantly higher when organic fertilizer is applied.

Total and Partial Balances

The analysis considered both biophysical and management characteristics in order to determine if site variations could explain nutrient balance differences throughout the 3 groups. We used cluster analysis to analyze all independent variables and establish the 3 groups of plots.

Total and partial balances obtained for the tree groups (C1, C2 and C3) are presented in table 1. The analysis of variance presented no significant differences for total (p=0.8511) and partial (p=0.4867) nutrient balances among groups. Similarly, Nitrogen and phosphorus total (p=0.5088) and partial (p=0.4996) balances were not significantly different. .On the contrary, potassium presented significant differences between groups for both total (p=0.0268) and partial (p=0.050) balances.

Table 1. Analysis of variance for total and partial NPK plots Waslala cocoa, Nicaragua Kg ha^{-1} year $^{-1}$.

Variable	C1 n=23	C2 n=3	C3 n=9	P value
N_total	-3,0±4,2a	-9,3±11,6a	-5,7±6,7a	0,8511
P_total	1,6±0,5a	0,5±0,8a	0,5±1,4a	0,5088
K_total	-5,0±1,1a	-9,8±3,0ab	-10,6±1,7b	0,0268
N_partial	-0,2±2,0a	-4,2±3,3a	-5,1±5,7a	0,4867
P_partial	0,6±0,5a	-0,4±0,8a	-0,5±1,4a	0,4996
K_partial	-5,7±1,1a	-9,3±3,0ab	-10,8±1,7b	0,0500

Figures 2 and 3 present total and partial nitrogen nutrient balances example calculated for the 36 studied plots using the Nutmon model. Observed input and output variation resulted in negative total and partial nutrient balances.

Figure 2. Total nitrogen balance

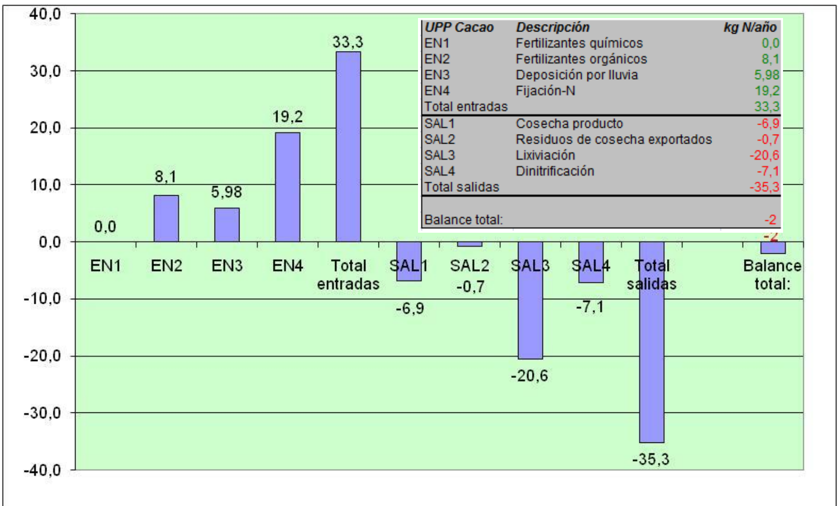
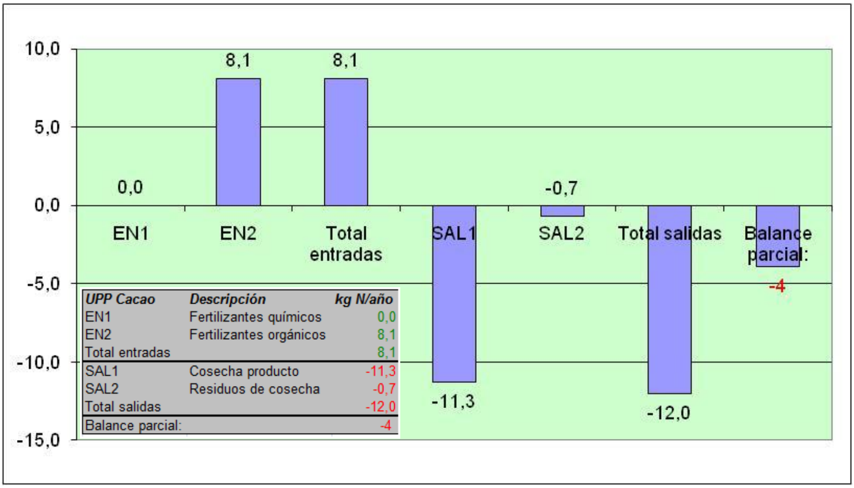


Figure 2: Partial nitrogen nutrient balance (Gate balance)



Nutrient balances were calculated to determine the sustainability and fertility of organic cocoa systems. Both total and partial balances, despite of their different behaviors, allowed the comparison of fertility status, presence and interaction of crops with animal component, presence of leguminous trees and levels of nutrient extraction among the three studied groups.

Conclusions

Studied production systems presented negative nitrogen partial and total balances and positive phosphorus balances.

In the case of the Nutmon model, differences between total and partial balances are relevant only for nitrogen, as a result of input such as symbiotic nitrogen fixation, rain deposition, and outputs such as leaching and denitrification. Phosphorus and Potassium total and partial balances resulted in no significant differences.

The most important parameters to be estimated by the Nutmon model in organic production systems are the extraction of products and the incorporation of atmospheric nitrogen fixation products (number of leguminous trees) and manure. Moreover, soil physical variables and chemical equations such as bulk density,% clay,% nitrogen and available potassium are also considered.

Balance analysis established the nutritional status of plots at a given period, providing an idea of management systems and their available resources.

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A comparative study on soil quality in organic and conventional tea fields

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Key words: Tea, Soil quality, Microbial biomass, Organic farming, Conventional farming

Abstract

In order to understand the change of the soil quality under the organic tea cultivation, a comparative study was conducted by collecting soils from 5 farms under organic and conventional farming systems. The basic soil quality parameters were analyzed. The results show that the pH value, the total organic C and N contents were higher in organic fields. However, the total P concentrations were generally lower in organic fields. No significant difference was found in soil total K content. The biomass C, ninhydrin-N and P, and the ratios of C_{mic}:C_{org}, $Nnin_{mic}$:N_{tot} *and* P_{mic}:P_{tot} *were significantly higher in organic fields in the most of comparative pairs. These findings suggest that organic agriculture could promote C sequestration and improve soil quality, but need applications of natural P fertilizers in long term.*

Introduction

Public concerns over environmental health and food quality and safety have led to organic tea expanding rapidly in China in the last decade. About 30,000 ha of tea field is under organic management, with the quantity of production 25,000 ton in 2009. It was increased by 33 and 50 times, respectively compared with that in 1999. However, with the gradually decrease of profit margin between organic and conventional tea, and the organic producers increasingly concern the soil quality and sustainability of organic tea production. Organic farming system avoids the use of synthetic fertilizers and pesticides, rely on organic inputs and recycling for nutrient supply, and emphasize cropping system design and biological processes for pest management (Rigby & Ca´ceres 2001). Tea is a perennial crop and no crop rotation takes place in its fields. Tea is also a leaf harvested crop and needs more nitrogen than other crops with seeds or fruits as final products. Nitrogen is a leading limiting factor for tea growth and productivity. Will the soil quality be deteriorated? It is concerned by organic tea producers. In order to understand the change of the soil quality under the organic tea cultivation, a comparative study was conducted. The soils were collected from 5 farms under organic and conventional farming systems. The basic soil physical, chemical and biological parameters were studied.

Materials and methods

Sites characteristics: Soil samples were collected from five farm pairs all located in Zhejiang province, eastern China. The annual mean temperature and precipitation are

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around 17℃ and 1500 mm, respectively. The selected sites have varied years involving in organic management. The management systems employed in selected farms are listed in Table 1. For the site of Shaoxin, a conversional tea field was also selected to see the change of soil quality from conventional to organic management.

Tab. 1: Organic and conventional farming system employed at 5 farms studied

Farm	Management	Fertilizers applied annually
Shao-xin	Organic	Compost 9000kg ha-1 for 8 years
	Conversional	Compost 12000kg ha-1 for 2 years
	Conventional	Compost 6000kg ha-1, mineral N, P_2O_5 and K_2O 600, 300 and 300kg ha-1, respectively
Wuyi	Organic	Commercial organic fertilizer 9000kg ha-1 for 11 years
	Conventional	Commercial organic fertilizer 4500kg ha-1, Mineral N, P_2O_5 and K_2O 600, 200 and 200kg ha-1, respectively
Yiwu	Organic	Rape seed cake 4500 or compost 6000kg ha-1 for 9 years
	Conventional	Rape seed cake 2250kg ha-1, Mineral N, P_2O_5 and K_2O 450, 225 and 225kg ha-1, respectively
Lanxi	Organic	Rape seed cake 4500 or compost 6000kg ha-1 for 6 years
	Conventional	Compost 3000kg ha-1, Mineral N, P_2O_5 and K_2O 450, 225 and 225kg ha-1, respectively
Jiang-shan	Organic	Compost 6000kg ha-1 for 3 years
	Conventional	Mineral N, P_2O_5 and K_2O 450, 225 and 225kg ha-1, respectively

Soil sampling and treatment: Soils were sampled in September, 2007. In each field 3 replicate samples were taken using a hand trowel. Each replicate consisted of 8 randomly taken sub-samples of 0-20 cm depth. Plant residues, roots, stones and obvious macrofauna were removed by hand then the soil was sieved at field moisture < 2 mm and stored at 4^oC for analysis of microbial biomass. Sub-samples were air-dried and ground < 160 µm for pH, total organic C, N, P and K analysis.

Soil analysis: Soil pH was determined using a combined glass electrode in 1:1 (w:v) ratios of soil with distilled water. Soil total organic C and N were determined by Elementar vario Max CN Analyzer. Total P and K were determined following digestion with a mixed solution of HF-$HClO_4$-HNO_3 by using inductively coupled plasma atomic emission spectroscopy (ICP-AES). Soil microbial biomass C and ninhydrin-N and P were determined by the fumigation-extraction method (Brookes *et al* 1985, Vance *et al* 1987, Wu *et al* 1990**).** All results are expressed on an oven-dry soil basis (105°C, 24h) and are the mean and standard error of three replicate analyses.

Statistical analyses: A one-way analysis of variance was used to compute means and least significant differences (LSD) with different management as factors in different farms by SPSS 13 for Windows.

Results

Table 2 shows mean values for the fields of different management systems. A very same trend was found in all five farm soils that the content of total organic C and N were higher in organic fields than in conventional fields, although most of them no statistically significant difference. The differences of total organic C and N between the organic and conventional fields were particularly significant at the farm of Wuyi, the oldest of the organic systems. On the average, the total organic C and N in organic fields were increased by 7.2 and 7.7%, respectively, compared with the conventional fields. However, the total P and K concentrations were quite different. They were lower in organic fields in most of the pairs. In Shaoxin and Wuyi sites, a significant difference was found for P concentrations.

Tab. 2: Soil total organic C, N, P and K concentrations under different management systems

Farm	Management	Total organic C (%)	Total N (%)	Total P (mg kg^{-1})	Total K (%)
Shao-xin	Organic	2.07±0.17	0.16±0.01	445±74 a	1.05±0.03
	Conversional	1.82±0.15	0.15±0.01	636±83 a	1.06±0.02
	Conventional	1.87±0.04	0.15±0.01	1450±120 b	1.12±0.05
Wuyi	Organic	1.91±0.03 a	0.19±0.00 a	557±32 a	0.77±0.02
	Conventional	1.75±0.02 b	0.17±0.00 b	731±32 b	0.79±0.02
Yiwu	Organic	1.42±0.08	0.12±0.01	572±76	0.80±0.01
	Conventional	1.33±0.15	0.10±0.01	499±106	0.81±0.02
Lanxi	Organic	1.47±0.06	0.12±0.02	1070±331	0.77±0.01
	Conventional	1.43±0.36	0.12±0.01	1572±20	0.79±0.01
Jiang-shan	Organic	0.96±0.03	0.07±0.00	362±6	0.80±0.02
	Conventional	0.93±0.03	0.07±0.00	350±4	0.76±0.05

Different letters denote significant difference (p<0.05) within a column in a same farm.

The different management systems had great impact on pH value and size of microbial communities in soils (Table 3), which were all higher under organic management. The pH in Shaoxin farm, the biomass C in Shoxin and Wuyi farms, the biomass ninhydrin-N Shaoxin, Wuyi and Yiwu farms, and biomass P in all farms except for the Jiangshan farm were found significant difference.

Tab. 3: Soil pH and microbial biomass under the different management systems

Farm	Management	pH (H_2O)	Biomass C (mg kg^{-1})	Biomass ninhydrin-N (mg kg^{-1})	Biomass P (mg kg^{-1})
Shao-xin	Organic	4.21±0.08 a	362.9±22.0 a	21.0±0.9 a	28.2±4.7 a
	Conversional	4.05±0.08 a	301.5±8.8 ab	17.8±2.0 ab	18.0±2.7 ab
	Conventional	3.86±0.01 b	218.6±42.4 b	15.3±1.2 b	12.6±1.1 b
Wuyi	Organic	3.86±0.11	183.6±8.8 a	14.5± 0.5 a	40.5±4.2 a
	Conventional	3.53±0.07	98.1±12.9 b	7.4±1.5 b	23.7±2.2 b
Yiwu	Organic	4.40±0.30	247.1±64.3	44.8±4.0 a	10.8±1.2 a
	Conventional	3.72±0.12	156.1±12.2	15.1±3.3 b	5.1±1.3 b
Lanxi	Organic	3.95±0.21	255.4±93.1	66.2±10.0	5.1±0.3 a
	Conventional	3.73±0.24	152.0±19.4	22.2±17.2	2.2±0.1 b
Jiang-shan	Organic	4.07±0.05	108.4±6.8	20.2±1.8	12.1±0.9
	Conventional	3.81±0.08	87.9±2.7	14.8±0.6	10.1±0.3

Different letters denote significant difference (p<0.05) within a column in a same farm.

The ratios C_{mic}:C_{org}, $Nnin_{mic}$:N_{tot} and P_{mic}:P_{tot} were quite different between farms and the management systems in the same farm (data not shown). These ratios were higher in organic fields than in conventional fields. Significant or noticeable differences were found in Shaoxin, Wuyi and Yiwu farms, where the organic management system employed for at least 8 years. These ratios in conversional fields in Shaoxin farm were in the middle between conventional and organic fields, indicating that the organic farming system had positive impact on the size of microbial communities.

Discussion and conclusions

Soil quality plays a vital role in the sustainable development of organic agriculture. Many studies have found that the organic management could increase soil total organic C and N, and the microbial activities compared with the conventional management with annual crops and rotation adopted (Fließbach A. *et al*. 2007, Tu C. *et al* 2006, Mader P. *et al* 2002). However, the organic system would mine reserves of soil K and P, which were built up under the conventional management (Gosling P. & Shepherd M. 2005). The results here show that tea as a perennial crop and no rotation adopted, the soil pH value, the total organic C and N contents were higher in organic fields compared with the conventional fields. The biomass C, ninhydrin-N and P, and the ratios of C_{mic}:C_{org}, $Nnin_{mic}$:N_{tot} and P_{mic}:P_{tot} were significantly higher in organic fields in most of the comparative pairs. However, the total P and K concentrations were generally lower in organic fields. These findings suggest that organic agriculture could promote C sequestration and improve soil quality, and make the organic tea production sustainable, but needs applications of natural P and K fertilizers in long term.

Acknowledgments

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Effect of grass filter strips on reducing PO_4- loss in runoff from forage cropland

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Key words: Grass filter strips, PO_4-P, Runoff, Livestock manure

Abstract

The performance of grass filter strips (GFS) in abating PO_4-P concentrations from the forage cropland was tested in an experiment on the 10% slope in Grassland and Forages Division, National Institute of Animal Science, Rural Development Administration (RDA) from October 2007 to September 2009. Forage croplands with rye-corn double cropping system applied with composted cattle manure (CCM) were tested in a natural condition. The plots were hydrologically isolated. Main plots consisted of the length of GFS, such as 0m, 5m, 10m and 15m. Concentrations of PO_4-P in surface runoff water were reduced as the length of GFS increased. Especially, GFS with 10m and 15m reduced PO_4-P concentrations significantly compared to that with 0m and 5m ($p<0.05$). The results from this study suggest that GFS improved the removal and trapping PO_4-P from forage croplands.

Introduction

An estimated 42 million tons of livestock manure (LM) are collected in South Korea, annually. Environmental contamination can occur when application of LM to the land is in excess of crop utilization potential, or is done under poor management conditions causing nutrient losses due to environmental factors such as soil erosion or surface runoff during rainfall (Ramos *et al*., 2006). Surface runoff during rainfall can cause significant pollution following the application of LM to the land (Allen and Mallarino, 2008). Also increasing concentrations of P in surface runoff may contribute to eutrophication of lakes and rivers. In Korea, most of crop cultivation lands, except paddy fields, are on a slope and the significant precipitation experienced during a normal summer season leads to runoff of nutrients rather than their leaching into the subsurface. To control the nutrients loss in runoff from agriculture land, GFS are commonly used as a best management practice in some countries. GFS slows runoff and promote infiltration (Meyer *et al*., 1995) and enhance deposition of soil and organic matter (Melville and Morgan, 2001). Objectives of this study were to determine the effect of GFS on PO_4-P loss in runoff from corn field with LM application.

Materials and methods

The experiment was conducted from October 2007 to September 2009 on the 10±3% slope in Grassland and Forages Division, National Institute of Animal Science, Rural Development Administration. Forage croplands with rye-corn double cropping system with application of CCM were tested in a natural condition. The plots were hydrologically isolated in a randomized block with 3 replicates. Main plots consisted of

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the length of GFS, such as 25m^2 (5×5m), 50 m^2 (5×10m), 75 m^2 (5×15m). Application rates were calculated in total nitrogen contents. All plots were applied at 200 kg N ha^{-1} $year^{-1}$ of CCM on each plot at 10 days before seeding. GFS were installed in March 2007 with mixed grassland of Orchard grass, Tall fescue, Perennial ryegrass, Kentucky bluegrass and White clover. The monitoring wells for sampling the surface water in GFS were constructed with 40cm long and capped at the bottom (Figure 1). All representative samples were rapidly collected from plastic sampling bottles when rainfall occurred, immediately frozen in deep freezer and stored at -20°C. All samples were analyzed within 24 hours after collecting the sample. PO_4-P concentrations were determined using HS-2300 Plus -water analyzer (Humas, Korea).

Results and Discussion

Average concentrations of PO_4-P in runoff water were reduced as the length of GFS increased (Figure 2, 3). Especially GFS with 10m and 15m reduced PO_4-P concentrations significantly compared to that with 0m and 5m ($p<0.05$). The effectiveness of GFS in reducing PO_4-P transport in runoff from agriculture land has been recorded by number of authors (Schmitt *et al.,* 1999, Heathwaite *et al.,* 1998). Also The UK Code of Good agricultural Practice for the protection of Water (MAFF, 1991) recommends leaving a 10m buffer strip between agricultural land and adjacent watercourse. This may have been the result of adsorption by plants and infiltration of runoff with colloidal particles (Chaubey *et al.,* 1995). Our results demonstrate the potential for PO_4-P loss in surface runoff where rainfall closely follows fertilizer or LM application (Figure 2). Hooda *et al.* (1997) working in Scotland recorded 42% of annual P loss in the week following slurry application to grassland. Therefore, slurry run-off is carefully handled in aspect of environmental preservation, because 60～70% of annual rainfall (1100～1400mm) of Korea occurs during the summer period (July to September). The results from this study suggest GFS improved the removal and trapping PO_4-P loss from corn field with LM application in forage crop land in Korea. .

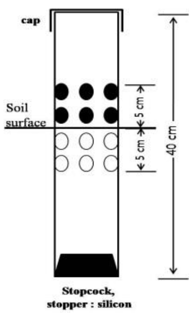

Figure 1: The design of sampling wells used in grass filter strip.

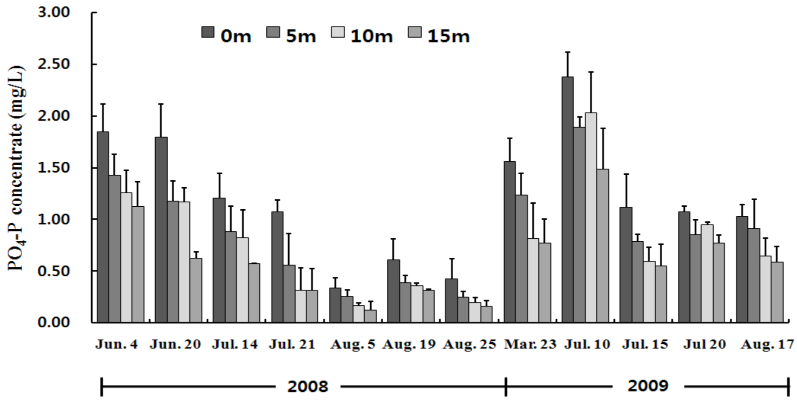

Figure 2: Changes of PO_4-P concentration in surface runoff water by the length of grass filter strips. Values represent the means ± SD of the three replicates. 0m, 5m, 10m and 15m : Length of grass filter strips.

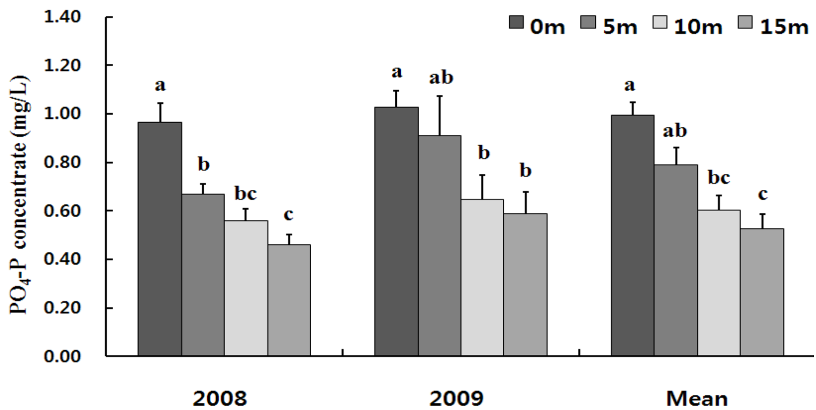

Figure 3: Annual average PO_4-P concentration in surface runoff water by the length of grass filter strips. Values represent the means ± SD of the three replicates. [a, b and c] : Different letters within the same column represents significant differences at the 5% level. 0m, 5m, 10m and 15m : Length of grass filter strips.

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Effect of IMO and EM technology application on soil microbial and soil nutrient status

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Key words: indigenous microorganism (IMO), effective microbe (EM), soil microbial, soil nutrient status

Abstract

Microbial inoculants technology of indigenous microorganism (IMO) and effective microorganism (EM) originated from Korea and Japan respectively are widely used by Malaysian organic farmers. They are claimed to be effective in enhancing crop performance. This technology brings out the potentiality and capability of mixed communities of local microorganisms against selected, single cultures and imported microbes. Thus, an experiment was conducted to evaluate the microbial performance of IMO and EM technology on leafy vegetables grown under rain shelter at the Integrated Organic Farm at MARDI Serdang. Microbial populations were significantly ($p<0.01$) higher in microbial inoculated with compost treatment (IMO and EM) compare to others. At the end of assessment on the application of EM and IMO, it showed a comparable result with no significant differences on yield performance and some of soil nutrient status. However, there is an increased in microbial population with ranging between 5.45-7.12 log_{10} cfu for both treatments at the end of planting cycles.

Introduction

Soil fertility is more than often equated with the chemical and physical properties of the soil. The microbial component is often ignored. There are also very few reports on the inoculation effect of matured compost on microbial community, including non-culture able microbes (Kato and Miura, 2008). Performance of imported inoculum is largely influenced by the climatic similarity of the country of origin. It is also reported that the imported microbes may find difficulty in competing with the more hardy indigenous microbes in tropical soil (Aini, 2006).

In view of non-chemical usage in organic farming, many organic farmers have incorporated microbial inoculants as their field practice. In Malaysia, two microbial technologies from Japan and Korea have been introduced since 2001. The effective microbe (EM) technology from Japan consists of selected, mixed laboratory cultures of beneficial naturally occurring microorganisms known to increase the microbial diversity of soils and plant (Higa, 1994). The indigenous microorganisms (IMO) from Korea (Cho, 1997) is based on local biomass to culture local micro-flora does not require laboratory means for mass culture. The procedures and the use of biomass sources as a substrate (carbohydrate sources e.g rice bran) to culture microbes and transform organic wastes into valuable bio-fertilizers are easy for farmers to adopt. Farmers claimed that the technology reduced cost of production by 30% compared to conventional practice (Aini, 2006).

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The efficiency of micro-organisms in soil is of fundamental importance for ecosystem functioning, through determining nutrient cycling, organic matter decomposition and energy flow (Doran and Zeiss, 2000). Microbial application promotes diversification of microbial ecologies in soil and plant surface (Baker et al., 1999). However, the survival of microbial inoculants from isolation to compost production and finally soil application is questionable because there is no or too little information available. The objective of this study was to evaluate the effects of microbial inoculants (EM and IMO) on the soil nutrient and crop performance.

Materials and methods

Field experiment

Three cropping seasons were conducted at Integrated Organic Farm, MARDI, Serdang. The test crop (*Brassica albogabra* L, *Brassica chinensis*, *Lactuca sativa*) was grown under a rain shelter. Treatments consist of composts with microbial inoculants IMO and EM, urea and normal compost as control. The crops were grown on 7m x 1m sized beds with a Randomized Completely Block design (RCBD) replicated five times. Composts were applied at 4kg per meter square in every two week intervals until harvesting.

Soil sampling and Laboratory Analyses

Composite samples of soils at 0-20 cm depth were sampled before the application of compost (initial) and after harvest (30th day) of each cropping season for soil nutrient status and soil microbial population analysis The soils were air dried and ground to pass a 2 mm sieve for analyses of pH, organic carbon, total N and P and exchangeable K, Ca, Mg, Na. Wet samples of soil were used for microbial population studies of total colony forming unit (cfu-log10) using total plate count.

IMO and EM preparation and application

EM preparations were based on the EM manual by APNAN (Asia-Pacific Natural Agricultural Network) and IMO from the nature farming manual. Composts were made from combinations of chicken dung, empty fruit bunch, and rice bran with ratio 2:3:1.

Crop Performance

30 day old crops weres harvested and weighed at the end of each season. Only the fresh weight of the whole plant was taken. Data on yield collection will be based on yield per hectare and comparison of economic yield to the normal practices.

Results and Discussion

Table 1, shows a fluctuation in soil microbial populations in the first season of planting due to the microbial adaptation to the local climatic condition of the soil. There is a significant ($p<0.01$) increasing trend of microbial population from initial towards the end of season of planting in IMO and EM treatments. Organic matter in the compost serves the basis for soil fertility through the breakdown nutrients as nitrogen, phosphorus and a range of the other nutrients (Chan, 2008).

Table 1: Microbial population in the soil at initial and end of three planting season

Treatment	Microbial population in soil at the end of planting (log_{10} cfu)			
	Initial	1	2	3
T1 : EM	4.33 b	6.33a	6.89b	7.12 a
T2 : IMO	4.01 c	5.01b	5.23c	5.45 d
T3 : Urea	4.68 a	5.89a	7.23a	6.34 c
T4 : Control	4.82 a	6.01a	6.79b	7.01 b

Means with the same letter in a column are not significantly different (P < 0.05) as determined by Duncan Multiple Range Test

Table 2: Soil chemical properties* at end of three planting season

		After application of treatments			
Parameter	Unit	EM	IMO	Urea	Control
pH (H_2O)		5.70 b	4.81b	5.58ab	6.19a
Total N	%	0.18 a	0.14ab	0.11b	0.08c
Organic C	%	0.97a	1.03a	0.91a	1.08a
Available P	ppm	99.94b	82.31c	167.72a	107.20b
K	meq/100g	0.80a	0.35b	0.68a	0.41b
Na	meq/100g	0.27a	0.28a	0.31a	0.27a
Ca	meq/100g	4.48b	2.26c	5.06b	6.51a
Mg	meq/100g	2.20a	1.8b	0.34c	0.85c

*Values are given as a mean of five replicates. Means with the same letter in a column are not significantly different (P < 0.05) as determined by Duncan Multiple Range Test

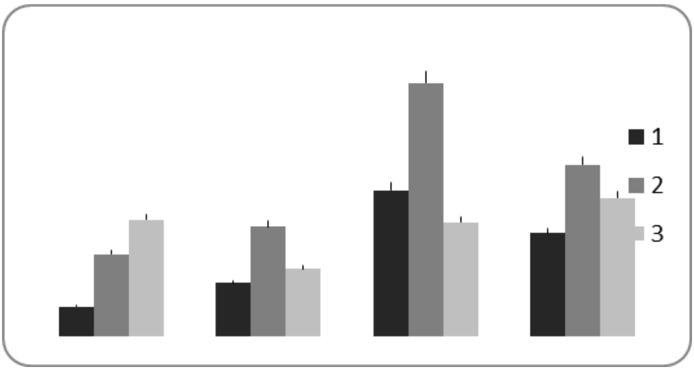

Figure 1: Crop performance in term of yield in three of planting season

In the study we could see higher values in total N, organic carbon, K and Mg in EM and IMO treatments (compared to urea treatment. However, some of the soil nutrient status did not have many changes from the initial soil samples (Table 2). It is also revealed the relationship between the availability of the soil nutrient component and the outcome of yield is neither linear nor significant. The period of experiment is only 5 months; hence the changes may not be significant at this point of time. Perhaps the changes would be significant with a longer period of time. Soil microorganism is undeniably important for their role and significance in driving the processes of nutrient cycling and degradation of organic matter. But, there are other microorganisms present and numbers are usually much more than the applied IMO and EM itself. Because of this, the efficacy will not always prove to be true as stiff competition will prevail between the autochthonous microorganism and the introduced ones (Van Vliet at el., 2006).

Conclusions

As conclusion, treatments with EM and IMO showed some effect on nutrient status and not in crop performance, however there is an increased in soil microbial population as the microbial adapting to new environment.

Acknowledgments

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Solubilization of insoluble mineral phosphates by bacteria in Malaysian soils

Matthews, S.[1] & Halimi M.S.[2]

Key words: Solubilization, Mineral Phosphate, Bacteria

Abstract

The production and usage of bio-fertilizers or bio-inoculants are vital in the development of organic farming. Bio-inoculants based on phosphorus solubilizing bacteria, solubilize the unavailable phosphorus abundant in the soil, to an available form which is accessible to plants. Low phosphorus availability for plant growth has become a major issue in agriculture sector worldwide. Most of the soils in the Tropics particularly in Malaysia, are acidic. Phosphorus form insoluble compounds with iron and aluminium in acidic soils and with calcium in calcareous soils. In this study bacteria were screened for the ability to solubilize mineral phosphates especially calcium phosphate, aluminium phosphate and iron(III) phosphate. Ten bacteria were identified as mineral phosphate solubilizers. All the bacteria were able to solubilize calcium phosphate, iron phosphate and aluminium phosphate according to various level of efficiency. The best Ca-P solubilizer is STMPSB 8, which could solubilize 1772.5±112.4 mg/L orthophosphate. The best Fe-P solubilizer is STMPSB 9 which could release 1679.11±8.43 mg/L of orthophosphate. The best Al-P solubilizer is STMPSB 8 which have recorded 1198.57±14.04 mg/L of orthophosphate release. STMPSB 8 could be designated as the best mineral P solubilizer for all the three insoluble phosphates as it exhibits high solubilization capacity for Fe-P, Al-P and Ca-P.

Introduction

Phosphorus (P) is the second major nutrient needed for the growth and development of plants. Malaysia which is located in the tropical belt has acidic soils that are abundant with aluminium phosphate and iron (III) phosphate. Lau and Ahmad (1990) have investigated that acid soils of Malaysia are dominated by iron and aluminium, contain low P and high phosphate fixing capacities. It was estimated that the P content in Malaysian soil is 10 mg of P kg-1 of soil and the inorganic soil P are mainly present as aluminium, iron and calcium bound phosphates. P- solubilizing bacteria have the potential to be used as bio-fertilizer or bio-inoculants in organic farms to promote a sustainable and eco-friendly agriculture system .

The objective of this research is to isolate mineral phosphate solubilizing bacteria and to verify their ability to dissolve aluminium phosphate (Al-P), iron (III) phosphate (Fe-P) and calcium phosphate (Ca-P) to orthophosphate (Pi), an available form of P for crops in order to produce bio-fertilizer which is suitable for Malaysian soils.

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Materials and methods

Isolation of mineral phosphate solubilizing bacteria (MPSB)

The bacteria were isolated from soil and compost using serial dilution and plating method. The soil or compost was tested immediately or kept at 4ºC prior to testing. The sample was homogenized in sterile distilled water containing 0.85 % NaCl (w/v) and serially diluted until 1010. For plating, 100 µl of the sample was used and each dilution has duplicate plates. The ideal growth medium for phosphorus solubilizers, NBRIP medium was obtained from Nautiyal (1999). Molten NBRIP agar was used for the detection of mineral phosphate solubilizing bacteria (MPSB). All the plates were incubated at 28ºC for 5 days for selectively screening the bacteria which have the ability to release inorganic phosphate from tricalcium phosphate. Colonies which produce clear zone in NBRIP agar were purified in nutrient agar. Ten bacterial isolates were selected to test the ability to solubilize insoluble phosphates namely Ca-P, Al-P and Fe-P in NBRIP liquid medium.

Molybdenum blue method

Each purified colony of bacteria was grown overnight in nutrient agar at 35° C. One loopful of bacteria from the nutrient agar was inoculated in NBRIP broth supplemented with insoluble mineral phosphates. Ca-phosphate (5g/l) was substituted with Al-phosphate (5g/l) and Iron (III) phosphate (5g/l) in separate sets of experiments and incubated for 96 h in a rotary shaker at a speed of 180 rpm at room temperature. The broth cultures were sampled at 24 h, 48 h and 96 h for orthophosphate release analysis. The samples were centrifuged at 9,000 rpm for 3 minutes. Filtration of the supernatant was done using Whatman filter paper No. 42. Soluble orthophosphate concentration was determined using the molybdenum blue method as described by Murphy and Riley, 1962 and modified by Watanabe and Olsen, 1965 (Olsen and Sommers 1982).The absorbance was read at 882 nm using a spectrophotometer. A calibration curve was prepared using potassium anhydrous dihydrogen phosphate.

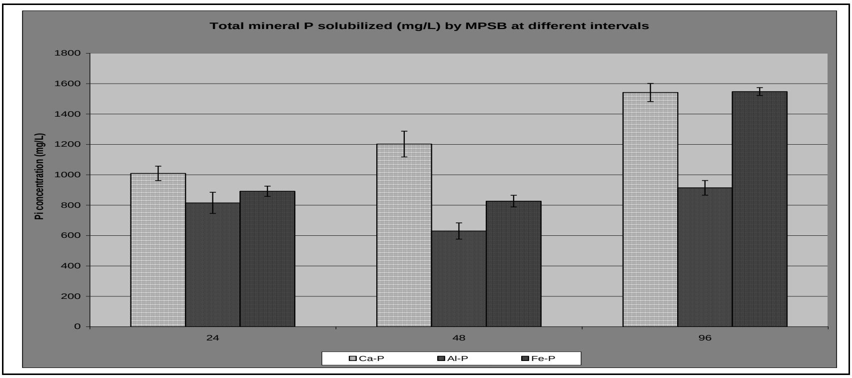

Figure 1: Orthophosphate release from Ca-P, Al-P and Fe-P by mineral phosphate solubilizing bacteria at different intervals. Values are means of two independent readings. Error bar (± S.D.) are shown when larger than the symbol

The control broth was prepared without adding in bacterial inoculums for all three sets of experiments but the result was not shown in the data as the value was too small and ignorable. Each sample was prepared with two replicates. The data was analysed using single factor ANOVA to determine significant treatment effects at 5% significance level.Results

Ten isolates of phosphate solubilizing bacteria were tested for their ability to dissolve calcium phosphate, iron phosphate and aluminium phosphate for 96 h. For calcium phosphate solubilization, STMPSB 8 recorded the highest solubility (1772.5±112.4 mg/L), followed by STMPSB 4 (1726.8±53.4 mg/L). It was observed that the solubility of iron (III) phosphate was the highest for STMPSB 9 (1679.11±8.43 mg/L) and trailed by STMPSB 8 (1633.44±5.61 mg/L).The highest orthophosphate from Al-P was released by STMPSB 8 (1198.57±14.04 mg/L) and followed by STMPSB 3 (1047.86±47.74 mg/L). The solubility dropped after 24 h but started to increase after 48 hours for Al-P and Fe-P. On the other hand, Ca-P solubilization over time showed a positive correlation (R2=0.9827) between the concentration of orthophosphate and time of solubilization. The concentration of orthophosphates at different intervals for all three insoluble mineral phosphates was significant at $p < 0.05$. The average concentration of orthophosphate throughout the experiment was 1250 mg/L, 1088.2 mg/L and 786.3 mg/L for Ca-P, Fe-P and Al-P respectively. In all three insoluble mineral phosphates, the highest solubility was achieved at 96 h which accounts for 1547.26± 83.11 mg/L Pi release from Fe-P, 1541.28±188.6 mg/L Pi release from Ca-P and 914.02±152.72 mg/L Pi release from Al-P.

Discussion

Since Malaysian soils are mostly acidic and insoluble phosphates are associated with aluminium and ferric ions, it is important to check on the ability of mineral phosphate solubilizing bacteria in dissolving Al-P and Fe-P. An increase in orthophosphate concentration for all three insoluble mineral phosphates at 96 h shows that the efficiency of P solubilization increases over time. Over all, Ca-P could release more soluble P followed by Fe-P and Al-P. This result is in agreement with Almas *et al*. (2009) which says that the aluminium phosphate solubilization rates were lower than the P-Ca solubilization. Illmer *et al*. (1995) has described that soluble P from clay minerals can increase the toxic level of Al^{3+} in solution and therefore could suppress the P-solubilizing activity. This could explain the reason of the low solubility of Al-P by mineral phosphate solubilizing bacteria. According to Sulbaran *et al*. (2008), the solubilization efficiency of $AlPO_4$ and $FePO_4$ were very low. Other researchers also found that soluble P with Ca-P was significantly higher compared to Fe-P and Al-P (Hong-Joo *et al*. 2006, Heekyung *et al*. 2005).

All the ten isolates possess the ability to solubilize insoluble mineral P though he solubilizing efficiency defers between isolates. The variation in the solubility happens probably because of the adaptive nature of the enzymes responsible for P solubilization. . Previous research findings indicated that there are many mechanisms involved in the solubilization of mineral phosphates. Generally organic acids production by bacteria were reported to correlate with mineral phosphates solubilization by acidifying the environment surrounding it (Almas *et al*. 2009).

The best Ca-P solubilizer is STMPSB 8, which could solubilize 1772.5 mg/L orthophosphate. The best Fe-P and Al-P solubilizers are STMPSB 9 and STMPSB 8 accordingly. STMPSB 8 could be designated as the best mineral P solubilizer for all the three insoluble phosphates as it exhibits high solubilization capacity for Fe-P, Al-P and Ca-P. This result also indicates that all the ten bacteria can be applied to acidic soil as they can dissolve the insoluble P in NBRIP broth efficiently. Chen *et al*. (2008) have stated that mineral phosphate solubilizing bacteria, had significant effect on plant growth both in pot and field conditions and therefore hold a great potential for development as biofertilizer.

Conclusions

In this study, ten mineral phosphate solubilizing bacteria were found to solubilize Ca-P, Fe-P and Al-P efficiently in NBRIP broth. These potential isolates need to be tested on field to experiment their efficiency in releasing insoluble phosphates especially in acidic soils as an initial step to produce P based bio-fertilizer for organic farming.

Acknowledgments

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Relative effectiveness of various amendments in improving yield and nutrient uptake under organic crop production

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Key words: Amendments, barley, organic, nutrient uptake, pea, wheat, yield

Abstract

Field experiments were established in 2008 on two certified organic farms in northeastern Saskatchewan to determine the feasibility of compost, alfalfa pellets, wood ash, rock phosphate, gypsum, Penicillium bilaiae and MykePro in improving crop yield and nutrient uptake. Compost and alfalfa pellets increased yield and nutrient uptake of wheat (2008), pea (2009) and barley (2010), with moderate increase in seed yield of barley from wood ash in 2010, but rock phosphate, Penicillium bilaiae, MykePro and gypsum had no effect on crop yield and nutrient uptake. In summary, the results suggest the potential of some amendments in improving yield of organic crops, most likely by preventing deficiencies of some nutrients.

Introduction

There is a great interest in organic farming in Canada and internationally (Macey 2005), where synthetic fertilizers/chemicals are not applied to prevent nutrient deficiencies in crops. In the Canadian Prairies, most organically farmed soils are deficient in available N, many low in available P, and some contain insufficient S and K for optimum crop yield (Entz et al. 2001; Watson et al. 2002). Maintaining high soil fertility is an important issue facing organic agriculture in Canada (Jans 2001). The N deficiency can be minimized by growing/green manuring N-fixing legumes (Buhler 2005). However, if soils are deficient in available P, K, S or other nutrients, only alternative is to use external nutrient sources. Manure/compost can provide these nutrients, but often there is not enough manure or it is uneconomical to apply in remote areas. Information on the efficacy of nutrient sources in improving yield of organic crops is lacking in Canada. This study was aimed to determine feasibility of compost, alfalfa pellets, wood ash, *Penicillium bilaiae*, rock phosphate, gypsum and MykePro in increasing yield and nutrient uptake in organic crops.

Materials and methods

Two 3-year (2008 - wheat, 2009 - pea, and 2010 - barley) field experiments were established on certified organic farms in Saskatchewan in spring 2008. During summer 2007, land was managed as tilled fallow in Experiment 1 at Naicam, and as green manure fallow in Experiment 2 at Star City. Precipitation in the growing season (May to August) was below average at both sites in 2008, slightly above average at Naicam and near average at Star City in 2009, and above average at both sites in 2010. Various amendments in Experiment 1 (Table 1) and Experiment 2 (Table 2) were broadcast and incorporated into top 10 cm soil a few days prior to seeding on 7.5 m and 1.8 m plots in a randomized complete block design in four replications.

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The nutrient contents in amendments were 1.5% N, 0.3% P, 1.9% K and 0.3% S in compost, 3.0% N, 0.1% P and 2.1% K in alfalfa pellets, 0.4% P, 4.1% K and 1.0% S in wood ash, 7.4% P in rock phosphate, and 12% sulphate-S in gypsum. *Penicillium bilaiae* and MykePro were used to increase availability of soil P to the crop. Seed and straw yields were measured at maturity, and plant samples analyzed for total N, P, K and S to determine nutrient uptake. The data were subjected to analyses of variance (SAS Institute 2004). Least significant difference ($LSD_{0.05}$) was used for mean separation, and LSD and standard error of mean (SEM) are presented in each table.

Tab. 1: Seed yield of wheat in 2008, pea in 2009 and barley in 2010 with various amendments applied in spring 2008, 2009 and 2010 at Naicam, Saskatchewan (potentially P-deficient soil – Experiment 1 established in spring 2008)

Amendments	Seed yield (kg ha^{-1})		
	2008 wheat	2009 pea	2010 barley
Control (no amendment)	1902	3423	1253
Compost @ 10 Mg ha^{-1}	1927	3799	2385
Compost @ 20 Mg ha^{-1}	2146	3179	2576
Compost @ 30 Mg ha^{-1}	2189	3326	2874
Wood ash @ 1 Mg ha^{-1}	1743	3198	1827
Wood ash @ 2 Mg ha^{-1}	1847	3102	1779
Wood ash @ 3 Mg ha^{-1}	1951	3027	1820
Rock phosphate granular @ 10 kg P ha^{-1}	1635	3393	1601
Rock phosphate granular @ 20 kg P ha^{-1}	1757	3347	1526
Rock phosphate granular @ 30 kg P ha^{-1}	1871	3051	1659
Rock phosphate finely-ground @ 10 kg P ha^{-1}	1717	3177	1203
Rock phosphate finely-ground @ 20 kg P ha^{-1}	1815	3252	1368
Rock phosphate finely-ground @ 30 kg P ha^{-1}	1880	3226	1283
Alfalfa pellets @ 1 Mg ha^{-1}	1817	2968	1432
Alfalfa pellets @ 2 Mg ha^{-1}	1954	2787	1693
Alfalfa pellets @ 4 Mg ha^{-1}	2083	2345	2174
Alfalfa pellets @ 6 Mg ha^{-1}	2079	1785	2128
Control + Inoculate seed with *Penicillium bilaiae*	1823	3076	1306
Rock phosphate granular @ 20 kg P ha^{-1} + Inoculate seed with *Penicillium bilaiae*	1853	3372	1534
Rock phosphate finely-ground @ 20 kg P ha^{-1} + Inoculate seed with *Penicillium bilaiae*	1854	3150	1462
MykePro	1896	3279	1412
$LSD_{0.05}$	229	534	332
SEM	80.9***	188.7***	117.0***

*** refers to significant treatment effects in ANOVA at $P \leq 0.001$.

Results and discussion

Experiment 1 at Naicam

In 2008, seed yield of wheat increased with compost and tended to increase with alfalfa pellets compared to the un-amended control (Table 1**)**. In 2009, there was no increase in seed yield of pea from any amendment, most likely due to N-fixing legume. In 2010, there was a substantial increase in seed yield of barley from compost and alfalfa pellets, and a moderate increase in yield from wood ash compared to the control. Total biomass yield, and uptake of N, P, K, or S in seed + straw were usually highest with compost and alfalfa pellets (data not shown). This suggested that N and other nutrients from compost and alfalfa pellets became available to the crop in the first year of application and in later years. On this potentially P-deficient soil, we expected increase in seed yield from finely-ground rock phosphate compared to granular rock phosphate, but it did not happen. *Penicillium bilaiae* and MykePro were not effective in increasing yield, and *P. bilaiae* did not improve the performance of rock phosphate.

Tab. 2: Seed yield of wheat in 2008, pea in 2009 and barley in 2010 with various amendments applied in spring 2008, 2009 and 2010 at Star City, Saskatchewan (potentially S-deficient soil – Experiment 2 established in spring 2008)

	Seed yield (kg ha^{-1})		
Amendments	2008 wheat	2009 pea	2010 barley
Control (no amendment)	264	668	2233
Compost @ 10 Mg ha^{-1}	435	796	3359
Compost @ 20 Mg ha^{-1}	470	965	3570
Compost @ 30 Mg ha^{-1}	580	1180	3671
Wood ash @ 1 Mg ha^{-1}	305	765	2348
Wood ash @ 2 Mg ha^{-1}	341	760	2705
Wood ash @ 3 Mg ha^{-1}	315	791	2804
Alfalfa pellets @ 1 Mg ha^{-1}	377	493	2663
Alfalfa pellets @ 2 Mg ha^{-1}	340	585	2872
Alfalfa pellets @ 4 Mg ha^{-1}	400	629	3859
Alfalfa pellets @ 6 Mg ha^{-1}	429	726	4067
Gypsum @ 10 kg S ha^{-1}	391	758	2110
Gypsum @ 20 kg S ha^{-1}	328	633	2103
Control + Inoculate seed with *Penicillium bilaiae*	319	691	2128
Rock phosphate finely-ground @ 20 kg P ha^{-1}	271	619	2170
Rock phosphate finely-ground @ 20 kg P ha^{-1} + Inoculate seed with *Penicillium bilaiae*	317	663	2133
Rock phosphate granular @ 20 kg P ha^{-1}	317	592	2323
Rock phosphate granular @ 20 kg P ha^{-1} + Inoculate seed with *Penicillium bilaiae*	347	589	2227
MykePro	341	626	2202
$LSD_{0.05}$	92	221	367
SEM	32.3***	77.9***	129.3***

*** refers to significant treatment effects in ANOVA at $P \leq 0.001$.

Experiment 2 at Star City

In 2008, seed yield of wheat (although very low) increased with compost and alfalfa pellets compared to the control (Table 2). In 2009, seed yield of pea increased only with compost over the control. In 2010, there was a substantial benefit in seed yield of barley from compost and alfalfa pellets, and a moderate increase in yield from wood ash compared to the control. Total biomass yield, and uptake of N, P, K, or S in seed + straw also gave a good response to compost and alfalfa pellets (data not shown), suggesting that these nutrients in compost and alfalfa pellets became available to the crop. On this potentially S-deficient soil, we expected seed yield increase with gypsum, but it did not happen.

Conclusions

Composted manure and alfalfa pellets showed potential benefit in improving yield and nutrient uptake of organic crops. These amendments may provide economical benefits, but the net returns depend upon the price premiums on organically-grown crops (Zentner et al. 2001) and the cost of application.

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Increasing effect of Si fertilizers on plant drought tolerance: theory and practice

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Key words: reduced water irrigation rate, silicon, monosilicic acid, polysilicic acid

Abstract

New technology for reducing water irrigation application rate was elaborated and tested in laboratory and field experiments. The technology is based on application of Si fertilizers high in active Si. Active Si (solid and liquid forms) makes possible the reduction in water irrigation application rate by up to 40% without a negative influence on plant biomass. Several mechanisms of the Si action have been suggested. It is important that the Si-rich materials tested are classified for organic farming. The elaborated technology could be adapted for any soil-climatic conditions and quality of irrigating water.

Introduction

Water is a limiting factor for plant growth in the dry and semi-dry regions. At present, 70 to 90% of fresh water is used for irrigation purposes in dry countries. Among negative consequences of intensive irrigation is cultivated land salinization, a major abiotic stress that adversely affects crop productivity and quality. To provide food security and sustainable economy, water-saving agricultural technologies are becoming increasingly important. As shown in recent studies, active forms of Si or Si fertilizers could be prospective for reducing irrigation water rate and increasing plant drought tolerance (Gao et al., 2006; Gong et al., 2005; Matichenkov & Bocharnikova, 2003). Silicon fertilizers were shown to provide significant increase in yield of different crops by 10 up to 70% (Snyder et al., 2006). Several mechanisms have been suggested to explain beneficial Si impacts on growth of plants exposed to water stress: a) increasing volume and mass of root system;

b) reducing water evaporation from leaves through reductions in stomatal pore diameter and change in inclination of the leaf blade; c) keeping water inside and outside of cells by molecules of mono- and polysilicic acids with possible water release as a result of dehydration;
d) formation of silica-gel inside or outside of plant cells which serves as a rechargeable water tank (Biel et al., 2008).

The main aim of this study was to investigate effects of solid and liquid Si fertilizers on cultivated plants exposed to water stress.

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Materials and methods

Greenhouse experiments

Greenhouse experiments were conducted at the Institute Physical-Chemical and Biological Problems in Soil Science RAS (Russia) and at the Indian River Research and Education Center, University of Florida (USA). The following Si-rich materials were used: amorphous silicon dioxide (SiO_2) as chemically pure source of active Si; Natural Silica (NS) (Synergy Fertilizers Pty Ltd, North Queensland, Australia) and Zum-Sil (liquid Si fertilizer, Terra Product Plus Co., Miami, USA). Both commercial Si fertilizers had certification for using on organic farms. Barley (*Hordeum vulgare* L) was grown on native Spodosol collected in central Florida. Several irrigation rates 100, 80, 60, and 40%, where 100% was optimum, were used. Solid Si substances were applied to the soil at the rates 0, 1000, and 2000 kg ha^{-1}. Zum-Sil solutions (diluted 1:1000 and 1:5000) were used for irrigation. Four replications for each treatment were conducted. After 3-week growth, the barley was harvested and plant weight was measured.

The second experiment was performed in climatic chamber with wheat (*Triticum aestivum* L.) on Chestnut Soil collected in south Russia. Two regimes of soil moisture were simulated: 1) optimum water regime (12-16% of soil moisture) and 2) water deficiency regime (7-10% of soil moisture). The soil was treated with the same Si materials as those in the 1st experiment. The rates of solid Si were 0 and 1000 kg ha^{-1}, Zum-Sil was diluted 1:5000 and applied with irrigation water. The following conditions were sustained in the climatic chamber: light intensity 140 Wt/m^2, air temperature 22 (day)/18 (night) C^o and 26 (day)/20 (night) C^o and relative humidity 65% and 55%, accordingly for optimum water regime and water stress; photoperiod was 16 h for both regimes. The plants were grown for 4 weeks and then were harvested. The weight and height of plants were measured. Four replications for each treatment were conducted. The concentrations of actual Si in the soil in the end of both experiments were analyzed by elaborated method (Matichenkov et al., 1997). All data obtained was analyzed by variance (ANOVA) to determine average and confidence intervals. The Fisher's least significant difference (LSD) was calculated for 5% of confidence level.

Field experiment

The field experiment was performed in the Central Florida, on the north of Okeechobee Lake. The local Si-rich soil amendment (Pro-Sil, Pro-Chem Co., Florida, USA) as a source of active Si was applied at the rate 5 t ha^{-1} on the area 33 ha and the same field was kept as control. Both fields were planted with sorghum (*Sorghum bicolor*). The main aim of the experiment was determination of the Si effect on reducing phosphorus leaching from cultivated area. But during 4 mo. no rain was in the region, as a result, many farmers lost all crop. Thus, spontaneously the experiment on an influence of Si fertilizer on plants under water deficiency stress has occurred.

Results

Greenhouse experiments

Barley growth was inhibited at reducing irrigation levels from 0.75 to 0.41 g of dry weight of 10 plants (Table 1). The reduction in water irrigation rate had no influence on the soil actual Si in the control pots. All Si substances tested positively affected plant growth both under optimized condition and water stress condition. Among treatments conducted, the maximum increases in plant biomass from 0.75 to 1.17 and from 0.41 to 0.77 g of dry weight of 10 plants, accordingly under 100 and 40 % of irrigation was provided by the higher rate of Natural Silica 2 t ha^{-1}. Zum-Sil was more effective when diluted 1:1000, the increases in the biomass were from 0.75 to 1.14 and from 0.41 to 0.55 g of dry weight of 10 plants for 100 and 40 % of irrigation, accordingly.

Table 1. Effect of Si fertilization on barley grown under various regimes of irrigation

Treatment	Optimum irrigation		80% irrigation		60% irrigation		40% irrigation	
	10 dry plants, g	Actual Si in soil, mg/kg	10 dry plants, g	Actual Si in soil, mg/kg	10 dry plants, g	Active Si in soil, mg/kg	10 dry plants, g	Actual Si in soil, mg/kg
Control	0.75	5.2	0.65	5.3	0.54	5.4	0.41	5.2
SiO_2, 1 t/ha	0.92	22.3	0.90	21.8	0.78	22.8	0.62	19.7
SiO_2, 2 t/ha	1.12	40.5	0.95	38.2	0.82	38.1	0.74	33.5
NS, 1 t/ha	1.06	35.5	0.95	35.6	0.80	32.4	0.58	30.5
NS, 2 t/ha	1.17	45.6	0.98	44.3	0.84	42.4	0.77	40.3
Zum-Sil[1*]	1.14	33.4	1.04	32.1	0.78	30.2	0.55	27.9
Zum-Sil[5*]	0.99	28.4	0.92	27.6	0.74	26.4	0.62	20.4
LSD_{05}	0.04	1.3	0.04	1.5	0.03	1.7	0.03	1.5

Zum-Sil[1*] - dilution 1:1000 and Zum-Sil[5*] – dilution 1:5000

The experiment conducted in a climatic chamber had demonstrated beneficial effect of the Si application on the wheat tolerance to water stress as well (Table 2). The drought simulated resulted in reduced wheat biomass from 0.33 to 0.20 g of dry weight of 10 plants and reduced soil actual Si from 8.45 to 6.32 mg Si/kg of soil. The application of Si-rich materials increased the biomass of wheat. Under optimum moisture, the maximum increase in the wheat biomass in comparison with the corresponding control was provided by SiO_2. Under water deficiency, NS showed the best effect on plant growth.

Table 2: Effect of Si substances on weight of 3-week old wheat and actual Si in Chestnut Soil

Treatment	Optimum moisture		Water deficiency	
	10 dry plants, g	Actual Si, mg/kg	10 dry plants, g	Actual Si, mg/kg
Control	0.33 a*	8.45 a	0.20 a	6.32 a
SiO_2, /ha	0.42 b	18.62 d	0.31 b	18.41 c
NS, 1 t/ha	0.38 a	14.70 c	0.32 b	12.32 b
Zum-Sil,	0.37 a	12.82 b	0.28 b	11.24 b
LSD_{05}	0.04	0.62	0.03	0.56

Means followed by different letter within rows are significantly different ($P \leq 0.05$).

Field test

The winter 2000-2001 in the Central Florida was extremely dry. During 4 mo., there was no rain on the north of Okeechobee Lake. As a result, non-irrigated crops, including sorghum have totally withered except sorghum on the field treated by Si. On this field, the actual Si after application of Si fertilizer increased from 5.0 to 18.6 mg Si kg^{-1}. All sorghum plants on the treated field stayed green without visual effect of water deficiency stress. The crop production composed 24.2 t ha^{-1}, while previous years the average crop production was 20.0 t ha^{-1}. This field demonstration had confirmed a high positive plant response to Si fertilization under drought stress.

Discussion

The obtained results are related with our previous investigations (Matichenkov & Bocharnikova, 2003). In general, all experiment had demonstrated that application of active Si allows reducing water irrigation application rate by 20 to 30% without negative influence on crop production. The soil actual Si concentrations increased as a result of the application of Si-rich materials. Natural Silica and amorphous silicon dioxide both at the rate 2 t ha^{-1} provided higher soil Si concentrations. The reduction in water irrigation level led to slight decrease in actual Si in the pots treated by Si.

The correlation between biomass of barley and soil actual Si was evaluated for different irrigation levels. The coefficients of correlation were ranged between 0.89 and 0.94. As evident from high coefficients of correlation, Si can be a limiting factor for plant growth under water stress. On the base of our and literature data, the technology for optimization and reduction of irrigation water application rates was elaborated. This technology includes determination of the level of active Si deficiency in selected area, selection of the most effective Si fertilizer for selected soil, and determination of the basic parameters for their application.

Conclusions

Si fertilizers possessing high active Si level and certified for organic farming can be used for increasing plant drought tolerance and reduction of water irrigation application rate at organic farms.

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Biomass and abundance of the anecic earthworm Lumbricus terrestris L. under perennial fodder crops

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Key words: earthworm biomass, earthworm abundance, crop sequence

Abstract

Cultivation of perennial fodder crops potentially supports large populations of anecic earthworms which may have substantial positive effects on soil fertility. We quantified the effects of three perennial fodder crops (lucerne [Medicago sativa *L.*]*, chicory* [Cichorium intybus *L.*] *and tall fescue* [Festuca arundinacea *Schreb.*]*) grown for one, two or three years respectively, on the population of the anecic earthworm* Lumbricus terrestris *L. in a field experiment on a Haplic Luvisol near Bonn/Germany. Two or three years as compared to one year of fodder cropping and hence soil rest had significantly increasing effects on earthworm biomass and abundance. The fodder crop species had merely minor effects on* L. terrestris*.*

Introduction

In arable farming systems the cultivation of perennial fodder crops is considered to have manifold positive effects on soil fertility, e.g. to increase soil organic matter content and abundance of soil organisms such as earthworms. Fodder crops can enhance earthworm populations by the quantity and quality of crop residues that serve as a food source for the lumbricids. Furthermore, perennial cultivation does not include tillage events which evidently decrease earthworm populations (Chan 2001). In this study, the effects of three fodder crop species cultivated continuously for 1, 2 and 3 years on biomass and abundance of the anecic earthworm *Lumbricus terrestris* L. were investigated. This species is known for creating semi-permanent, vertical burrows that potentially increase soil water infiltration (Ernst *et al.* 2009) as well as subsoil accessibility for plant roots, and thus may have substantial positive effects on soil fertility.

Materials and methods

On a Haplic Luvisol (loamy silt, *Campus Klein-Altendorf* / University of Bonn, MAT 9.6 °C, total annual precipitation 625 mm), a field experiment was set up with lucerne (*Medicago sativa* L.), chicory (*Cichorium intybus* L.) and tall fescue (*Festuca arundinacea* Schreb.) in four field replicates with a plot size of 6 x 10 m. In order to investigate the populations of *Lumbricus terrestris* L. simultaneously under crops in their 1st, 2nd and 3rd year of cultivation in autumn 2009, the crops were sown successively in spring 2007, 2008 and 2009 (Tab. 1). Before sowing, the soil was tilled with a mouldboard plough to 30 cm depth. Hence, the time period without soil disturbance (soil rest) was also varied. Fodder crops were mulched up to four times in each vegetation period. Crop residues remained on the soil surface.

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Table 1: Crop sequences under study

Treatment	Luc1	Luc2	Luc3	Chi1	Chi2	Chi3	Fes1	Fes2	Fes3
2007	rye	rye	Luc	rye	rye	Chi	rye	rye	Fes
2008	oats	Luc	Luc	oats	Chi	Chi	oats	Fes	Fes
2009	Luc	Luc	Luc	Chi	Chi	Chi	Fes	Fes	Fes

Luc: Lucerne (*Medicago sativa* L.); Chi: Chicory (*Cichorium intybus* L.); Fes: Tall fescue (*Festuca arundinacea* Schreb.)

Earthworms were extracted from the soil in 2009 at two dates in autumn (which is a favourable season for earthworm samplings) using the mustard extraction method (Gunn 1992). This method has been shown to be efficient for sampling anecic earthworm species (e.g. Lawrence & Bowers 2002). In short, 10 L of tap water containing 85 g mustard (type: 'Düsseldorfer Löwensenf') were poured into metal frames with a surface area of 0.25 m^2. In each field plot, one frame was set up at 1 m distance from the plot margin. Earthworms appearing on the surface within 30 min after application were collected and transferred to water filled boxes, covered and stored for later analysis. Mean values were subjected to two-way ANOVA followed by LSD-tests.

Results

Apart from the anecic *Lumbricus terrestris* L., frequently endogeic earthworm species such as *Allolobophora caliginosa* (Savigny) and *Octolasium lacteum* (Oerley) were extracted. However, they were not included in the analysis, because they have little relevance for formation of semi-permanent biopores. Biomass of *L. terrestris* was influenced by the duration of fodder cropping but not by the fodder crop species (Fig. 1). At both sampling dates, the lowest biomass was found in the 1st year of fodder cropping. No significant differences were detected between the 2nd and 3rd year of fodder cropping. There was no significant interaction between fodder crop species and duration of cropping.

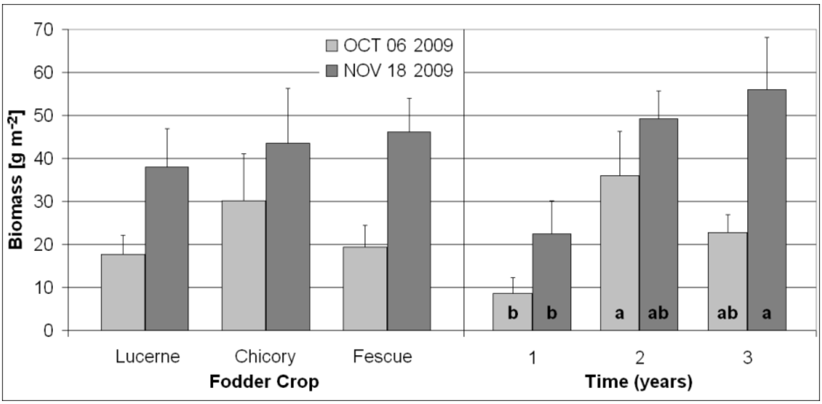

Figure 1: Biomass of *Lumbricus terrestris* L. as affected by crop species and duration of cropping. Error bars represent standard errors. Different letters indicate statistical differences (two-way ANOVA with LSD-test, p<0.05).

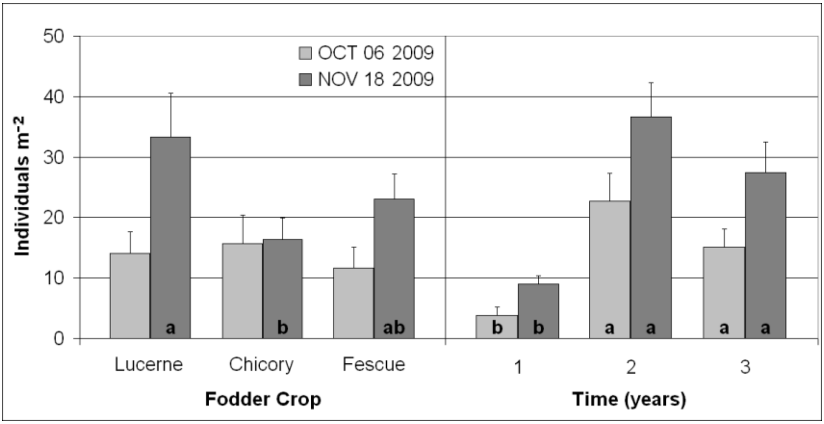

Figure 2: Abundance of *Lumbricus terrestris* L. as affected by crop species and duration of cropping. Error bars represent standard errors. Different letters indicate statistical differences (two-way ANOVA with LSD-test, p<0.05).

The abundance of *L. terrestris* was higher under lucerne than under chicory at NOV 18, however no effect of fodder crop species was recorded on OCT 06 (Fig. 2). In the 2nd and 3rd year of fodder cropping the abundance was generally higher than in the 1st year of fodder cropping. No interaction between fodder crop species and duration of cropping was detected.

Discussion

Beneficial effects of crop rotations with forage crops on earthworm populations were found in previous studies: Eltun *et al.* (2002) revealed that in crop rotations containing 3 years of continuous ley, earthworm biomass and numbers were higher than in crop rotations with annual crops only. In a study of six different cropping systems, Riley *et al.* (2008) found out that the presence of grass-clover leys increased earthworm density, biomass and burrow density.

In our field experiment, the efficiency of the mustard extraction method was evidently higher on NOV 18 than on OCT 06. However, both samplings revealed that 2 years and 3 years of fodder cropping as compared to 1 year of fodder cropping had a pronounced positive effect on the population of *Lumbricus terrestris*. To some extent, this effect may be caused by the absence of tillage events going along with growing perennial cops. The negative impact of tillage on earthworm populations includes mechanical disturbance as well as a greater variability in the soil temperature and moisture regime (Curry 2004). In addition, the input of organic matter is one of the determining factors of earthworm abundance. In an experiment by Schmidt *et al.* (2003), omitting plowing by itself had only a modest effect on earthworm populations, whereas the presence of a permanent white clover sward increased the populations greatly. Thus, it is plausible that increased total amount of organic residues in rotations with 2 or 3 years as compared to 1 year of fodder cropping had an impact on the population of *L. terrestris* in our experiment, especially since in our field experiment the crop biomass was not removed and therefore served as a potential food source for earthworms.

In contrast, differences in shoot biomass quality and quantity between the fodder crop species apparently had merely minor effects on *L. terrestris*. In average, lucerne yielded more shoot biomass (14 t FM ha^{-1} a^{-1}) than chicory and fescue (10 and 11 t FM ha^{-1} a^{-1}). Furthermore, the three investigated fodder crops are known to have quite different properties, especially regarding C/N-ratios and leaf structure, thus, we expected a marked influence of fodder crop species on earthworm population. In a laboratory study, *L. terrestris* gained more weight when fed with lucerne leaves as compared with red clover or corn leaves (Shipitalo *et al.* 1988). The increase of abundance under lucerne at one sampling date in our study indicates that lucerne is potentially beneficial for promoting earthworm populations. However, effects of fodder crop species were not as pronounced as the effect of duration of fodder cropping.

Conclusions

Under the conditions of our field experiment, time of soil rest apparently had a more crucial effect on biomass and abundance of *Lumbricus terrestris* L. than differences between the fodder crop species. The results highlight the importance to include perennial crops grown continuously for at least two years in crop rotations for increasing soil fertility.

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Dynamic changes of soil chemical and biological properties in organic/integrated/conventional vegetable growing systems in greenhouse

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Keywords: Greenhouse, Vegetable cropping system, Organic agriculture

Abstract

Greenhouse experiments were conducted at Quzhou experimental station, Hebei province, China, to examine the effects of conventional, integrated and organic vegetable growing systems on the soil chemical and biological properties based on six year's on-site field trial. The results showed that soil organic matter(SOM) and soil nutrients (TN, TP and available nutrients) were significantly increased after continuous compost amendment while the contents of soil organic matter (6.01%) and TN (0.36 $g \cdot kg^{-1}$) are much higher in the soil with the organic treatment than that with conventional one (2.99% and 0.19$g \cdot kg^{-1}$). The available nutrients exhibited the same trend. And it found out that earthworm and nematode density were extremely higher in organic soil (1267 numbers$\cdot m^{-2}$ and 1441 numbers$\cdot m^{-2}$, respectively) than in conventional one (46 numbers$\cdot m^{-2}$ and 85.6 numbers$\cdot m^{-2}$, respectively). The high use of organic fertilizers shaped the system sharply in a 6-year round trial and further studies need to be focused on the fate of nutrients, especially N, and the mechanisms in rebuilding of soil health in such an intensified cropping system.

Introduction

Organic agricultural systems had been given growing concerns in last decade for their positive effects on the increasing of soil fertility and soil microbial activity (Reganold, 1988; Drinkwater et al.,1995; Droogers & Bouma,1996; Mäder et al., 2002).There were few long-term experiments on organic agriculture in the world, and to date all studies targeted on those cereal crops and the rotation cropping systems (Dringwater et al.,1998; Raupp, 2001), and rare was focus on the vegetables, especially vegetables grown in the intensive greenhouses, either covered with glasses or plastics. The objective of this present study was to examine the effects of three different systems (organic, integrated and conventional vegetable growing systems) in greenhouses on the soil chemical and biological properties based on a long-term field trial since 2002.

Materials and methods

The experiment was conducted in three side-by-side greenhouses at Sitan village (36º52´N,115º01´E), Quzhou, Hebei, China with three treatments: (1) conventional managed system (CON) with less animal manure (averaged 7.5 t/ha per crop); (2)

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integrated managed system with manure compost(INT) (averaged 16.2 t/ha per crop); (3) Organic managed system with cattle manure compost (ORG) (averaged 29.1 t/ha per crop). Detail nutrients and other inputs are showed in Tab. 1.

Tab.1-Average input of nutrients, pesticides and irrigations of the three different systems among 2002-2008

	CON	INT	ORG
Total N (kg ha-1 yr-1)	861.50	783.63	889.75
Total P (kg ha-1 yr-1)	327.00	300.60	387.19
Total K (kg ha-1yr-1)	281.25	859.87	1282.24
Pesticides spraying times yr-1	20	10	0
Pesticides use rate (kg ha-1yr-1)	29.10	9.15	0.00
Irrigation times yr-1	8	8	8

Each greenhouse was arranged into three plots as replicates. The compost was made on site with cattle manure, maize straw, wheat bran and cotton-seed cake. It took about 15 to 28 days. The final contents of C/N ratio, N, P, and K in the compost were 25-30, 1.21%, 0.6% and 1.58%.The cropping patterns during the experimental period from 2002 to 2008 were cucumber, tomato, celery, tomato, cucumber, tomato, cucumber, tomato, celery, tomato, cucumber and tomato. Totally 12 crops were grown in the research period.

Results

1. Soil chemical properties

Although the initial soil organic matter (SOM) was at a same level in the three greenhouses, it increased from 16.63 to 60.10 mg·kg^{-1}, nearly 3.6 fold in ORG after 12 growing cycles. Meanwhile soil TN in ORG increased from 0.12 to 0.36 g·kg^{-1} and soil TP in ORG had a 228% increase (from 0.14 to 0.32 g·kg^{-1}) in the same period. The available nutrients in organic growing system were also increased substantially. The alkaline hydrolytic N, available P and available K in the organic greenhouses increased 1.8 -3.3 fold compared to 1-2.3 fold in the conventional greenhouses in a 6-year round (Tab 2).

Tab. 2 Soil nutrients concentration changes in 0-20 cm soil layer in three different systems

		Total N (%)	Total P (%)	Organic matter (%)	alkaline hydrolytic N (mg/kg)	Available P(mg/kg)	Available K(mg/kg)
CON	Mar（2002）	0.136	0.222	1.893	128.38	163.05	212.83
	Mar（2008）	0.190	0.260	2.990	153.70	162.50	479.50
INT	Mar（2002）	0.119	0.124	1.525	95.35	81.68	364.28
	Mar（2008）	0.260	0.250	4.040	192.40	278.10	648.10
ORG	Mar（2002）	0.117	0.138	1.663	101.28	139.13	257.30
	Mar（2008）	0.360	0.320	6.010	275.90	350.30	839.60

The high application of compost surely introduced those nutrients into soil and ready for the plant uptake of the time and later cropping season. In this study, compost amended soil received more nutrients than conventional one, so the SOM and STN in the ORG and INT soils were also above the level of them in the CON soils. Further, our studies showed the nitrate in the organic celery stem was lower than that in conventional one and the nitrate concentration in organic soil profile (2m) was much lower than that in conventional soil (Xie, 2008; Liang, 2009). But more tests for produce, soil and water environment are needed to prove this.

2. Soil earthworm density

The earthworm densities in three different greenhouses in last years were showed the big difference between organic and conventional treatment and the difference were becoming greater along with the operation of the trial. Organic treatment had as high as 33 fold of the number (averaged) than that of conventional. And this could be proved by the pictures taken in the sites (Fig.1).

Conventional field Organic field

Fig. 1 Earthworm showed in the two soils

3. Soil nematode population and diversity

The number of soil free living nematodes for organic, integrated and conventional systems were averaged of 1441, 917 and 85 individuals 100 g^{-1} dry soil, and organic treatment had a much higher population of nematode for each of the sampling date and exhibited a significant differences ($p<0.01$) between treatments.

Tab.3 The number of different trophic groups of nematodes in three systems (ind. 100g-1 dry soil)

	ORG	INT	CON
Total	1441.31±88.60c	917.73±151.19b	85.62±17.02a
Bacterivores	1056.87±68.49c	618.36±90.01b	20.28±4.63a
Fungivores	0±0a	0±0a	1.27±1.27a
Plant-parasites	315.38±63.21b	266.89±110.10b	23.22±17.18a
Predators-omnivores	69.06±7.36b	32.47±2.00a	40.85±8.58a

For different nematode trophic groups, there was much higher population of both bacterivores (BF) and plant-parasites (PP) nematode in organic treatment than other two treatments. But the population of fungi-feeders (FF) was very low for any treatments, and the omnivores-predators (OP) nematode showed a limited higher in organic than others. The dynamic changes of the nematode community are still working and the past studies demonstrated that the organic system had a stable and comparative output in terms of crop yield and lower incidence of major diseases for different crops in last 6 years (Xie, 2008; Liang, 2009; Yang et al., 2009).

Conclusions

The greenhouse trial in this paper was a special case for the organic agriculture. It was conducted in the greenhouse, applied with high amount of organic fertilizer, and had showed substantial differences between three different management systems. The preliminary results would provide some implications to the development of organic agriculture in those high intensive agricultural systems and the understanding the resilience mechanisms and rebuilding of a health soil after amendment of organic fertilizers. Further deep studies on the nitrate balance and soil biodiversity dynamics are needed to be done.

Acknowledgments

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Phosphatase and Dehydrogenase Activities in Soils as influenced by Soil Depth, Organic and Conventional management systems

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Key words: soil enzymes, organic farming, conventional farming, soil depth.

Abstract

Many recent studies from around the world have compared organic and conventional farming systems in terms of soil properties. A field study was conducted to determine the activity of acid Phosphatase, alkaline Phosphatase and Dehydrogenase in four representative soil profiles one each from < 3years, 3-6 years and > 6 years of organic farming practice and one profile from conventional farming system under central dry zone of Karnataka, India. The activity of dehydrogenase increased significantly in all three organic farming fields irrespective of cropping systems evaluated over conventional farming, with maximum activity being in the profile where organic farming is practicing for > 6years. The organic farming being practiced in < 3 years and 3-6 years fields recorded significantly lower levels of acid and alkaline phosphatase activities in the surface horizon when compared conventional farming system. Depth-distribution studies showed that all the three enzyme activities were concentrated in surface soils and decreased with depth.

Introduction

A growing number of studies show that organic farming leads to higher quality soil and more soil biological activity than conventional farming. Soils are a fundamental resource base for agricultural production system. Agricultural management systems have been historically adopted without recognizing consequences on soil conservation and environment quality, and therefore significant decline in soil quality has occurred worldwide. Since, soil biological and biochemical properties do respond rapidly and enzymatic activity is highly sensitive to external agents and easy to determine, measurement of the activity of numerous hydrolytic enzymes has been widely used in recent years to study the effect of changes in soil use on processes that affect of soil quality (Bandick and Dick 1999). Studies of enzyme activities in soil are important as they indicate the potential of the soil to support biochemical processes which are essential for the maintenance of soil fertility. Dehydrogenases represent a class of enzymes that give us information about the influence of natural environmental conditions of the microbial activities of the soil (Schäffer 1993). The objective of the present study was to determine the impact with different periods of organic farming practice and conventional farming approach on soil dehydrogenase activity; acid phosphatase and alkaline phosphatase build up along with soil profile depth.

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Material and Methods

The study was conducted in central dry agro climatic zone of Karnataka, India. The zone comprises an area of 1.94 million ha. The annual rainfall ranges from 454 to 718 mm and more than 55% is received in monsoon season. The crops grown in the sampling sites were with maize-cotton rotation. The soil samples from different horizon depths were collected during 3rd and 4th of February 2009.A composite sample obtained from 8-10 cores of each horizon was thoroughly homogenized, stored under refrigerating conditions and analyzed for the activities of dehydrogenase and acid and alkaline phosphatases by adopting methods of Tabatabai and Bremner (1969), respectively. The soils were classified as per keys to Soil Taxonomy.The pH and other parameters (Table 1) were estimated by adopting standard procedures (Jackson 1967). The results were analyzed by ANOVA, with treatment (Organic Farming and Conventional Farming) as the independent variable. All statistical analyses were performed with the program SPPS 11.0 for Windows (SPSS, 2001). All values are expressed as mean values. Significant statistical differences between treatments were established by the Tukey`s test at $P < 0.05$.

Results and Discussion

The enzyme activities (phosphatases and dehydrogenase) were consistently higher (Table 2) in the surface layer (AP horizon) in all the four representative profiles studied. Soil acid and alkaline phosphatases were significantly low in < 3 years and 3-6 years of organic farming practice when compared to conventional farming. However, in the field where organic farming being practiced over 6 years recorded highest acid and alkaline phosphatase activity. The dehydrogenase activity was increased significantly in all three organic farming fields irrespective of cropping systems evaluated over conventional farming, with maximum activity being in the field where organic farming is practicing for > 6years. Soil enzyme activities may be increased by incorporation of organic materials in the soil (Nannipieri *et al.* 1983) and this increased activity has generally been attributed to increased microbial biomass resulting from organic matter enrichment in the soil where organic farming is being practiced over 6 years. The activities of dehydrogenase, acid and alkaline phosphatase in our study decreased markedly with depth in organic as well as conventional farming systems (Table 3). This decrease in dehydrogenase and phosphotase activities with depth was associated with decrease in organic matter content.

Conclusions

In our present study it was concluded that the continuous usage of organic manures over 6 years in organic farming system enhanced the dehydrogenase, acid and alkaline phosphatase activity significantly over the conventional farming system.

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Table 1. Description of representative Profiles under Central dry agro climatic zone of Karnataka, India

Horizon	Depth (cm)	Matrix colour (moist)	Texture	Structure (Grade-size-type)	Classification	pH	SOC (%)
P-1: (Organic farming 0-3yrs) Lat: 130 -57'35.6" Longi: 760 38' 51.1" Elevation: 635 MSL							
A	0-12	10YR 3/3	sc	2m sbk	Fine,mixed,iso hyperthermic, lithic Haplustepts (Inceptisol)	8.4	0.9
BW1	12 - 24	10YR 3/2	sc	2m sbk		8.6	1.0
BW2	24-70	10 YR 3/2	sc	2m sbk		8.6	0.5
BW3	70-89	10 YR 3/2	sc	2m sbk		8.4	0.2
BC	>89	Weathered parent material					
P-2: (Organic farming 3-6 yrs) Lat: 140 20' 20.4" Longi: 760 21' 14.3" Elevation: 666 MSL							
A	0-19	7.5YR 3/3	sc	2m sbk	Fine, mixed,iso hyper thermic, Typic Paleustals (Alfisol)	8.1	1.4
BW1	19-34	7.5YR 3/3	sc	2m sbk		8.2	1.0
BW2	34-52	7.5YR 4/3	c	2m sbk		8.2	0.9
BW3	52-76	7.5YR 3/3	c	2m sbk		8.7	0.7
BC	> 76	Weathered parent material					
P-3: (Organic farming >6yrs) Lat: 140 20' 36.9" Longi: 760 23' 25.6" Elevation: 708 MSL							
A	0-14	7.5YR 3/2	sc	2m sbk	Fine, mixed, isohyperthermic, Typic Haplustepts (Inceptisol)	7.3	1.5
BW1	14-35	7.5YR 3/3	sc	2m sbk		7.8	1.2
BW2	35-60	7.5YR 3/2	sc	2m sbk		8.1	1.1
BW3	60-80	7.5YR 4/2	sc	2m sbk		8.3	0.9
BC	> 80	Weathered parent material					
P-4: (Conventional farming) Lat: 130 57' 39" Longi: 760 38' 51.4" Elevation: 662 MSL							
AP	0-16	10 YR 3/2	sc	2m sbk	Clayey-skeletal, mixed, isohyperthermic,Typic haplustepts (Inceptisol)	7.9	0.9
BW1	16-28	10 YR 3/2	sc	2m sbk		8.1	0.8
2BW1	28-75	10 YR 3/2	sc	2m sbk		8.4	0.5
BW2	75-89	10 YR 3/2	sc	2m sbk		8.7	0.4
BC	> 89	Weathered parent material					

P : Profile sc: Sandy clay c: Clay

Grade: 2-moderate SOC: Soil Organic Carbon **Type:** sbk- subangular blocky

Table 2. Phosphatase and dehydrogenase activity in the plough layer (Ap horizon) as affected by different time periods of organic farming practice

Parameters	Enzyme activity		
	Acid phosphatase (µg p-NP g-1 h-1)	Alkaline phosphatase (µg p-NP g-1 h-1)	Dehydrogenase (µg TPF g-1 h-1)
A. Organic farming			
< 3years	53.22 NS (0.001)	55.26 NS (0.003)	1060 * (58.6)
3-6 years	54.57 NS (2.7)	56.69 NS (2.9)	1246 * (86.5)
> 6 years	57.12 * (7.5)	59.12 * (7.4)	1272 * (90.4)
B. Conventional farming	53.12	55.06	668

Table 3. Phosphatase and dehydrogenase activity as affected by soil depth with different time periods of organic farming practice over conventional farming

Horizon	Acid phosphatase (µg p-NP g-1 h-1)				Alkaline phosphatase (µg p-NP g-1 h-1)				Dehydrogenase (µg TPF g-1 h-1)			
	CF	OF			CF	OF			CF	OF		
		< 3 yrs	3-6 yrs	>6 yrs		< 3 yrs	3-6 yrs	>6 yrs		< 3 yrs	3-6 yrs	>6 yrs
AP	53.12	53.2 NS (0.001)	54.57 NS (2.7)	57.1 * (7.5)	55.06	55.2 NS (0.003)	56.6 NS (2.9)	59.12 * (7.4)	668	1060 * (58.6)	1246 * (86.5)	1272 * (90.4)
BW1	37.18	37.1 NS (-0.2)	43.63 * (17.3)	48.3 * (30.1)	37.55	43.32 * (15.3)	50.39 * (34.2)	57.64 * (53.5)	312	419 * (34.3)	606 * (94.3)	701 * (124)
BW2	31.03	14.62 NS (-52.8)	30.0 NS (-3.1)	38.41 * (3.7)	19.05	17.63 NS (-7.4)	40.25 * (111)	57.01 * (199)	206	309 * (50)	343 * (66.5)	304 * (47.5)
BW3	12.96	8.25 NS (-36.3)	22.3 * 72)	24.3 * (88.1)	14.75	11.54 NS (-21.7)	29.53 * (100)	41.33 * (188)	170	284 * (67)	264 * (55.2)	290 * (70.5)

CF: conventional farming OF: organic farming yrs: years

* $p < 0.05$, as compared to conventional farming; Figures in parenthesis show per cent increase/ decrease over conventional farming.

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Effects of organic fertilization on soil biological activity under organic farming

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Key words: Organic fertilization, soil biological activity

Abstract

Organic farming attempts to protect environmental quality, and enhance beneficial biological interactions and processes. Experiments were carried out, at the experimental station of the Technical Center of Organic Agriculture and organic farms (Tunisia), on studies of the effects of organic fertilization treatments on organic matter and Nitrogen contents and biological activity (mesophilic and thermophilic bacteria and fungi) of soil grown with olives and potato crops under organic farming. The main results can be summarized as follows:

- The soil biological activity has been improved by most of the organic fertilization treatments and depends upon the experimental region, and the growing crops.
- The soil organic matter and Nitrogen contents have been improved by compost.
- The green and fresh manure improved the biological activity slightly better than the compost.
- The animal manure has improved the mesophilic bacteria and fungi better than the green manure. Opposite results were found for thermophilic bacteria and fungi.
- The analysis of biological activity led to the identification of some beneficial micro-organisms which may be used in biological control.
- The use of various organic matters has led to micro-organisms' diversification and may contribute to the equilibrium if the biological balance.

Introduction

The soil is a life natural body, a living entity, and an ecosystem containing a wide variety of different flora and fauna. The biological activity of the soil depends on the availability of nutrients and energy supplied by soil organic matter, crops and live stock residues. Organic farming attempts to close the nutrient cycle, protect environmental quality, and enhance beneficial biological interactions and processes. Soil fertility is a critical issue on organic farming and is considerably affected by its biological activity. The issue is related to maintaining the quantity of soil organic matter, which is a critical component of soil productivity. The level of organic matter in soil is considered to be a good function of the net input of organic residues by the cropping system (Gregorich *et al*. 1994; cited by Bahouaoui 2008). Organic fertilization usually contributes to a stimulation of soil biological activity, a diversification of the microscopic life in the soil, a breaking of the disease build-up and weed problems (Caporali *et al*. 2004).

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Compost stimulates soil biological activity that helps release nutrients for plant use and improving soil structure, thereby reducing soil erosion (Nethan *et al*. 2005; cited by El-Shokary 2007). The objective is to study the effects of organic fertilization on biological activity (mesophilic and thermophilic bacteria and fungi) of soil grown with olives, and potato crops.

Materials and methods

Two experiments were carried out at organic farms and the Technical Center of Organic Agriculture (Tunisia).

Experiment 1. Effect of compost on biological activity of conventional and organic olive farms: Two olive farms grown under conventional and organic farming are compared in North (Tebourba) and South (Hajeb) areas in relation to soil organic matter and nitrogen contents, and biological activity. The North area is characterized by a temperate climate (cool temperature and high rainfall); however the South is characterized by an arid climate (high temperature and dry low rainfall). The soil organic matter and Nitrogen contents were determined at 20 and 40 cm depth. The total flora was counted at 20 cm depth. The identification of micro-organisms was made**.**

Experiment 2. Effect of different organic matter amendments on soil biological activity grown with potato under organic farming.
The experimental design is a completely randomized block design with four replications and four treatments:

- Green manure (GM)
- Animal manure (AM)
- Compost made from animal manure and crop residues: CAM-CR
- Control (weeds:W)

The mesophilic and thermophilic bacteria and fungi were counted and the identification of micro-organisms was made.

Results

Experiment 1 The results showed that the compost used in organic farming has improved the soil organic matter and total nitrogen contents at 20 and 40 cm depth in North (Tebourba) and South (Hajeb) areas. Total soil flora has been improved by compost amendment (Fig. 1).

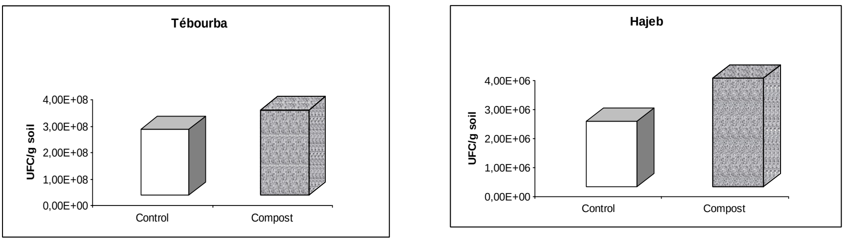

Figure 1: Effect of compost amendment on soil total flora : olive farm

The results indicate that more micro-organisms were identified in the North and organic farms than in the South and conventional farms respectively.

Experiment 2.
Table 1 shows that all the organic matter amendment treatments have significantly increased the number of mesophilic bacteria and fungi from 25.3 to 87% and 37.3 to 62.6% respectively compared to the control. Animal manure has given the highest number of these micro-organisms.

Tab. 1: Number of mesophilic bacteria and fungi (potato crop)

Treatments	Mesophilic bacteria (^{6}CFU/g soil)	%	Mesophilic Fungi (^{5}CFU g sol)	%
Control (weeds :W)	1,50 c	100	2,49 c	100
Animal manure (AM)	2,81 a	187,3	4,05 a	162,6
Green manure (GM)	1,88 b	125,3	3,42 b	137,3
CAM-CR	2,45 a	163,3	3,43 b	137,7
	*		*	

* significant for P<0.05

Table 2 shows that the animal and green manure have increased themophilic bacteria and fungi more than the other treatments.

Tab. 2: Number of thermophilic bacteria and fungi (potato crop)

Treatments	Thermophilic bacteria 10^5 CFU g soil	%	Thermophilic fungi 10^4 CFU g soil	%
Control (weeds :W)	2,65 a	100	2,39 b	100
Animal manure (AM)	2,82 a	106,4	3,03 a	126,7
Green manure (GM)	3,12 a	117,7	3,18 a	133
CAM-CR	2,49 a	94	2,11 b	88,3
	ns		*	

* significant for P<0.05 ns not significant

The results have showed that the identified micro-organisms depend on the treatment. So, the more diversified the organic matter source is, the more micro-organisms are identified. Some of them are useful and do have antagonistic effects.

Discussion

The olive farms in the North gave better soil results in relation to organic matter and nitrogen contents and total flora than in the South because of the better climatic conditions. The high number of micro-organisms identified in both experiments may contribute to hasten the organic matter decomposition. Then the released nutrients will benefit to the potato and olive crops. Many authors (Cherif et *al*. 2003, Daami-Remadi *et al*. 2006, Saligkarias *et al*. 2002) reported antagonistic micro-organisms against pathogen agents. The high number of micro-organisms would contribute to the biological control and the equilibrium of the biological balance.

Conclusions

The soil flora has been improved by most of the organic fertilization treatments and depends upon the experimental region, and the growing crops. This may contribute to the improvement of soil biological activity. The green and animal manure have improved the soil flora slightly better than the compost.

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Changes of soil microbe communities in plastic film house by green manure crop cultivation

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Key words: green manure crop, hot pepper, no tillage, soil microbial community

Abstract

To improve the soil condition for no-tillage organic pepper cultivation, four different green manure crops were cultivated. Fertilizer supply was depended on the biomass of the cultivated green manure crops, nitrogen supplies were 314kg in Vicia villosa and 341kg per ha in Vicia angustifolia. In the microbial community analyzed by phospholipid fatty acid (PLFA) method, soil microbe populations were different among the green manure crops and fungi group was increased at Vicia angustifloia and Vicia villosa. The biological ratio indexes of fatty acids in the soils, the ratio of gram-negative to gram-positive bacterial PLFA and that of aerobes to anaerobes were high at Vicia hirsute and Vicia tetrasperma, suggesting the enrich of the aerobic conditions at these green manure crops. The ratio of saturated to unsaturated fatty acids increased at Vicia angustifloia and Vicia villosa suggesting anaerobic conditions. Abundant biomass and uncomposted organic matter, the ratio of fungi to bacteria was increased at Vicia angustifloia and Vicia villosa.

Introduction

Winter annual green manure crops may be an effective tool for organic agriculture systems and these systems also improve soil structure and accumulation of organic matters. According to a definition of organic agriculture proposed by Codex alimentarius commission, organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity (CODEX 1999). The organic cover cropped soil had the largest and most heterogeneous microbial population while the biomass of the organic-manure amended soil was the least heterogeneous, and the most metabolically active (Wander *et al.* 1995). Soil management practices affect soil microbial communities, which mediate many processes essential to the productivity and sustainability of soil. Especially no tillage practices increased soil organic matter contents not only improves soil structure and water retention, but also serves as a nutrient reservoir for plant growth and an substrate for soil microorganisms (Feng *et al.* 2003). Red hot pepper is one of the most important vegetable crops for seasoning foods in Korea. However, the yield of peppers grown in the plastic film house was decreased because of injury by continuous cultivation of pepper single crop (Kim & Chung 2005). Therefore, this study was carried out to improve the soil condition by cultivation of green manure crops in winter season and to investigate the differences

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of soil microbe populations by different manure crops for reducing the injury caused by continuous single cropping for long time.

Materials and methods

To select promising green manure and covering crops for the no tillage organic red pepper cultivation. Four different crops, *Vicia tetrasperma, Vicia hirsute, Vicia angustifolia and Vicia villosa* were fall-seeded at a rate of 60 kg ha^{-1} in continuously red pepper cultivated plastic film house soil. At just before transplanting pepper seedlings, growth characteristics of seven-month grown green manure crops were measured and biomass also examined. No additional herbicides and fertilizers were added to any cover crop plots and the pepper grown without tillage. A randomized block design was used with three replications and individual plots were approximately 40 m^2 (4 X 10m) for this research.

Soils were sampled to a depth of 10 cm with a soil probe (diameter: 5 cm) at three points in each plot before the red pepper were transplanted. The sampled soils were dried at shady place and passed through a 2-mm mesh sieve and stored within closed plastic bags at -80℃ in the dark until analysis. Microbe populations were analyzed by phospholipid fatty acid (PLFA) method (Feng 2003). In brief, lipids were extracted from soils by a one-phase chloroform, methanol and water extractant, and then fractionated into neutral lipids, glycolipids and phospholipids on a silicic acid column. The phospholipids were then subjected to alkaline methanolysis and analysis on a gas chromatograph with a flame ionization detector. Statistical analysis of data was carried out using SAS and to determine the significance among the means of treatments, LSD was computed at the 5 % probability level.

Results

As the plant height was high the biomass also increased, so that significant differences were found on fresh and dry weight among the green manure crops. Dry weights were 435g in *V. tetrasperma*, 579g in *V. hirsute*, 699g in *V. villosa* and 724g per m^2 in *V. angustifolia* (Table 1). Nutrition composition was not different among the four green manure crops, means that the fertilizer supply was depended on the biomass of the cultivated green manure crops. Nitrogen supplies were 191kg in V. tetrasperma, 269kg in V. hirsute, 314kg in V. villosa and 341kg per ha in V. angustifolia (Table 2).

Tab. 1: Growth of green manure crop cultivated in plastic film house in winter season.

Green manure crops	Plant height (cm)	Root length (cm)	Fresh weight (g m-2)	Dry weight (g m-2)	Dry/fresh weight
Vicia tetrasperma	49.6±3.4	16.3±0.8	2,093± 40	597±20	0.29
Vicia hirsuta	46.5±1.9	21.7±0.9	1,593± 27	435±26	0.27
Vicia angustifolia	59.3±3.0	21.6±0.3	2,883±311	724±90	0.25
Vicia villosa	81.3±2.0	20.4±1.9	3,157±539	699±46	0.22

* Values are means±SD

Tab. 2: Nutrition compositions and supply amount of nitrogen, phosphate and potassium of green manure crops cultivated in plastic film house in winter season.

Green manure crops	Nutrition composition (%)					Fertilizer supply (kg ha-1)		
	T-N	T-C	P_2O_5	K_2O	C/N	N	P_2O_5	K_2O
Vicia tetrasperma	4.5	41.0	1.0	3.8	9.1	269±25	59.7± 5.9	227±15
Vicia hirsute	4.4	42.3	0.9	3.1	9.7	191±16	39.1± 4.7	135± 4
Vicia angustifolia	4.7	41.1	0.9	5.2	8.8	341±37	65.2±10.7	376±24
Vicia villosa	4.5	41.7	1.0	4.5	9.3	314±27	69.9± 3.1	315±87

Values are means±SD

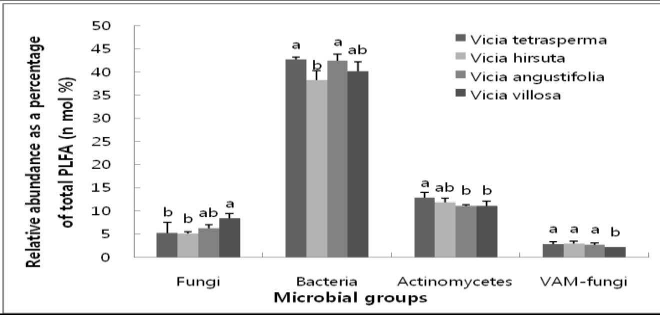

Figure 1: Relative abundance of fungi, bacteria, actinomycetes and VAM-fungi by the analysis of phospholipid fatty acids in the soils with four different green manure crops cultivation. The vertical bars indicate the standard deviation of the means

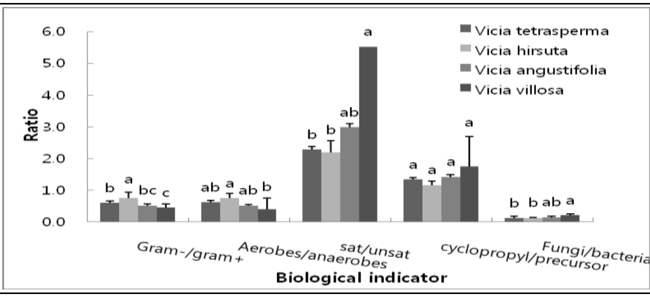

Figure 2: Changes in the biological ratio indexes of fatty acids in the soils amended with four different green manure crops cultivation. The vertical bars indicate the standard deviation of the means

In the soil microbe populations analyzed by PLFA, they were differed among the green manure crops. Fungi group was increased at *V. angustifloia* and *V. villosa*, bacteria group was increased at *V. tetrasperma* and *V. angustifolia*, actinomycetes group was increased at *V. tetrasperma*, and VAM-fungi group was decreased at *V. villosa* (Figure 1). In changes of the biological ratio indexes of fatty acids in the soils, the ratio of gram-negative to gram-positive bacterial PLFA and that of aerobes to anaerobes were high at *V. hirsute* and *V. tetrasperma.* It suggested that more aerobic soil conditions were made by these two crops cultivation. The ratio of saturated to unsaturated fatty acids increased at *V. angustifloia* and *V. villosa*. The ratio of fungi to bacteria was also increased at *V. angustifloia* and *V. villosa* (Figure 2).

Discussion

Winter grown green manure crops reduced nitrogen losses significantly securing a higher N supply for succeeding crops and resulting in changes of the soil nitrogen utilization and growth of pepper due to different cover crops (Sung *et al.* 2008). In present study, the supply amounts of fertilizer were also different depending on the kind of green manure crops. Fertilizer supply was higher in *V. villosa* and *V. angustifolia* compared to other cover crops, but the long plant height of *V. villosa* inhibited the pepper growth at early stage on the no-tillage organic cultivation (data not shown). Soil management practices and cultivation of cover crops affected soil microbial communities, which in turn influence soil ecosystem processes (Peng *et al.* 2003). In present study, only one year cultivation practices differed the microbial communities under different green manure crops. As the biomass of green manure crops decreased the gram-negative bacteria and aerobes increased under *V. hirsute* and *V. tetrasperm*, suggesting the more aerobic conditions at the soil surfaces. However as the biomass increased the ratio of saturate to unsaturated fatty acid and the ratio of cyclopropyl fatty acids to precursor were increased, it could be concluded that anaerobic conditions increased soils covered with *V. angustifloia* and *V. villosa*. High ratios of fungi to bacteria, which mean abundant biomass and uncomposted organic matter, were measured soil covered with *V. angustifloia* and *V. villosa* which have more biomass.

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Biological nitrogen fixation of mycorrhizal alfalfa (*Medicago sativa* L.) in an organically managed field

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Key Words: Alfalfa, Rhizobia, Mycorrhiza, Nitrogen Fixation , isotope ratio and organic farming.

Abstract

This study assessed the effects of interactions between Mycorrhiza fungi and Rhizobia in efficacy on the growth, yield and biological nitrogen fixation of Alfalfa under dry condition, which was laid out by a factorial experiment in the form of a randomized complete block design (RCBD) with 4 replicates. Three factors, each one in 2 levels were studied; first factor was Rhizobium (without Rhizobium, with Bradyrhizobium meliloti), second factor was Mycorrhiza (without Mycorrhiza, with Mycorrhiza containing mixed Glomus etunicatum, Glomus intraradices and Glomus claroideum), and third factor was Irrigation (without irrigation, with irrigation). Results showed that in most parameters there were no strong significant differences between treatments. Using co-inoculation of mycorrhiza with rhizobia could increase nitrogen derived from the atmosphere, total fixed nitrogen and nitrogen yield in a small amount.,A high level of precipitation during the period of this experiment (481.8 mm) caused that non-irrigation treatments were not really in the strong drought condition. Still irrigation could increase some of the parameters. Also results of biological nitrogen fixation showed that in the field of experiment there was high natural BNF.

Introduction

The cornerstone for soil fertility in organic farming is the use of legumes to fix atmospheric N_2. The annual nitrogen fixation rates of Alfalfa range broadly from 85 to 360 kg ha^{-1}. The resulting N benefit to succeeding crops is very variable, depending on the performance of the Alfalfa crop. Environmental factors and management practices affect the fixation process and the amount of N_2 fixed. It was also well documented that AMF colonisation and AM fungal activity is enhanced by *Rhizobium,* resulting in better plant performance (Subba-Rao, 1985; Barea et al., 1987; Garbaye, 1994). Arbuscular mycorrhizal fungi (AMF) and *Rhizobium spp*. form an intimate association with leguminous plants which is often termed the “tripartite symbiosis”. Legume forage crops provide a source of biologically fixed nitrogen for the organic system. The forage is then fed to animals rather than sold directly, thereby minimizing the flow of nutrients from the farm. Biological nitrogen fixation (BNF) is the result of symbiosis between legumes (*Fabaceae*) and nodulating bacteria (Rhizobia).

Materials and Method

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The trial was located on the organically managed fields of the research station 'Gross-Enzersdorf' of the University of Natural Resources and Life Sciences, Vienna, in Raasdorf (Longitude: 16° 35 ' 32'' E; Latitude: 48° 13 ' 53'' N; Elevation: 151 m). Climate of this area is characterized by hot, dry summers with little dew, and cold witers with little snow. The mean annual temperature is 9.8°C, the average precipitation 554 mm. Soils were Calcaric Phaeozems (WRB,1998) from fine alluvial sediment with a silty loam texture, organic carbon contents of 2.2 % in the Ap horizon, and a pH_{CaCl2} value of 7.6 in the topsoil. The weather data were assessed by the gauging station of the Institute for Agronomy and Plant Breeding, University of Natural Resources and Life Sciences, Vienna (BOKU). Treatment variants differ with respect to the inoculation and irrigation of Lucerne (Table1). The seeding density was 25 kg ha^{-1} in all cases, Alfalfa cultivar was Sitel (Origin and maintainer: Netherlands / Barenburg Holland BV, Atationsstraat 40,6678 AC, Oosterhout; thousand seed weight: 2.3 g).

Table 1: Treatments.

Variant	Inoculation	Irrigation
1	Rhizobia	No
2	Mycorrhiza	No
3	Rhizobia + Mycorrhiza	No
4	No inoculation	No
5	Rhizobia	Yes
6	Mycorrhiza	Yes
7	Rhizobia + Mycorrhiza	Yes
8	No inoculation	Yes

To estimate BNF with using ^{15}N dilution method, for each Alfalfa treatment, we considered one plot that was cropped with a grass mixture as reference crop. The seeding density was 25 kg ha^{-1} in all cases. The grass mixture consisted of 25 % of each of the species [Perennial Ryegrass (Dtsch. Weidelgras), False Oat (Glatthafer), Cock´s Foot (Knaulgras) , Red Fescue (Rotschwingel)]. The rhizobia used originated from the commercial inoculum collection of Becker Underwood Company with the trade name of Histick. The carrier material of inoculum's was sterilized peat based and contained minimum $2x10^{9}$ viable cells of selected *Sinorhizobium meliloti* per gram. Alfalfa seeds of each plot (30.56 g/plot) were inoculated with 6.5 g of rhizobium inoculum. Multispecific cultures of the AMF species included *Glomus etunicatum,Glomus intraradices and Glomus claroideum* was produced by INOQ Agri company. The other characteristics of the inoculum are as follows: carrier material: Vermiculite; Grain size (mm):1-2; Specific weight (g/l): 570-610; pH: 5.7; Most probable number of propagules (MPN): 150 +_ 9. The inoculum was previously weighted for each mycorrhizal plot (850 g /9 m^{2}) , spread congenial at the soil surface of each plot by hand, then it mixed with soil until 5 cm depth before sowing. First irrigation was done on 12 April 2007 for all the plots by sprinkler. Five irrigations during the experiment and in each irrigation 108 litre water per plot (12mm/plot) were used. For this kind of irrigation we have used water tanker for transporting water to the field. The trial took place in April 2007 at Raasdorf on organically cultivated fields of the University of Natural Resources and Life Sciences, Vienna. The research was laid out by a factorial experiment in the form of a randomized complete block design (RCBD) with 4 replicates. In this experiment, biological nitrogen fixation was estimated by the ^{15}N dilution method. The earliest application of $^{15}N_2$ in N_2 fixation studies was by Burris and Miller (1941). The plant-available soil N pool is enriched with ^{15}N by spraying ^{15}N fertilizer at the soil surface, thereby artificially increasing the difference between the $^{15}N/^{14}N$ ratio of the air and that of the soil N pool. A legume and a reference crop (grass-mixture) were grown on the ^{15}N-labelled soil. The percentage of legume N content derived from the air (N_{dfa}) was calculated using the isotopic differences between the two crops (McAuliffe et al. 1958):

$$N_{dfa} = [1-(\text{atom \% } ^{15}N \text{ excess legume / atom \% } ^{15}N \text{ excess reference crop})] * 100\%$$

In preliminary work at the experimental site, it was found that the $\delta^{15}N$-value of the plant-available N pool is below 5 ‰. BNF and % Ndfa were therefore estimated using the ^{15}N dilution method. The soil labelled with ^{15}N at the beginning of the vegetation period in April 2007, received 0.1 kg ^{15}N ha^{-1} (N as 1 kg potassium nitrate ha^{-1}, 10 at% ^{15}N).

The amount of N from BNF can be calculated as follows:

$$N_{fix} \text{ shoot [kg ha}^{-1}] = N_{dfa} * \text{shoot N content} * \text{DM yield [kg ha}^{-1}]$$

N_{fix} = amount of N from BNF

N_{dfa} = nitrogen derived from the atmosphere

DM yield = dry matter yield of legume shoots

Results

The nitrogen content in the shoots ranged from 2.75 % to 3.95 % N at harvest 1 and from 2.60 % to 4.89 % N in second harvest. In the stubbles 1.17-4.76 % N and in the root 0.42-4.23 % N were determined in the second harvest. Total fixed nitrogen was evaluated at the end of the experiment. Results of analysis of variance showed no significant differences between main treatment effects, double and triple interactions of treatments on total nitrogen fixation. The main effect of using Rhizobium inoculation, Mycorrhizal inoculum and applying irrigation could increase this parameter by an amount of 31.4, 24.1 and 40.5 kg ha^{-1}, respectively. Although all of the treatments in double and triple interactions were in the same group (a), data show that using mycorrhiza could increase total nitrogen fixation, but this effect was not very strong (Fig. 1). Also the nitrogen derived from the atmosphere (Ndfa) indicated no differences between treatments. The amount of nitrogen yield in the different parts of the Alfalfa was almost the same. Since the nitrogen content in the shoots was higher than that in the roots, multiplying nitrogen percentage and yield of the parts resulted in very similar N yield (Fig. 2; Ardakani et al., 2009). We observed clear inverse relation between inorganic soil nitrogen and nitrogen fixation at the first harvest. The negative relationship between mineral-N contents in soil and nitrogen fixation rates is well known. Symbiotic nitrogen fixation is an energy consuming process, thus legumes obtain less of their N_2 requirement from atmosphere if there is an adequate supply available from the soil.

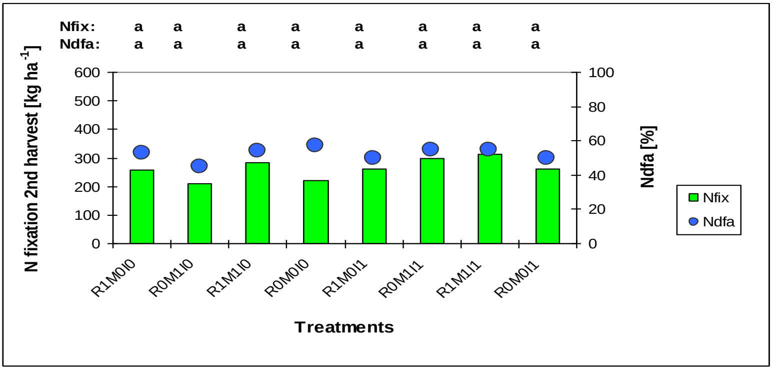

Fig. 1: Effect of treatments on Nfix total and Ndfa.

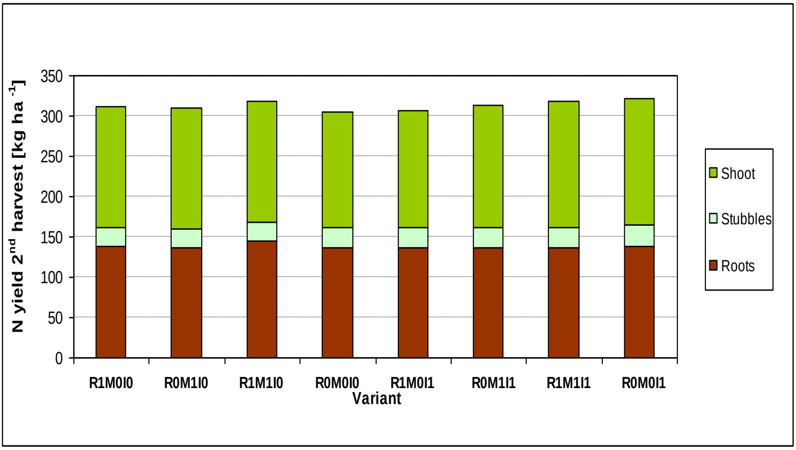

Fig. 2: Nitrogen yield in different part of Lucerne treatments.

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Investigation of the brix index and biomass changes resulted from reciprocal effect of humic acid organic fertilizer on tomato

Bagher Zadeh, A.[1], Salhie, B., Aramesh, Fooladkar, M.

Key words: Humic Acid, tomato, quantitative index, qualitative index, organic fertilizer.

Abstract

Extensive use of chemical fertilizer in the recent decade in order to produce more agricultural products, resulted in the pollution of soil, water and living environment . A test was performed to study and determine the suitable amount of Humic Acid on three varieties of tomato in khorasan Razavi province in 2009-2010 in a farm placed in Ahmad Abad (in the suburb of Mashhad) in the form of split plots in Random complete block base design. 4 levels of Humic Acid 0,1,1.5,2 (kg/ha) on three varieties of tomato named (super ch , Estern , super chief) in 3 repetitions that totally consisted 12 treatment was used. The target in this test was to study the positive impact of organic fertilizer in order to increase tomato product and determine the suitable amount of HA fertilizer. During this study , the consumption effect of different levels of HA, fruit weight , Biomass, dry fruit weight and brix index showed a great significant difference in the %1 level , but in PH index investigation no significant difference was observed between varieties and consumption levels of the organic fertilizer .

However, to determine the effective level, a minimum level of PH belonged to 2 kg/ha treatment for Super Ch variety. To determine the most suitable consumption level of HA on fruit output (production) and biomass, 1.5 (kg/ha) level on Superchief variety produced the greatest reaction. However in the study of brix index Super Ch variety, the greatest reaction was produced for 1.5 (kg/ha) level.

Introduction

In regard to living environment considerations, using different kinds of organic acids to improve the quality and quantity of farming and horticultural products has become widespread recently. Law amount of organic acids had considerable impacts an improving physical, biological and chemical soil characters; Moreover, due to the presentation of hormonal compounds, they have useful impacts on increasing production and improving the quality of agricultural products (Samavat and Malakooti 2004). Humic Acid is a natural organic polymer compound that is resulted from decay of organic soil ingredients, pit, lignin, etc; it can be used to increase production and it's quality (Icon & colleagues 1985). There are numerous reports about the HA affect way that we can divide in to two groups: direct impact as a hormanoide compound (kaco and Agnola 1984) and indirect impact to increase the absorption of nutrition elements through these characters: cluttering, rehabilitation and preserving the membrane

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penetrability (Chen ovaeid 1990). In farming experiment they observed that phosphorus absorption amount increased to %25 as compared to the lack of Humic Acid and showed that Humic ingredients have an impressive impact on increasing so many enzymes activity , specially phosphatase' enzyme (vang & Colleagues 1995), in the study of Humic Acid consumption impact on wheat and Zea mays product , they found out that this organic fertilizer has caused a meaningful increase on seed quantity and wheat biomass (Aidin & Colleagues 1999).

Methods and materials

This experiment was done in 2009-2010 in Ahmad Abad fields placed 35 kilometers from mashhhad in a private farm.

The experiment was in the form of split plots with random complete block base design in 3 repetitions. The plot was 6 m * 4m with 0/5 m margin. Cultivation distances on the row were 25 cm and between rows were 120 cm distance between repetitions wer 1 m.

Plan factors: 1. factor with original plots (A) : consisted of three varieties of tomato named (a1= Super ch, a2 Eastern, a3= Super chief).

2. Factor with secondary plots (B) consisted of four different amount of Humic Acid: (b0=0, b1=1, b2=1.5, b3 2 kg/ha) time and special maner of doing different Humic acid treatments in 3 phases are discussed below:

1) In May, the first irrigation after cultivation, so that Humic acid with different doses was sprayed on the sail surface, then water was flowed in the plot so that water wouldn't penetrate other plots. 2) In the middle of the vegetative growth in June before flowering. 3) The last plase, while 50% of flowering took place in July, the performance method was the same as the precious method. The characters studied in colluded: (bush length, fruit product(output), fruit quantity , special surface of leaf and fruit dry weight) . Then after harvest in 3 phases: (i.e.At the end of the growth, mature time and fruit production), we prepared data, calculated the average and firmly analyzed data and variance. Therefore, averages were compared via doncan method. We should mention that for statistical calculation and variance analysis

Mstat C software was used and for drawing graphs and curves Excel software was used.

Results and Conclusions

According to the investigations, fruit weight index in bush, that is the witness of fruit output itself, in consumption of different concentrations of humic acid, significant difference was observed in 1% level. We should mention that, the mutual impact of variety in organic fertilizer showed a significant difference in 5% level; the most effective concentration to increase prodact was 1.5 kg/ha and the most amount of fruit output in the interaction of impacts of these two factors was Superchief variety; The result showed that humic Acid consumption due to the availability of phosphorus and other elements in wheat has resulted in production incease propagation section and going to seed. (Jhon et al 2004). In a study on tomato, Humic Acid caused a considerable increase in fruit output in bush. (Radpour et al. 2007). To determine biomass index, density difference alone and the reciprocal impacts of fertilizer in variety showed a significant difference. Super chief variety had the most amount of biomass as compared to 1.5 kg/ha humic acid consumption with regard to treated seeds experiments humic Acid solution showed 3% increase in stem and leaf dry weight. (Azam & malik 1983).

They found out humic acid causes increase in plant biomass. (Aamntra & Grey 1988) the studies showed that organic fertilizer consumption has caused increase in Amaranthus sp biomass. According to (mahboob khomami 2008) using organic materials in the form of vermin compost has caused %40 increase in dry weight (biomass) of tomato. (Marir & colleagues 2001) we should mention that these results were reported in the study and measuring of fruit dry weight. Qualitative characters that consisted of brix index and fruit Ph were measured; results indicated that variety differences in brix index study had a significant difference in 5% level ; the impact of different concentration of organic fertilizer had a significant difference in 1 % level . the maximum amount of the reciprocal impact of fertilizer consumption and variety was 7/34 that be longed to the reaction of super chief variety to 1.5 kg humic Acid . By using Humic Acid, researchers found out that this organic fertilizer, by incensing the photosynthetic materials causes increase in the quality of rice product. (Neri ; & colleagues 2002).

Consumption of humic materials in compost fertilizer form has caused changes in the amount of soluble solid materials (brix) (Noorihoseini& colleagues 2007). In determining Ph, significant difference was not observed in any of the factors, but the minimum Ph was 2/6 that result from reciprocal impact of 2 kg/ha humic Acid in Super CH

Table 1. variance analysis and mid square (MS) of the characters under study.

S.O.V	Df	Fruit Yield(product) in bush(kg)	Biomass (gr)	Fruit dry weight(g)	Brix (%)	PH
repetition	2	0.212*	1519.694*	197.744ns	0.608*	0.992*
variety	2	0.015ns	10015.444*	716.714*	1.721*	0.201ns
Humic Acid	3	0.739**	10770.111**	4001.337**	4.599**	0.161ns
Variety in HA	6	0.118*	1318.778*	105.019ns	0.330ns	0.148ns
Error	18					

*,**significant in 5%&1% level respectively , Ns: non _significant

Table2: comparison of consumption average of various amount of HA on characters under study.

Character / amount of HA(kg/ha)	Fruit Yield(product) in bush(kg)	Biomass (gr)	Fruit dry weight(gr)	Brix (%)	PH
0(control)	1.20c	100.80c	72.12d	5.154b	4.623a
1	1.35bc	140.41b	86.57c	5.366b	4.510ab
1.5	1.86a	184.90a	121.00a	6.727a	3.972b
2	1.54b	150.11b	103.11b	6.069a	3.134c

In each column ,averages sharing at least one letter in 1%level are not significantly difference.

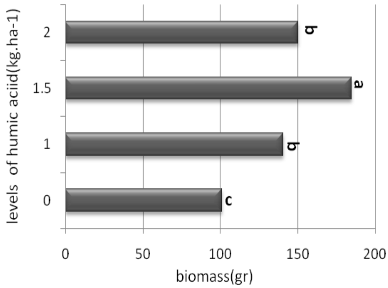

Fig 1: Effect of different levels humic acid on plant biomass

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Physico-chemical properties between organic and conventional kiwifruit orchards in Korea

Cho, Y.[1], Kim, B.[2], Cho, H.[3] & Jeong, B.[4]

Key words: organic, kiwifruit, soil, nutrient

Abstract

Organic kiwifruit orchard soils were compared with conventional ones in Korea. Soil structure of organic soil had higher gaseous and liquous phase as well as soil porosity in the surface soil. Although the nutritional level of each orchards were quite different among soils, the analysis of both system revealed that organic kiwifruit orchard soil had similar or even higher nutrient level (N and organic matter content in surface soil) compared to conventional ones. The organic matter content of deep soil also had the high tendency in deep soil of organic soil. Higher level of nitrogen in organic surface soil is presumably due to the excessive application of organic compost and liquid fertilizer rather than the contribution by grasses such as green manure. Available phosphorous level of organic system was quite high but similar in surface soil of both system, compared to the recommended level. Potassium, calcium and magnesium levels were also enough in organic kiwifruit orchard soils.

Introduction

One of the concerns in organic kiwifruit production will be soil fertility management as other organic crops (Hasey *et al.* 1995, Davis and Abbott 2006). In Korea, there are very small numbers of organic kiwifruit growers (about 24 vs. 2,500 conventional growers in total, unpublished survey data by Fruit Research Institute, 2010). So, most of organic growers did not receive much interest on soil management by research sector in Korea. As the yield of kiwifruit reaches 20 up to 30 tonnes per ha recently so the nutrient loss with fruits is expected to be high if there is enough input for the nutrient loss. Although the recommended standard fertilization amount of each nutrients application were well set out in conventional production system (Hasey *et al*. 1995, Song *et al*. 2008), the soil nutritional conditions under organic management was not investigated in Korea. This survey was carried out to diagnose current soil nutritional conditions of organic kiwifruit orchards and support organic kiwifruit growers.

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Materials and methods

Four organically-certified and five conventional kiwifruit orchard soils were chosen to evaluate the physical properties and chemical characteristics. Most soil types were sandy loam or loam. All the orchards were at least 20-year old up to 32-year old. Among them, organic orchards were managed for 5 to 20 years organically. Generally organic soils were given organic compost in winter as basic fertilizer and some plant extracts formulas during growing season as additional fertilizer (Tab. 1). Both organic and conventional orchards returned the pruned shoots and branches into orchard soil by leaving them right after pruning. Organic orchards were separated by wind breaking nets (using less 2mm^2 net, 5m high net wall sometimes roof covered), agricultural roads (3 to 3.5m wide) and trenches (1m wide and deep) around orchard block. Sampling was done on mid November 2010. Stainless cylindrical cores (100cm^3, 2 inches in diameter) were used for sampling and soils were measured according to ASTM procedure (ASTM 2010). Soil hardness on surface soil was measured by Yamanaka soil hardness tester. For the analysis of soil chemicals, surface (between 0 and 15cm under soil surface) and deep (between 15 and 30cm) soils were collected, aerated for 1 week in room temperature and analyzed by the soil chemical analysis manual of RDA (RDA 1988), which included CN-analyzer (Vario Max) for organic matter and total nitrogen, Lancaster method for available phosphate, UV-spectrophotometer (Perkin Elmer 7300 DV) for exchangeable cations.

Tab. 1: Comparative fertilization and soil management practices between organic and conventional kiwifruit orchard

Practices	Organic	Conventional
Main compost materials and composting procedure	Cow or pig manure mixed with rice straw and bran, composted with occasional aeration under cover for 6 to 7 months	Same as organic
Amount of applied fertilizer per ha	25 tonnes compost, liquid fertilizer extracted from wild herbs 10 to 15 times sprayed on vine per season	15 tonnes compost, 25kg NPK or NK applied 2 times
Soil surface management	Previously rye (*Secale cereal*) sown for 2-3 years, currently native herbs cut and mulched 2-3 times per year	Rye sown or herbicide sprayed 2 times per year

Results and Discussion

Organic soil showed lower solid phase, similar level of liquous phase and higher gaseous phase (Tab. 1). The ratio of soil porosity of organic soil was also higher than that of conventional. Surface soil hardness was not different between organic and conventional soil. This higher soil porosity of organic soil could be the results from more input of organic compost and no use of herbicides. More compost and no herbicide use would create better soil environment where microorganisms and small soil animals to be more prosperous, form eco-balance therefore increase small animal population to furrow soil, leading better soil structure than conventional ones (Mäder *et al.* 2002, Pulleman *et al.* 2003). Soil pH was similar in both systems even if there were 2 orchards to exceed pH 6.5 (recommended maximum) (Tab. 2). However, total-N and organic matter content was higher in organic soil than conventional in surface soil although there were no different between both system in deep soil. The organic matter content in deep organic soil seemed to be high but was not significant statistically. Available P and exchangeable cations were similar level. The each nutrient levels of both system were above the recommended level in kiwifruit orchard in Korea (Song *et al*. 2008). The nutrients were distributed in more surface soil than deep soil. Overall, organic soils have not less nutrients than conventional under current production system. Most organic kiwifruit orchards have not used green manure currently but used to sow rye in autumn. These levels of soil nutrients in organic kiwifruit production system coincide with previous report in New Zealand soil (Carey *et al.* 2009). One possible reason would be more organic compost and frequent liquid plant extract spray than conventional (Tab. 1). There is a tendency of putting significant amount of other nutrient sources in Korean organic kiwifruit orchards as well (unpublished document). Especially available phosphorous was very high compared to the recommended level in both systems (Tab. 2), which would be also attributed to higher external input of phosphorous sources by compost and plant extracts in organic and chemical fertilizer in conventional (Tab. 1). However, overall the soil nutritional inputs of organic kiwifruit production system even tends to exceed the removals so soil nutritional balance does not become issue at the moment (Carey *et al*. 2009). This might be due to externally sourced fertilizers such as compost, plant extracts and some other sources like fish oil because Korean and New Zealand organic orchards actively apply those farming materials but rarely have green manure in the system (Personal communication with Zespri and organic farmers).

Tab. 2: Physical property of organic and conventional kiwifruit orchard soil

Farming system	Solid phase (%)	Liquous phase (%)	Gaseous phase (%)	Soil porosity (%)	Surface soil hardnessz (mm)
Organic	31.8	35.8	32.4	68.2	14.2
Conventional	42.3	33.3	24.4	57.7	14.6
	*	n.s	*	*	n.s

zMeasured by Yamanaka soil hardness tester. *Significant for P<0.05, n.s: none significant

Tab. 3: Chemical property of organic and conventional kiwifruit orchard soil depending on soil depth

Surface soil (0-15 cm depth)

Farming system	Soil pH	Total nitrogen (%)	Org. matter (g/kg)	P_2O_5 Z (mg/kg)	Exchangeable cation (cmol+/kg)		
					K	Ca	Mg
Org.	6.8	0.34	69.0	1,032	1.82	12.84	4.20
Con.	6.7	0.24	45.4	1,085	1.93	11.92	3.46
	n.s	*	*	n.s	n.s	n.s	n.s
Recommended	6.0-6.5	-	20-35	200-300	0.3-0.6	5.0-6.0	1.2-2.0

zAvailable phosphorous. *Significant for P<0.05, n.s: none significant. Org.; organic, con; conventional.

Deep soil (16-30cm depth)

Farming system	Soil pH	Total nitrogen (%)	Org. matter (g/kg)	P_2O_5 Z (mg/kg)	Exchangeable cation (cmol+/kg)		
					K	Ca	Mg
Org.	6.4	0.22	40.0	692	1.56	8.91	2.65
Con.	6.5	0.14	26.4	539	1.61	7.20	2.24
	n.s	n.s	n.s	n.s	n.s	n.s	n.s

zAvailable phosphorous. *Significant for P<0.05, n.s: none significant. Org.; organic, con; conventional.

Conclusions

The current cultural practices shows more input of organic compost and nutrients by frequent foliar spray of plant extracts thereby Korean soils of organic kiwifruit orchards are considered they have developed better soil structure and are keeping good nutritional level. Probably some orchards need to consider reducing the application level of organic fertilizers following proper soil analysis.

Acknowledgments

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Isolation and characterization of cellulolytic bacteria present in indigenous microorganism (IMO) 1 preparation under bamboo tree ecosystem habitat

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Key words: Indigenous microorganism, cellulose degraders, BIOLOG ECO plate

Abstract

*This study of IMO 1 involved bamboo tree ecosystem habitat, aimed to isolate species of cellulose degrading bacteria. Indigenous microorganisms naturally inoculated by placing cooked rice under a bamboo tree for four days. The IMO 1 from six different bamboo trees were tested using BIOLOG ECO microplates to see the microbial carbon utilization patterns. Selected microbes were grown on cellulose agar and 10 bacterial isolates obtained and had undergo phenotypic assessments which are Gram staining, ability to degrade cellulose, spore forming and ability to grow at 60^0C(thermophilic). As a result, five species of bacteria managed to be isolated (*B3,B6,B8,B9 and B10*) and found to have the ability to degrade cellulose, can form spores and able to grow at 60^0C.*

Introduction

Indigenous microorganisms (IMO) are microorganisms which are native to a given ecosystem or region. This IMO technology came from Korea and adapted by Department of Agriculture (DOA), Malaysia in 2002. It is now widely used by farmers in Kelantan, Terengganu, Perak and Selangor, Malaysia. In IMO preparation which consists of four stages, namely IMO 1, IMO 2, IMO 3 and IMO 4, it makes use of rice in trapping decomposing microbes. Microbes obtained are typically from bamboo tree ecosystem. This study of IMO 1 involved bamboo tree ecosystem habitat, aimed to isolate species of cellulose degrading bacteria. Cellulose is rather resistant to biological attack and is only degraded by a small subset of bacteria (Jürgen M., 2005). Since cellulose is the most common plant polymer in nature, composting process which usually involved plant materials as the main ingredient can be enhanced by incorporating cellulolytic bacteria to it. Thus, better IMO can be prepared to be used in composting.

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Materials and methods

Study site

This study was conducted in Terengganu of north-eastern Peninsular Malaysia. The study site was Lake Kenyir (Tasik Kenyir, 05°09' N, 102°44' E) at an elevation of about 165 m a.s.l. The climate is predominantly tropical moist climates with mean annual rainfall of about 3000 mm and mean annual temperature of 26°C. The area contains a great diversity of habitats of more than 8000 species of flowers, 2500 species of plants and trees, 8000 species of orchids, 370 species of birds and 300 species of fresh water fish.

Collection of samples

Indigenous microorganisms naturally inoculated by placing cooked rice under a bamboo tree for four days.

Laboratory Analysis

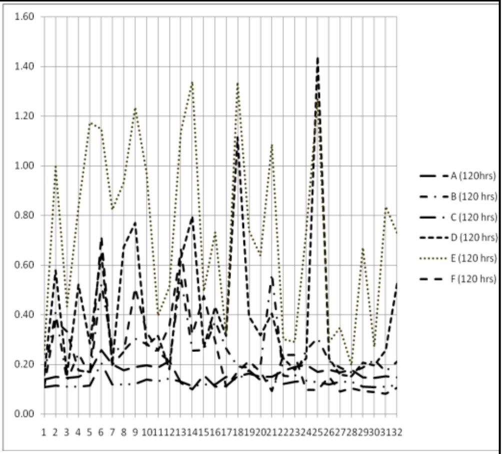
The IMO 1 from six different bamboo trees(A,B,C,D,E and F) were tested using BIOLOG™ to see the microbial carbon utilization patterns. BIOLOG ECO microplates (BIOLOG, Hayward, USA) were used to evaluate the functional diversity at different bamboo trees. From each IMO sample, the bacterial cells were extracted as described by Hitzl *et al*. (1997). The original samples had a density of $3x10^3$ – $4x10^4$ cells/well. Each well of the BIOLOG ECO microplates was inoculated with 150 µl suspension at 28^0C. Absorbance was read at 590 nm every 24 h for 120 h with the BIOLOG Micro Station reader (ML3402, Microlog, USA). The 31 substrates used are listed in Figure 1, and were classified into the following biochemical categories (according to Insam (1997)): Polymers (Po), carbohydrates (CH), carboxylic acids (CA), amino acids (AA), amines/amides (Am).

Selected microbes(from the bamboo tree with the most diverse microbes) were grown on cellulose agar. 10 bacterial isolates obtained and had undergo phenotypic assessments: Gram staining, ability to degrade cellulose, spore forming and ability to grow at 60^0C.

Enzymatic degradation of cellulose: Cellulose degradation was tested on Jensen Agar [JA, 0.5g Na_2HPO_4, 0.5g K_2HPO_4, 0.2g $MgSO_4.7H_2O$, 0.25g $CaCl_2.H_2O$, 0.1g $FeCl_3.6H_2O$,15.0g Difco Agar and 1.0L distilled water] supplemented with Carboxymethyl Cellulose (CMC). After 24 hours of incubation, the media were flooded with an aqueous solution of Congo red (1.0mg/ml media) for 15 minutes (Teather and Wood, 1982). The Congo red solution was then poured off and plates were flooded with 1M NaCl for 15 minutes. Degradation of cellulose was visualized as a clear zone around the bacterial colony. The diameter of the clear zone around colonies was used to assay the degree of cellulose activity.

Spore forming determination: Bacterial cultures were stained for endospore formation using the procedure described by Cappuccino and Sherman (2005) and the observation was done using a light microscope with 1000x magnification (oil immersion).

Results



No.	Substrates	No.	Substrates
1	D-Mannitol (CH)	17	c-Hydroxybutyric acid (CA)
2	Pyruvic acid methyl ester(CA)	18	L-Threonine (AA)
3	N-Acetyl-D-Glucosamine (CH)	19	Glycogen (Po)
4	D-Galacturonic acid (CA)	20	Itaconic acid (CA)
5	Tween40 (Po)	21	a-Cyclodextrine (Po)
6	L-Asparagine (AA)	22	Glucose-1-phosphate (CH)
7	Tween80 (Po)	23	Glycyl-L-glutamic acid (AA)
8	D-Galacturonic acid c-Lactone (CA)	24	b-Methyl-D-Glucoside (CH)
9	L-Phenylalanine (AA)	25	L-Serine (AA)
10	D-Glucosaminicacid (CA)	26	i-Erythritol (CH)
11	L-Arginine (AA)	27	Phenylethyl-amine (Am)
12	D-Cellobiose (CH)	28	a-D-lactose (CH)
13	D-Xylose (CH)	29	Putrescine (Am)
14	D-Malic acid (CA)	30	2-Hydroxy benzoic acid (CA)
15	a-Ketobutyric acid (CA)	31	D,L-a-Glycerol phosphate (CH)
16	4-Hydroxy benzoic acid (CA)	32	Water (H_2O)

X Axis – different carbon sources utilized at 120 hours   Y Axis – optical density (OD)

Figure 1: Different carbon sources utilization patterns by BIOLOG Ecoplate at 120 hours

As shown in Figure 1, bamboo tree, E showed highest microbial diversity and activity based on the carbon utilization pattern while bamboo tree, C showed the lowest in terms of both microbial diversity and activity.

Bacteria Isolate(B)	Gram stain	Cellulose degrader	Spore forming	OD at 600 nm	Ability to grow in 60^0C
1	+, rod	no	yes	0.254	yes
2	+, rod	no	yes	0.247	yes
3	+, rod	yes	yes	0.362	yes
4	+, rod	no	yes	0.039	yes
5	+, rod	no	yes	0.258	yes
6	+, coccus	yes	yes	0.046	yes
7	+, rod	yes	no	0.000	no
8	+, coccus	yes	yes	0.639	yes
9	+, rod	yes	yes	0.021	yes
10	+, rod	yes	yes	0.237	yes

Table 1: Bacterial isolates' characterization based on different properties

IMO 1 from bamboo tree, E was chosen to have the bacterial community characterized and six isolates found to be a cellulose degrader and five(5) of it positive for all three(3) abilities – cellulose degrading, spore forming and thermophilic (Table 1).

Discussion

The 31 carbon sources in the BIOLOG ECO microplate belong to six kinds, including nine carboxylic acids, six amino acids, four polymers, two amines/amides, three carbohydrates, and three miscellaneous carbon sources. The relative use efficiency of the six kinds of carbon sources by the soil bacterial community is shown in Fig. 1. A high relative use efficiency was found for carbohydrates, amino acids, polymers, and miscellaneous. In contrast the relative use efficiency for carboxylic acids and amines/amides was low. IMO 1 from bamboo tree, E was chosen to been isolated and characterized its microbial community since it showed the best result in BIOLOG ECO microplate study. Highest in microbial diversity and activity means that the possibility to isolate most potential cellulolytic bacteria is higher than the other lower one. From 10 bacterial isolates tested against three different properties/abilities, six of them found to be the cellulose degrader but only five isolates (B3,B6,B8,B9 and B10) can be considered worth to be further research on as they posessed all the properties/abilities of a competent bacteria to be incorporated for composting process which occurs at extreme temperatures and conditions.

Conclusions

This study managed to highlight five potential cellulolytic bacterial isolates. Although found as a cellulose degrader, further study need to be done since not necessary cellulolytic bacteria in lab environment can have the same ability in nature condition. Thus, this finding is significant in pursue of better composting process for green agriculture technology in the near future.

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Quality Characteristics of Livestock Faeces Composts Commercially Produced in Gyeonggi Province in 2008

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Key words: Livestock faces, Compost, Compost quality, Compost manufacture

Abstract

By surveying the 70 composting plants in Gyeonggi Province, the total commercial production of livestock faeces composts (LFCs) in 2008 was estimated to be about 480,000 Mg year-1 and they were manufactured mainly by using both mechanical mixer and bottom air blower. LFCs were composed mainly of chicken faeces 29.2%, pig+chicken faeces 23.1%, pig faeces 20.0%, livestock faeces+oil cake 12.3%, pig+ chicken+cattle faeces 10.8% and pig+cattle faeces 4.6%. On the basis of the current official standard which was revised on March 2010, 11 composts out of surveyed 76 ones did not meet the LFCs quality standard (LQS) due to inadequate content of water (5), OM/N (1), NaCl (2) and Zn (3). The OM/N declined by adding chicken faeces and oil cake, while Ca content increased by the addition of chicken faeces and NaCl increased by adding cattle faeces.

Introduction

Gyeonggi Province surrounding Seoul is the largest area of livestock industry in Korea. In 2010, Gyeonggi Province produced livestock faeces amounting to about 8.5Tg which was 19% of the total production in Korea. Therefore, the environment-friendly management of livestock faeces is one of the greatest issues in order to preserve the rural environment in this area. Livestock faeces are one of the important materials as an organic source for arable land. There are lots of reports on the application effects of livestock compost into arable soil and some other ones about determining the application rate of livestock compost for crop cultivation. In this regards, the quality of livestock compost has been emphasized and the relevant official standard has been revised more strictly. In Korea, there has been an official LQS and the current official standard was revised in March 2010. The main factors of LQS are the contents of water, organic matter, inorganic matter, NaCl and 8 kinds of heavy metals, and the ratio of OM/N, etc. This survey was conducted to promote the environment-friendly recycling or proper use of livestock faeces as a nutrient supplying material for organic farming by obtaining information about the current state of livestock faeces compost manufactured in Gyeonggi Province. Therefore, some aspects of quality and manufacturing techniques of LFCs were examined especially in relation to the LQS.

Materials and methods

76 samples of commercial LFCs were collected at the warehouse of 70 compost manufacturing plants located in Gyeonggi Province where approximately 100 of

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commercial LFC manufacturing plants were in operation. The current production state of some LFC manufacturing plants was examined by questionnaire survey and LFC quality factors such as OM, OM/N, T-N, P_2O_5, K_2O, CaO, MgO, Na_2O, NaCl, water content, and heavy metals (Cu, Zn, Cd, As, Cr, Ni, Pb, Hg) were analyzed by soil and plant analysis method recommended by the National Institute of Agricultural Science and Technology in Korea. Some analysis methods used in this study were as follows. Organic matter was determined by ashing method measuring a loss in weight. Nitrogen was obtained by Kjeldahl method after decomposing samples with conc. sulfuric acid. Cations such as potassium, calcium, magnesium and sodium were analyzed by decomposing them with strong acid (perchloric acid 9 + sulphuric acid 1) and determined by inductively coupled plasma spectrophotometer (ICP, GBC Integra XMP, Australia). Heavy metals except mercury were measured by decomposing them with nitric acid in microwave (Tekton Qwave 2000, Canada) and analyzed by ICP, and mercury was directly analyzed by mercury analyzer (Leco AMA254, USA).

Results

The total production of livestock compost products was estimated to be about 480,000 Mg $year^{-1}$ by surveying 70 plants and they were manufactured mainly by using mechanical mixer and bottom air blower. Major components of surveyed compost products were in the order of chicken feces 29.2%, pig+chicken feces 23.1%, pig feces 20.0%, livestock feces+oil cake 12.3%, pig+chicken+cattle feces 10.8% and pig+cattle feces 4.6% (Tab. 1).

Tab. 1: Share and component ratio by raw materials of livestock composts

Raw materials	P	Ch	P + Ch	P + Ca	P + Ch + Ca	Li + O
Share (%)	20.0	29.2	23.1	4.6	10.8	12.3
Component	P-S	Ch-S	P-Ch-S	P-Ca-S	P-Ch-Ca-S	P-Ch-Ca-S-O
Ratio (%)	57-43	64-36	31-32-37	38-32-30	35-14-24-27	18-6-29-24-23

P; pig faeces, Ch; chicken faeces, Ca; cattle faeces, Li; livestock faeces, O; oil cake, S; sawdust

Chemical properties of 76 composts produced in Gyeonggi Province in 2008 were as follows; 41.8 ± 7.8% of OM , 29.2 ± 7.5 of OM/N, 1.53 ± 0.51% of T-N, 1.98 ± 0.81% of P_2O_5, 1.46 ± 0.57% of K_2O, 4.48 ± 1.95% of CaO, 0.87 ± 0.41% of NaCl, 37.9 ± 11.6% of water and 16.0 ± 2.8 of compost quality score (Tab. 2).

Tab. 2: Chemical properties of composts produced in Gyeonggi Province in 2008

Component	OM (%)	T-N (%)	OM / N	P_2O_5 (%)	K_2O (%)	CaO (%)	NaCl (%)	Water (%)	IOM (%)	QS†
Average	41.8	1.53	29.2	1.98	1.46	4.48	0.87	37.9	20.3	16.0
Minimum	26.4	0.58	15.2	0.24	0.31	0.62	0.36	13.4	2.5	7.0
Maximum	61.2	3.31	55.0	4.94	2.98	7.67	2.24	64.3	43.8	21.0
SD	7.8	0.51	7.5	0.81	0.57	1.95	0.41	11.6	1.5	2.8

† QS; quality score of compost, 1-23 (degree by scores; 17-23 1^{st}, 12-16 2^{nd}, below 11 3^{rd})
Quality component; OM (1-9, above 25%), IOM (1-9, below 55%), Water (1-5, below 55%)
- IOM; inorganic matter content
- NaCl content; dry weight basis (others; fresh weight basis)
- Heavy metal content (mg kg^{-1}, DW); Cu 117.5±73.4 (22.4-379.2), Zn 457.2±241.9 (97.1-1445.4)

On the basis of the current official standard which was revised in March 2010, 60 composts out of 76 composts surveyed in this study met the LQS and 5 products met the general compost standard, while 11 products did not meet the compost standard due to the violation of content limit in water (5), OM/N (1), NaCl (2) and Zn (3). But the violation in water content practically does not matter since it changes over the time during storage period. Consequently, the composts having problem in terms of chemical properties were 5 products, accounting for 6.6% of all the surveyed ones. As for the compost quality by manufacturers, all the 10 composts produced by farmer's cooperative societies met the LQS and 50 percent of them was the first grade in quality degree and the rest was the second grade. Forty-six composts out of 57 ones (80.7%) made by civil factories met the LQS and the first grade in quality degree was 33.3%, the second grade 40.4%, the third grade 7.0%, general compost grade 5.3%, and substandard one 14.0%. Only 4 composts out of 9 ones (44.4%) made by farming guilds met the LQS and their quality was distributed evenly as 22.2% in each first, second and general compost degree, respectively and 33.3% in substandard one (Tab. 3).

Tab. 3: Quality degree distribution of composts by the types of manufacturers

Quality degree of compost		Sum	Farmer`s co-operative soc.	Farming guild	Civil
Sum		76 (100)	10 (100)	9 (100)	57 (100)
Livestock compost	1st grade	26 (34.2)	5 (50)	2 (22.2)	19 (33.3)
	2nd grade	30 (39.5)	5 (50)	2 (22.2)	23 (40.4)
	3rd grade	4 (5.3)	0 (0)	0 (0)	4 (7.0)
General compost		5 (6.6)	0 (0)	2 (22.2)	3 (5.3)
Substandard compost		11 (14.4)	0 (0)	3 (33.3)	8 (14.0)

OM/N declined in the composts made from chicken faeces and oil cake because of their high N content. Ca content increased by the addition of chicken feces and NaCl by adding cattle faeces, while water content decreased in the composts mixed with oil cake due to the need of low water content to enable the compost to be formed in a pellet shape (Tab. 4).

Tab. 4: Chemical properties of composts by the raw materials

Raw materials	OM (%)	OM/N	T-N (%)	P_2O_5 (%)	K_2O (%)	CaO (%)	MgO (%)	Na_2O (%)	NaCl (%)	Cu (mg/kg)	Zn (mg/kg)	Water (%)
P	39.6^{ns}	32.7^{ab}	1.30^{b}	1.63^{ns}	1.22^{ns}	2.74^{cd}	0.69^{ns}	0.24^{b}	0.46^{c}	84^{ns}	287^{ns}	46.0^{a}
Ch	41.1	26.2^{c}	1.63^{b}	2.10	1.63	6.63^{a}	1.33	0.23^{b}	0.44^{c}	47	222	34.2^{ab}
P + Ch	40.3	27.9^{bc}	1.47^{b}	1.99	1.40	4.81^{abc}	0.92	0.27^{b}	0.49^{c}	80	306	40.2^{ab}
P + Ca	45.5	34.2^{ab}	1.34^{b}	1.57	1.87	1.99^{d}	0.81	0.47^{a}	0.89^{a}	86	444	38.8^{ab}
P+Ch+Ca	40.9	35.4^{a}	1.17^{b}	1.76	1.45	4.23^{bc}	1.07	0.31^{ab}	0.59^{bc}	83	269	41.3^{a}
Li + O	48.3	22.6^{c}	2.27^{a}	2.29	1.57	5.63^{ab}	1.00	0.46^{a}	0.76^{ab}	68	261	28.3^{b}

P; pig faeces, Ch; chicken faeces, Ca; cattle faeces, Li; livestock faeces, O; oil cake.
* DMRT ($p<0.05$), values in the same column with different superscripts differ significantly.

Discussion

Pig and chicken faeces were mainly used as the raw materials of commercial livestock faeces composts, while cattle faeces occupied only a small part. This seems to be caused by the low nutrient content of cattle faeces and resultant safety in private use as a soil ameliorator. The average contents of N, P_2O_5 and K_2O in LFCs were 1.5%, 2.0% and 1.5%, respectively. This result implies that P_2O_5 content in both compost and soil is most important factors when the compost application rate is determined as reported by Kim et al. (2000) and Jakob et al. (2002). Compost quality by manufacturer was better in the order of farmer`s cooperative society > civil > farming guild. This seems to be derived from the fact that generally farmer`s cooperative society has fine financing and facilities together with a sense of responsibility, and civil operators have abundant experience and know-how. Many farming guilds, however, are organized to get the subsidiary financial support from government and the operators are relatively less experienced. The result of chemical properties of composts by the raw materials may be useful when manufacturer should adjust the mixing ratio of the raw materials for improving their compost quality.

In Korea, 'environment-friendly agricultural products certification' has been enforced since 1997. This certification system is on the legal basis of "environmentally-friendly agriculture fosterage act" Organic agriculture is the highest step among the environment friendly agricultural systems of Korea. For the production of environment-friendly agricultural products, this act emphasizes the recycling of plant and animal origin wastes as the Codex guideline. Livestock faeces are very important renewable resources particularly in Korea suffering the lack of agricultural by-products as the source of crop nutrients. Since Korea has intensive farming system due to the limited arable land resulting in a few of organic livestock farms derived mainly from short of pastures or small size of farm lands, it is very hard to secure the faeces from organic livestock farms. So it is permitted temporarily to use the faeces from traditional livestock farms as an organic agricultural materials as far as it is proven to be free from antibiotics and to be below a half of LQS`s upper limit concentration of eight kinds of heavy metals. Though this measure was introduced as a locally adapted system by taking account of the current state of insufficient nutrient materials and resultant dependence on imported vegetable oil cakes for organic farming, this act is in the process of revision this year in order to fulfill the international "equivalency" in the certification system of organic agricultural products. At present, anyway, the results of this survey would be informative information on the quality of LFCs and for making a good choice of LFCs for organic farmers.

Conclusions

The proportion of the main raw materials of surveyed compost products was in the order of chicken faeces 29.2%, pig+chicken faeces 23.1%, pig faeces 20.0%, livestock faeces+oil cake 12.3%, pig+chicken+cattle faeces 10.8% and pig+cattle faeces 4.6%. Chemical properties of surveyed LFCs were as follows; OM 41.8±7.8%, OM/N 29.2±7.5, T-N 1.53±0.51%, P_2O_5 1.98±0.81%, K_2O 1.46±0.57%, CaO 4.48±1.95%, NaCl 0.87±0.41% and water 37.9±11.6%. Compost quality score(total 23) was 16.0±2.8 and the first grade compost was 34.2%, the second grade 39.5%, the third grade 5.3%, general compost grade 6.6% and substandard grade 14.4%, respectively. OM/N was lower in chicken and oil cake composts, while CaO content was higher in chicken compost and NaCl in cattle compost. Cu and Zn were tended to be high in pig compost.

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Evaluating pigeon pea relayed with a maize/soybean mixture for soil fertility and weed incidence

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Key words: improved fallow system, green manure, soil fertility improvement, weed incidence, harvest index

Abstract

Field trials were conducted in 2001, 2002 and 2003 at the Institute for Agricultural Research farm Samaru (11^{0}11'N, 07038'E and 686m above sea level) in the northern Guinea savannah ecological region of Nigeria to estimate the effect of pigeon pea relayed with maize/soyabean mixture for green manure on soil fertility and weed incidence. Treatments consisted of maize and cowpea in the following ratios – 100:0 (sole maize), 67:33, 50:50, 33:67 and 0:100 (sole cowpea); with or without pigeon pea relay. Plots that received the pigeon pea manure had significantly higher harvest index, total N uptake, soil organic carbon (SOC) soil organic nitrogen (SON), and lower weed cover score than those that did not receive the green manure. Sole soyabean and plots with high proportions of soyabean also showed similar improvements as the plots that had the pigeon pea green manure, indicating that the legume crops improved soil fertility which resulted in lower weed incidence and thus improved crop yields. Pure maize and plots with high maize proportions had significantly higher available phosphorus than pure soyabean stands indicating that phosphorus is an important soil nutrient for this mixture and should be applied in sufficient quantity. This trial showed that sustainable soil fertility improvement can be undertaken in this region through improved fallow systems and that drought resistant/tolerant legumes of economic importance to the farmer can be used in this practice.

Introduction

Most African soils are of ancient origin, from igneous rocks, low in nutrients and have been subjected to leaching for a long time. They are therefore typically impoverished and seriously deficient in phosphate and other nutrients. In spite of this low nutrient level, large amounts of nutrients are lost annually through soil mining, erosion and leaching (Zake, 1993, Smalling and Nandawa 1996, Henao and Baanante, 1999); accelerating the rate of degradation, which is largely responsible for the low level of crop yields often obtained. The continuous application of high rates of chemical fertilizers, without organic manures, has been implicated in soil degradation processes responsible for low yield levels. Khan *et al.*, 2007 and Mulvaney *et al*., 2009 reported net decline in soil-C and total soil-N in after 40-50 years of synthetic N fertilization in the principal grain growing region of the USA. The loss of organic N decreases soil productivity and the agronomic efficiency of fertilizer N and has been implicated in widespread reports of yield stagnation or even decline for grain production in Asia. Mulvaney *et al.,* 2009 suggested therefore that long-term sustainability may require agricultural diversification involving a gradual transition from intensive synthetic N

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inputs to legume-based crop rotation. To overcome and sustain the problem of low soil productivity however, Odion *et al*. 2007 advocated the use of improved fallow systems, a concept first conceived by the International Institute of Agricultural Research (IITA) - involving the cultivation of drought tolerant leguminous crops that will be protected for its grain and/or fodder by the farmers, from bushfires or grazing during the dry season, and which can be incorporated as green manure at the beginning of the growing season to improve soil fertility. This trial therefore focused on the use of pigeon pea as a cover crop on the fertility and weed incidence in an Afisol.

Material and Methods

Field trials were conducted in the 2001, 2002, and 2003 cropping seasons, at the experimental farm of the Institute for Agricultural Research (IAR) Samaru (11^{0}11'N, 07^{0}38'E, 686m above sea level), in the northern Guinea savannah of Nigeria; to investigate the effects of a pigeon pea green manure crop into a maize/soyabean mixture on the performance of the crops and its effect on soil fertility. The maize/soyabean mixture consisted of five crop proportions – sole maize and sole soyabeans and 67:33, 50:50, and 33:67 ratios of both crops in a replacement series; with or without a pigeon pea cover crop relay. Relayed pigeon pea cover crop (var. ICPL 87) was planted between maize stands, on August 28, 2001, August 29, 2002, and September 01, 2003; at the rate of three seeds per hole, at the tasselling stage of maize. The maize crop was harvested on October 10, 2001, October 15, 2002, and October 20, 2003 when the leaves had turned yellow and kernel fully matured. Soyabean was harvested on November 5, 2001, November 15, 2002, and November 20, 2003 - at maturity; when 95% of the pods turning brown (Fehr *et al*., 1971). The pigeon pea green manure was incorporated into the soil as green manure on June 10, 2002 and June 12, 2003; the incorporated crop was allowed to decompose before harrowing and ridging took place.

In 2001, composite soil samples were taken from the experimental area before land preparation, for physical and chemical soil properties determination, while in 2002 and 2003, soil samples were taken per treatment after incorporation of pigeon pea for the determination of organic carbon, soil N, and exchangeable K, using standard procedures. The soil was air dried and sieved through a 2-mm stainless steel sieve. Sieved samples were stored for routine analysis.

The weed cover score was taken at 6, 9 and 12 weeks after sowing (WAS), using a scale of 1 – 10; where 1 represented no weed cover and 10 represented complete weed cover.

Results

Harvest index: The harvest index was highest at the pure stands of maize and soyabean; but while in the maize crop the difference between the pure stand and the mixtures was between 32% and 46% in 2001, in 2002 and 2003 after the incorporation of green manure and crop residues, it decreased to between 3% and 10% and 24% and 32% respectively (Table 1). For the soyabean crop, the difference between the pure stand and the mixtures was between 6% and 21% in 2001 and widened to 18% and 28% in 2002 and 34% in 2003 after the incorporation of green manure and crop residues.

Soil organic carbon: Pure maize plots had the lowest soil organic carbon and pure soyabean plots the highest soil organic carbon content except at the sub-soil in 2003 when pure maize plot was highest (Table 3). Soil organic carbon increased with the proportion of soyabean in the mixtures. Plots relayed with pigeon pea always gave higher soil organic carbon than those not relayed with it at both the surface and sub-soil.

Soil nitrogen: Pure maize plots gave the least and pure soyabean plots the highest soil nitrogen content and mixed plots N content increased with the proportion of soyabean in the mixture (Table 3). Plots relayed with pigeon pea had higher nitrogen content than those not relayed with pigeon pea.

Soil available phosphorus: Pure soyabean plots tended to give lower concentrations of available P than other plots, while plots that were relayed with pigeon pea had higher concentrations of soil available P than plots that were not relayed with it (Table 3).

Weed 'cover' score: Weed cover score was lower for the pure soyabean plots and highest for the pure maize plots and mixed stands were in-between (Table 2). The plots relayed with pigeon pea also had lower weed cover scores than those not relayed with pigeon pea.

Discussion

Crop performance:

Crop performance improved with the incorporation of crop residues and green manure as measured by the harvest index. This resulted from an improved soil condition as evidenced from the improved soil fertility. Earlier findings, e.g. Myers *et al*. 1994 and Singh *et al*. 1999; associated such increases in crop performance better utilization of nutrients by the crops through synchronization of nutrients and the demand by the crops.

Soil fertility:

Soil fertility improved with the incorporation of crop residues and green manure, though in the case of P, it would seem a higher rate is required to meet crop need or amendment with rock phosphate undertaken to improve the soil organic P. In the savannahs where soil degradation is rapid and the continuous use of chemical fertilizers accentuates this situation, the practice of green manure and the incorporation of crop residues will greatly slow the rate of soil degradation as well bring more land into cultivation as the land is reclaimed (Greenland, 1975). Odion *et al*., 2009 and Sambo *et al*., 2009, have also reported soil fertility improvement using green manure which could necessitate the reduction in the use of chemical fertilizers and improve soil health.

Weed incidence:

Lower weed incidence in plots that were relayed with pigeon pea and sole cropped soyabean could mean that improved soil fertility and that cover cropping as well as closer plant spacing reduced weed infestation. The implication therefore is that this sort of practice could reduce chemical weed control in the savannahs thus alleviating a major problem associated with food production among the resource poor farmers.

Conclusion

This experiment has shown that an improved fallow system is possible within the savannah agro-ecology. This practice will impart positively on farming in this region as sustainable soil fertility maintenance measures have been problematic for farmers and a major bottleneck to improving food security in this region. The legume crops used for the practice produce edible grains which can improve the farmer's diet and can equally be sold to improve his capital base. Soil fertility is further improved through the return and incorporation of crop residues; the implication of this is that soil fertility and crop production in the savannahs can now be improved upon through a combination of approaches. This process will slow soil degradation processes and keep land in production for a longer time thus ensuring food security in the region and perhaps even assist in the restoration of degraded lands.

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Table 1: Effects of component crop proportion and relayed pigeon pea on maize and soyabean harvest index in a maize/soyabean mixture at Samaru

	Harvest index of maize				Soyabean harvest index at harvest			
Treatments	2001	2002	2003	Combined	2001	2002	2003	Combined
Component crop proportion (P)								
Sole crop (100:0)	85.2a	63.8	37.3a	62.1a	18.3a	20.2a	21.0a	19.8a
Maize+Soyabean (67:33)	45.8b	57.1	25.1b	42.7b	14.4b	14.4c	13.9b	14.2c
Maize + Soyabean (50:50)	56.5a	61.2	28.3b	48.7a	16.0ab	15.8bc	14.1b	15.3bc
Maize + Soyabean (33:67)	58.0a	61.4	26.7b	48.7a	17.2ab	16.6b	14.0b	15.9b
SE +	1.14	1.61	0.67	0.40	0.38	0.25	0.44	0.12
Relay (R)								
With pigeonpea	61.0	68.9a	35.7a	55.2a	18.6a	19.3a	17.3a	18.4a
Without pigeonpea	61.8	52.9b	23.0b	45.9b	14.4b	14.1b	14.2b	14.2b
SE +	0.57	0.81	0.33	0.20	0.19	0.13	0.22	0.06
Interaction								
P x R	**	**	**	**	**	**	**	**

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using DMRT,** = Significant at 1% level of probability

Table 2: Effects of component crop proportions and relayed pigeonpea on weed cover score at Samaru during 2001, 2002 and 2003 wet seasons

	Weed cover score			Weed cover score			Weed cover score		
Treatment	6 WAS	9 WAS	12 WAS	6 WAS	9 WAS	12 WAS	6 WAS	9 WAS	12 WAS
Component crop proportions (P)									
Sole maize (100:0)	2.33ab	5.50a	7.50a	3.17	4.83a	6.33a	3.17a	7.33a	8.33a
Sole Soyabean (100:0)	1.83b	1.67d	2.17e	2.50	2.50c	2.17d	2.50b	3.33d	4.17d
Maize + Soyabean (67:33)	2.50a	3.17b	5.33b	2.83	3.50b	4.33b	3.00b	5.50b	5.50b
Maize + Soyabean (50:50)	2.17ab	2.67c	4.33c	2.83	3.17b	3.83b	2.83ab	4.17c	5.17bc
Maize + Soyabean (33:67)	2.00ab	2.00d	2.83d	2.50	2.67c	3.17c	2.67ab	3.67cd	4.67cd
SE +	0.078	0.065	0.084	0.084	0.066	0.074	0.076	0.072	0.071
Relay (R)									
With pigeonpea	2.07	2.80b	4.27	2.93	2.80b	3.27b	2.93	4.20b	5.20b
Without pigeonpea	2.27	3.20a	4.60	2.60	3.87a	4.67a	2.73	5.40a	5.93a
SE +	0.039	0.033	0.042	0.042	0.033	0.037	0.038	0.036	0.036
Interaction									
P x R	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within column and treatment set are not significantly different using DMRT

WAS = Weeks after sowing

Table 3: Effects of component crop proportion and relayed pigeonpea on soil organic carbon, soil nitrogen and soil available phosphorus in a maize/soyabean mixture at Samaru.

	Soil organic carbon (gkg-1)				Soil N (gkg-1)				Soil available phosphorus (mgkg-1)			
	2002		2003		2002		2003		2002		2003	
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
Component crop Proportion (P)												
Sole maize (100:0)	1.30d	1.44b	1.40d	3.86a	0.08d	0.11a	0.05c	0.08bc	7.77b	4.39b	10.31b	6.87b
Maize + Soyabean (67:33)	3.25c	1.52b	4.40c	2.23c	0.12c	0.08c	0.15a	0.07c	6.73d	4.11c	10.52b	7.47a
Maize + Soyabean (50:50)	4.30b	1.15c	5.00b	2.82b	0.13b	0.12a	0.15a	0.11a	8.33a	5.31a	10.35b	7.60a
Maize + Soyabean (33:67)	4.45b	1.61b	5.47a	2.27c	0.12c	0.10b	0.14b	0.08b	7.15c	3.51d	11.22a	6.93ab
Sole Soyabean (100:0)	5.28a	2.32a	5.47a	2.82bc	0.19a	0.12a	0.15a	0.04d	7.33c	5.29a	9.13c	6.12b
SE ±	0.023	0.034	0.019	0.045	0.001	0.015	0.323	0.001	0.040	0.034	0.070	0.113
Relay (R)												
With pigeonpea	4.78a	1.69a	5.26a	3.07a	0.160a	0.110a	0.170a	0.090a	9.72a	4.95a	12.15a	8.98a
Without pigeonpea	2.65b	1.52b	3.42b	2.41b	0.100b	0.100b	0.080b	0.060b	5.21b	4.09b	8.46b	5.02b
SE ±	0.009	0.013	0.008	0.018	0.0003	0.0004	0.129	0.0002	0.016	0.013	0.028	0.045
Interaction												
P x R	**	NS	**		**		**		**		**	**

Means followed by the same letter(s) within column and treatment set are not significantly different using DMRT,WAS = Weeks after sowing ,** = highly significant, NS = Not Significant

Soil quality and *Phaseolus* bean yields as affected by organic matter and EM in a degraded tropical soil

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Key words: Organic matter, Effective Microorganisms, Soil quality, Crop yields

Abstract

Degraded tropical sols require organic matter to revitalize their quality. As microbial solutions could have beneficial impacts on this process, a 12 month field study evaluated the benefits of three organic materials and Effective Microorganisms (EM) on selected soil parameters and yields of a Phaseolus crop grown on the same plots. Organic matter, especially those with a low C: N ratio improved soil C, nutrients, respiration and infection of bean roots by mycoorhiza and rhizobium, resulting in higher yields, and EM accentuated these effects. The usefulness of EM with organic matter in these degraded tropical soils was evident under tropical farming conditions.

Introduction

Soil Carbon and microbial biomass are becoming important criteria in determining soil quality Thus microbial inoculants, bio- plant growth promoters, biofertilzers and pesticides are being widely promoted and used due to their efficacy in enhancing soil properties and crop yields, especially in organic systems (Rigby & Caceres 2001).

Effective Microorganisms (EM) (Higa 1991), a mixture of lactic acid bacteria, phototrophic bacteria and yeast, (the species of are known and listed) is widely used in all continents and registered in many nations. EM is made by EM Research Organization in all continents using local microbes. Due to its popularity, this product has attracted much attention, and research (Daly & Stewart1999; Xu 2000) indicate its benefits while others (e.g. Mayer *et al.* 2008) report its ineffectiveness especially under temperate conditions. However Jilani *et al*. (2007) state its usefulness in increasing beneficial soil micro flora. Due to these confusing results, and as EM is widely used in the developing nations of the tropics, a field study was carried out over one year, using three cropping cycles on a low fertility soil akin to those of most tropical smallholder systems and to which agrochemicals had not been added for five years, to determine the impact of EM on soil microbial biomass, organic matter and crop yields, when used with three common organic additives.

Materials and methods

The study was carried out in 2008/9 over a period of 12 months on a farm with a soil of very low quality (pH (1:2.5 H_2O) 5.1, Organic C $g.kg^{-1}$, 5.87; N $mg.kg^{-1}$ 15.4) located in the intermediate zone of Sri Lanka. The rainfall received at the site was 1430 mm and the mean temperature was 28° over the period of study..

In August 2008, plots of 3 x 5m were prepared and the following organic materials – rice straw, leaves *Gliricidia sepium* or cattle manure (CM) were applied at a rate equivalent to 4 MT per ha to individual plots, and a control plot was maintained without any additives. Activated EM added at a rate equivalent to 5 litres per ha, (dilution

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1:500 @ 6 litres per plot) to 50% of the plots selected randomly, and the organic matter mixed into the soils. The soils of control plots were also mixed in a similar manner. Within 14 days after incorporation, beans (*Phaseolus vulgaris* L Var Top crop, duration 50 days) was planted at a spacing of 10 x 20 cm. EM was applied at the same dilution and rate to the plots that received EM at the beginning, at 2 weeks, at flowering and pod set. The plots without EM were supplied with similar quantities of water. Weeding was carried out and fresh pod yield determined. This process was repeated on the same plots on three occasions. The experiment was conducted within a two factor factorial design with four replicates at each planting.

At the beginning of the study and at flowering of beans, soil samples were taken from each plot to a depth of 30 cm and the following determined: pH (1:2.5 H_2O), Soil C (dichromate oxidation) N (Kjeldhal), P (Bray), K (NH_4OAc), soil respiration at 55% moisture and incubation for 7 using NaOH to trap the CO_2 (Salamanca *et al.* 2002). In addition at flowering 4 plants were carefully uprooted, roots washed, nodule numbers per plant counted and mycorrhizal infection of roots determined with Tryptophan blue staining using the grid line intersection method .The data of all three seasons were pooled and analysed using the GLM procedure an probability and LSD values used tyo determine treatment differences.

Results and discussion

Tab. 1. Impact of organic matter and EM on selected soil properties at flowering of beans (mean of 3 crops)

Organic matter	EM	pH (1:2.5 H_2O)	Organic C($g.kg^{-1}$)	N ($mg.kg^{-1}$)	P ($g.kg^{-1}$)	Exch, K ($g.kg^{-1}$)
Rice straw	With	5.2	13.4	30.4	5.2	265
	None	5.7	14.5	35.1	4.8	242
Gliricidia	With	5.2	10.9	34.9	5.9	315
	None	5.5	11.2	30.2	5.6	286
CM	With	5.1	11.4	41.4	5.8	304
	None	5.7	13.3	38.0	5.0	275
Control	With	5.0	6.5.	17.6	3.0	225
	None	6.1	7.4	20.1	3.5	184
Probability	Organic matter	0.251	0.017	0.038	0.040	0.008
	EM	0.043	0.033	0.010	0.38	0.045
	Interaction LSD	NS	0.30	NS	0.09	10.22

CM and Control represent cattle manure and no organic matter respectively

Organic matter and EM had no significant impact on soil pH (Table 1), although the microbial solution (pH 3.5 – 4.0) marginally reduced this parameter. Soil C increased significantly due to rice straw, while the lowest increment was with Gliricidia leaves, due to their high and low C: N ratios. EM reduced soil C, due to decomposition by microbial activity (Javaid 2010). Thus in most instances, N, P and K contents in soils with organic matter and EM were higher, illustrating the benefit of the microbial solution and organic matter in increasing nutrient contents of degraded soils. In the control plot, application of EM reduced N, P and K levels, indicating that EM should not be added alone to tropical soils with low organic matter. With organic matter such as rice straw with a high C: N ratio, EM reduced soil N, which could be due to the binding of N by microbes.

EM increased soil respiration to a greater extent than adding organic matter alone (Table 2), confirming earlier results of Jilani *et al.* (2007) in the tropics and contradicting that of Mayer *et al*. (2010) under temperate conditions. This also showed the benefit of organic matter and EM in increasing microbial biomass of a degraded tropical soil, which is vital in smallholder organic farming. The benefits of organic matter with a greater N content, such as Gliricidia or cattle manure in increasing soil respiration, which is accentuated by EM, is illustrated by this study.

Tab.2 Soil microbial indices and yields of beans as affected by organic matter and EM (mean of 2 seasons)

Organic matter	EM	Soil Respiration (μg CO_2-$Cg^{-1}.day^{-1}$)	Mycorrhizal infection (% per cm of root)	$Nodules.plant^{-1}$	Pod yield ($g.m^{-2}$)
Rice straw	With	8.5	47	25	1569
	None	6.4	35	15	1251
Gliricidia	With	10.5	58	35	1940
	None	8.9	42	27	1720
CM	With	12.7	51	30	1801
	None	9.5	40	22	1642
Control	With	3.6	15	12	614
	None	2.8	9	7	659
Probability	Organic matter	0.004	0.048	0.022	0.031
	EM	0.018	0.037	0.040	0.009
	Interaction LSD	NS	1.21	0.932	55.12

CM and Control represent cattle manure and no organic matter respectively

The greater microbial activity with organic matter, which is enhanced by EM, is seen by the mycorrhizal infections and nodule numbers at flowering of beans. The higher the soil respiration, which indicates microbial activity, greater is the degree of infection by Mycorrhiza and nodulation. Gliricidia increased these parameters to the greatest extent while the increments were lowest with rice straw and EM. Even in the soils of the control plots, EM increased soil respiration and thus infection of roots by Mycorrhiza and nodules marginally. The positive and significant correlations between soil respiration and mycorrhizal infection of roots (r = 0.54) and nodules per plant (r= 0.61) at flowering of beans due to the addition EM confirming results of Javaid (2009) in African soils, was greater than when EM was not added (r=0.48 for mycorrhiza infection and r= 0..52 for nodule numbers). This clearly suggested the benefits of EM with organic matter for developing soils and rhizophere of plants grown in tropical degraded soils.

Organic matter increased bean yields (Table 2), the highest increments being with Gliricidia and cattle manure. The lowest increments were with rice straw due to the ability of the better quality organic additives to provide nutrients and enrich soil biota. EM enhanced these benefits to a greater extent, and in the absence of organic matter, EM lowered yields. Thus, the study illustrated the practical benefits of EM, when used with good quality organic matter, due to its ability to stimulate the rhizosphere of crops grown in degraded tropical soils, especially under low input organic systems. It is evident that EM alone should not be used in these degraded soils.

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Gratitude is expressed to Mr J Gunasekera for providing the land and labour..

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Influence of continuous application of organic amendments on growth and productivity of red pepper and soil properties

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Key words: Organic farming, Soil properties, Nutrient balance, Red pepper

Abstract

Organic farming has rapidly increased in Gangwon province, Korea, but there is a concern about nutrient accumulation and nutrient imbalance in the soil of organic farming. This study was conducted for four years to investigate the impact of continuous application of organic amendments on growth and yield of red pepper and soil characteristics compared with chemical fertilizers application. Treatments of organic amendments including oil cake, rice straw compost, amino acid compost, rice bran compost, and mushroom media compost resulted in comparable growth and yield of pepper to chemical fertilizers. Available phosphate level in the soil amended with rice bran compost or mushroom media compost was relatively high compared with the other treatments due to relatively high phosphate levels in the composts. Adjustment of nutrient composition in the organic resources is difficult. Therefore, the results in the study imply that nutrient imbalance should be carefully considered in organic farming without use of chemical fertilizers.

Introduction

Organic farming has rapidly increased in response to consumer's preference to safe food, farmer's desire to live in a clean environment, and government's policy to reduce fertilizers use. In Korea, certified number of farms, area, and products for organic farming increased from 442, 450 ha, and 10,672 Mg in 2001 to 9,403, 13,343 ha, and 108,810 Mg in 2009, respectively (National Agricultural Products Quality Management Service 2010). In Gangwon province, the number of farms, area, and products increased from 62, 66 ha, and 1,391 Mg in 2001 to 851, 1,281 ha, and 14,551 Mg in 2009, respectively.

There is a concern, however, about nutrient accumulation and nutrient imbalance in the soil of organic farming and nitrate contamination to ground water due to over-application of livestock compost and organic amendments including oil cake. Lee *et al*. (2006) reported that organic farmers in Korea generally applied greater amounts of organic amendments including livestock compost than recommended level. Nitrate level in surface soils of organic Chinese cabbage fields was 3.6 times higher than that of conventional farming and 4.7 times for sub-soils (Sohn *et al*. 1996). Phosphate and electrical conductivity also showed similar trend. Sohn & Han (2000) reported that nitrate level of organic farming soils in Paldang, Korea was four to seven times compared with conventional farming soils nearby, and two times for available phosphate. Cho *et al*. (2009) also reported that 1.4 times phosphate and 1.5 times potassium for organic farming upland compared with conventional one. In addition,

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livestock compost has been commonly used in organic farming, Korea (Lee *et al*. 2006). Recently, several researches showed residual veterinary antibiotics in livestock feces and urines (Seo *et al*. 2007). Therefore, we need to search other organic amendments than livestock compost.

The objective of the study was to investigate the influence of continuous application of organic amendments on growth and yield of red pepper and soil characteristics compared with chemical fertilizers application.

Materials and methods

The four-year experiment was performed at the Gangwon Agricultural Research & Extension Services greenhouse and field in Chuncheon, Korea from 2007 to 2010. Red pepper was cultivated with application of organic amendments including oil cake, rice straw compost, amino acid compost, rice bran compost, and mushroom media compost before transplanting of red pepper. Chemical composition of the organic amendments on a fresh weight basis is shown in Table 1.

Table 1: Chemical composition (%, fresh weight basis) of the organic amendments used in the study

Organic amendment	OM	T-N	P_2O_5	K_2O	CaO	MgO
Rice straw compost	18	0.7	0.2	0.7	0.7	0.3
Rice bran compost	48	1.9	1.4	0.6	1.1	2.8
Mushroom media compost	30	1.4	1.0	0.8	0.5	0.4
Oil cake	75	4.7	2.1	1.1	0.6	0.6
Amino acid compost	25	5.2	0.6	2.5	2.2	1.3

The application rates of organic amendments were determined based on recommended nitrogen fertilization rate after soil testing and nitrogen content of the organic amendments. As a result, less or excess amounts of phosphate and potassium was applied depending on relative nutrient composition of the organic amendments. For instance, phosphate was over-applied for rice bran compost and mushroom media compost and potassium was less-applied for oil cake and rice bran compost compared to recommended fertilization based on soil testing.

The treatments were arranged in a randomized block design with three replicates. All statistical analyses were performed with the SAS (ver. 9.2, SAS, Cary, NC) program. An alpha value of 0.05 was chosen to indicate statistical significance.

Results and Discussion

Leaf greenness of red pepper for the organic amendments was comparable to that for chemical fertilizer in the greenhouse, while low leaf greenness for mushroom media compost in the field (Fig. 1). Decomposition of mushroom media compost seemed to be relatively slow due to high content of lignin, 60%. Productivity of red pepper for the organic amendments was also comparable to that for chemical fertilizer in the greenhouse, while low yield for mushroom media compost in the field (Fig. 2). The mushroom media compost may improve soil physical properties rather than supply sufficient nutrients to red pepper. Buckerfield & Webster (2002) reported soil physical improvement, soil biological property improvement, and soil moisture conservation effect of mushroom media compost.

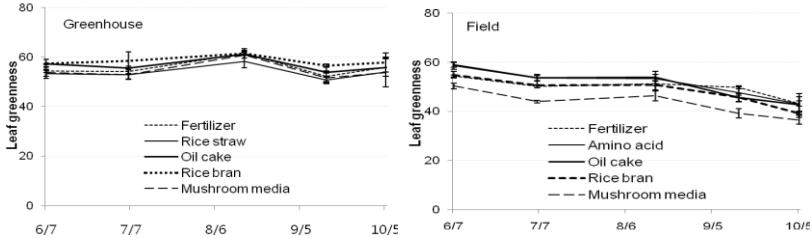

Figure 1: Leaf greenness of red pepper in greenhouse (left) and field (right)

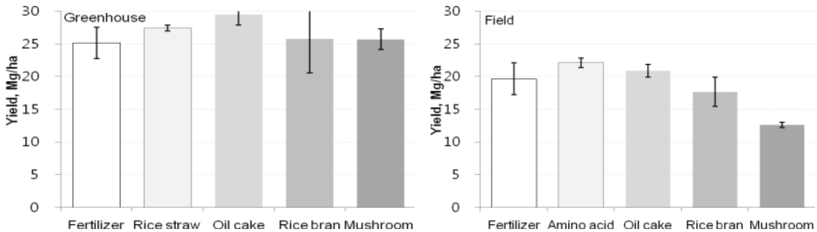

Figure 2: Yield of red pepper in greenhouse (left) and field (right)

Application of organic amendments resulted in increase in soil pH and organic matter (Table 2, 3). Available phosphate levels for rice bran compost and mushroom media compost were relatively high and exchangeable potassium levels for oil cake and rice bran compost were low compared with the other treatments.

Table 2: Soil chemical properties in the greenhouse after harvesting red pepper

Treatment	pH	EC dS/m	OM g/kg	P_2O_5 mg/kg	Ca cmol+/kg	K	Mg
Chemical Fertilizer	6.3bc	2.1a	17 c	504 b	6.7a	0.43b	2.0a
Rice straw compost	6.7 a	1.9a	18bc	572ab	6.8a	0.76a	2.2a
Rice bran compost	6.4bc	2.2a	19ab	622 a	6.5a	0.42b	2.3a
Mushroom media compost	6.6ab	1.9a	19 a	602 a	7.0a	0.80a	2.4a
Oil cake	6.2 c	2.1a	19ab	516 b	6.2a	0.25c	1.9a

Table 3: Soil chemical properties in the field after harvesting red pepper

Treatment	pH	EC dS/m	OM g/kg	P_2O_5 mg/kg	Ca cmol+/kg	K	Mg
Chemical Fertilizer	6.2c	0.29a	15 c	503b	4.6b	0.67a	1.1a
Amino acid compost	6.1c	0.22a	15 c	496b	6.6a	0.49b	1.5a
Rice bran compost	6.8a	0.14b	17 a	620a	4.7b	0.33c	1.2a
Mushroom media compost	6.8a	0.10b	16 b	623a	5.0b	0.58a	1.5a
Oil cake	6.3b	0.13b	16ab	492b	5.1b	0.25c	1.5a

Table 4: Soil physical properties after harvesting red pepper

Treatment	Bulk density, g/cm3		Aggregate, %	
	Greenhouse	Field	Greenhouse	Field
Chemical Fertilizer	1.12b	1.03a	34.5b	41.6b
Rice straw compost	1.08a	1.03a	39.1a	54.0a
Rice bran compost	1.08a	1.01a	36.1ab	48.6ab
Mushroom media compost	1.09a	1.02a	38.3a	54.7a
Oil cake	1.10ab	1.03a	36.9ab	50.7ab

Soil physical properties including bulk density and water-resistant aggregate were improved by applying organic amendments compared with those for chemical fertilizer (Table 4).

Conclusions

Application of organic amendments including oil cake, rice straw compost, amino acid compost, rice bran compost, and mushroom media compost resulted in comparable growth and yield of red pepper compared with those for chemical fertilizer. In addition, soil pH, soil organic matter, bulk density, and aggregate were improved by applying of the organic amendments. However, nutrient imbalance by phosphate accumulation and potassium deficit needs to be carefully considered when organic amendments such as rice bran compost and mushroom media compost were continuously applied to agricultural land.

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Microbial composition and diversity of the long term application of organic material in upland soil

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Yong-Ki Kim[5], Hyeong-Jin Jee[6]

Key words: Microbial diversity, Colony forming units (CFUs), Biolog, Denaturing gradient gel electrophoresis (DGGE)

Abstract

Organic and chemical fertilizer amendments are an important agricultural practice for increasing crop yields. In order to maintain the soil sustainability, it is important to monitor the effects of fertilizer applications on the shift of soil microorganism, which control the cycling of many nutrients in the soils. Here, culture-dependent and culture-independent approaches were used to analyze the soil microorganism and community structure under six fertilization treatments, including green manure, rice straw compost, rapeseed cake, pig mature compost, NPK +pig mature compost, NPK and control. Both organic and chemical fertilizers caused a shift of the cultural microorganism CFUs after treatments. Bacterial CFUs of the organic fertilization treatments were significantly higher than that of chemical fertilization treatments. The DGGE profiles of the bacterial communities of the samples showed that the green manure treatment was a distinct difference in bacterial community, with a greater complexity of the band pattern than other treatments. Cluster analyses based on the DGGE profile showed that rice straw compost and pig mature compost had a similar banding pattern and clustered together firstly. Rapeseed cake, NPK, NPK + pig manure compost and control clustered together in other sub-cluster and clearly distinguished from green manure.

Introduction

Organic farming has often been shown to improve soil fertility by increasing soil organic matter and supporting the living organism in soil. Soil microbial diversity is a key indicator of soil microbial function and can be affected by management practices. Traditionally, soil microbial communities are investigated using methods based on isolating and culturing the microorganism. However, cultivation method is that only a small fraction of microorganism is cultivatable. The drawbacks of the cultivation method can be overcome by using phospholipid fatty acid (PLFA), Biolog and

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molecular techniques such restriction fragment length polymorphism (RFLP), denaturing gradient gel electrophoresis (DGGE) and terminal restriction fragment length polymorphism (T-RFLP). The objective of this study was to examine the soil microbial composition and diversity of long term organic and conventional fertilizer in upland soil by using Biolog and PCR-DGGE methods

Materials and methods

Soil samples were collected from a long-term experiment field at Suwon, Gyeonggi Province of Korea. The soil samples (0-20 cm) from seven individual plots per treatment were collected. The total numbers of culturable bacteria and fungi were determined as colony forming units (CFUs) on agar plates by dilution plate methods. Soil bacterial community function was determined by using Biolog Eco MicroPlate (Biolog Inc., CA, USA). A soil suspension was prepared by adding 4 g soil to 36 mL sterile saline solution. This solution was vigorously shaken for 30 min to dislodge bacteria before diluting to 10-3. A 150 µL aliquot of the bacterial suspension was inoculated into each well of a Biolog EcoPlate (Biolog Inc., Hayward, Ca). The plates were incubated at 25° and read every 24 h with microplate reader at wavelengths of 590 nm. Soil DNAs were extracted using the FastDNA® SPIN kit for soil (Bio 101 inc, USA) according to the manufacturer's instructions. For soil bacteria, polymerase chain reaction (PCR) conditions for primer GC-341f and 518r were performed. DGGE was performed by using 8% acryamide gel with a 40% to 60% denaturant gradient. The electrophoresis was run in a Dcode Universial Detection System Instrument (Bio-Rad Laboratories, USA) at a constant temperature of 60℃for 12.5 h at 60 V. After running, the gels were stained with EtBr and then photographed with UV transillumination.

Results and Discussion

Both organic and chemical fertilizers caused a shift of the cultural microorganism CFUs after treatment (Table 1). Bacterial CFUs of the organic fertilization treatments were significantly higher than that of chemical fertilization and control. There was no significant difference in the actionomyces and fungi CFUs among the treatments.

Table 1 Microorganism colony formation units (CFUs) of the soil fertilization treatments by the plate counting method (log CFUs g^{-1}soil)

Treatment	Bacteria	Actinomyces	Fungi
Green manure	7.1aa	6.3a	4.4a
Rice straw compost	6.9ab	5.9a	4.2a
Rapeseed cake	6.8ab	5.9a	4.2a
Pig mature compost	6.6ab	6.1a	4.7a
NPK+ Pig mature compost	6.4b	6.3a	5a
NPK	6.3b	6a	4.6a
Control	6.1b	6.3a	4.6a

[a] Means followed by the same letter within each column are not significantly different at P < 0.05.

The average well color development (AWCD), richness (R) and Shannon- Weaver index (H) varied for different soil sample (Table 2). The AWCD value was the highest in green manure, the lowest in control. The values represent the metabolic activity of soil bacterial community in using the carbon sources, suggesting that the effect of green manure on soil bacterial community metabolic function is opposite. It is clearly indicated that the richness as evaluated by the number of carbon sources used and the metabolic diversity as calculated by Shannon-Weaver index were remarkably the highest in Green manure. It is infers that catabolic diversity of the soil bacterial community could be increased by applying green manure.

Table 2. Effect of different treatments on catabolic diversity of the soil bacterial community as evaluated by average well color development (AWCD), Richness (R) and Shannon- Weaver index

Treatment	AWCD	R	H
Green manure	1.47aa	27.75a	3.20a
Rice straw compost	0.90b	21.22ab	2.88ab
Rapeseed cake	0.63b	17.0ab	2.61abc
Pig mature compost	0.91b	19.11ab	2.68abc
NPK+ Pig mature compost	0.72b	17.67ab	2.58abc
NPK	0.58b	14.33b	2.39bc
Control	0.42b	11.44b	2.12c

[a] Means followed by the same letter within each column are not significantly different at $P < 0.05$.

The DGGE profiles of the bacterial communities of the samples are shown in Fig. 1. The green manure treatment showed a distinct difference in bacterial community, with a greater complexity of the band pattern than other treatments. Cluster analyses based on the DGGE profile showed that rice straw compost and pig mature compost had a similar banding pattern and clustered together firstly. The rapeseed cake expeller, NPK, NPK + pig mature compost and control clustered together in other sub-cluster and clearly distinguished from green manure treatment.

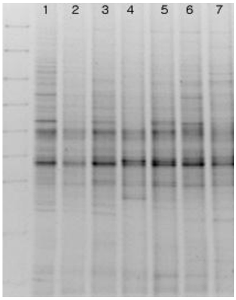

Fig. 1 DEEG profiles of bacterial 16S rRNA gene fragments of soil samples under different treatments. Lane: 1 green manure, 2 Rice straw compost, 3 Rapeseed cake, 4 Pig mature compost, 5 NPK + pig mature compost, 6 NPK, 7 Control.

Conclusions

These results show that long term fertilization had effects on soil microbial communities and the use of green manure mainly increased the catabolic diversities of bacterial communities.

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Effects of legume mixture on nitrogen fixation and transfer to grasses in spring paddy field

Lee, H.[1]

Key words: Biological nitrogen fixation, N transfer, ^{15}N dilution method

Abstract

Nitrogen fixation by legumes can be valuable sources for organic farming. This study was to investigate the effect of different legume mixtures on nitrogen fixation and transfer to grasses on spring paddy field. Three different mixtures were used (rye+hairy vetch, Italian ryegrass+crimson clover, oat+pea) in a randomized complete block design with three replications and sowed in pots with different sowing rate (5:5 rye:hairy vetch,7:3=Italian:crimson, 6:4=oat:pea) on early March. ($(^{15}NH_4)_2SO_4$ solution at. 99.8 atom%^{15}N was applied to the each pot at the rate of 2kg N ha^{-1} on 16th April. Forage were harvested at ground level in heading stage and separated into legume and grass. Total N content and ^{15}N value were determined using a continuous flow stable isotope ratio mass spectrometry. DM yield of rye+vetch, Italian+crimson and oat+pea were 6,607, 3,213 and 4,312kg/ha, respectively. Proportion of N from fixation was 0.73(rye+vetch), 0.42(Italian+crimson) and 0.93(oat+pea). The percentages of N transfer from legume to grass were from 61% to 24% in different method by treatments and –35% to 21% in isotope dilution method.

Introduction

One of the advantages with grasses and legume mixture is that legume can fix atmospheric nitrogen and the process is essential for organic farmers who try to make good use of natural organic resources as possible as they can. The roughages from mixed forage can supply balanced nutrition of protein and energy for ruminants.

Legume is important because they have residual effects on the succeeding crops so that the plant contributes N economy in agricultural crop production system. The inclusion of leguminous crops into rice crop system may contribute towards improving the prospects of their long term sustainability because they are able to fix N_2 from air (Chalk, 1998). Rye is winter crops grown in mid part of South Korea and the mixture of legume with forage cereal become popular these days because farmer begin to recognize the role of legumes in organic farming. There are some reports on legume in N dynamic as dry season crops immediately following single or double lowland rice.

To maximize forge yield in oat-hairy vetch mixture, authors recommended that the plant had to seed in the fall and harvest in the spring in South Korea (Kim, etc, 2002). The findings of N_2 fixation and N transfer from legumes to forage cereals on paddy soil is limiting in Korea. This research was to measure N_2 fixation in legumes mixed with cereals and estimate the amount of transferred N to grasses by ^{15}N dilution and different method.

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Materials and methods

The studies reported here were conducted in pot trial from Jan, to June in 2006. There were three different treatment; hairy vetch+rye, crimson clover+Italianrye grass, oat+pea mixture. The experimental design was complete randomized with three replications plus only barley pots as reference crops. The pot was 45×43x30cm and sowed 4 rows $(^{15}NH_4)_2SO_4$ solution at 99.7 atom% excess was applied to pots at the rate of 2kg/ha on February 1st. All pot was well irrigated to maintain paddy moisture condition. Condition crop was harvested from central two rows in the pot at ground level and separated into grass and clover fraction. A sub sample of the plant was taken for analysis of 15N concentration by a continuous flow stable isotope ratio mass-spectrophotometer. Biological nitrogen fixation by legume was estimated by people et al (1989) method, using grasses as the control. The transfer of biologically fixed N with difference method and 15N dilution was by chalk (1996).

Results

DM yield were 7,217kg/ha in rye+vetch, 3,314kg/ha in Italian ryegrass and 4,466kg/ha in oat+pea mixture<Table 1>.The N production was 208kg in vetch+rye,54kg in crimson clover+Italianrye grass and 53kg/ha in pea+oat treatment. N production was greatly influenced by DM production in the mixture because rye+ vetch combination was higher than that of two treatments <Table 2>. The proportion of N derived from atmospheric nitrogen with different treatments were 0.73, 0.42 and 0.93 respectively. The highest biological nitrogen fixation was from pea+oat while lowest on crimson clover+Italian rye grass mixture. Estimates of N transfer from legumes to grasses were presented in <Table 2>. Transfer rate from legumes to grasses was different with measurement; higher rate in N difference method than in isotopic method. Italian+crimson and oat + pea plots showed minus value, indicating no N transfer from legumes. Different method revealed higher transfer amount than ^{15}N dilution method.

Tab. 1: Effects of legume+ grass mixture on DM yield and total N production.

Treatment	Grasses			Legume			DM yield (kg/ha)	TN (kg/ha)
	DM Yield (kg/ha)	N (%)	N production (kg/ha)	DM yield (kg/ha)	N (%)	N production (kg/ha)		
Rye+vetch	6,607.1	2.839	186.2	610.1	3.528	21.8	7,217.2	208.0
Ital.+Crimson	3,213.5	1.666	53.1	101.1	1.293	1.2	3,314.4	54.3
Oat+pea	4,321.9	1.123	48.7	144.3	3.510	5.0	4,466.2	53.7

Tab. 2: Proportion of N from N_2 and estimate of N transfer from legumes to forage grasses by different and ^{15}N dilution method.

Treatment	Method	⁎Prop.N from N_2	Botanical composition (G:L)	TN	Transfer rate (%)
Rye+Vetch	Difference	0.73	92:8	208.0	61
	15N dilution				21
Itali.+Crimson	Difference	0.42	97:3	54.3	24
	15N dilution				–32
Oat+pea	Difference	0.93	97:3	53.7	36
	15N dilution			-35	-18.8

(atoms%15 N excess soil delived N)

The N-difference method

Nleg(=>non-leg) = Nnon-leg(m) - Nnon-leg(p)·R(1)

Pnon-leg(<=leg) = Nleg(=>non-leg)/Nnon-leg(m)

= 1 - (Nnon-leg(p)·R/Nnon-leg(m))

^{15}N-dillution method

Pnon-leg(<=atm) = 1 - (Enon-leg(m)/Enon-leg(p)

Pleg(<=atm) = 1 - (Eleg(m)/Enon-leg(p)

Discussion

7,217kg DM/ha in rye+ vetch mixture was lower yield than Kim's report (2002) partly because of pot trial and spring seeding. DM yield of the remainder treatment was also lower than other researcher's results (Kim et al 2010). Even though the yield was not satisfied it can be good sources of natural compost for organic rice cultivation. Proportion of derivation from atmospheric nitrogen was variable. Chen (1998) reported 0.95 to 0.85.On the other hand, Lailaw (1998) showed 0.95 to 0.78 with nitrogen application. Transfer from legumes to grasses was highest in vetch+rye mixture while other two treatments showed minus transfer. It seemed that low composition of legume in the mixture was the main reason for minus transfer. Poor stand of legumes don't guarantee beneficial effect of legume in mixed stand(grass:legume=92:8 in rye+vetch treatment).Generally 50% of legume composition is recommended for N contribution.

Conclusion

DM, biological nitrogen fixation from atmospheric nitrogen, transfer from legumes to grasses were investigated.DM was ranged from 7,217kg to 3,314kg/ha and N derivation proportion from atmospheric nitrogen was 0.73 in vetch+rye pots, 0.42 in crimson+Italian ryegrass and 0.93 in pea+oat combination. N transfer from legumes to grasses varied with treatments, highest at rye+vetch pots with 61% and lowest at Italian +crimson mixture with minus 31%.Transfer rate revealed that difference method was higher than that of in isotope method .

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How can grassland biodiversity affect carbon sequestration?

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Key words: soil, grassland, diversity, organic matter, sequestration

Abstract

In our research we focused on studying the diversity of grassland on Czech organic farms in upland areas and on selected soil characteristics of these biotopes. A number of correlations were evidenced between soil characteristics. By cluster analysis and further evaluation, we divided the plots – grassland – into three groups, from newly established vegetation to species-rich communities. We carried out non-parametric analysis on the results and thus proved a statistically significant difference between the species-rich and species-poor vegetation and content of carbon and nitrogen in the soil. We also found slightly different humus quality under the richer vegetation. These results show that in the 0 – 20 cm layer, 58.9 tonnes of C ha^{-1} was measured under species-poor pastureland and 106.1 tonnes of C ha^{-1} under species-rich vegetation. The results indicate that besides supporting species diversity, the quality change can also be important for carbon sequestration.

Introduction

Soil plays an important role in the carbon cycle on Earth and also ensures key functions relating to productivity of the world's agroecosystems. The possible increase in carbon content of soil is influenced by a number of factors, including agricultural management. The potential carbon sequestration due to a change in land management is estimated at 250–500 kg C ha^{-1} per year (Lal, 2003), with the greatest carbon storage rate occuring in the conversion of arable land to grassland or forest (Guo and Gilford, 2002).

There are many publications dealing with the question of carbon in various agroecosystems. Few publications have so far dealt with the influence of biodiversity on carbon fluxes. Among the few studies published, Adair et al. (2009) state that the total subsurface C allocation increased in response to increasing biodiversity. Fornara and Tilman (2008) showed that high-diversity mixes of plant species in perrenial grassland stored 500 and 600% more C and N than monoculture plots.

In our research we studied the hypothesis that different forms of management, leading on one hand to higher production, but lower biodiversity, and on the other hand considerate management with higher biodiversity of grassland, will also differ in the content and quality of organic matter in the soil and in the possible level of carbon sequestration.

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Materials and methods

In our study we evaluated grassland ecosystems, including soil quality, from the year 2000, on 10 farms in the Jeseníky microregion (Czech Republic) which are managed organically according to EU Council Regulation No. 834/2007. We used methods utilized in accredited Czech laboratories (Zbíral 1995, 1996, 1997). During the research we evaluated texture, bulk density and porosity, minimum air capacity, conductivity, content of exchangeable ions, organic matter content and quality, organic nitrogen, and conducted a respirometric test.

Botanical evaluation of the studied localities was compiled from data gained during floral and phytogenic field surveys using Czech Flora nomenclature (Kubát, 2002). For the purpose of studying the vegetation, 2 – 3 homogenous micro-localities were randomly chosen (from possible locations registered by farmers according to individual forms of management) on each organic farm; the area of each plot was roughly between 16 and 25 m^2.

From the year 2000 evaluation was carried out 3 times, always in the same vegetation period (spring). All plots were maintained as grassland and only varied in the form of management. i.e.: the type of renewal.

With the use of Kruskal-Wallis analysis we identified statistically significant differences in individual groups of grass vegetation on the basis of soil characteristics. In this article these differences are only stated for C and N. Cluster analysis was used to express the similarities between individual farms according to soil characteristics. A “Statistical” programme (StatSoft) was used.

Results

According to botanical monitoring we divided the locations – grassland into three groups, from newly established grass vegetation to species-richer communities:

1. Temporary grassland – newly-established grassland with species richness of the herb level between 12 – 20 vascular plant species within the area

2. Temporary grassland - older re-cultivation with species richness of the herb level between 21 – 27 vascular plant species within the area.

3. Seminatural grassland – species-rich communities - this group includes original pasture areas which have not been re-cultivated for at least 40 years and are grazed extensively (very low density of animals, no fertilizing). Species richness of the herb level is between 28 – 40 vascular plant species within the area.

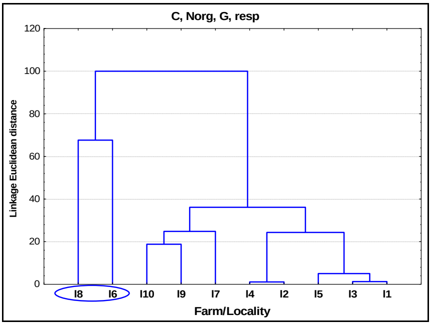
During our research we registered important correlations between a number of soil characteristics and the content of organic carbon and organic nitrogen. Non-parametric analysis of these results confirmed a statistically significant difference between species-poor and species-rich plant communities in terms of the content of carbon and nitrogen in the soil. During our evaluation we found that the difference between intensive and extensive species-rich communities varies between 40 - 50 t C per ha. This is evident from the data obtained, which show that 58.9 t C ha^{-1} was found in the 0 – 20cm layer in re-cultivated, species-poorer pasture while in species-rich communities this amount was significantly higher – 106.1 t C ha^{-1}.

A slightly better quality of humus, expresed by HA:FA, under species-richer vegetation was not significant in our results. Other differences were also registered in other soil parameters in individual types of communities. Statistically significant differences found in parameters relating to soil organic matter are stated in Table No. 1. Species-rich communities were also earmarked from the overall set by cluster analysis (Fig. 1) in terms of soil organic matter ($C_{org.}$ and $N_{org.}$). Similar differences between individual types of communities were also registered in other soil characteristics.

Tab. 1: Comparison of $C_{org.}$ and $N_{org.}$ content in relation to diversity of grassland (Kruskal-Wallis ANOVA (and Post hoc Comparison, *p* <0.05)

	$C_{org.}$ (%)	$N_{org.}$ (mg kg-1)
Newly established grassland	2.02 *	2069.90*
Older grassland re-cultivation	2.76	3167.13
Species rich communities of grassland	3.93*	5704.15*

* statistically significant difference



Key:  farms with species-rich communities of grassland

Figure 1: Hierarchical tree of relationship between localities in evaluation of C, $N_{org.}$ and respiration

Discussion and conclusions

Significant differences between plant communities are in accordance with e.g. results by Conant et al. (2001), who conclude that grassland can act as a significant carbon sink with the implementation of soil-protection management. Steinbeiss et al. (2008) described how C storage significantly increased with species-richness. Similarly, results of Austrian research refer to the difference in the carbon content of soil in intensively utilized grassland and extensive communities (alpine meadows) (Gerzabek et al., 2002). Some studies also emphasize a higher biomass of subsurface plant parts in species-richer grassland in comparison to intensively fertilized re-cultivated grassland.

Carbon sequestration in soils has been discussed in recent years in relation to many factors (e.g. climate change, type of agricultural management, soil type, initial condition). The amount of carbon which can be sequestrated in soils differs according to land use and type of management. Grassing arable land is very important for sequestration, amounting to 7.03 ± 2.08 t, or 5 t. On the basis of this, scenarios for potential carbon sequestration in European soils have been drawn up (Gumbert, 2002). For a conversion from arable land to permanent grassland this potential is estimated at 140 Mt CO_2 per year (Vleeshouwers and Verhagen, 2002). However, these changes can be initiated, according to our findings not only by grassing but also via qualitative changes in grass vegetation, i.e. improving their species diversity: considering the difference between intensive and extensive species-rich communities which could be about 40 – 50 t C ha^{-1} as we found during our research.

According to our results, and other observations, an increase in sequestrarion is not only possible due to the transformation of arable land into grassland, but also through management leading to richer communities. The time factor is important in this. Thus the aims of organic farming can be achieved while increasing biodiversity.

Acknowledgments

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Mineralization of nitrogen contained in mixed oil cake under different soil moisture conditions

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Key words: Mineralization, Mixed oil cake

Abstract

This study was conducted to investigate the nitrogen mineralization of mixed oil cake (MOC) under different soil moisture condition. Chemical properties of soil used in this experiment were 6.1 of pH (1:5) and 17g kg^{-1} of soil organic matter content in paddy soil, and 6.4 of pH (1:5) and 17g kg^{-1} of soil organic matter content in upland soil. Chemical contents of mixed oil cake (MOC) used were 45g kg^{-1}of nitrogen and 15 of organic matter/nitrogen ratio. MOC was applied at 100% level recommended nitrogen amount (N 147kg ha^{-1} of paddy soil 147, 100kg ha^{-1} of upland soil) by soil testing. Ammonium-nitrogen content of paddy soil treated with MOC was lower compared with chemical fertilizer plot. Nitrate-nitrogen content in upland soil by application of MOC was increased continuously till 30 DAT and decreased slowly thereafter.

Introduction

It is well known that a part of applied fertilizer nitrogen is immobilized during decomposition of organic matter in soil and this immobilized fertilizer nitrogen is remineralized under favorable C/N ratio in submerged soil condition. Decomposition of applied organic matter such as compost and rice straw has markedly influenced soil chemical and microbiological parameters. As a result, it seems that dynamics of immobilization and mineralization of the applied fertilizer nitrogen and released nitrogen from organic matter still need to be studied. Decomposition under anaerobic conditions results in much lower quantities of net immobilization than decomposition under aerobic conditions (Alexander, 1961). Norman (1931) found a slight tendency for slower decomposition under acid conditions than under neutral to alkaline conditions. In determining the appropriate application rate of organic matter to cropland, it is critical to know its mineralization rate. This is especially important for N, since much of N in organic matter is in the organic form. Since application of organic matter can improve the soil's physical and biological properties in addition to the soil's chemical characteristics, integrating the chemical parameters with the physical and microbiological parameters could be useful for a better assessment of change in soil quality by different treatments. Organic matter N mineralization rates from organic matter applied to land vary depending on soil and environmental conditions as evidenced by a series of studies reported in the literature (Bernal & Kirchmann, 1992; Douglas & Magdoff, 1991; Keeney et, al., 1975; Parker & Sommers, 1983; Sabey et, al., 1975).

Materials and methods

This study was conducted at wagner pot (1 5000^{-1} a) in a plastic vinyl house located in Gyeonggi-do Agricultural Research & Extension Services, Hwaseong-si, Korea, in 2006. Chemical properties of the soil used in the experiment were 6.1 of pH (1:5) and

17g kg^{-1} of soil organic matter content in paddy soil (Tab. 1), and 6.4 of pH (1:5), 17g kg^{-1} of soil organic matter content in upland soil (Tab. 2). Chemical contents of mixed oil cake (MOC) used were 45g $kg^{-1}$of nitrogen, 23.4g kg^{-1} of phosphate, 14.3g kg^{-1} of potash, 700g kg^{-1} of organic matter content, and 15 of organic matter/nitrogen ratio, respectively (Tab. 3). MOC consisted of castor oil cake 70%, rice bran 15%, by-product 15% of amino acid. MOC was applied by pellet state at 100% level of recommended nitrogen amount (N 147kg ha^{-1} of paddy soil 147, 100kg ha^{-1} of upland soil) by soil testing compared with chemical fertilizer plot. In the chemical fertilizer plot, urea was used as nitrogen source (without phosphate and potash). Paddy soil was maintained at flooding condition and upland soil maintained field moisture capacity. Ammonium-nitrogen of paddy soil and nitrate-nitrogen of upland soil were analyzed by Kjeldhal method.

Tab. 1: Chemical properties of paddy soil used in the experiment

pH (1:5)	OM (g kg^{-1})	Av. SiO_2 (mg kg^{-1})	Av. P_2O_5 (mg kg^{-1})	Ex. Cations ($cmol_c$ kg^{-1})		
				K	Ca	Mg
6.1	17.2	159	59	0.26	5.5	1.3

Tab. 2: Chemical properties of upland soil used in the experiment

pH (1:5)	OM (g kg^{-1})	EC (dS m^{-1})	Av. P_2O_5 (mg kg^{-1})	Ex. Cations ($cmol_c$ kg^{-1})		
				K	Ca	Mg
6.4	7.0	4.0	285	0.64	7.3	1.9

Tab. 3: Chemical contents of mixed oil cake used in the experiment

pH (1:5)	OM (g kg^{-1})	Av. P_2O_5 (g kg^{-1})	K_2O (g kg^{-1})	CaO (g kg^{-1})	MgO (g kg^{-1})	T-N (g kg^{-1})	OM/N ratio
6.1	700	23.4	14.3	10.3	8.4	45	15

Results

The ammonium-nitrogen content of paddy soil from 10 days to 50 after mixed oil cake treatment (DAT) was lower compared with chemical fertilizer plot. The ammonium-nitrogen content of paddy soil in plot of mixed oil cake (MOC) treatment was increased rapidly at 20 DAT and decreased slightly at 50 DAT (Tab. 4). The ammonium-nitrogen content of surface water was highest at 10 DAT in chemical fertilizer plot and at 50 DAT in MOC plot (Tab. 5). In upland soil MOC treated, the nitrate-nitrogen content was increased continuously to 30 DAT and decreased slowly thereafter. But the nitrate-nitrogen contents of upland soil by application of chemical fertilizer was decreased successively (Tab. 6).

Tab. 4: Changes of ammonium-nitrogen content in paddy soil

Treatments	NH_4-N(mg kg^{-1})				
	10 DAT*	20 DAT	30 DAT	40 DAT	50 DAT
Control	21 c	68 c	70 c	78 b	66 b
Chemical fertilizer (N 147kg ha^{-1})	116 a	142 a	162 a	161 a	150 a
Mixed Oil Cake (N 147kg ha^{-1})	28 b	90 b	96 b	132 a	130 a

*DAT: Days after treatment.
5% level of Duncan's Multiple Range Test

Tab. 5: Changes of ammonium-nitrogen content in paddy surface water

Treatments	NH_4-N(mg kg^{-1})				
	10 DAT	20 DAT	30 DAT	40 DAT	50 DAT
Control	5 b	6 a	7 a	3 b	3 b
Chemical fertilizer (N 147kg ha^{-1})	29 a	9 a	10 a	7 b	6 b
Mixed Oil Cake (N 147kg ha^{-1})	6 b	8 a	10 a	13 a	14 a

*DAT: Days after treatment.
5% level of Duncan's Multiple Range Test

Tab. 6: Changes of nitrate-nitrogen content in upland soil

Treatments	NO_3-N(mg kg^{-1})				
	10 DAT	20 DAT	30 DAT	40 DAT	50 DAT
Control	195 c	201 b	202 c	171 c	167 b
Chemical fertilizer (N 100kg ha^{-1})	296 a	279 a	234 b	197 b	178 b
Mixed Oil Cake (N 100kg ha^{-1})	232 b	277 a	309 a	258 a	219 a

*DAT: Days after treatment.
5% level of Duncan's Multiple Range Test

Discussion and Conclusions

Chemical properties of soil and surface water investigated 5 times per 10 days. Mineralization of ammonium nitrogen in paddy soil was lower from mixed oil cake than from chemical fertilizer by 50 days after treatment. However, from 20 days after treatment, nitrate nitrogen content of mixed oil cake was higher than of chemical fertilizer in upland soil. The changes in ammonia nitrogen contents of paddy soil and nitrate nitrogen content of upland soil indicated that stabilization of mixed oil cakes in soils requires at least 30-40 days of period.

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Effects on soil fertility when animal manure is anaerobically digested for biogas production

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Key words: soil organic matter, humus, earthworms, slurry, perennial ley, cereals

Abstract

Organic farming systems work to reduce dependency of fossil fuels and emissions of greenhouse gases. Utilising manure for biogas production is helpful for both these problems. However, few studies have examined the long-term impact on soil fertility when (some) organic matter in the manure is converted to methane and escapes from the carbon cycle of the farm. In 2010, a field study for this purpose was initiated on an organic research farm with dairy cows in Tingvoll, Norway. A biogas plant was established, from which digested slurry will be compared with untreated slurry in two cropping systems, perennial ley and arable crops. By September 2011, yields from the first cropping season, analyses of the manure and initial soil characteristics will be available.

Introduction

Anaerobic digestion of organic wastes to produce methane (CH_4) for energy purpose is a well established technology. The biological process requires a working temperature of at least 35 °C. In Europe, some countries supporting renewable energy, e.g. Germany, have established many farm-level biogas plants in recent years. Some are found on organic farms or institutions (e.g. vocational schools), but many organic farmers are still reluctant to adopt this technology. Soil fertility is the primary goal of any organic farmer, aiming for self-sufficient production systems with minimal purchases of nutrients and organic matter. Soil organic matter, humus, is the key stone in formation of soil structure and crop nutrition (Elmholt *et al.*, 2008). Humus is essential for soil aggregate formation and stability, which affect water and nutrient behaviour in the topsoil. Loss of humus has caused ecological disasters, e.g. in the United States around 1930, where the dark topsoil was lost by erosion due to excessive tillage. Soil humus content is influenced by the on-farm recycling of organic matter, and a principal argument against digesting animal manure for biogas production is that this may reduce the quality and quantity of humus in the soil. During digestion, organic matter will be transformed to CH_4 and lost from the farm cycle of carbon (C), instead of being available for natural degradation processes in the soil.

Animal manures increase and maintain soil fertility, partly due to their positive effect on the soil humus content. Based on more than 30 years of research, the DOK-experiment in Switzerland (Mäder *et al.*, 2002) has demonstrated that organic farming systems, when compared with systems using only mineral fertilizers, contribute to establish soil fertility. The organically managed soils contained more humus, had a

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more desirable structure with a higher capacity of water infiltration, and a more active microbial community to sustain the processes of plant nutrient turnover. In Norway, a higher level of humus was maintained in soil amended with animal manure since 1922, than if mineral fertilizer was applied (Riley, 2007). Positive effects of animal manure, combined with ley in the crop rotation, have also been found on earthworm activity and soil structure (Riley *et al.*, 2008). In agronomy studies of digestate effects, crop yield has so far been the main focus (e.g. Möller et al., 2008). Digestate impact on soil nutrient content and enzyme activity has been studied, e.g. by Vago *et al.* (2009), although with other organic wastes added during digestion. Replacing mineral fertilizers with biogas residues will probably increase the soil organic matter content. However, we focus on a dairy farm recycling the digestate from a manure-based biogas plant to the soil as fertilizer. Our aim is to evaluate whether such treatment of the manure can maintain soil fertility as good as the use of untreated manure.

Processing the raw manure in a biogas plant changes its chemical content, and results in a slurry with less dry matter, less easily degradable organic carbon (C) and an enhanced fraction of mineral nitrogen (N). Results from a recent Danish study indicate that the amount of C applied to the soil will be significantly less when manure is digested before application. On the other hand, organic matter in non-digested manure is also rapidly mineralized in the soil (Johansen *et al.*, 2009). Thus, non-digested manure, with more rapidly decomposing organic matter, may not contribute any more to the formation of stable humus than the digested manure, in which the applied amount of C will be lower but probably more stable. We may also hypothesize that the negative effects of less available organic matter for soil life may be balanced by a better plant availability of applied N, beneficial for plant growth. This in turn may give more plant debris production, contributing to increase the humus in the soil. At least in roughage production systems, the effects on soil fertility may be minor. These questions have not been sufficiently studied under Nordic climatic conditions, and need also to be evaluated under long-term field conditions.

The application of less easily degradable organic C may impact the earthworm population negatively, because the most common species in Norway, the field worm (*Aporrectodea caliginosa* Savigny) (Pommeresche & Løes, 2009) is endogeic (soil eating) and probably unable to compensate reduced input of organic C by increased availability of plant material. Applying digested manures, endogeic earthworms may lose the competition with soil microorganisms for available C as shown by Ernst *et al.* (2008). We also expect earthworms to be negatively affected by manure digestion, due to sensitivity to ammonium (NH_4^+) (Edwards, 1988), which may be found in relatively high concentrations in the digestate. However, as NH_4^+ is usually rapidly transformed to nitrate in cultivated soil, this risk may be small in practice. Possible reductions in earthworm activity may impact soil organic matter content and soil physical characteristics negatively, and reduce soil quality in general.

A field experiment to study the mentioned topics was established at an experimental organic farm in Tingvoll, Norway, in 2010. The aim of this paper is to present the design of the study, and first results of soil, manure and plant production monitoring, which will be available by September 2011.

Materials and methods

The organic experimental farm at Tingvoll (62°54'N, 8°11'E) belongs to the foundation Norwegian Centre for Ecological Agriculture (NORSØK), which also hosts a division of the Norwegian Institute for Agricultural and Environmental Research, Bioforsk Organic

Food and Farming, with about 40 employees. Organic management of the farm, with dairy cows, was established in 1988. During 2010, a new house was built for the herd of 22 cows. A small biogas plant was established alongside, to digest the manure from the herd. Equipment has been installed to compare digested and non-digested slurry.

In the project "Effects of anaerobically digested manure on soil fertility - establishment of a long-term study under Norwegian conditions" (Soileffects), a long-term field experiment was established at Tingvoll research farm in 2010-11. The project will describe the initial status of the experimental sites (2011), and results of the early transition period with respect to soil structure, chemistry and biology. Soil fauna is expected to have a larger annual variation than soil physical and chemical characteristics, due to larger sensitivity to weather conditions. Hence, transition effects will be studied twice in selected species, in 2012 and 2013. For soil physical and chemical conditions, measurements of transition effects will be made in 2013.

To avoid masking of manure treatment effects due to fertile soil conditions, the experimental site has been placed on a field with relatively low productivity. The field was cultivated from a poorly drained area with deciduous forest about 40 years ago and still requires large applications of manure to increase the level of plant nutrients, especially phosphorus (P). Two levels of manure will be compared; exact amounts determined by the P concentration, but the levels named according to their approximate nitrogen (N) application. Two cropping systems will be included. A perennial ley will mimic the actual production of the farm. An arable system, in which most above-ground plant material is removed, may reveal other effects of manure digestion on soil humus etc. A grass-clover ley was established in 2010 and will be used for the ley system. Plots for the arable system will be ploughed and cultivated in spring 2011, and oats will comprise the first crop. Later crops will be barley and annual green fodder crops. In the arable system, the high manure level will be about 170 kg total N ha^{-1} yr^{-1}; equal to the amount of N that EU regulations allow organic farmers to purchase. In the ley system, the high level will be about 220 kg N ha^{-1} yr^{-1}; equal to the amount of manure that is usually available on conventional farms in the district. The low manure levels will comprise half of these amounts. Control treatments without manure application will also be included.

The manure samples will be analysed for chemical composition, and characterised with respect to viscosity, infiltration rate in field, smell and colour. Possible changes in soil structure will be characterised by field bulk density, pore characteristics, air and water permeability and aggregate stability. Soil chemistry characteristics will include humus characterisation, pH and plant nutrient assessment. Soil biology will include studies of earthworms, mites and springtails. Earthworms from the field will also be studied in detail in pot experiments, especially to assess the effect of NH_4^+ concentrations in the digested slurry. The soil microbiota will be characterised by accumulated respiration, microbial biomass, and shifts in microbial community structure described by phospholipid fatty acid technique.

Crop dry matter yields will be recorded by three cuts of ley during the season and harvesting of grain at ripening. During the season, visual observations will be made of weeds, fungal diseases and possibly other plant health related problems, and cereal lodging.

Results

By September 2011, results will be available describing manure characteristics, initial soil characteristics and first year yields in two cropping systems.

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The effect of organic matter and soil compaction on growth and nutrient uptake by clover plant

Nadian, H.[1]

Keywords: Soil compaction, Organic matter, Phosphorous, Zink, Clover, Cupper

Abstract

A pot experiment was conducted to study the interaction between organic matter and soil compaction on growth and P, Zn, Fe, Cu uptake by clover plant (Trifolium alexandrinum L.) in a calcareous soil. The experiment had a completely randomized design consisting of a 3×3×3 factorial combination of three rates of organic material manure (0, 4.5, and 9.0 g kg-1 soil), three soil compaction levels (bulk densities of 1.40, 1.65 and 1.80 Mg m-3) and three rates of P (0, 25, and 50 mg kg-1) with three replications. The results indicated that soil compaction decreased root length and root dry weight of clover plant. However, addition of organic matter increased root growth at each corresponding soil compaction levels. Total P uptake by impeded roots decreased. A similar trend t observed for total uptake of Zn, Fe and Cu. However, organic matter application due to increase root length and root dry weight improved uptake of P, Zn, Fe and Cu. Soil compaction differently affect root concentration of P, Zn, Fe and Cu. Soil compaction decreased root P and Fe concentrations, but had no significant effect on root Zn and Cu concentrations. Soil compaction decreased root growth and this resulted in a significant decline in P, Zn, Cu and Fe accumulation. Organic matter compensated, in part, for the adverse effect of soil compaction and significantly improved root growth and plant nutrition, particularly P and Zn nutrition.

Introduction

Soil compaction resulting from trafficking of farm machinery may increase soil bulk density and mechanical impedance. An increase in soil bulk density may alter pore size distribution and consequently may alter movement of air, water and nutrients. All these can affect plant growth via soil mechanical impedance (Barzegar et al. 2006) and/or via soil poor aeration (Atwell &Steer 1999) caused by low air-filled porosity and discontinuity of pores. Mechanically impeded roots are usually shorter, thicker and more irregularly shaped than the thinner fibrous roots that develop under low-strength conditions (Begough et al. 2006). The increase in root diameter in mechanically impeded roots is due to an increase in thickness of the cortex, in which cells become shorter in longitudinal direction and wider in transverse, while the cell volume is unaffected. A number of authors reported that increased mechanical impedance increased lateral branching (Goss 1977), while others reported restricted root branching with increasing mechanical impedance (Hoffmann & Jungk 1995). In a strong soil, however, outgrowth of lateral roots may be obstructed because most pores are smaller than the diameter of the laterals roots. Another phenomenon obscuring the influence of a high mechanical impedance on root branching is the fact that lateral roots emerge much closer to the apex of the main axes than at low mechanical

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impedance (Goss 1977). An impeded root system may greatly restrict plant uptake of less mobile nutrients like P, Zn, Fe and Cu particularly in soils with low concentrations of these nutrients.

It has been shown that the increases in organic matter improve physical, biological, and chemical characteristics of soils (Nelson & Oades 1998). A number of studies have illustrated that organic matter increased soil structural stability, water-holding capacity at higher soil water potential, soil porosity, and infiltration rate and decreased soil compactability (Hoffmann & Jungk 1995). Organic matter additions may also improve water and nutrient uptake by Q1 crops (Goss 1977). The objective of this study was to investigate the influence of soil compaction on the performance of clover and the changes in P accumulation by Berseem or Egyptian clover following organic matter and P fertilizer additions.

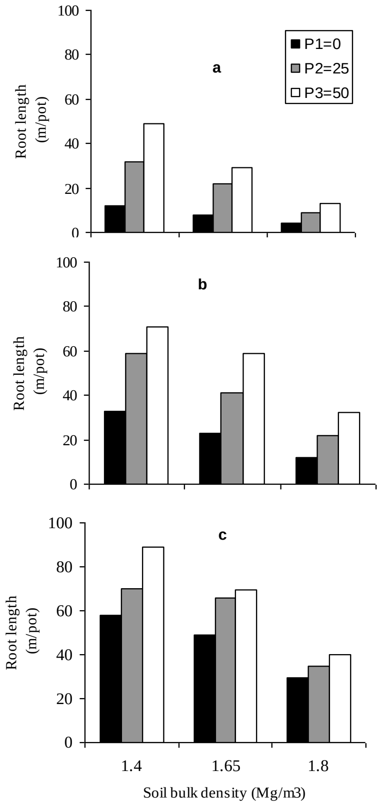
Materials and Methods

A 3 × 3 × 3 factorial experiment with a randomized complete block design including three soil compaction levels (bulk densities of 1.4, 1.65 and 1.8 Mg m^{-3}), three rates of P (0, 25, and 50 mg kg^{-1} using KH2PO4) and three rates of organic matter as farmyard manure (0, 20, and 40 Mg ha^{-1} or 0, 4.5 and 9.0 g pot^{-1}) were used in a pot experiment. In treatment of organic matter, the decomposed farmyard manure was mixed throughout the soil in each pot containing 1.31 kg soil. The soil in each pot was compacted by a hydraulic ram to the desired bulk density. Six seedlings of *Trifolium alexandrinum* L. were transplanted in each pot. The watering regimen of pots consisted of weighing each pot once a day and adding water to the mass corresponding to 70% of field capacity. Two weeks after transplanting, the number of seedlings in each pot was reduced to 3. Plants were harvested 7 weeks after transplanting. Root length (Barzegar et al. 2006), P concentration (phosphovanado-molybdate method), Zn, Cu and Fe (atomic absorption) were measured. Statistical analysis was performed by using SAS statistical package.

Results and Discussion

The results showed that root length of clover plant was significantly decreased as soil compaction was increased (Table 2) and confirmed the previous results for Trifolium alexandrinum (Atwell &Steer 1999, Barzegar et al. 2006). In fact, increase in soil compaction increased mechanical impedance of the soil and this in turn suppressed root length. Root dry weight to root length ratio which is regarded as root diameter indicator usually increases with increasing soil compaction. In this study, root dry weight to root length ratio increased with increasing soil compaction (result not shown). It has been shown that mechanically impeded roots are usually shorter, thicker and more irregularly shaped than the thinner fibrous roots that develop under low-strength conditions (Begough et al. 2006). The increase in root diameter in mechanically impeded roots is due to an increase in thickness of the cortex, in which cells become shorter in longitudinal direction and wider in transverse, while the cell volume is unaffected (Barzegar et al. 2006). The observed decrease in plant growth in this study might be attributed to the increased penetrometer resistance of the soil and poor aeration due to soil compaction. In a heterogeneous soil, the influence of restricted aeration is difficult to distinguish from that of restriction to plant growth caused by mechanical resistance. However, addition of organic matter enhanced root growth and compensated, in part, for the adverse effect of soil compaction. Organic matters increases the size of soil pores and this, in turn, declines soil compactibility

(Nelson & Oades 1998). A similar trend to that of root length was observed for shoot dry weight (Result not shown). It has been shown that change in morphology of plant root due to soil compaction alters nutrient uptake, particularly those of less immobile nutrients like P (Hoffmann & Jungk 1995). In present study, increasing soil bulk density from 1.4 to 1.8 Mg m-3 significantly decreased shoot P concentration from 1.7 to 1.0 mg g-1 (Table 1). A similar tend was observed for root P concentration (result not shown). Both decline in plant biomass and tissue P concentration due to soil compaction resulted in a significant decline in P accumulation. Application of organic matter, particularly in treatment whit 9.0 g kg-1 soil, improved P nutrition of clover plant (Table 1).



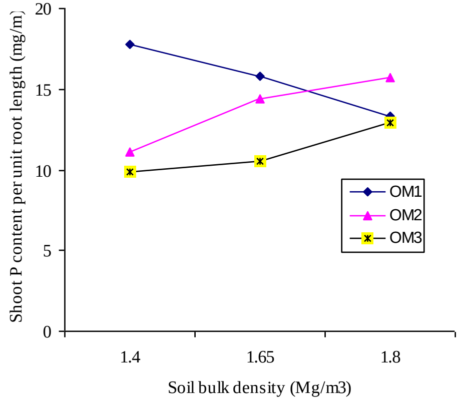


Fig. 3 Effect of soil compaction on shoot P content unit root length in treatments with no added organic matter (OM1), 4.5 (OM2) and 9.0 (OM3) g organic matter per kg soil.

Fig. 1 Effect of soil compaction, P applied: P1=0, P2=25 and P3=50 mg kg^{-1} soil and organic matter: 0 (a), 4.5 (b) and 9.0 (c) g pot^{-1} on root length of clover plant

Addition of organic matter from 0 to 9.0 g kg^{-1} soil increased total P uptake from 2.8, 1.9 and 0.9 to 9.9, 7.1 and 3.1 at bulk densities of 1.4, 1.65 and 1.8 Mg m^{-3}, respectively (Table 1). In spite of decline in P uptake with increasing soil compaction, shoot P content per unit root length increased as soil compaction was increased (Fig. 2). While in treatment with no added P, shoot P content decreased with increasing soil compaction (Fig. 3). The increased plant P content with increasing soil compaction in the presence of organic matter can be attributed to improve soil physical properties which make it possible to grow better of plant roots in compacted soil. The effect of soil compaction on root Zn concentration was not significant. Addition of organic matter increased root Zn concentration at each corresponding soil compaction levels. The decreased root Zn content with increasing soil compaction was therefore due to the decline in root biomass. However, Zn uptake per unit root length increased with increasing soil compaction when organic matter was added (result not shown). A similar trend to that of root Zn concentration and root Zn content (but not to that of Zn uptake per unit root length) was observed for Cu uptake (Table 2). Soil compaction decreased root Fe concentration. Addition of organic matter improved Fe nutrition of clover plant.

Tab. 1: Effect of soil compaction and SOM on mineral nutrition of *T. alexandrinum*

Shoot Cu content 1	Shoot Cu concentration 1	Shoot Fe content g pot-1	Shoot Fe concentration g g-1 d. wt.	Shoot Zn content g pot-1	Shoot Zn concentration g g-1 d. wt.	Total P uptake mg pot-1	Shoot P concentration g g-1 d. wt. m	Bulk density Mg m-3	Organic matter g kg-1
8.9	11.2	35.2	50.2	11.2	13.9	2.8	1.7	1.40	
6.8	11.3	24.6	41.0	9.8	14.0	1.9	1.7	1.65	0.0
5.7	11.5	18.6	38.6	8.1	13.8	0.9	1.0	1.80	
11.9	8.5	91.3	65.3	34.2	24.4	6.5	2.0	1.40	
8.7	8.6	59.6	49.7	24.1	24.3	4.3	1.9	1.65	4.5
5.7	8.1	44.3	44.2	17.1	24.3	1.9	1.3	1.80	
15.8	7.2	130.8	62.3	73.1	33.2	9.9	2.4	1.40	
8.8	7.3	71.9	55.3	39.7	33.1	7.1	2.3	1.65	9.0
7.5	7.4	48.6	48.3	29.8	33.1	3.1	1.8	1.80	

Conclusion

Soil compaction decreased plant root growth and this resulted in a significant decline in P, Zn, Cu and Fe accumulation. However, at each soil compaction levels, organic matter compensated, in part, for the adverse effect of soil compaction and significantly improved root growth and plant nutrition, particularly P and Zn nutrition.

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Trend and changes on the soil fertility of selected organic farms of varying ages of development in Malaysia

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Key words: organic farming, soil fertility, plant nutrients

Abstract

In Malaysia, long-term studies on soil fertility status of organic farming have not been conducted. A study was carried out on soils collected from farms of varying ages of development to see the trend and the changes in the fertility of the soil. Top soil samples (0-30cm) were collected from 7 sites which have been developed for organic farming over a period of 10 months (Lojing, Cameron Highlands), one year (Kenaboi, Kuala Pilah), two years (Zenxin Farm, Kluang), three years (Zenxin Farm, Cameron Highlands), six and eight years (Loh Organic Farm, Semenyih) and nine years (Manson Valley, Cameron Highlands). Soil samples were analysed for pH, electrical conductivity, soil organic carbon, total nitrogen, available phosphorus, cation exchange capacity, and exchangeable cations (K, Ca, Mg and Na). Overall, there was an observed increase in soil fertility status between the newer and the older farms. Increase in soil pH of up to 7.10 was seen in farms of six years and above. Increase of about 50% in soil organic carbon, available P and exchangeable cations was observed in the nine year old farms. Available P levels increased significantly ($p<0.05$) over time from 0.77 ppm to as high as 5.07 ppm. Soil EC was relatively stable with time, indicating that the use of animal manure did not increase salinity which reflected good organic management practices. Exchangeable Ca, Mg and Na in the soil increased significantly ($p\leq0.05$) with time.

Introduction

Organic farming practices use green manures, compost and manure applications to increase the fertility of the soil. Many studies show that organic farming practices improves soil fertility, increase soil microbial activity and biological processes that enhance the health of the soil. A decrease in disease and parasitic nematodes had also been observed (Scow et al., 1994). In addition, vesicular-arbuscular mycorrhizal fungi, known to enhance P absorption by host roots (Linderman, 1988), had significantly greater populations in the organic orchard plots than the conventional ones (Werner, 1997). In Malaysia, very few long-term studies on the effect of soil fertility status of organic farming had been carried out. This paper will report the long term changes on the soil fertility of selected organic farms of varying ages of development.

Materials and methods

A study was conducted on soils collected from seven farms of varying ages of development to see the trend and the changes in the soil fertility. The farms have been developed for organic farming over a period of 10 months (Lojing, Cameron Highlands, Pahang), one year (Kenaboi, Kuala Pilah, Negeri Sembilah), two years

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(Zenxin Farm, Kluang, Johor), three years (Zenxin Farm, Cameron Highlands, Pahang), six and eight years (Loh Organic Farm, Semenyih, Selangor) and nine years (Manson Valley, Cameron Highlands, Pahang). All farm used compost and animal manure for fertilisation. Generally between 10 to 40 metric ton/ha of chicken dung was applied and incorporated into the soil depending on the types of crop grown. All organic fields were irrigated using sprinkler irrigation systems for all vegetable crops. At each sampling, 30 soil cores (2.5 cm diameter, 30 cm depth) were taken only from area that has been planted with leafy vegetable. Five replications of each sampling site were maintained for chemical analysis. The soil was mixed thoroughly in a bucket, sieved through a 2-mm-mesh screen, and air-dried prior to analysis. At each site, similar set of soil samples were taken from undisturbed area. Soil samples were analysed for seven soil fertility parameters: pH, electrical conductivity (EC), soil organic carbon (OC), total nitrogen (TN), available phosphorus (P), cation exchange capacity (CEC), and exchangeable cations (K, Ca, Mg and Na). Descriptive statistics, including the mean, range, standard error (SE), skewness and coefficient of variation (cv), were determined for each set of data. To determine whether there was a significant difference in soil properties with varying ages of development of the farms, two-way analysis of variance (ANOVA) was carried out using the Statistical Analysis System 9.1.3 (SAS Institute 2003). All statistical analyses were performed for a significance level of $p \leq 0.05$.

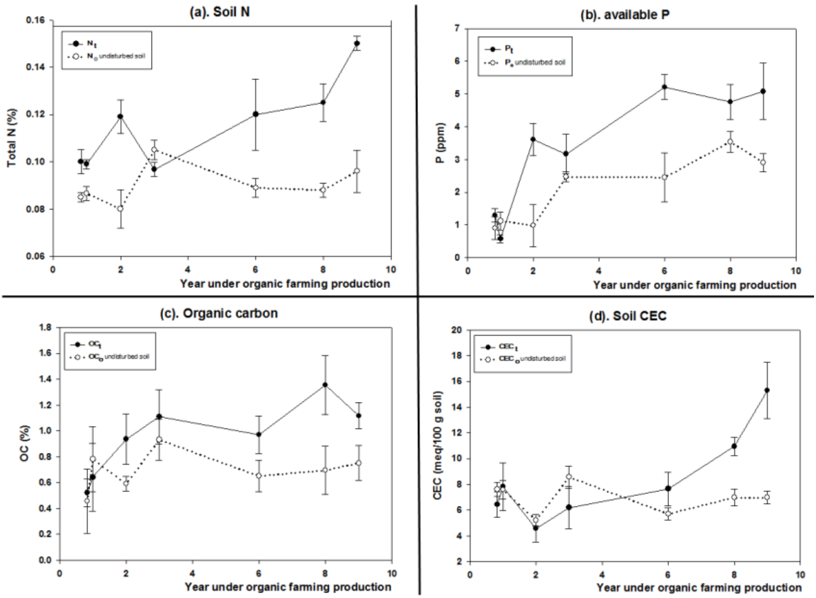

Figure 1: Changes in soil N, available P, organic carbon and CEC over time

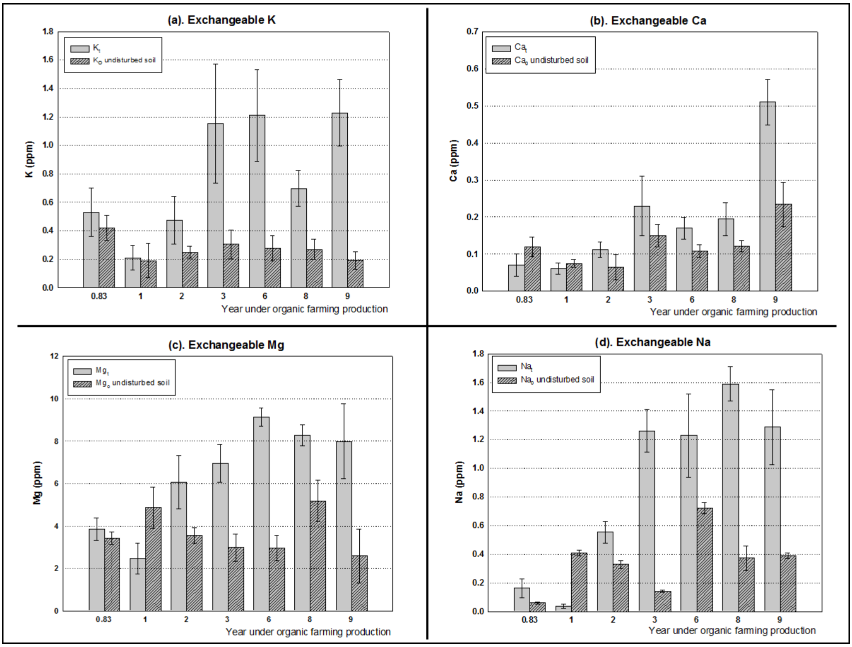

Figure 2: Changes in exchangeable cations over time under organic farming

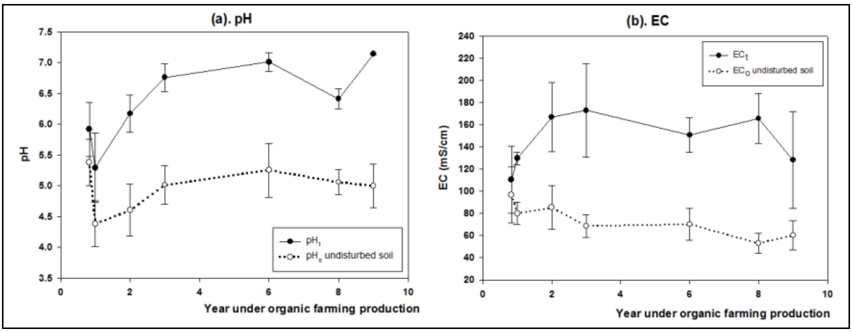

Figure 3: Changes in soil pH and EC over time under organic farming

Results

Figure 1 shows a significant increase in soil pH and relatively stable EC value over time in the organic farming system. During the first four years of organic farming practices, the levels of total soil N fluctuated, and then increase significantly for total N to a highest level of 0.15 % N (Figure 1a.). Available P levels increased significantly over time from 0.77 ppm to as high as 5.07 ppm (Figure 1b.). Over time, organic management tended to increase OC and CEC of the soils. Results showed OC content increased gradually in the first four year and the fluctuated over time (Figure 1c.). The soil CEC in the top 30 cm (Figure 1d.) of the soil increased significantly by 50% (from 4.55 to 11.45 meq /100 kg soil).Generally, the level of exchangeable K, Ca, Mg and Na increased significantly ($p \leq 0.05$) overtime (Figure 2).

Discussion

Significant increase in soil pH (up to 7.0 in the top 30 cm soil) with time under organic farming system (Figure 3), reflect the importance of organic manure and other organic matter inputs in buffering the soil. The EC values were relatively stable over time (Figure 1c.) which showed that the use of organic inputs as fertilizer did not increase salinity. Good organic management practices generally do not increase soil salinity. EC is a measure of total cation and anion in the soil solution and its value depends on the soil type.Generally, total soil N increased with the use of organic practices (Reganold, 1988).This observation is often experienced in the early year of organic farming with decrease in N due to shifts in biological activities and N sources (Werner, 1997). During the first two years, the soils showed very slow but important increase in SOC (Figure 1c.). The active fraction of SOC has been most closely associated with soil fertility improvement by holding plant nutrients and preventing leaching.The capacity of a soil to hold plant nutrients so that they are easily released or “exchanged” into the soil solution is measured by the CEC. Soil CEC is estimated from the sum of exchangeable cations in the soil. CEC is important because it represents the primary soil reservoir of available K, Ca, Mg, Na and several micronurients. Most of the variations in soil CEC are closely related to SOC (Figure 1c. and 1d.).Apart from N, P and K required for healthy plant growth in organic farming system, certain elements such as Ca, Mg and Na must be made available to the plants from the soil. A deficiency of one of the above elements may limit yields. The major cations are calcium, magnesium, potassium, sodium and aluminium, that are held in the soil by organic matter and clay. The level of exchangeable K, Mg and Na remained constant three years after the farm converted to organic farming (Figure 2).

Conclusions

Over time, there was an observed increase in soil fertility status between the newer and the older farms in organic production system. Low nutrients content (especially N) is observed in the early years of organic farming practices, but increased significantly over time. Significant increase in soil organic carbon, available P and exchangeable cations was observed in the nine year old farms. Over time, organic management practices contributed to a relatively stable soil EC. Exchangeable K, Ca, Mg and Na in the soil increased also significantly with time.

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Cropping systems

Vetch cover crop management and organic fertiliser application in organic zucchini production: I. Effect on yield and produce quality

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Key words: vetch, green manure, mulching, anaerobic digestate, compost, N mineralisation.

Abstract

A field experiment was carried out in Southern Italy (Mediterranean environment) to study the effects of two vetch residue managements (vetch as green manure and mulched by roller crimper) and of different organic materials (fertilisers or soil amendments) on yield and produce quality of zucchini crop. Zucchini yield was influenced positively by vetch residue managements: in the treatments with vetch as green manure and as mulching the marketable yield increased of the 60 and 33%, respectively in comparison with the treatment without vetch. This result indicated that the choice of vetch management could reduce the level of application of N fertilisers for subsequent crop. Among fertilisation treatments, the highest yields were recorded with the application of an organic fertiliser based on animal manure and the anaerobic digestate. Therefore, anaerobic digestate, characterized by high mineralization rate in the soil, was able to supply adequate amount of macro and micronutrients.

Introduction

The use of vetch (*Vicia sativa L.)* as cover crop may improve soil fertility and increase the yield of subsequent crops in rotation. The favourable effects of legumes could be due to the residues that contain a considerable amount of N and have relatively low C/N,,leading to a rapid release of N (Gilmour *et al.* 1998). However, the termination method of the cover crop could influence N mineralization of cover crop residues.

Organic wastes must be adequately processed in order to obtain an organic fertiliser or an amendment. Two main processes have been developed to transform organic materials into organic fertilisers for agronomic utilization: the aerobic and the anaerobic process. Aerobic transformation of organic wastes takes to a stabilized and well humified material (compost) which is usually characterized by slow mineralization rate in soil. On the other hand, anaerobic digestate is composed of organic substances, in a chemical reduced form, at low molecular weight which, according to the starting materials, are able to supply to soil nitrogen and other nutrients according to a greater mineralization rate respect to compost (Montemurro *et al.* 2010).

On the light of these considerations the objectives of this research were to study the influence of different vetch residues management and the application of different

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organic fertilisers on zucchini (*Cucurbita pepo L.*) yield, yield components and produce quality.

Materials and methods

The research was carried out at the experimental farm of the CRA-Research Unit for the Study of Cropping Systems (Metaponto - MT - Southern Italy; 40° 24' lat. N; 16° 48' long. E; 8 meters a.s.l.). The experimental design was a strip-plot with two factors and three replications. The first factor was vetch management and the following treatments were compared: (i) fa_llow (control), in which vetch was not cultivated and tilled before the zucchini planting (FA); (ii) green manure, in which vetch biomass was chopped and plough into soil (GM) and (iii) roller crimped, in which the vetch biomass was rolled crimped (RC) in order to obtain a soil mulching layer made of the vetch residues. Within each vetch residue management the application of the following organic materials (second factor) were tested: (i) organic fertiliser composed of animal manure (Org); (ii) anaerobic digestate based on wine distillery wastewater (WDD); (iii) composted municipal solid organic wastes from separate collection (SUW); and absence of fertiliser (N0). The vetch was sown (80 kg ha^{-1}) in the middle of November 2009 and at the first legume stage, vetch was simultaneously terminated in both the management treatments. The organic materials were applied to soil in one solution 20 days before transplanting of zucchini, at the rate of 100 kg N ha^{-1}. This dose, which was lower than the normal N fertilisation for the crop, was defined taking into account the contribution of vetch biological N fixation. Zucchini was transplanted on the 6^{th} of June at 100 cm x 70 cm spacing. During the zucchini growing at 17, 27, 40 and 52 days after transplanting (DAT) nitrate content (Nitrachek reflectometer; MERCK) on sap from petioles of leaves and soil mineral nitrogen at 0-30 cm of depth were determined. At harvest total and marketable yield, fruits average weight, number and fruits dry matter (70 °C for 48 hours) were determined. Statistics analysis was carried out by using the procedures of statistics SAS. The effect of the treatments was evaluated by the ANOVA and for the comparisons among the averages the SNK test was utilized.

Results

The response of the zucchini crop was significantly affected by vetch residue management and the marketable yield had an average increase of the 57 and 22% in the GM and RC treatments compared with FA treatment (fig. 1a). Among the fertilisation treatments the highest cumulative yields were recorded in the Org and in WDD, whereas the SUW and N0 treatments showed the lowest yields (fig. 1b). The highest marketable yield obtained in the GM treatment was due to both the marketable fruits number and their average weight, whereas in the RC treatment only to the marketable fruits number (tab. 1). No significant difference was found for the fruit average weight among fertilisation treatments, so the marketable yield was influenced only by fruits number. Furthermore, the vetch residue management influenced significantly the nitrate average content in petiole sap, in fact the GM and RC treatments increased respectively this parameter of 94 and 61% in comparison with FA (control) treatment (tab. 1). At 17 DAT, RC treatment showed the same mineral nitrogen soil concentration of GM (55 mg kg^{-1}), that increased of the 53% in respect to FA treatment. At 27 DAT, the GM treatment showed higher values than the other two treatments of about 35 %. Finally, at the end of cropping cycle no significant was found among vetch residue management treatments (fig. 2a). Mineral N content of the soil of the four different fertiliser/amendment treatments was similar in the first part of the zucchini cropping cycle, then, after 40 DAT the Org and WWD treatments showed higher values than the SUW and the control (N0) treatments (fig. 2b).

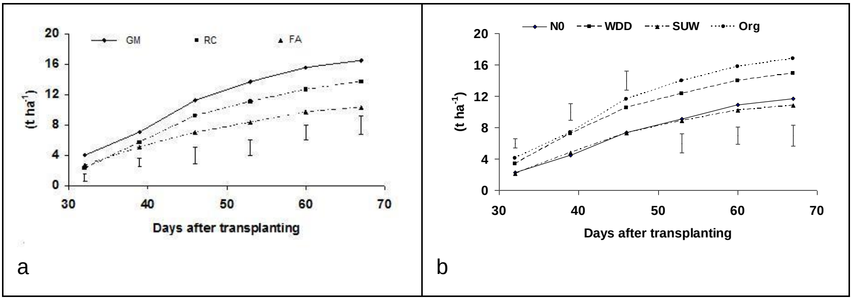

Figure 1: Effects of vetch residue management (a) and fertilization (b) on cumulative marketable yield. The vertical bars represent the Least Significant Difference (P< 0.05)

Tab. 1: Total yield, marketable fruits number, average weight of marketable fruits, dry matter of fruits and petiole nitrate content of Zucchini

Treatments	Total yield (t ha^{-1})	Marketable fruits (N m^{-2})	Marketable fruit average weight (g)	Fruit dry matter (t ha^{-1})	Nitrate average content (mg kg^{-1})
Vetch residue management					
FA	11.6 c	5.4 b	190.7 b	0.59 c	877.0 c
RC	14.8 b	6.6 a	207.6 b	0.80 b	1409.8 b
GM	17.5 a	7.4 a	223.0 a	0.96 a	1702.4 a
Fertilization					
N0	12.7 b	5.8 b	200.0	0.67 b	1356.4
WDD	16.2 a	7.0 a	212.9	0.88 a	1394.1
SUW	11.9 b	5.6 b	192.9	0.63 b	1326.1
Org	17.7 a	7.4 a	225.7	0.96 a	1242.3

Within vetch residue management and fertilization, the values in each column followed by a different letter are significantly different according to SNK at the $P<0.05$ probability level.

Discussion

Due to atmospheric N fixation, the vetch increased N availability to the zucchini crop and increased its yield and petiole nitrate content. In particular the highest results were obtained in the treatment with vetch as green manure probably due to the high biomass production ability of vetch that, incorporated into soil and progressively mineralised, largely increased the available N content in the soil. This hypothesis is confirmed by the higher value of mineral N observed in the soil of the GM treatment compared to those measured in the other two treatments (fig. 2a). The intermediate values of yield, petiole nitrate and soil mineral content showed by the RC treatment could be explained considering that, in this treatment, only the below soil vetch biomass was mineralised after the termination of cover crop, while the above soil biomass remained above the soil surface as mulching and thus, did not completely mineralise during the zucchini cropping cycle. Accordingly, part of the N contained in the cover crop residues remained available for the next crop.

As far as the fertiliser/amendment effect is concerned, the higher yield and yield quality of zucchini measured in the Org and WWD treatments (tab. 1) was probably attributable to the higher amount of available N observed in the soil where these two organic materials were applied (fig. 2b) compared to the SUW and N0 treatments. This finding, which is in accordance with a research carried out by Montemurro *et al.* (2010), demonstrated that the animal manure and the anaerobic digestate showed a greater mineralization rate respect to the compost.

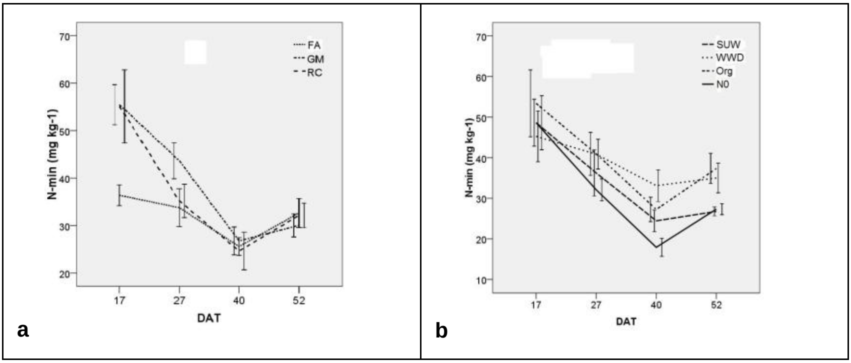

Figure 2: Effects of vetch residue management (a) and fertilization (b) on mineral N content of the soil.

Conclusions

The results of this research highlighted that in cropping systems for vegetables production, the use of alternative termination methods of cover crops combined with the application to soils of organic fertilisers/amendments having different mineralization rates could be an effective approach to modulate the N availability to crops.

Acknowledgments

The present study was carried out in the frame of the *Orweeds* (Weed control in organic farming by indirect approaches) project, funded by the Italian Ministry of Agriculture (Action 2.2 of the National action plan for organic farming).

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Vetch cover crop management and organic fertiliser application in organic zucchini production: II. Effect on weed presence and crop-weed competition

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Key words: cover crop termination, weed management, roller crimper, competitive indexes, organic zucchini

Abstract

A field experiment was carried out in Southern Italy in growing zucchini (Cucurbita pepo L.) after vetch (Vicia sativa L.) combining three strategies of cover crop management (green manure, mulching by roller crimper and no vetch) with different organic materials (fertilizers and soil amendments) application.The main aim was the evaluation of the efficacy of different cover crop residue managements on weed control in vegetable organic cropping systems. At zucchini harvest, total above soil biomass for crop and weeds, competitive indexes and weed population composition were measured. The cover crop management influenced the above soil zucchini and weeds biomass. Similarly, Crop relative biomass index (RBc) and Competitive Balance Index (Cb) were affected by the vetch termination method. The application of different fertilisers and soil conditioners determined differences in the Relative Biomass Total index (RBT) values (being the compost with 1.59 t ha^{-1} the significantly higher value). The results obtained demonstrated that the use of alternative termination methods of cover crops combined with the application to soils of organic fertilisers/amendments having different mineralisation rates could be an effective approach to control weeds and reduce crops-weeds competition.

Introduction

Competition has an important role in both natural and agricultural plant communities, defining their composition and representing one of the main cause of crop yields reduction. The inclusion of cover crops within cropping systems can determine many different agronomic benefits (i.e. reduction of soil nutrient losses due to leaching and/or increase of in-field biodiversity). With respect to weeds, cover crops and cover crops residues have been reported to negatively affect germination and establishment of weed seeds, influencing in field weed incidence and composition. Especially in Mediterranean areas, the use of cover crops as green manure is a basic practice in organic agriculture. However, in the past decade, the no-till physical termination of cover crops by the roller–crimper has received increased attention (Ashford and Reeves 2003). The roller crimper is a cylinder with protruding fins that rotates on a lengthwise axis as it is drawn over the soil, crimping and crushing the cover crop to form a flat, uniform layer of mulch into which the agronomic crop is sown or transplanted. Therefore, the layer of mulch is able to give a strong protection against

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weeds, limiting their germination and growth (Davis *et al.* 2010). Crop-weed interaction and weed community dynamics can be also greatly influenced by crop fertilisation strategy. Since weeds are usually able to uptake nutrients more quickly and efficiently than crops at early growth stage, the rate of nutrients release of organic fertilizers and soil conditioners can influence the weed – crop competition (Barberi, 2002).

The present work had the aim to evaluate the effect of different termination methods (green manure and roller crimper) of vetch (*Vicia sativa L.)*, in combination with different organic fertilisers and soil conditioners application, on weed presence and dynamic in organic zucchini (*Cucurbita pepo* L.).

Materials and methods

The research was carried out at the experimental farm of the CRA-Research Unit for the Study of Cropping Systems (Metaponto - MT - Southern Italy; 40° 24' lat. N; 16° 48' long. E; 8 meters a.s.l.). The experimental design was a strip-plot with two factors and three replications. The first factor was vetch management and the following treatments were compared: (i) fallow (control), in which vetch was not cultivated and tilled before the zucchini planting (FA); (ii) green manure, in which vetch biomass was chopped and plough into soil (GM) and (iii) roller crimped, in which the vetch biomass was rolled crimped (RC) in order to obtain a soil mulching layer made of the vetch residues. Within each vetch residue management the application of the following organic materials (second factor) were tested: (i) organic fertilizer composed of animal manure (Org); (ii) anaerobic digestate based on wine distillery wastewater (WDD); (iii) composted municipal solid organic wastes from separate collection (SUW); and absence of fertilizer (N0). The vetch was sown (80 kg ha^{-1}) in the middle of November 2009 and at the first legume stage, it was simultaneously terminated in both the management treatments. The organic fertilisers and soil conditioners were applied to soil in one solution 20 days before transplanting of zucchini, at the rate of 100 kg N ha^{-1}. This dose, which was lower than the normal N fertilization for the crop, was defined taking into account the contribution of vetch biological N fixation. Zucchini was transplanted on the 6^{th} of June at 100 cm x 70 cm spacing. Stands for zucchini growing in absence of weeds and for weeds in absence of crop were set up to enable the determination of competitive indexes. Weed control was not carried out in any treatments. At 52 days after transplanting (harvest) the detection of weed species composition was made in elemental plots of 1 m x 0.7 m. The whole above soil biomass for each area was collected and divided in weeds, zucchini residues and yield. To determine the weeds-crop competition, the following competitive indexes were calculated: i) Crop relative biomass (RBc) and Relative Biomass Total (RBT), as a measure of the extent to which the components compete for limiting resources (Paolini *et al*., 2006); ii) Competitive Balance Index (C_b), as a measurement of competitive ability of the components in mixtures (Wilson, 1988). All data were subjected to ANOVA and means were compared by the Duncan Multiple Range Test (DMRT) at $P \leq 0.05$.Results

Zucchini and weed biomass productions are reported in tab. 1. Zucchini total above soil dry biomass showed differences between the vetch managements, with the highest and lowest values in FA and GM treatments, respectively. No differences were showed for fertiliser factor. In zucchini dry residue biomass the GM and the FA treatments showed the significantly highest and lowest values, respectively. Furthermore, for this parameter, not statistically significant difference was observed for the fertilizer-soil conditioner factor. As far as weed above soil dry biomass is concerned, FA and RC treatment showed similar results, while the GM treatment was significantly higher than the two other vetch management treatments. No differences were shown between fertilizer-soil conditioners treatments. Results about the fruit yield are available in the article by Leogrande et al. in the proceedings of this Congress.

Tab. 1: Zucchini and weed dry biomass at harvest

Treatment	Zucchini total above soil dry biomass (t ha^{-1})	Zucchini above soil dry residue biomass (t ha^{-1})	Weed above soil dry biomass (t ha^{-1})
Cover crop management			
FA	1.99 b	1.40 b	0.47 b
GM	3.29 a	2.33 a	1.43 a
RC	2.56 ab	1.76 ab	0.50 b
Fertilizer			
N0	2.37	1.70	0.48
WDD	2.90	2.02	0.72
SUW	2.21	2.01	0.88
Org	2.97	1.58	1.12
Means	2.61	1.83	0.80

FA = fallow; GM: green manure; RC: roller crimped.
N0= absence of fertilization; WDD=anaerobic digestate; SUW= compost; Org= organic fertilizer.
The mean values in each column followed by a different letter are significantly different according to DMRT (more than two comparison) at the $P \leq 0.05$ probability level.

In tab. 2, the competitive indexes are reported. The relative biomass for zucchini crop (RBc) was significantly higher in the RC in comparison to the other two vetch managements (FA and GM), which showed similar value. No difference were observed between the tested fertilizer and soil conditioners for this parameter. The mixture weed-crop relative biomass (RBT) didn't show statistical differences between the vetch management factor, even if RC was higher than FA and GM.

Tab.2: Competitive indexes

Treatment	RBc	RBT	C_b
Cover crop management			
FA	0.80 b	1.37	0.10 ab
GM	0.79 b	1.39	-0.15 b
RC	1.00 a	1.45	0.58 a
Fertilizer			
N0	0.81	1.26 b	0.54
WDD	0.86	1.35 ab	0.23
SUW	0.90	1.59 a	0.11
Org	0.89	1.43 ab	-0.16
Means	0.86	1.40	0.18

FA = fallow; GM: green manure; RC: roller crimped.
N0= absence of fertilization; WDD=anaerobic digestate; SUW= compost; Org= organic fertilizer.
RBc= crop relative biomass; RBT=mixture weed-crop relative biomass; C_b=competitive balance.
The mean values in each column followed by a different letter are significantly different according to DMRT (more than two comparison) at the $P \leq 0.05$ probability level. Among the fertilizers and soil conditioners, the SUW and N0 treatments showed significant differences,

whereas, for this parameter, the WDD and Org treatment presented intermediate, not statistically different values. Furthermore, the RC vetch management showed a statistical significant higher competitive ability (C_b) respect to the GM treatment, while FA did not show statistically different values respect the other two treatments. No statistical differences were observed for C_b among the fertilizers and soil conditioners treatments.

Discussion

The higher biomass values (tab.1) of zucchini and weed biomass in GM treatment was probably attributable to the increase of available soil N due to its release by the vetch residue decay during the zucchini cropping cycle. The intermediate value of zucchini residues in the RC treatment, could indicate a lower N availability for the zucchini crop respect to the GM because only the below soil vetch biomass was mineralised after the termination of cover crop (the above soil biomass remained above the soil surface as mulching - see also paper I, Leogrande *et al*.), Despite that, in the RC treatment, weed biomass showed lower values than the GM treatment and similar to the control (FA). This finding indicated that the vetch mulching layer was able to efficaciously control the weed germination and growth in the zucchini crop. The effectiveness of the RC treatment in controlling weeds was also demonstrated by the C_b index, which showed a significantly higher value (i.e. crop more competitive respect to the weeds) in RC than in GM. Similarly, the RBc index showed a significant lower reduction of zucchini total biomass in presence of weeds in RC than in GM and FA. The low RBT value of the N0 treatment could be due to the higher competition between the crop and the weeds, which took place in condition of limited resources (i.e. lower soil N availability).

Conclusions

The results of this research highlighted that in cropping systems for vegetables production, the use of alternative termination methods of cover crops combined with the application to soils of organic fertilisers/amendments having different mineralisation rates could be an effective approach to control weeds and reduce crops-weeds competition.

Acknowledgments

The present study was carried out in the frame of the Orweeds (Weed control in organic farming by indirect approaches) project, funded by the Italian Ministry of Agriculture (Action 2.2 of the National action plan for organic farming).

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Barley cover crop management for weed control in organic zucchini production

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Key words: weed control, cover crop management, roller crimper, barley, zucchini

Abstract

A field experiment was carried out in Central Italy (Mediterranean condition), growing zucchini (Cucurbita pepo L.) after barley (Hordeum vulgare L.).The main aim was the evaluation of the efficacy of different cover crop termination methods on weed control in vegetable organic cropping systems. The experimental design was a strip plot with two factors: barley termination (fallow as control, FA; green manure, GM and roller crimper, RC) and zucchini genotype (HF1 Dietary and HF1 Every). At zucchini harvest, yield, fruit size, weed above soil biomass and weed population composition were measured. Along the cropping cycle of zucchini, soil mineral N was monitored.
Results showed that marketable yield was similar between the FA (control) and the RC treatment, while the zucchini yield in the GM treatment was significantly lower than the two other barley management treatments. It was attributable to the reduction of available soil N due to N immobilization caused by the incorporation into the soil of the barley biomass as well as the competition for the nutritive element between the crop and the weed, which was particularly intense in the GM treatment respect the other ones. The Every yielded 38% more than the Dietary demonstrating that, in the organic cropping condition in which the experiment was carried out, the Every was more productive. Furthermore, termination by roller crimper was found to be more effective than green manure for weed control.

Introduction

During recent decades, the organic food and farming (OFF) sector has grown considerably in Europe and a great interest has been in particular directed to the capacity of organic vegetable production systems to provide safe, quality food, while preserving the environment and addressing the socio-cultural and economic requirements of farmers and society (European Commission, 2010).

Raviv (2010), in his recent review on sustainability of organic horticulture, reported that one of the major as-yet-unsolved problems of organic vegetable production is weed control. He also reported that tillage, utilised as a replacement for synthetic herbicides used in conventional agriculture, is the main weed control measure currently employed by organic growers.

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However, despite tillage (i.e. harrowing and hoeing) and other direct physical weed control methods (i.e. flaming) are considered effective and reliable approaches to weed control in the most of the pedo-climatic conditions in which organic vegetable production is performed, the sustainability of their use is a critical issue because of the large amount of auxiliary - not renewable, fossil origin - energy consumption and their negative effects on soil quality (Barberi, 2002; Raviv, 2010).

On the other hand, preventive methods for weed management, based on agroecologically sound approaches as proper rotation designing and/or use of cover crops, have no negative effects and a great potential for playing a primary role in weed control in the organic vegetable production systems.

This is the case of cover crops, which are often utilised in vegetable cropping systems as green manure and are introduced in the rotation with the main aim of increasing soil organic matter content and/or nutritive elements availability to crops. Furthermore, cover crops, if properly managed (i.e. terminated by a roller crimper) could play a relevant role in weed control (Davis, 2010).

Thus, the present research was addressed to evaluate the effect of different cover crop termination methods on weed control in organically managed vegetable production systems. In more detail, this study was aimed to compare the effect of barley green manure and barley roller crimped on weed control in organic zucchini cultivated in Central Italy.

Materials and methods

The research was carried out in the MOnsapolo VEgetal (MOVE) long term experiment, located at the Vegetable Research Unit of the Research Council for Agriculture (CRA-ORA) in Monsampolo del Tronto (AP), (latitude 42° 53' N, longitude 13° 48' E), along the coastal area of the Marche Region, Central Italy. The climate at the site of the MOVE long term experiment is "thermomediterranean", as classified by UNESCO-FAO (1960) and the soil is *Typic Calcixerepts* fine-loamy, mixed thermic, according to the USDA Soil taxonomy.

In a strip plot factorial experimental design with two factors and three replicates, Zucchini (*Cucurbita pepo L*.) was grown after barley (*Hordeum vulgare L*.) utilized as cover crop. The first factor was barley management and the following treatments were compared: (i) FA: fallow (control), in which barley was not cultivated and tilled before the zucchini planting; (ii) GM: green manure, in which the barley biomass was chopped and ploughed into soil and (iii) RC; roller crimped, in which the barley biomass was rolled crimped in order to obtain a soil mulching layer made of the barley residues. The second factor was the zucchini genotype and two different F1 hybrids (*Every and Dietary*) were compared. After the barley termination, zucchini was transplanted on the 10th of May 2010. Zucchini harvest started 35 days after transplanting (DAT) and ended at 84 DAT; fruits were collected in accordance to fruit ripening. Total yield was then calculated as the sum of the different harvests; marketable and not – marketable yield were evaluated according to the local market standards. Marketable fruit size was measured, as well.

At the end of the zucchini harvest, above soil weed biomass and weed species were determined for each treatment. Furthermore, soil mineral N was measured in soil samples collected along the zucchini cropping cycle, at 28, 43, 72 and 127 DAT.

Results

Yield and product quality of zucchini are reported in tab. 1. Marketable yield was similar between the FA and the RC treatment, while the GM treatment was significantly lower than the two other barley management treatments.

Tab. 1. Yield and product quality of zucchini.

	Marketable yield (t ha^{-1})	Not marketable yield (t ha^{-1})	Marketable fruit size (g $fruit^{-1}$)
Cover crop management			
FA (control)	37.25 a	1.75 a	228
GM	20.92 b	0.33 b	221
RC	35.25 a	0.65 b	218
Genotype			
Dietary	26.17 b	1.08	215 b
Every	36.09 a	0.75	229 a
Means	31.13	0.91	222

Note:
FA = fallow; GM: green manure; RC: roller crimped.
The mean values in each column followed by a different letter are significantly different according to LSD and DMRT (two and more than two comparison. respectively) at the $P \leq 0.05$ probability level.

Not marketable yield was significantly higher in the FA compared with the GM and the RC treatments. Furthermore, no difference was observed for the marketable fruit size for the barley management factor. The Every hybrid yielded 38% more than the Dietary and had a higher average marketable fruit size, as well. No significant difference was observed for the not marketable yield between the two genotypes.

Above soil weed biomass (tab. 2) was significantly lower in the RC in comparison to the other two barley management treatments (FA and GM), which showed not significantly different values between them, even if the GM weed biomass was lower than FA. No difference was observed between the two tested genotypes for this parameter.

As far as weed population composition is concerned, no differences were observed among the treatments at zucchini harvest (results not showed).

Discussion

As far as the genotype is concerned, the results obtained demonstrated that the Every is more productive than Dietary, at least in the organic cropping condition in which the experiment was carried out.

The significant lower yield measured in the GM treatment was probably attributable to the reduction of available soil N due to N immobilization caused by the incorporation into the soil of the barley biomass (results not showed) as well as the competition for the nutritive element between the crop and the weed. In fact, the weed presence in the GM treatment showed similar values than the control treatment indicating that the green manure management did not contribute to control weeds (tab. 2).

Tab. 2: Weed presence at zucchini harvest.

	Above soil weed biomass (t ha^{-1})
Cover crop management	
FA (control)	5.13 a
GM	3.85 a
RC	0.72 b
Genotype	
Dietary	2.76
Every	3.71
Mean	3.23

Note:
FA = fallow; GM: green manure; RC: roller crimped.
The mean values in each column followed by a different letter are significantly different according to LSD and DMRT (two and more than two comparison. respectively) at the P ≤ 0.05 probability level.

Results regarding the above soil weed biomass and weed population composition demonstrated that the use of the roller crimping technique for barley termination allowed an effective weed control. On the other hand, the obtained outcomes showed that the management of barley by green manuring (which is the most widespread technique for cover crop management in organic horticulture) did not determin an acceptable weed control in the following zucchini crop.

Conclusions

Including cover crops within cropping systems can create a variety of agronomic benefits, including improved soil structure, reduced soil nutrient losses due to leaching, and suppression of weeds. However, the method by which cover crops are terminated is critical respect to their efficacy for weed control (Davis, 2010). Termination by roller crimper was found to be more effective than green manure for weed control in zucchini and it is likely that this approach is successfully applicable to a number of different vegetable crops. Furthermore, the roller crimper technique to terminate cover crop should be considered a high sustainable approach to weed control in organic vegetable farming system because the low energy consumption and the absence of negative effects on soil quality.

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Organic no-till agriculture in Western Canada

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Key words: no-till, organic agriculture, weed control, roller-crimper, green manure

Abstract

Weed control is rated one of the top challenges faced by Canadian organic growers.Organic farmers rely on mechanical practices to control weeds, such as tillage, as the use of chemical herbicides is restricted in organic production. However, frequent tillage leads to soil degradation and environmental pollution, and it requires fossil fuel energy. Our research team has been exploring ways of reducing tillage in organic fields. The research project examined the implementation of no-tillage practices in organic production systems in the Canadian Prairies. In 2008, we initiated a long-term tillage versus rolled (no-till) experiment in Carman, Manitoba, Canada. The green manure crop was rolled in late-summer in order to produce a thick mulch to suppress weeds. The following spring, flax was directly seeded into the green manure residues (mulch). In spring 2009, we seeded into a mulch of 4.5 t dry biomass ha^{-1}, whereas in spring 2010, we seeded into 7.6 t dry biomass ha^{-1}. In 2009, flax yields in the tilled systems (2264 kg ha^{-1}) were significantly higher than in the rolled treatment (1983 kg ha^{-1}). However in 2010, flax yield in the rolled treatment (1804 kg ha^{-1}) was higher than in the tilled treatment (1134 kg ha^{-1}). Mulches of barley-hairy vetch were found to be efficient in suppressing weeds when the mulch produced high biomass.

Introduction

Weed control is rated one of the greatest challenges faced by Canadian organic growers (OACC 2009). Canadian organic farmers rely on mechanical practices to control weeds, such as tillage, as the use of chemical herbicides is restricted in organic production. However, frequent tillage on organic farms leads to soil degradation, environmental pollution, and fossil fuel dependency (Zentner *et al*. 2004).

One way to reduce tillage on organic farms without using herbicides is to integrate the use of mulches in the cropping system. The mulch farming system has been widely used by Brazilian no-till farmers for over three decades (Bernoux *et al*. 2009). The mulch plays various roles in the cropping system, including water retention, weed suppression, and reduction of synthetic pesticide use. The mulch production systems may be an option for Canadian organic farmers interested in reducing tillage on their

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farms. In Western Canada, roller-crimpers have been used as an alternative to chemical herbicides to terminate a green manure crop. The rolling action crimps the plant stem, leaving a mulch on the soil surface, thereby eliminating the need for tillage to terminate the crop.

The objective of the study is to examine the feasibility of implementing no-till practices in organic grain production systems in Western Canada. Moreover, we want to assess the ability of a mixture of barley and hairy vetch to produce mulch and its impact on subsequent crop productivity. No tillage is needed when the roller-crimper is used to terminate the green manure.

Materials and methods

The use of a roller-crimper has been tested at the Organic Crops Field Laboratory, in Carman, Manitoba, Canada, since 2007. The experiments were conducted on an Orthic Black Chernozem soil with a fine sandy loam texture.

In 2008, we initiated a long-term experiment (experiment 1) looking at till vs. no-till under both organic and conventional management in Carman, Manitoba. Experiment 1 is divided in a split-plot design, with 4 blocks. The main plot is the tillage system, with 2 levels: no-till and tilled. The sub-plot is the management system, with 2 levels: organic and conventional. Each of the 16 experimental units was 4 m wide by 30 m long.

In 2009, we established a second experiment (experiment 2) looking at till vs. no-till under organic management, and this exact same experiment was replicated on another plot in 2010 (experiment 3). Both experiments 2 and 3 are randomized complete block design with 4 blocks. The main factor of interest is the method of termination of the green manure, and its 3 levels are rolled, tilled, and one cut of hay then tilled. Each of the 12 experimental units was 8 m by 8 m.

The crop rotation consisted of green manure (barley, hairy vetch)-flax-oat-green manure-wheat (Table 1). In year 1 of the crop rotation, the green manure of hairy vetch (*Vicia villosa*) and barley (*Hordeum vulgare*) was rolled in July, in order to produce a thick mulch to suppress weeds for the rest of the season and for the subsequent growing season. In year 2, flax (*Linum usitatissimum*) was directly seeded into the green manure mulch. In year 3, oats (*Avena sativa*) were directly seeded into the flax residues and the left over mulch from the green manure grown in year 1.

Table 1: Crop rotation plan for the three experiments from 2008 to 2012.[1]

	2008	2009	2010	2011	2012
Experiment 1	Barley and hairy vetch (Y1)	Flax (Y2)	Oats (Y3)	Barley and hairy vetch (Y4)	Wheat (Y5)
Experiment 2	-	Barley and hairy vetch (Y1)	Flax (Y2)	Oats (Y3)	Green manure (Y4)
Experiment 3	-	-	Barley and hairy vetch (Y1)	Flax (Y2)	Oats (Y3)

1 Y*n*: Year *n* of the rotation.

Mulch biomass was estimated in spring prior to planting by collecting aboveground dead fallen or standing plant material in two quadrats (0.5 m by 0.5 m) by experimental unit. Crop yield of flax was measured by harvesting the grain yield of two quadrats (1 m by 1 m) per experimental unit. Weed biomass at harvest was estimated by collecting weeds in two quadrats (0.5 m by 0.5 m) per experiment unit, at the day of harvest.

Statistical analyses were conducted using Statistical Analysis System 9.2 (SAS). To compare the effects of tillage system and management system on crop yield, analysis of variance was conducted using the MIXED procedure of SAS. Block was considered a random factor. Means were separated using the Least Square Difference test. All data were verified for normality or residuals, constant variance and independence.

Results

Green manure biomass production and crop yield:

In spring 2009 (experiment 1), we seeded flax into a mulch of 4.5 t dry biomass ha^{-1}, whereas in spring 2010 (experiment 2), we seeded flax into a mulch of 7.6 t dry biomass ha^{-1}.

In 2009 (experiment 1), flax yields in the tilled systems (2264 kg ha^{-1}) were significantly higher than in the rolled treatment (1983 kg ha^{-1}) (Fig.1). However in 2010 (experiment 2), flax yield in the rolled treatment (1804 kg ha^{-1}) was much higher than in the tilled treatment (1134 kg ha^{-1}).

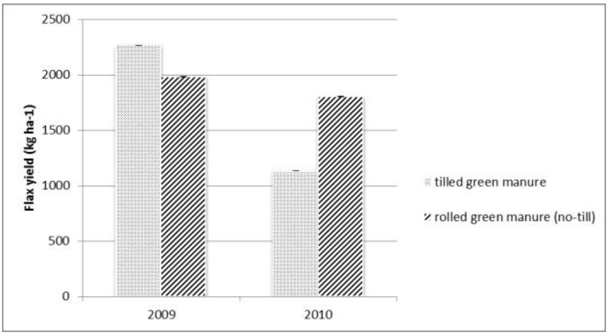

Figure 1: Flax yields in tilled and no-till organic systems.

Weed biomass at harvest and subsequent crop productivity in reduced mulch:

In 2010 (experiment 2), weed biomass at harvest in the flax field was higher in the tilled treatment (0.40 kg m^{-2}) than in the rolled treatment (0.18 kg m^{-2}).

In May 2010 (experiment 1), the mulch was not very effective in controlling weeds in the no-till oats, as there were only 2.8 t ha^{-1} mulch biomass left on the soil surface.

Discussion

In 2009 (experiment 1), the thin mulch was not effective in suppressing weeds, resulting in a flax yield penalty in the no-till treatment. However, in 2010 (experiment

2), a thicker mulch was found to be effective in suppressing weeds in the no-till treatment (Fig.1). Overall, mulches of barley-hairy vetch were found to be efficient in suppressing weeds when the mulch produced high biomass.

The 6-year yield average of tilled organic flax in our Organic Crops Field Laboratory, in Carman, Manitoba, Canada, was 1192 kg ha^{-1} (Entz 2010). No-till flax in our experiments 1 and 2 yielded more than our 6-year yield average of tilled flax. Hence, no-tillage practices are promising in Western Canada, and there is a need for further research on rolled green manure and its affect on subsequent crops.

Conclusions

Continuous no-till in organic farming in Western Canada is definitely a challenge in terms of control of weeds and crop yield, although preliminary results from field experiments in 2009 and 2010 suggest that thick mulches have the ability to suppress weeds in mulch production system in Western Canada, threby reducing the need for tillage or herbicides.

The three experiments described above will continue until 2012. Further grain, plant and soil analyses will be performed in 2010 and 2011, and results from a third growing season will be collected in summer 2011. Various mixtures of green manures will be tested in 2011 in order to select plant species that could produce mulches of high biomass with a slow decomposition rate. Future research will examine effects of tillage systems on soil biota, mycorrhizal colonization, soil aggregate stability and crop residue decomposition.

Acknowledgments

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Identification of key factors for reducing N and P leaching from organic crop rotations

Neumann, A.[1], Torstensson, G.[1] & Aronsson, H.[1]

Key words: Nitrogen, phosphorus, leaching, crop rotation, catch crops

Abstract

Leaching of nitrogen (N) and phosphorus (P) for different 6-year organic crop rotations was examined in separately tile-drained field plots on two different sites in southwest Sweden. On each site, two different farming systems, one with dairy cows and one without stock, were evaluated to identify parts of the crop rotations with the greatest risks of N and P leaching and to examine the scope for improvement. Although organic farming methods themselves already led to a reduction in nutrient leaching, critical periods in the crop rotation could nevertheless be identified for the two soil types. While P leaching is of major importance on clay soils, sandy soils are strongly susceptible to N leaching. From the present study it could be concluded, that key factors for reducing N and P leaching from clay soils are late ploughing, avoidance of early incorporation of clover-grass leys in order to sow a winter cereal, the use of undersown crops and an even distribution of nutrients within the crop rotation. For the sandy soil, where measures like undersown crops and spring tillage were already integrated in the studied crop rotation, potato cultivation and application of farmyard manure were identified as the main sources of N losses to the drainage water.

Introduction

The Baltic Sea is exposed to high nutrient loads, leading to severe outbreaks of algal bloom. Nitrogen (N) and especially phosphorus (P) are the sources of this eutrophication and agricultural activities are substantially responsible for a large share of these nutrients to the sea. In Sweden, 47% of the total N and 40% of the total P load to the Baltic Sea are estimated to come from agricultural land. Leaching is the main source for these nutrient losses as in Sweden surface runoff is not a significant factor. Organic agriculture, with its reductions in animal density and use of fertilizers, offers a form of agricultural land use which may make it possible to reach the intended reductions of non-point pollution from agricultural land as defined in international agreements such as the Water Framework Directive and the Baltic Sea Action Plan. However, some components of organic crop rotations are subject to considerable nutrient leaching. For example, clover-grass leys (CG), which are a central component of organic crop rotations in order to supply the system with N, need to be incorporated into the soil and this incorporation has often been reported to cause a high release of mineral N in the soil (e.g. Lindén & Wallgren 1993). Preliminary observations indicate that the incorporation of CG might also be a critical stage for P leaching (Ulén *et al.* 2005). On the other hand, N leaching during the growth of CG has been shown to be low and the same seems to be true for P losses (Ulén *et al.* 2005). Therefore, whole crop rotations instead of just single components need to be considered when studying nutrient losses from organically managed farmland to the water. Currently, Sweden is

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one of the EU-27 countries with the highest percentage of organic farming (12.5% of the total arable land), a share which is still increasing. This shows the importance of taking this farming method into account when trying to identify key factors for reducing nutrient leaching from agricultural land. It was therefore the aim of the present study to monitor N and P losses from organic crop rotations with and without livestock and to figure out, which parts of the crop rotation are most exposed to leaching risks and have to be improved. The study uses observed data for the amounts of N and P in drainage water from different organic crop rotations at two sites with different soil types in southwest Sweden.

Materials and methods

The two sites used for the present study represent two common soil types used for agricultural production in Sweden: (1) a clay soil and (2) a sandy loam (Figure 1). On both sites, independently tile-drained plots with a surface area of 0.16ha (40x40m) and drainage pipes at an average depth of 1m were used to collect drainage water for analyses for tot-N and tot-P. Crop biomass was sampled, dried at 50°C and analyzed for N and P content.

(1) Lanna, 58°21'N, 13°08'E;
Ø annual temperature 6.1°C,
Ø annual precipitation 558mm;
Uderic Haploboroll; **clay**/silt/sand/gravel
47/46/6/1 (0-30cm), 56/41/3/0 (30-60cm)

(2) Mellby, 56°29'N, 13°0'E;
Ø annual temperature 7.2°C,
Ø annual precipitation 803mm;
Fluventic Haplumbrept; clay/silt/**sand**/gravel
9/14/**77**/0 (0-30cm), 2/7/91/0 (30-60cm)

Figure 1: Map of south Sweden with the sites and soils used in the study

The 6-year crop rotations, representing organic crop production with livestock (+L) and without livestock (-L) are described below. Vegetation covers during the winter are given in brackets. The abbreviation BF stands for bare fallow.

(1) clay: +L: **1**=winter wheat (BF), **2**=broad bean (BF), **3**=spring barley (BF), **4**=oat (insown CG), **5**=CG (CG), **6**=CG (freshly sown winter wheat)

-L: **1**=winter wheat (BF), **2**=broad bean (BF), **3**=oat (insown CG), **4**=CG (BF), **5**=spring wheat (insown CG), **6**=CG (freshly sown winter wheat)

(2) sand: +L: **1**=oat (insown ryegrass), **2**=oat-mixture (insown ryegrass), **3**=potato (freshly sown rye), **4**=spring barley (insown CG), **5**=CG (CG), **6**=CG (freshly sown oil seed rape)

-L: **1**=oat (insown CG), **2**=CG (CG), **3**=potato (freshly sown rye), **4**=rye (insown CG), **5**=CG (CG), **6**=spring wheat (insown CG)

Although crop rotations were designed including as many catch crops as possible growing during the winter, bare fallow after autumn ploughing appeared 3x in the crop rotations on the clay soil. This was because spring ploughing is not practical on this site. There was no autumn ploughing on the sandy soil, with one exception in +L, where CG was incorporated in late summer before the sowing of oil seed rape.

In order to take the effect of year into account, the same components of the crop rotation were grown in different years. This means that each of the 6-year crop rotations circulated on six field plots with two replicates, so that three of the crops in the rotations were present every year. CG was cut 2-4 times in each crop rotation. However, while biomass was left on the field in –L, it was removed for forage production in +L and returned as slurry (return of nutrients: clay 295/42 and sand 426/70 kg N/P ha^{-1} over the 6-year crop rotation).

Results

The sandy soil showed higher leaching of N to the drainage system than the clay soil, while for P leaching the opposite was the case (Figure 2). Mean annual N leaching loads were 6.8 and 9.1 kg ha^{-1} (clay) and 32.1 and 23.7 kg ha^{-1} (sand) for +L and –L, respectively. For P leaching the values were 0.39 and 0.55 kg ha^{-1} (clay) and 0.20 and 0.15 kg ha^{-1} (sand). For both N and P, the +L crop rotation showed significantly lower leaching compared to the –L crop rotation. On sandy soil the opposite was the case for N and no significant difference between the farming systems was found for P.

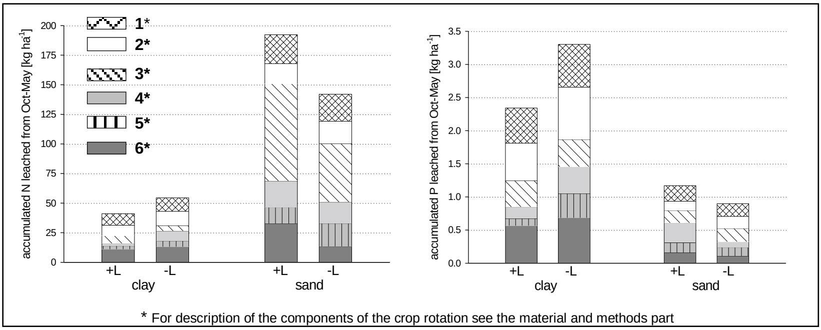

Figure 2: Amounts of N and P leached (October till May) from the different 6-year crop rotations (+L, -L) on clay soil and sandy loam

On the clay soil, the drainage periods during the growth of freshly sown winter wheat (**6**), BF after winter wheat (**1**) and BF after broad bean (**2**) were most exposed to N and P leaching (Figure 2). On the sandy soil, the drainage periods with freshly sown rye after potatoes (**3**) and freshly sown oil seed rape after incorporation of CG (+L: **6**) showed the highest N leaching, while for P leaching no difference between the components of the crop rotation was determined. N losses through leaching after potatoes corresponded to 164% (+L) and 82% (-L) of the harvested amount of N.

Discussion and conclusions

In a national survey for 2005 the estimated yearly nutrient losses from agricultural land in the studied areas were on average 25.0 and 46.6 kg N/ha and 0.56 and 0.65 kg P/ha for the clay soil site and the sandy soil site, respectively (SwEPA 2005). The lower leaching losses from the present study indicate that organic farming methods may lead to below average nutrient leaching. However, the results also show that some components in the crop rotation are more susceptible to nutrient leaching than others. Two conclusions are that there is room for improvement with respect to crop rotations and that different soils require different measures.

On clay soils, choosing a late date for ploughing/incorporation of CG seems to be an important measure to reduce N and P leaching, which in turn means that winter cereals are not suitable after CG incorporation. Lower nutrient losses in the +L crop rotation compared to the –L crop rotation indicate that effective measures to reduce nutrient losses include (i) allowing for only one CG incorporation through the use of biennial CG and (ii) distributing nutrients more evenly within the crop rotation by removing CG biomass and returning the nutrients in the form of manure. Stinner *et al.* (2008) reported that the positive effect of (ii) could also be reached when harvested CG material was digested in a biogas digester and digestion effluents were used as a fertiliser within the crop rotation. This could therefore be a possibility for stockless organic farms on clay soils to increase N use efficiency and reduce N losses. Phosphorus losses were highest after broad beans. This may be due to the tap root system of the beans leading to an increase in the occurrence of macropores. Undersown CG could be a possible countermeasure for reducing these losses, as the present study shows that on clay soils, CG is not only a useful catch crop for N but also for P.

On sandy soils, phosphorus leaching is less severe and as a result measures can target the reduction of nitrogen leaching. One key factor is the reduction of the residual soil N content and this is why undersown crops, catch crops and spring tillage were included in the studied crop rotations. However, the drainage periods after potatoes showed very high N losses even though rye was sown 3-4 weeks after the potato harvest. Reents & Möller (1999) found that sowing a winter cereal immediately after potato harvest can be more effective in reducing residual soil N than sowing it a few weeks later. Haas (2002) suggested undersown crops in potatoes as a useful measure to reduce residual soil N. However, as potato will always be a critical crop in terms of nitrogen leaching on sandy soils, other measures suitable for organic farming methods, for example the use of N efficient potato varieties (Shreshta *et al.* 2010), should also be taken into account. From the +L crop rotation can be seen, that incorporation of CG in early autumn in order to establish a new crop should be avoided. Higher N leaching from the +L crop rotation additionally highlight the importance of N management and cautious farmyard manure application on sandy soil.

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Herbs in high producing organic grasslands – effect of management

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Key words: Herbs, grasslands, herbage quality, caraway, chicory

Abstract

In many organic grasslands herbs are established due to their expected beneficial properties for nutritive value and biodiversity. However, knowledge about grassland herbs is limited. Three mixtures were therefore established at different grazing/cutting and fertilization managements to examine the growth potential and feeding value. The competitiveness of the different species varied greatly. Chicory, plantain and caraway were competitive in mixtures with traditional grassland species. Lotus and salad burnet were weak competitors and chervil and sainfoin were very weak. The feeding value was also highly variable. Caraway had high digestibility of organic matter, also compared with the traditional grassland species, whereas plantain and salad burnet had lowest digestibility. The management, grazing, cutting, slurry and sward age, affected the proportion of the herb species. The proportion of caraway increased at cutting, slurry application and sward age. The proportion of plantain also increased at cutting but decreased at slurry application and sward age. The proportion of chicory increased with slurry application and decreased with sward age independently of cutting/grazing. The experiment showed that inclusion of herbs in the sward increased the biodiversity, made the herbage mass more diverse without affecting the dry matter yield.

Introduction

On Danish organic dairy farms, herbs are often sown together with grass/clover – broadcast or strip sown. Diverse swards increase ecosystem services and sustainability (Tilman et al., 1996), but the amount of herbs in the sward is often limited (Smidt & Brimer, 2005). The expectations are that herbs contribute to greater biodiversity, better drought tolerance, higher N utilization in the cow, higher mineral content, reduced parasitism, and a positive effect on the milk and meat quality. However, knowledge about herbs in intensively managed swards is very limited. An experiment was therefore established to examine the growth potential and feeding value.

Materials and methods

The study was carried out in an organic dairy cattle crop-rotation system on loamy sand running since 1987 at Research Centre Foulum in Denmark (9°34’59 E, 56°29’22 N). Three seed mixtures were established by undersowning spring barley (*Hordeum vulgare*) in 2006, 2007 and 2008 and were composed of: mix-1) perennial ryegrass (*Lolium perenne*), white clover (*Trifolium repens*) and red clover (*Trifolium*

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pratense), mix-2) mix-1 together with herbs (chicory (*Cichorium intybus*), long-leaved plantain (*Plantago lanceolata*), caraway *(Carum carvi)*, lotus/birds foot trefoil (*Lotus coniculatus*), salad burnet (*Poterium sanguisorba*), sainfoin (*Onobrychis viciifolia*) and chervil (*Anthriscus cerefolium*)) and mix-3) mix-2 together with festulolium (*Festulolium braunii*) and lucerne (*Medicargo sativa*). The seeds were sown at 0-1 cm depth at a rate of 26 kg ha^{-1}. The seed rate of the single species is shown in Table 1. In 2007-2009 the sward was either grazed continuously by heifers or cut four times. In 2007 there was only 1–year-old sward, in 2008 1- and 2-year-old, and in 2009 1-, 2- and 3-year-old swards. Further there were two application levels of cattle slurry: 0 and 200 kg total N ha^{-1}. There were two replicates. During the spring growth and 2^{nd} regrowth, parts of the grazed plots were fenced off and harvested at the same time as the cut plots. The botanical composition at cut 1 and 3 was determined by hand separation of subsamples. Herbage quality at cut 1 and 3 was determined in the single species of mix-3; in vitro organic matter digestibility (IVOMD) (Tilley & Terry, 1963), fibres (NDF and ADL; van Soest), and N (Dumas).

Results and discussion

The three mixtures represent a standard mixture for cutting and grazing (mix-1), a mixture including herbs (mix-2), and a mixture also including festulolium and lucerne with the aim to increase the persistence (mix-3). The annual dry matter (DM) yield of mix-1 and mix-2 was not significantly different, with an average in 2007-2009 of 12.2 and 12.5 t/ha, respectively. The yield of mix-3 was higher, 13.2 t/ha (P<0.0001), and the difference between mix-3 and the two others increased with age.

Tab. 1: Seed rate and botanical composition of the three mixtures. Mean of age and fertilization

	Seed rate			Grazing			Cutting		
Species	1	2	3	mix-1	mix-2	mix-3	mix-1	mix-2	mix-3
	% of total weight			% of herbage dry matter					
Festulolium			31						
P. ryegrass	82	66	28	54.8a	47.6ab	48.9ab	43.3b	24.4c	29.4c
W. clover	14	12	5	23.5a	17.5bc	16.1bc	19.8ab	14.4c	8.8d
R. clover	4	3	1	20.3b	16.9bc	12.0c	35.8a	32.3a	12.5c
Lucerne			15			3.5b			28.7a
Chicory		3	3		7.1ab	7.9a		7.9a	5.6b
Plantain		3	3		7.6bc	7.1c		14.1a	10.2b
Caraway		3	3		2.1b	2.4b		5.4a	3.4ab
Lotus		2	2		0.5b	1.0a		0.8ab	0.5b
S. burnet		3	3		0.3	0.3		0.3	0.4
Chervil		2	2		0	0		0	0
Sainfoin		3	3		0	0		0	0

P. ryegrass in mixture 3 include festulolium

Different letters within rows indicate significant difference (P<0.05)

Chervil and sainfoin did not establish as they were out-competed during the establishing year, and they do not appear to be useful in highly productive multispecies grasslands. Chicory, plantain and caraway were the herb species with the highest competiveness (Table 1). Lotus and salad burnet had a low competitiveness. The heifers grazed all species with the exception of the inflorescence of plantain.

The proportion of herbs in the herbage was higher under cutting than grazing; on average 29 and 18 % of DM respectively. In grazed plots the inclusion of herbs in the sward decreased both the proportion of grass and clover (mix-2 compared with mix-1, Table 1). However, in cut plots the herbs mostly decreased the proportion of grass, which is surprising, as the habit of the herbs is more like clover than grass. Under grazing there was only a small proportion of lucerne in mix-3, which partially may be due to the choice of a variety for cutting (Pondus). In grazed plots there were nearly no differences in the proportion of the herbs in mix-2 and mix-3, indicating that festulolium did not affect the competitiveness of the grass. Festulolium is otherwise known to be a tougher competitor than perennial ryegrass, but this seems not to be the case under grazing. Under cutting there was a high proportion of lucerne in mix-3, especially at the expense of red clover, which more or less has a habit similar to lucerne, but also the proportion of the herbs, especially plantain decreased.

Under grazing the proportion of grass and white clover increased and the proportion of red clover decreased compared to cutting. Plantain and caraway decreased under grazing whereas chicory, lotus and burnet were not affected by cutting/grazing management (Table 1).

The competitiveness of the herbs was also affected by sward age (Table 2). The plantain proportion dramatically decreased with sward age, whereas caraway increased significantly especially in spring growth, where it constituted up to 30 % of herbage dry matter (data not shown). The proportion of chicory and caraway increased by slurry application, whereas the proportion of plantain decreased.

Tab. 2: Proportion (% of DM) of the main herbs in relation to sward age (years) and slurry application, respectively. Chicory (Cc), Plantain (Pt) and caraway (Cw)

Age	Cc	Pt	Cw		Slurry	Cc	Pt	Cw
1	8.6	19.0a	1.4b		0 N	6.7b	14.5a	3.4b
2	9.0	8.3b	6.4a		200 N	10.1a	12.0b	5.2a
3	6.7	6.0b	8.9a					

Different letters within columns indicate significant differences (P<0.05)

Herbage quality varied significantly between the herb species. In vitro organic matter digestibility (IVOMD) of caraway was high in spring growth and it maintained a high digestibility during the growing season (Table 3). IVOMD of all other herbs were lowest in midsummer, as it is the case for the traditional grassland species, when temperature is highest. The lignin (ADL) content was relatively low in caraway. The digestibility and cell wall composition of chicory was more or less comparable with red and white clover. Plantain and lotus were comparable with lucerne, the cell wall content (NDF) in lotus was however lower. Salad burnet was only present in the first part of the growing season every year, and the digestibility was rather low. Sanderson et al. (2003) reported nearly the same nutritive value of plantain and chicory in monoculture and thus did not confirm the shown results. The leguminous species had especially in spring a higher content of crude protein (CP) than the non leguminous species. In summer growth this difference was reduced.

Tab. 3: Herbage quality of the single species in spring growth and 2nd regrowth. Mean of years. In vitro organic matter digestibility (IVOMD), neutral detergent fibre (NDF), lignin (ADL) and crude protein (CP).

	Spring				Summer			
Species	IVOMD	NDF	ADL	CP	IVOMD	NDF	ADL	CP
	% of OM	% of DM			% of OM	% of DM		
Grass	83.1a	42.5a	1.8f	8.8e	74.3b	51.7a	2.5f	17.7d
W. clover	81.5b	21.9f	2.6d	21.3ab	73.2b	30.4e	4.9c	23.5a
R. clover	79.0c	26.5d	2.4de	19.3c	70.4c	34.2d	3.9d	19.3c
Lucerne	71.2e	34.0b	4.8b	20.4b	62.9d	40.2c	6.6ab	21.3b
Chicory	84.2a	23.5e	2.2e	10.5d	68.4c	35.2d	3.8d	13.4f
Plantain	72.8d	33.8b	5.5a	10.3d	57.5e	46.6b	6.5b	11.8g
Caraway	83.3a	27.7d	2.6d	10.0d	81.7a	23.6e	3.0e	16.1e
Lotus	73.0d	26.7d	4.4bc	22.1a	63.0d	36.4d	7.1a	21.1b
S. burnet	61.0f	30.1c	3.9c	9.7d	-	-	-	-

Different letters within column indicate significant difference ($P<0.05$)

The herbage quality of the whole sward with calculation based on results in table 1 and 3 showed that mix-1 had the highest IVOMD, lowest NDF and ADL and lower CP. Mix-1 had thus the highest feeding value with traditional calculation of feeding value. But as the feeding value of the single herb species varied highly, the effect of herbs will depend of the species composition. In this experiment the proportion of caraway increased significantly and the proportion of plantain decreased much with increasing sward age. This affected the feeding value, as caraway had a high and plantain a low feeding value.

Conclusions

Multispecies and highly productive grasslands can be established by broadcasting seed mixtures. The best competitors were chicory, plantain and caraway of the herb species in this experiment. The herb species varied strongly with respect to growth, competitiveness and herbage quality and to the effect of different management. The effect on the total herbage therefore strongly depended on the herb species.

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Seasonal changes in nitrogen fixation in legumes and effect of root-deposited nitrogen on nitrogen uptake of the succeeding crop

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Key words: N_2 fixation, Root-deposited nitrogen, *Crotalaria spectabilis, Sesbania rostrata*.

Abstract

Green manure legumes having potentials of biological N_2 fixation can increase soil nitrogen level, when they are incorporated into the soil. The objective of this study was to investigate N benefits from belowground parts of C. spectabilis and S. rostrata in the succeeding crop grown immediately after incorporation. Two plants were grown in the pot, and shoots and roots were mixed separately or together into the soil. After incorporation of the two plants, seeds of tendergreen mustard plants were sown in the pots. The value of nitrogenase activity of the two plants increased from late-July to mid-August, and then drastically declined. On September 30, the value of stem nodules in S. rostrata were maintained at higher level. In C. spectabilis, total N content of succeeding crop grown in the R pots attained 30-45% compared to the S+R pots and the N recovery rates were definitely higher in the R pots than in the S+R pots. In S. rostrata, on the other hand, because activity of N_2 fixation in shoot was high level, the N recovery rates of succeeding crop were definitely higher in the S+R pots than in the R pots.

Introduction

Several tropical legumes such as *Crotalaria* and *Sesbania*, which play an important role in reducing mineral N fertilizer demand, are used as green manures in temperate regions. In order to improve soil fertility and maintain the sustainability, these N_2-fixing legumes should be more used in agricultural systems (Becker & Johnson 1999). The flow of N from green manure to the succeeding crops mainly occurs through the great amount of N in the aboveground parts of these legumes, and much of the N would be provided after decomposition of the aboveground parts. After incorporation of the legumes as green manure, N is released not only from the aboveground parts, N releasing after incorporation of the green manure also occurs through the decomposition of the belowground parts of the legumes. In addition to being mineralized by decomposition of roots and nodules, their debris is also the main source of N for the succeeding crops in the long-term N flow. The amounts of nitrogenous compounds released from legume root systems increase immediately after cutting the shoots, and the nitrogenous compounds would be then uptaken by the associated grasses (Osman & Diek 1982). N release via exudates from the root systems with active root nodules showing higher nitrogenase activity might also play important roles in short-term N flow even in the green manure incorporation. The objective of the present study is to investigate N benefits from belowground parts of *C.*

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spectabilis and *S. rostrata* in the succeeding tendergreen mustard plants grown immediately after incorporation.

Materials and methods

Crotalaria spectabilis and *Sesbania rostrata* were grown in 1/2000a Wagner pot containing 1:2 mixture of vermiculite and Acadamatuti that is subsoil of Andosol. They were sown in the pots on June 20, 2006. Rhizobial suspensions (OD_{620}: 0.2) were prepared from cultures of *Bradyrhizobium* sp. for *C. spectabilis* and *Azorhizobium* sp. for *S. rostrata* in YM and lactose medium, respectively. In order to compare growth and N_2-fixing capacity at different growth stages for each species, the plants were also sampled at July 30, August 20, September 10 and 30, 2006. At the each sampling time, nitrogenase activity of the root and stem nodules was determined by a detached system using the acetylene reduction assay. After measuring the acetylene reduction activity (ARA), shoots and roots were oven-dried, weighed, and then ground for analyzing N and C concentrations. Sampled plants were cut into 3-5 cm length, and mixed into the soil in the pot for cultivation of succeeding crop. For quantitative evaluation of N contribution of incorporated materials, the virgin soil mixed with Akadamatuchi and vermiculite was used. The effects of shoots and roots (S+R) and only roots (R) prepared from the both species were examined. Immediately after incorporation of the materials, seeds of tendergreen mustard (*Brassica rapa* L.) plants were sown in the pots containing the green manures. Tendergreen mustard plants were sampled on November 11 and 27 and December 7 of 2006. They were oven-dried, weighed, and ground for analyzing N concentrations.

Results

Shoot dry weight and N content of the two species differed among three harvesting dates; those harvested at September 10 were lower than those harvested at September 30 (Tables 1). The C/N ratios of *C. spectabilis* was higher in roots than in shoots during growing period, and the values continuously increased. However, C/N ratio of *S. rostrata* from reproductive stage was higher in shoots than in roots.

Table 1. Changes in growth and N content of *C. spectabilis* and *S. rostrata* grown as a green manure crop.

Harvesting dates	Plant parts	*C. spectabilis*			*S. rostrata*		
		Dry weight (g plant^{-1})	N content (mg plant^{-1})	C/N ratio	Dry weight (g plant^{-1})	N content (mg plant^{-1})	C/N ratio
Aug. 20	Shoot	9.6	268	15.1	14.1	307	7.7
	Root	3.3	73	15.5	5.7	114	16.3
Sep. 10	Shoot	35.3	730	19.0	66.9	1174	21.7
	Root	8.9	175	19.9	25.7	465	19.8
Sep. 30	Shoot	62.3	1103	23.3	103.0	1673	26.2
	Root	16.1	205	28.2	30.5	460	22.4

The changes in acetylene reduction activity of the two species increased from late-July to mid-August, and then drastically declined. On the other hand, the value on August 20 was 12-folds higher in the *S. rostrata* than in the *C. spectabilis*. On September 30, the value of root nodules in the two species were not detected, but the value of stem nodules in *S. rostrata* were maintained at higher level (Figure 1).

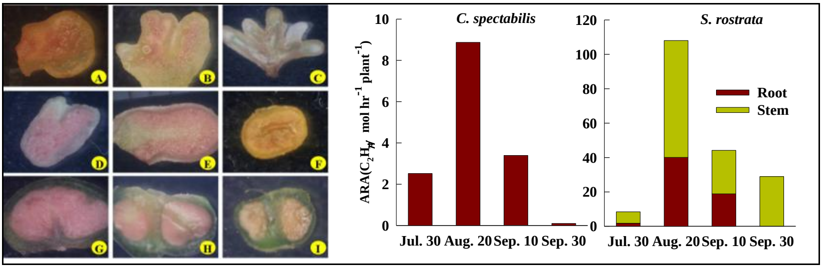

Figure 1. Changes in leghaemoglobin content (left) of nodules and ARA value (right) of *C. spectabilis* and *S. rostrata* grown as a green manure crop. A-C, root nodules of *C.spectabilis*. D-F and G-I, root and stem nodules of *S. rostrata*, respectively. Section of A, B and C of column was the nodules sampled on Aug. 30, Sep. 10 and 30, respectively.

Table 2 show the N uptake and recovery rate of tendergreen mustard plants grown after incorporation of the two green manure legumes at different times. The effect of incorporation of the two species on N uptake of the succeeding tendergreen mustard plants varied with different growth stages of the two species. In *C. spectabilis*, total N content of tendergreen mustard plants grown in the R pots attained 30-45% compared to the S+R pots. Thus, the N recovery rates of tendergreen mustard plants were definitely higher in the R pots (35.4-9.9%) than in the S+R pots (17.1-5.1%). In *S. rostrata*, on the other hand, total N contents of the tendergreen mustard plants in the R pots were relatively less than those in the S+R pots. Thus, the N recovery rates of tendergreen mustard plants were definitely higher in the S+R pots than in the R pots.

Table 2. N recovery of tendergreen mustard plants grown after incorporation of green manure crops.

Incorporation dates	Plant parts	*C. spectabilis*		*S. rostrata*	
		N content (mg $plant^{-1}$)	N recovery (%)	N content (mg $plant^{-1}$)	N recovery (%)
Aug. 20	R	36	35.4	37	21.1
	S+R	78	17.1	198	37.5
	t-test	**	**	**	**
Sep. 10	R	14	19.2	22	12.2
	S+R	34	9.5	96	15.2
	t-test	**	**	**	**
Sep. 30	R	7	9.9	13	6.5
	S+R	24	5.1	62	7.1
	t-test	**	**	**	*

Discussion

Previous studies on the effect of green manure legumes, such as *Crotalaria* and *Sesbania* species, on N contribution to the growth and N uptake of the succeeding crops, an apparent positive N benefit from the legume to the succeeding crop was observed. As reviewed by Daimon (2006), prerequisites for efficient application of green manures are selection of an appropriate plant species and the identification of the appropriate time of incorporation into soil for the succeeding crops. Of several prerequisites, potentials of dry matter production and N_2 fixation and changes in chemical properties of incorporated materials such as C/N ratio and L/N ratio, have previously been identified in *C. spectabilis* and *S. rostrata*, showing that a large biomass with lower ratios of C/N and L/N based on a higher N content could provide a greater benefit to the succeeding crops grown soon after incorporation. In the present study, N uptake of the succeeding tendergreen mustard plants depended on the total amounts of N input as incorporated materials, as shown by the difference in N content of the succeeding crop between the S+R pots and the R pots of each legume. Little has been known about contribution of root-deposited N in crop rotation systems, especially in the system including green manures. However, short-term N transfer pathway from legume to associated crop in mixed cropping system has been reported by some authors (Rasmussen *et al.* 2007). The sudden deprivation of photoassimilates, which has been translocated to the root system including root nodules with higher N_2-fixing activity, would also occur when shoots of the green manure legumes were harvested for being incorporated. We suggested that higher value of N recovery and earlier benefit of N uptake of succeeding crop in the R pots would be due to the pathway of this N flow from root system. As described above, it is suspected that inorganic N released from active root nodules after shoot removal assists the reduction of composition between microbial incorporation of the N and N uptake by the succeeding crop. The results in this study showed that the accumulated N of belowground part of the green manure crops promote growth and the N uptake of the succeeding crops, suggesting that the potential of these legumes could depend not only on greater biomass production but also on qualitative alteration of roots throughout the growing period.

Conclusions

Green manure legumes having potentials of biological N_2 fixation can increase soil nitrogen (N) level, when they are incorporated into the soil. These legumes could reduce the input of chemical fertilizer and pesticide that have often been used for improving both fertility and controlling pests in crop production. This study was conducted to understand the contribution of belowground parts of three green manure legumes, such as *Crotalaria* and *Sesbania* to the growth and N uptake of the succeeding crops. N contribution of belowground parts of these green manure legumes to the succeeding crops was relatively greater than that of aboveground parts. These results suggest that considerable amounts of root-deposited N might be utilized by the succeeding crop. Higher value of N_2-fixing ability of green manure plants throughout the growing stages should be considered as an important factor for releasing inorganic N from root or shoot nodules immediately after incorporation.

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Faba bean (*Vicia faba* L.): response to occasional direct seeding into straw residues under temperate climate conditions

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Key words: no-till, mulch, mouldboard plough, weed control, Organic Farming

Abstract

Field trials were carried out in 2009 at three experimental sites in Germany (two research farms: WG and FF; one commercial farm: NI). Faba bean (FAB) was occasionally directly seeded (oDS) into mulch layers of 0, 4 and 6 t ha^{-1} straw residues of precrop oats. Mouldboard ploughing combined with conventional seedbed preparation (MP) was used as the control treatment. Generally, weed shoot dry matter was higher in oDS treatments than with MP. Nevertheless, treatments with straw residues clearly affected the weed occurence. The higher the mass of residues the lower was the weed mass. By increased amounts of straw residues was found a tendency for higher grain yields of FAB, resulting in significantly higher yields compared with MP at NI. The shoot dry matter of FAB both in MP and oDS treatments was considerably lower at NI than at WG and FF, because of severe drought at the beginning of FAB flowering. Compared with the oDS treatment without straw residues (0 t ha^{-1}), 78 days after seeding the shoot mass of FAB increased in oDS treatments with straw residues (4 and 6 t ha^{-1}) by +179 and +233 g m^{-2} at site WG, while at site FF this effect was just +14 and +80 g m^{-2} respectively. The results show that sufficient mulch mass can sufficiently control annual weeds and thus enable oDS of faba bean in Organic Agriculture when pressure of perennials remains low.

Introduction

The principles relating to soil cultivation in Organic Agriculture (OA) have often been interpreted as avoiding disturbance and mixing of soil layers. However, mouldboard ploughing is still the common practice in OA for nutrient management, inverting farmyard manure, removing perennial weeds and enhancing root growth (Köpke 2003). In the past few decades, efforts to reduce soil tillage intensity in OA have increased in central Europe. No-till systems, i.e. direct seeding, may prevent soil compaction and erosion, improve topsoil trafficability, and save labour and energy costs (Holland 2004). In order to examine this no-till system under the guidelines of certified OA, we investigated occasional direct seeding (oDS) of faba bean (*Vicia faba* L.) into a mulch layer of residues of precrop oats. The straw mulch was assumed to enable sufficient control of annual weeds, and consequently achieve similar grain yields as with mouldboard ploughing.

Three field trials were performed at two experimental sites located on experimental farms of the University of Bonn and on a commercial organic farm in 2009 (Germany). This paper deals with the results for shoot mass of faba bean (FAB) and annual weeds, respectively, as well as how grain yield and yield components of FAB are affected by tillage treatments.

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Materials and methods

Field trials were carried out in 2009 at three experimental sites. Site WG is the organic research farm Wiesengut of the University of Bonn in Hennef (Germany), located on a clayey-silty to sandy-silty floodplain sediment (fluvisol, 50°47'N, 7°16'E; 65 m a.s.l.; MAT 10.3°C; MAP 840 mm). Site FF is a conventional experimental farm Frankenforst of the University of Bonn in Königswinter (Germany), located on a stagnic luvisol derived from loess (50°42'N, 7°12'E; 182 mm a.s.l.; MAT 9.0°C; MAP 700 mm). Site NI is a commercial organic farm in Niederkrüchten (Germany), located on a loamy sand to sandy loam soil (51°12'N, 6°11'E; 60 m a.s.l.; MAT 9.6°C; MAP 750 mm). The plot size was 12 m long and 3 m wide and the plots were arranged in a randomized block design with four replicates. oDS treatments differed in the amount of straw residues: 0, 4 and 6 t ha^{-1}, respectively. Mouldboard ploughing combined with conventional seedbed preparation of an oil radish winter cover crop, ploughing and seed bed preparation in early spring to FAB was used as a control (MP). Mechanical weed control was carried out in the control 15 days after sowing (DAS) by manual hoeing in the plots, simulating the effect of a hoeing machine that is generally used on the field scale. FAB were sown on March 21 and April 3 at site WG and NI (85 grains m^{-2}) respectively, and at FF on April 7 (45 grains m^{-2}), using a direct seeding machine (SEMEATO SHM 11/13). Shoot dry matter of annual weeds and FAB were determined 64 and 78 DAS by harvesting the shoot mass in two ½-m^2 subplots per plot. Grain yield was determined 130 DAS by harvesting an area of 10, 6.5 and 20 m^2 per plot at the WG, NI and FF sites, respectively. Yield components were measured by collecting 10 plants per plot. Number of pods per plant, seeds per pod, and thousand-seed mass (TSM) were determined. Analysis of Variance (ANOVA) was performed using SPSS (version 18) followed by Shapiro-Wilk's test. For ANOVA, means of oDS treatments were compared using Tukey's test. Dunett's test was used for pairwise comparison of means of the control with oDS treatments.

Results and Discussion

At all sites, as a consequence of deep soil loosening, enhanced mineralization and nitrification of soil-borne nitrogen in early spring and transformation into biomass, the shoot mass of FAB in mouldboard plough (MP) treatments was higher than with oDS treatments, although not always significantly (Fig. 1). The shoot dry matter of FAB both in MP and oDS treatments was considerably lower at NI than at WG and FF, because of severe drought at the beginning of FAB flowering (60 DAS). The abundance of perennial weeds such as *Taraxacum* C., *Rumex* spp. L., *Sonchus arvense* L., *Cirsium arvense* M. and *Equisetum arvense* L. was considerably reduced by MP. Furthermore, annual weeds like *Matricaria* spp. L., *Poa annua* L. and *Lolium multiflorum* L. occurred less frequently in MP treatments than with oDS. Early competitiveness of these weeds hindered early vigorous growth of FAB shoots. These results confirm that mouldboard ploughing in OA is the most effective measure to directly control annual and perennial weeds (Köpke 2003). However, compared with oDS treatments without straw residues (0 t ha^{-1}), shoot dry matter of FAB in oDS treatments with straw residues significantly increased by 17 and 21% at 78 DAS (oDS 4 t ha^{-1}:+179 g m^{-2}; and oDS 6 t ha^{-1}:+233 g m^{-2}) respectively at site WG, while at FF this effect was limited to just +14 and +80 g m^{-2} (not significant). This may be explained by the lowest density of weeds at this site. 6 t ha^{-1} straw residues in oDS decreased the weed shoot dry matter by 65% and 47%, equivalent to -72 g m^{-2} and -19 g m^{-2}, at the WG and FF sites respectively. The physical impedance and light

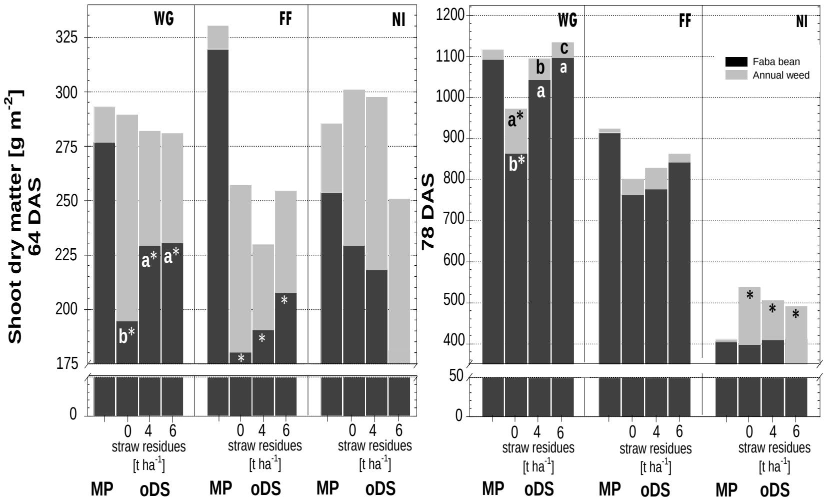

Figure 1: Shoot dry matter (g m^{-2}) of faba bean and weeds 64 DAS (left) and 78 DAS (right), as affected by tillage treatment: mouldboard ploughing (MP), and occasional direct seeding (oDS) into straw residues of 0, 4 and 6 t ha^{-1}, respectively. Different letters show a significant difference in oDS treatments. (Tukey test, α<0.05). Pairwise comparison of control with oDS treatments: Dunett's test, differences significant at P<0.05 indicated by asterisks '*'.

deprivation through at least 4 t ha^{-1} straw residues are the principle mechanisms to hinder the shoot mass development of annual weeds (Barberí 2002).Straw residues under oDS were particularly effective against *Matricaria* spp., a weed well known as indicating soil sealing. Results from the same year showed that shoot dry matter of *Matricaria* was reduced by 89% in oDS with 6 t ha^{-1} straw compared with the oDS treatment without straw (not shown). At the NI site, shoot dry matter of FAB was reduced by an increased amount of straw at 64 DAS. This result may at least partially be caused by the early competitiveness of grasses, which cannot be sufficiently suppressed by the mulch layers of oDS treatments.

Nevertheless, in contrast to a previous study of López-Bellido et al. (2003) with FAB in no-tillage systems under Mediterranean conditions, retarded FAB development and lower shoot mass resulted in no significant yield losses in oDS treatments. At FF, no significant yield differences were determined between MP (3.0 t ha^{-1}) and oDS (3.3 t ha^{-1}) treatments, which did not show an effect of the amount of straw residues on yield (Tab. 1). Different results were achieved at the WG and NI sites, which showed a tendency for higher grain yields caused by increased amounts of straw residues, resulting in significantly higher yields compared with MP at NI. Besides the effective physical weed suppression, another reason for increased grain yields in oDS treatments might be that straw residues may have saved water by reduced evaporation during the dry summer season of 2009. Previous studies reported higher seed yield of legumes under conventional tillage than no tillage conditions because of improved rooting conditions and water extraction, but this was not confirmed in the present study. Consistent with the study of López-Bellido et al. (2003), TSM and seeds per pod were greater in oDS treatments than in MP.

Tab. 1: Grain yield (t ha^{-1}) and yield components of faba bean as affected by mouldboard ploughing (MP) and occasional direct seeding (oDS) into straw residues of 0, 4 and 6 t ha^{-1}, respectively. Different letters show significant differences in oDS treatments. (Tukey test, α<0.05). Pairwise comparison of control with oDS treatments: Dunett's test, differences significant at P<0.05 indicated by asterisks '*'.

		MP	oDS + straw residues [t ha^{-1}]		
			0	4	6
Grain yield [t ha^{-1}]	WG	3.6	2.9 b*	3.6 a	3.7 a
	FF	3.0	3.4	3.1	3.4
	NI	2.7	2.9 b	3.4 a*	3.5 a*
Pods plant^{-1}	WG	16	10*	11.2*	11.4*
	FF	11.2	11	11	11
	NI	7	6	7	8
Seeds pod^{-1}	WG	2.6	2.8	2.7	2.7
	FF	3.0	3.1	2.9	2.9
	NI	2.3	2.5	2.5	2.5
TSM	WG	472	479	498	506
	FF	448	529 a*	488 ab*	506 b*
	NI	432	455	465	473

Conclusions

Sufficient weed suppression by at least 4 t ha^{-1} straw mulch from precrop oats enables occasional direct seeding of FAB in OA. Retarded early growth of FAB and lower shoot mass did not lead to significant yield losses compared with MP. Hence, intensive tillage may not be required to achieve high grain yields of FAB. The absence of clear effects of straw mulch on perennials makes further investigations necessary.

Acknowledgments

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Biogas: Implications on productivity of organic farming systems

Anspach, V.[1], Siegmeier, T.[2]&Möller, D.[2]

Keywords: internal benefits, farm cycle, utilisation of legumes, organic yields, ecological intensification, biogas digestate

Abstract

In Germany, 160-180 biogas plants exist on organic farms. German biogas production is characterised by high feed-in tariffs for electrical energy from renewable resources. But apart from these financial incentives organic farms, in particular, can benefit from internal effects in crop production– especially when nitrogen is the limiting factor. The integration of biogas production in organic farming systems implies changes in nutrient cycles and nitrogen supply due to anaerobic digestion of farm residuals/crops and subsequent fertilisation with digestates. In particular stockless organic farms can benefit from biogas production. Results presented here are based on survey data obtained from 77 organic farmers operating a biogas plant. Besides farm yard manure (FYM), the most important substrates for fermentation in organic biogas plants are clover/grass-leys. The main effects reported by farmers in this study are i) an improvement of yields on 73 % of farms, especially for cereals and grassland, ii) a better product quality on 40 % of farms (e.g. protein quality of wheat) and iii) benefits in weed control on 10 % of farms. Based on farmers' statements and the current literature our paper outlines the systemic potential of an integration of biogas production into organic farming systems while pointing out possible challenges and risks.

Introduction

Biogas production has increasing importance in Germany. Its growth is driven by federal subsidies for renewable energies. Biogas plants produce electricity, thermal energy and due to the subsidised feed-in tariffs for renewable electricity in Germany also positive returns on investment (Anspach & Möller 2008). Therefore, many organic farms too have built biogas plants in the last years despite high investment costs. From 2004 to 2010 their number increased from 73 to an estimated 160-180. In the same period, the installed electric power jumped from 5 to approximately 34-38MW_{el} (Anspach *et al.* 2010). Regarding the composition of substrates, we can distinguish three types of organic biogas farms :i) biogas plants based on FYM and residuals, ii) plants based on farm yard manure (FYM) and organic energy crops, and iii) plants with high percentages of conventional energy crops (Anspach & Möller 2008). All three are complying with EU-Regulations on organic farming as long as external substrates do not exceed the legal equivalent for external nutrient input (40 kg N ha^{-1} yr^{-1}).Many organic farming associations in Germany even promote biogas production. However, most private organic standards will not allow digestion of conventional substrates in the future and push towards adequate organic biogas concepts. Therefore and because of high production costs for energy crops, organic farms

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primarily use farm residuals (FYM, clover/grass-leys) as substrate. In contrast to conventional biogas producers, organic farms use a lower percentage of maize or cereals (Anspach *et al.* 2010).

Organic farming systems in Germany are traditionally based on crop rotations of 5-7 years with 4-5 years of cash crops and grain legumes (e.g. *Viciafaba minor*) and 1-2 years of clover/grass-leys serving as green manure, fodder, as well as weed and pest control. The farm nutrient cycle is restricted by nitrogen availability (Berry *et al.* 2002). Nitrogen supply is based on legume N_2-fixation and return of FYM to land before tillage. Over the last decade, however, economic pressure, changed market structures, and specialisation tendencies caused increasing numbers of organic operators to farm stockless or with lower stocking rates. These farms in particular are looking for a reasonable use for their surplus of clover/grass-leys. In practice, many farms mulch the grass-clover instead of harvesting and/or they reduce clover/grass-leys within the crop rotation with negative implications for biological N_2-fixation (Möller *et al.* 2008) and long-term risks of nitrogen undersupply. Especially for these farms, biogas production may offer opportunities to improve nutrient cycles. But also mixed farms with animal husbandry may benefit from biogas production. Anaerobic digestion, especially if legumes are used, may increase nitrogen accumulation. This is due to the higher productivity of legumes when harvested instead of mulched (Halberg *et al.* 2007) and reduced nitrogen leaching (Möller *et al.* 2008). Also, nitrogen losses from FYM in stables and storage can be reduced by anaerobic digestion (Möller 2009). Farms are able to apply digestates directly to the growing crop. Furthermore, the fermentation process positively influences the availability of nutrients for plants since organic nitrogen content decreases while mineral nitrogen increases (Stinner *et al.* 2008). The mentioned effects and the synchronisation of fertilisation and plant growth contribute to closing nutrient cycles. This paper presents experiences of German organic farmers with the integration of biogas production into their farms. Linking the empirical statements with a brief literature overview, our study outlines the potentials of biogas production for organic farming systems with a focus on fertilisation schemes, yield effects and product quality in crop and fodder production as well as possible influences on weed reduction.

Materials and Methods

The empirical data presented in this paper is based on a biannual survey among German organic biogas plant operators. It was first conducted in 2007 to investigate the structure of biogas production on organic farms and to gain initial insights into specifics of biogas production in organic agriculture (Anspach & Möller 2008). The study is designed as a census rather than a sampling and is carried out in close cooperation with the German organic farmers' associations. This paper refers to data from 2009.A semi-structured questionnaire was used. Farmers were asked to describe any agronomic effects occurring since biogas digestates were used for fertilisation and to estimate them wherever suitable.77 farmers provided comprehensive data on fertilisation schemes and estimations of the development of yields and product quality.

Results and Discussion

Most farmers noticed positive yield effects compared to times before digestate fertilising. 73 % reported noticeably increased yields, 16 % found no impact and 11 % were not able to estimate any effect. Negative yield effects were not reported. Most farmers stated average yield increases between 10-30 % (42 farmers) (Table 1).

Tab. 1: Average yield increase for selected crops fertilised with digestates as stated by farmers (n=77)

Yield increase (%)	0	< 10	10-19	20-30	> 30	No estimate
number of statements	12	4	20	22	10	9

Apparently cereals with high nitrogen demand benefit more from fertilisation with digestates. According to farmers, average yield increase was highest for maize (29 %) (Table 2). Grassland was also reported to show strong yield increase (25 %). It must be assumed that partially these differences reflect unequal distribution of available digestate among different crops. However, the survey shows that farmers are very well able to generate positive effects in practice through management regime changes implied by the integration of biogas production. Scientific findings support farmers' statements (e.g. Raubuch *et al.* 2005, Stinner *et al.* 2008).

Tab.2: Average yield increase for selected crops fertilised with digestates as stated by farmers (n=56)

Crop	Maize	Wheat	Spelt	Rye	Potatoes	Grassland	Clover
Yield increase (%)	29	22	19	12	14	25	16

In addition to yield effects, about 40 % of farmers reported a better quality of the harvested products. Another 32 % found no impact on quality parameters and 28 % were not able to estimate the effect. The most reported effect was improved baking quality of wheat/spelt. Unlike FYM liquid digestate may be applied to growing crops in spring. Higher protein content in grains when fertilised with biogas digestates compared to FYM is also reported in the literature (e.g. Stinner *et al.* 2008). Some farmers stated increased intake by livestock and ascribed this to improved fodder quality throughdigestatefertilisation.10% of respondents also reported influences of biogas production on weed control. Through anaerobic digestion seed germinability may be reduced (Engeli *et al.* 1993).However, the impact is hard to grasp and strongly dependent on occurrence and abundance of unwanted seeds in farms' untreated manure.

According to farmers' statements, the mobility and flexibility of digestate together with their high ammonium nitrogen content generate opportunities for new fertilisation schemes. Biogas digestates can substantially improve on-farm nitrogen cycles and total nitrogen accumulation. Still, prevention of nutrient losses during storage and application poses challenges because the risk of losses is much higher for mineral than for organic nitrogen. Therefore, it is important to cover the digestate storage tanks with gas-proof material, to reduce losses of methane and ammonia, and to use modern close-to-the-ground spreading techniques for the biogas digestates. The value of a flexible fertiliser for organic farms is – due to their overall low nitrogen levels (Berry *et al.* 2002) – considerably higher than for conventional farms. However, taking full advantage of this fertiliser also requires sufficient storage capacities. Otherwise, digestates might have to be applied at unfavourable times or to unpreferred crops.

Although respondents did not perceive any negative effects on soil properties and fertility, there is an on-going debate in the organic community about negative effects of anaerobic digestion that might result from changed nitrogen quality and carbon quantities. Raubuch *et al.* (2005) compared biogas digestates and the untreated manure and could not find changes in amino acid composition. Also Reents *et al*.

(2011) found no effect of digestate fertilisation on aggregate stability, C_{org} content, C/N_{ratio} or pH of the soil. Still, these issues have to be examined further.

Conclusions

Statements in our farm survey reflect the positive effects of biogas production suggested by scientific literature. Basically, organic farms can benefit in two different ways: i) direct fertilisation through biogas digestate and ii) indirect improvement of legume-based fertilisation within the crop rotation. It may be concluded that positive impacts on yield, product quality and weed control found in the literature can to some extent also be realised by organic farmers in practice. Particularly for the growing number of specialised stockless organic farms in Europe biogas plants offer opportunities. Biogas production may be regarded as a replacement for ruminants partially coping with the negative effects and systemic discrepancies of stockless organic farming; thereby enabling organic farmers to exploit specialisation effects while securing and increasing yields. The latter becoming ever more important in a world with growing food demands. Yield stability is also very relevant for securing or increasing organic farms' income. In summary: Biogas production can improve agricultural production and may contribute to ecological intensification of organic farming systems.

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Bullocks and organic farming in India: a sustainable relationship

Natarajan, A[1] & Chander, M[2]

Key words: Bullocks, utilization, problems, suggestions, organic agriculture

Abstract

A study was conducted with 210 agricultural farmers from seven districts of different agro-climatic zones in Tamil Nadu state of India to determine the relationship of bullocks in agriculture in terms of their utilization pattern. The results revealed that the overall average number of days of utilization in agriculture was 36.28 days. Apart from ploughing, cent per cent respondents in the study area used the manure from draught bullocks in their fields and recognized its importance in soil fertility. The farmers opined that the replacement of bullocks with tractors has many disadvantages like unsuitability to all types of lands (100 per cent), harm to soil texture (83.33 per cent), more spread of weeds (72.86 per cent), poor performance (45.24 per cent), unavailability in the needed hours (41.43 per cent) and high cost (35.24 per cent). In countries like India, where integrated farming is still prominent, bullocks play important role and most of such small scale farms in India are organic by default. Such farms have potential for conversion into sustainable organic farming by making efficient use of work bullocks.

Introduction

In India farmers still practice traditional farming, which is largely mixed or crop-livestock integrated farming, making it organic farming by default. The small and marginal farmers prefer to maintain bullocks for draught purpose a source of renewable and sustainable energy which helps Indian farmers in multiple ways. In spite of increasing mechanization of agricultural operations, animals remain an important source of energy for crop production in India. Though mechanization helps to increase the agricultural production in a speedy and easy manner, but the other side however, is that the mechanization is associated with emission of greenhouse gases like carbon dioxide and other trace gases due to burning of fossil fuels (Mishra & Dikshit 2004). India has a stock of about sixty million work animals used in various agricultural operations, thus saving fossil fuel worth ₹60 billion, annually (GoI 2007). To understand the dynamics of bullock use in Indian agriculture, a detailed study was conducted to assess in particular the utilization pattern of bullocks in Tamil Nadu, India (Akila 2009).

Materials and methods

The utilization pattern of draught bullocks was assessed with the draught animal owners in Tamil Nadu state, India. As per the 2003-2004 census report of the Government of India, the total indigenous bullock population was 9,31,000, crossbred bullock population was 1,65,0000 and work buffaloes were 31,000 which play major role in draught works in the state. Tamil Nadu is comprised of seven agro climatic zones and for the study, one district was selected from each zone of Tamil Nadu

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based on bullocks population, Villupuram for North Eastern zone, Krishnagiri for North Western zone, Erode for western zone, Sivagangai for southern zone, Tanjavur for Cauvery Delta zone, Kanyakumari for high rainfall zone and Kolli hills for hilly zone, thus, comprising seven districts from all zones of Tamil Nadu. From each district, three village *panchayats* were selected and from the cluster of villages, the farmers possessing draught animals were stratified into small (up to 2 ha), medium (2 – 4 ha) and large farmers (>4 ha) based on land size and from each strata, 10 farmers were selected randomly to represent different socio- economic strata. Thus, the final sample was 210 bullock owning farmers (70 small, 70 medium and 70 large farmers) across 7 districts. The yearly utilization pattern of draught bullocks in agriculture, effect of replacement of bullocks by tractors and problems in utilizing bullocks were studied through a pre- tested semi- structured interview schedule.

Results

i. Utilization pattern of bullocks in agriculture

The results indicated that 91.43 per cent large farmers and 40 per cent of the medium farmers maintained the animals mainly for their own use. Whereas, the small farmers utilized their bullocks for commercial ploughing (28.57 per cent), commercial carting (25.71 per cent) and for both commercial carting and ploughing (45.71 per cent), while 35.71 per cent of medium farmers used their bullocks for commercial carting apart from their own use. The small farmers in Tamil Nadu used the bullocks for 44.9 average number of days in a year followed by 38.77 days by medium farmers and 25.19 days by large farmers. The overall average number of days of utilization in agriculture was 36.28 days. The average working days of bullocks for all activites in a year was 220.54 days for small farmers, 156.16 days for medium farmers and 46.61 days for large farmers. The results also indicated that organic farming was practiced traditionally in the hilly zone,where bullocks were the only source of energy for ploughing (41.63 days). There, the tractors were not being used for ploughig due to difficult terrain, and farmers were making good use of cattle manure to fertile the soil.

ii. Manure – vital nutrient

Apart from ploughing, cent per cent respondents in the study area were using the manure from draught bullocks in their fields and recognised its importance in soil fertility.

iii. Replacing bullocks with tractors

Though the tractors are used in greater extent and cent per cent farmers felt the tractors can finish the work quickly and need of labour is less, yet they felt the disadvantages like unsuitability to all types of lands (100 per cent), harm to soil texture (83.33 per cent), more spread of weeds (72.86 per cent), poor performance (45.24 per cent), unavailability in the needed hours (41.43 per cent) and high cost (35.24 per cent) in replacing the bullocks with tractors.

iv. Problems associated with bullocks

Bullocks may positively contribute in organic farming and sustainable agriculture, yet the farmers(87.62 per cent) felt that bullocks consume more time to finish the work and work difficulty (50.95 per cent); problems in meeting out the feed cost of bullocks(90.48 per cent), burden during the idle period (47.62 per cent) are the major disadvantages associated with the bullocks.

V. Draught bullocks and Animal welfare

In order to qualify for organic farming the standards for organic production including animal welfare would have to be compiled within a study. Pathak&Chander 2004, found that though Indian traditional farming was organic by default, but some of the fundamental aspects of organic agriculture were not taken care of. This study showed that organic standards can be used as a yardstick to measure animal welfare even in non-organic conventional livestock production systems.

Discussion

In agriculture, draught bullocks are used mainly for ploughing, levelling & puddling, ridging & furrowing, seeding & weeding and carrying compost to the fields meant for raising crops. The farmers felt that ploughing by draught bullocks is essential after tractor ploughing and before planting the crops. Hence, during the season, the available draught bullocks were fully utilized for the above said purposes. Similarly, Phaniraja & Panchasara 2009, reported that the 70 million bullocks exclusively used over 60 days, for cultivation @ 6hrs/day, account for a total power output of some 9450 million KWH. Likewise, Singh 1998, also reported that Draught Animal Power(DAP) is the only feasible source of energy for agricultural work in mountains, which is mainly targeted for organic farming development among others by Indian Council of Agricultural Research. The work bullocks not only contribute manure, conserve natural resources like fossil fuel, but also create employment opportunities and generate income particularly for the small scale farmers in India (Akila and Chander 2011).

Most of the problems relating agricultural land, ground water and environment can be minimized while giving a boost to organic farming, when bullocks are efficiently used in farming, which also contribute dung and urine- the two valuable products used in organic farms. A minimum of 10-20 kg dung is obtained on an average from every bullock and this excellent source of Farm Yard Manure is important to improve the inherent soil fertility, and to have the extended manurial effect on the crops. Rightly, Skunmun 2005, & Padmakumar 2007, revealed that DAP and manure are pivotal for the poor to cultivate their land as its substitutes (tractor and chemical fertilizers, for instance) are unaffordable to them, thus, proper steps are required to be taken to conserve the indigenous draught breeds, which have valuable and complementary role in Indian agriculture.

The continuous use of tractors hardens the land was the common complaint of farmers. Besides that, productive use of draught animals will reduce the increasing dependence on petroleum products and thermal power by increasing the share of non-commercial primary energy sources in the total energy use in the country, in agricultural operations and in rural transportation. India would require 6.0 million tractors for the complete replacement of the working animals stock of over 60 million and, to run this much number of tractors for agricultural operations, we would require about 19.5 million tonnes of diesel each year. If this much amount of fuel were to be burnt through combustion to run the tractors in the absence of the working animal stock of over 60 million in India, it would have caused an emission of over 6.14 million tonnes of carbon dioxide.Such implications are highly valuable from the perspective of both national energy budget as well as global warming (Dikshit and Birthal 2010).

Conclusions

It is important to promote the continued use of draught animals in agriculture which is a time tested renewable energy source for sustainable agriculture in the face of dwindling reserves of the non renewable sources of energy. In addition, there are other environmental contributions of the working animal stock — consider implications of replacing it by agricultural machinery run on fossil fuel. But animal power does not get proper attention and it poses maintenance burden on the animal based farmers. Akila & Chander 2009, found that, since the farmers couldn't get much profit from the draught cattle, they couldn't meet out the feed cost and they were also unaware of the new implements that could improve the work efficiency of bullocks. The unit operational cost of DAP could be substantially reduced by their increased use. Using the rotary mode to operate agro-processing machines can increase the present utilization of the animal power. Abubakar & Ahmad 2010, found that utilization of animal traction would be increased significantly in Jigawa State, Nigeria, if more fund are injected in animal traction technology. The work animals can be effectively used in agriculture by maximizing their utilization, especially where organic famring is considered comparatively profitable and thus, being targeted for promotion and development, like in drylands and mountainous regions of India. In organic farming, animals' feeding and welfare are important considerations. Therefore the farmers have to take note of organic livestock production standards including welfare measures like stress free environment, ample access to fresh air, no over work/overloading, balanced feeding etc., The Government of India is committed for promoting organic farming in the country, for which many steps are being taken at different levels. The efficient use of DAP in small scale farms can effectively contribute towards making organic farming sustainable.

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Selection of variety of soybean suitable for inter-cropping cultivation of organic soybean introducing green forage rye

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Key words: Soybean, Rye, Inter-cropping, Rotation, Weed control

Introduction

Soybeans are an important food indispensable for our menu. In particular, soybeans contain a lot of various antioxidant substances such as isoflavone, saponin, tocopherol and phytic acid apart from the main ingredient protein. Hence soybeans receive the spotlight as a well-being food. Recently, in our country, as various soybean curd and soybean milk products are developed and sold, the opportunity to consume soybeans has become great and the quantity of the consumption increases every year.

The cultivation area of soybeans in our country in 2010 is 72,240ha (Major statistics of Ministry for Food, Agriculture, Forestry and Fisheries, 2010). In spite of the fact that consumer's preference to organic soybeans is high, the cultivation area of organic soybeans is assumed to be less than 1%. If we look into the result of organic cultivation developed so far, though there are studies such as diseases and weeds occurrence and control in organic and conventional rice paddy field(Lee et al., 2005), effect of winter crop hairy vethch and barley on paddy weed emergence(Seong et al., 2004). The reality is that there is no study on catch cropping cultivation of organic oybean introducing green forage rye.

This study reveals the degree of restraining weed growth by catch cropping cultivation or crop rotation of beans using a method of shading the light of plants grown on stalk remains after the harvest of cultivated rye and use as feed crop in winter and the relationship of competition between bean and weeds, intended as basic material for large scale organic cultivation of soybeans.

Materials and methods

This experiment was carried out in experiment field of Gyeonggi-do Agricultural Technology Research Center, Income Resource Research Institute, in order to select a suitable variety for catch cropping cultivation introducing rye, which is used as feed over the period of 2006 to 2007.

Rye variety as previous crop of soybean was Geuloohomil. Sowing was done with the width of 60cm and 30cm in mid October 2006. Sowing quantity was 20 kg per 1,000m^2. Cutting rye was done to make the height 20cm from the surface of the earth on May 8 (Kim & Chae, 1994), 10 days after coming into ears which is a suitable time for crop of rye. Fertilization was done 1 day before sowing with organic compost of 240kg/1,000 m^2 which is soil test diagnosis fertilization quantity right after cropping rye.

Soybean test varieties were five including Daewon soybean, and the characteristic of the varieties are listed in Tab. 1. Sowing soybeans was done between rye stalks with the gaps between stalks of 20cm on May 29. Investigation on weed was carried out for weeds within frames of 60x100cm 36, 68 days after sowing; species of grass, number of individuals, weight of dried materials were investigated and repeated 3 times. The

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values of investigation was converted into m^2 and recorded. Growth and yield characteristics of rye and soybean abided by the investigation standard of agriculture research business (Rural Development Administration, 2003) and for investigation on light penetration quantity using photometer (model: BQM, maker: APOGEE) at 11AM to 14PM in full seed stage (R_6). The intensity of radiation on the location of 0, 15, 30cm was noted on the point 10 and making atmosphere 100 calculated light penetration rate for each position.

Results and discussion

Growth and yield of rye before and after harvest

The result of investigating growth and yield of rye right before harvest of rye sowed in late October, 2006 is listed in Tab. 1. Length of grass was 176cm, number of stalks per m^2 was 578 units, number of leaves was 4.0, yield of raw material per 10a was 2,008kg and dried material was 565kg. On the 38th day after sowing soybeans, length of grass was 110cm and number of stalks was 330 units. Previous crop (rye) withering date was July 10.

Numbers of weed species, dried weight, multiple growing weed

To understand the competition relationship of soybean introducing rye which is feed crop with weeds while doing inter-cropping cultivation, the result of investigating, on the 36th day and 68th day after sowing soybean, number of individual weed, weight of dried material and number of weed species are listed in Tab. 2 and Tab. 3. Multiple growing species of weeds investigated on the 36th day after sowing are 8 species such as *Echinochloa crus-galli var. frumentacea, Portulaca oleracea, Chenopodium album var. centrorubrum, Cyperus amuricus, Amaranthus lividus, Capsella bursa-pastoris, Metaplexis japonica, Solanum nigrum.*.

Tab. 1: Major growth and development characteristic and quantitative nature of each experimented varieties (Characteristic of soybean offered RDA)

Varieties	Mature group (Ⅰ-Ⅸ)	Mature period (month. date)	Length of plant (cm)	Number of branches (ea/plant)	Blight (0-9)	100 seeds weight (g)	Yield (kg/ha)	Characteristics
Taekwang kong	Ⅲ	10.1	75	4.8	Strong	25.3	266	Many branches, Disease and environmental stress resistance
Daewon kong	Ⅲ	10.3	78	4.2	Strong	25.6	291	Many branches, Shattering resistance
Jangmi kong	Ⅳ	10.9	63	3.0	Strong	19.3	288	Shattering resistance, High yield
Jangsu kong	Ⅲ	10.4	91	2.1	Medium strong	22.2	241	Indeterminate type, few branches, Mechanization
Shinpaldal #2	Ⅲ	10.3	55	2.0	Strong	19.5	274	Few branches

Number of individuals grown, number of species of weed, and number of species of multi-growing weeds were the most in Shinpaldal #2 as 30.7 pieces, 13 species and 6 species but weight of dried weed was the heaviest in Daewonkong. Number of individual weeds and multi-growing species of weeds investigated on the 68th day after sowing was the most in Shinpaldal #2 among experimented varieties and dried weed weight was the heaviest in Daewonkond, but number of species of weeds grown was the most as 12 species in Shinpaldal #2. Multiple growing species of weeds were 5 kinds in Shinpaldal #2 and Jangmikong, 2 kinds in Daewonkong and Jangsukong, and 1 kind in Taegwangkong.

Tab. 2: Characteristics of growth and yield of rye before and after harvest

Before harvest of rye					38 days harvest of rye after sowing soybean		Withering date (month. date)
Culm length (cm)	Number of stalks (unit/m²)	Number of leaves (each)	Yield (kg/ha)		Culm length (cm)	Number of tillers (unit/m²)	
			Green forage	Dried			
176	578	4.0	2,008	565	110	330	7. 10

※Harvest date: May 20

Tab. 3: Comparison of weed dried weight and multiple growing weeds species among soybean varieties by inter-cropping with rye (36 days after sowing)

Varieties	No. of species (species)	Number of individuals (plant/m²)	Dried weight (g/m²)	Multi growing weed species♭
Taegwang kong	9	14.9c†	3.9bc	Echinochloa crus-galli var. frumentacea♩, Portulaca oleracea, Chenopodium album var. centrorubrum, Capsella bursapastoris,
Daewon kong	10	13.7c	7.7b	Echinochloa crus-galli var. frumentacea, Portulaca oleracea, Chenopodium album var. centrorubrum, Cyperus amuricus, Amaranthus lividus, Capsella bursapastoris
Jangmi kong	12	13.7c	4.5bc	Portulaca oleracea, Cyperus amuricus, Metaplexis japonica, Capsella bursapastoris
Jangsu kong	11	24.7b	5.4b	Echinochloa crus-galli var. frumentacea, Portulaca oleracea, Amaranthus mangostanus, Cyperus amuricus, Metaplexis japonica
Shinpald al #2	13	30.7ab	6.1b	Echinochloa crus-galli var. frumentacea, Portulaca oleracea, Amaranthus mangostanus, Cyperus amuricus, Solanum nigrum, Metaplexis japonica

†Means with the same letter in a column are not significantly different according to DMRT.
♭Criteria of multi-growing weeds: More than 2 or more individuals within enumeration district. ♩Species of grass superior to soybean in space competition.

Tab. 4: Comparison of weed dried weight and multiple growing weed species among soybean varieties by inter-cropping with rye (68 days after sowing)

Varieties	Number of plant species (species)	Number of individuals (pieces)	Dried weight (g/)	Multiple growing weed species[♭]
Taegwang kong	10	11.5[c†]	122.2[bc]	Cyperus amuricus
Daewon kong	6	9.0[cd]	177.3[a]	Echinochloa crus-galli var. frumentacea[♩], Amaranthus lividus
Jangmi kong	11	20.0[b]	60.7[cd]	Chenopodium album var. centrorubrum, Portulaca oleracea, Amaranthus mangostanus, Stellaria media, Cyperus amuricus
Jangsu kong	10	20.5[b]	38.5[d]	Portulaca oleracea, Cyperus amuricus
Shinpaldal #2	12	28.5[a]	112.1[bc]	Echinochloa crus-galli var. frumentacea, Portulaca oleracea, Amaranthus mangostanus, Stellaria media, Cyperus amuricus

†Means with the same letter in a column are not significantly different according to DMRT.
♭Criteria of multi-growing weeds : More than 2 or more individuals within unit district.
♩ Species of grass superior to soybean in space competition.

Light penetration rate of each variety

The result of investigating the light penetration rate of rye harvested 10 days after coming into ears and regenerated and the light penetration rate of soybean in leaf enlargement period R5 stage is listed in Tab. 4. Light penetration rate became lower as coming down from the height of grass to the surface of the earth in all experimented varieties. Among the varieties, Taegwangkong was the highest at 87.5% in the plant crown 0 cm. In Daewonkong, Jangmikong, and Jangsukong all are about 61% and in Shinpaldal #2 light penetration rate was low at 50.9%. Grass height under 15cm was 4.9-9.7% and grass height under 30cm was 1.4-2.0%.

Tab. 5: Comparison of light penetration rate among soybean varieties at inter-cropping with rye

Varieties	Light penetration rate (%)			
	Atmosphere	Culm length (cm)	Height of grass under 15cm	Height of grass under 30cm
Taegwangkong	100.0	87.5[a†]	9.7[a]	2.0[a†]
Daewonkong	100.0	60.3[b]	5.3[bc]	1.4[a]
Jangmikong	100.0	61.1[b]	4.9[c]	2.0[a]
Jangsukong	100.0	61.2[b]	6.7[b]	1.8[a]
Shinpaldal #2	100.0	60.9[b]	5.5[bc]	1.7[a]

†Means with the same letter in a column are not significantly different according to DMRT.

Tab. 6: Growth and yield of each varieties of soybean following inter-cropping cultivation with rye

Varieties	Flowering stage (month. date)	Maturing stage (month. date)	Culm length (cm)	Diameter of culm (mm)	No. of branches (earth/stalk)	No. of nodes (node)	No. of Seed (ea/plant)	Weight of seed (g/plant)	Percent of repined seeds (%)	Weight of 100 seeds(g)	Yield (kg/ha)
Taegwang kong	8. 2	10.20	84[bc]	8.4[b]	8.3[a]	16.3[b]	80.8[b]	19.2[b]	87.2[a]	27.3[b]	120[b†]
Daewon kong	7.26	10.22	92[b]	7.5[bc]	8.5[a]	16.3[b]	113.3[a]	29.3[a]	87.9[a]	29.4[a]	189[a]
Jangmi kong	8. 2	-[‡]	141[a]	9.9[a]	5.7[b]	22.4[a]	79.7[b]	18.3[b]	85.4[b]	26.8[b]	109[b]
Jangsuk ong	7.25	10.20	85[bc]	8.0[b]	3.7[c]	16.5[b]	41.1[c]	8.7[c]	85.1[b]	25.0[c]	58[c]
Shinpal dal #2	7.23	10.20	65[c]	8.0[b]	4.4[bc]	13.2[c]	53.0[bc]	9.4[c]	84.9[b]	21.4[d]	59[c]

[†]Means with the same letter in a column are not significantly different according to DMRT.

[‡] Immature.

Characteristics of growth and yield among the varieties of soybean following inter-cropping cultivation with rye

The results of investigating the characteristics of growth and yield of soybeans to select soybean varieties suitable for inter-cropping cultivation with rye is listed in Tab. 5 and Tab. 6. Among the varieties for flowering date was July 26 to August 2 which is somewhat late, and maturation date was around October 20 which is 14 days later than normal maturation time of October 6. Jangsukong could not reach the maturation date until we had the first frost. The length of culm was 141cm in Jangmikong, which was the highest, and 92cm in Daewonkong, 85cm in Jangsukong, 84cm in Tawgwangkong, and 65cm in Shinpaldal #2. The diameter of the culm was 7.5 to 9.9mm and the number of branches was 8.3 in Taegwangkong which has many branches and in other varieties 3.7 to 5.7 which was the medium number of branches. The number of nodes was 22.4 in Jangmikong, 16.5 in Jangsukong, 16.3 in Taegwangkong and Daewonkong, and 13.2 in Shinpaldal #2. In Daewonkong, the number of seeds per plant was 113 which was the most, and the weight of seeds per culm was 17.9g which was the heaviest and the weight of 100 seeds was 29.4g which was the heaviest. The weight of seeds per ha was 189kg in Daewonkong which was the highest. Based on these results, the advantageous variety of organic soybeans suitable for catch cropping cultivation of organic soybean introducing green grass rye is Daewonkong, which has many branches and long branch, and heaver seed weight.

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High variability of symbiotic nitrogen fixation in farming conditions

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Key words: On-farm research, organic farming, SNF, spatial heterogeneity, *Trifolium pratense* L.

Abstract

*Symbiotic nitrogen fixation (SNF) in perennial legume-grass leys is the primary source of N to organic farming systems in northern countries. This work aimed to quantify SNF in organically managed red clover (*Trifolium pratense *L.)-grass leys and to relate SNF to explanatory variables. The study was carried out on 27 farms located in the coastal regions of Finland and included 117 ley crops subjected to regular organic farming practices. SNF was calculated from clover herbage dry-matter yield with an empirical model. In the accumulated first and second cuts of one- and two-year-old red clover-grass leys, SNF averaged 185.4 kg N ha^{-1} yr^{-1} (SD ± 90.0 kg N ha^{-1} yr^{-1}); fixation in the aftermath added 62.1 kg N ha^{-1} yr^{-1} (SD ± 49.8 kg N ha^{-1} yr^{-1}). Due to the poor persistence of red clover, SNF declined with ley age. Between- and within-field coefficients of variation of SNF in one- and two-year-old leys averaged 51.1 and 51.8%, respectively. SNF was positively related to soil fertility parameters, mainly to soil structure. It is concluded that the preceding crop value of legume-grass leys needs to be assessed individually. The spatial heterogeneity of soil properties can be reduced through site-specific amelioration and regular applications of animal manure.*

Introduction

Correct assessment of symbiotic nitrogen fixation (SNF) is crucial for the design of crop rotations and the N-supply of single crops. Legume growth, and thereby SNF, depend on species, stand age, weather conditions, soil properties, and management (Mela 2003). The spatial heterogeneity of soil properties is high not only between but also within single fields (Geypens *et al*. 1999). Legume growth is likely to reflect this variability. In northern countries, perennial red clover (*Trifolium pratense* L.)-grass leys are of paramount importance for the N-supply of organic farming systems. The objectives of this work were (i) to quantify SNF in organically cropped red clover-grass leys, (ii) to explore between- and within-field variations of SNF, and (iii) to relate SNF to stand age and environmental conditions. On farm-research was expected to highlight issues unresolved at farm level for further experimental research.

Materials and methods

SNF was assessed in 117 organically managed perennial red clover-grass leys. These ley crops were integrated in the crop rotation cycles of 27 different farms and subjected to regular agricultural practices. The location of the farms in two distinctly different regions, the southern and the north-western coastal zones of Finland (= south and northwest, respectively), was expected to elucidate possible impacts of different climate and soil conditions on SNF. The rotations of all farms included ley and grain

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crops. The leys were undersown in cereal nurse crops, except in one of the farms. The seed mixtures included mainly red clover (27 farms), timothy (*Phleum pratense* L.; 25 farms), and meadow fescue (*Festuca pratensis* L.; 18 farms). In some cases white clover (*Trifolium repens* L.) or alsike clover (*Trifolium hybridum* L.), or both, were added in small proportions. The average clover content (by weight) of the seed mixtures was 31.7% (SD ± 16.9%). The harvest regimes were limited to two cuts per season, which is the generally recommended strategy for perennial mixed leys in Finland (Mela 2003).

Herbage samples were collected during two growing seasons, 2001 and 2002. Newly established leys were sampled at the end of each growing season (n = 38). Samples from one-, two-, and three-year-old leys (= three production years) were taken prior to the first and to the second cuts (n = 79). Here, the average interval between samplings and cuts was 6 days in the south, and 5 days in the northwest. Samples from the aftermath were obtained at the end of the growing periods (n = 52). In each site and at each occasion samples were always taken from four 0.25 m^2 plots situated at equal distances along the longest diagonal across the field. The herbage was cut with shears at 20 to 30 mm above the soil surface and separated by hand into a clover and a grass fraction (the latter also including dicotyledonous herbs others than clovers), which were then dried with air-flow dryers at 25-30ºC to a constant weight. All biomass weights were corrected to dry matter weight (DM).

Simulation with a grassland growth model (Riesinger *et al*. 2008) showed that when the farmers cut the leys the herbage production on average was 13.0% higher than at the time of sampling. Since the final statistical models for observed and simulated data were the same, only observed data and results of analyses based on these are reported here. SNF was calculated from clover herbage dry-matter yield with an empirical model that estimates total SNF in cut one- and two-year-old red clover-grass leys in temperate climate under low external input conditions (Høgh-Jensen *et al*. 2004). SNF was related to sampling year, ley age, geographical location, interaction between ley age and geographical location, and soil properties by general linear modelling (GLM) in SPSS 15.0 (SPSS Inc. 2006). Soil properties included cation-exchange capacity (CEC), soil organic matter content (SOM), pH-value, and concentrations of phosphorus (P), potassium (K) and magnesium (Mg). Within-field variation of SNF was assessed as the coefficient of variation of SNF in the four sub-samples from each field.

Results

The autumn growth of newly established leys on average fixed 38.6 kg N ha^{-1} yr^{-1} (SD ± 25.2 kg N ha^{-1} yr^{-1}). SNF in the accumulated annual growth of one- and two-year-old leys averaged 247.5 kg N ha^{-1} yr^{-1} (SD ± 114.4 kg N ha^{-1} yr^{-1}); of that the contribution of the aftermath was 62.1 kg N ha^{-1} yr^{-1} (SD ± 49.8 kg N ha^{-1} yr^{-1}) (Table 1).

In the statistical model, sampling year was retained as a significant explanatory variable only in the model for the aftermath, in which SNF was lower 2002 than 2001. Being a function of clover herbage biomass, SNF in the first cut was significantly lower than that in the second cut. Clover herbage biomass and SNF were consistently negatively related to ley age. During the production years, percentages of clover and SNF were significantly higher in the south than in the northwest. However, once soil properties were included into the analysis, region lost its previous significance as an explanatory variable for SNF. SNF was significantly positively correlated with soil-CEC and with concentrations of soil-K and -Mg (not shown).

Tab. 1: Symbiotic nitrogen fixation (SNF) in organically cropped red clover-grass leys in the coastal regions of Finland (n = 52; means averaged over two growing seasons, standard deviations in parenthesis)

	Accumulated cuts (kg N ha-1 yr-1)a		Aftermath (kg N ha-1 yr-1)		Accumulated growth (kg N ha-1 yr-1)b	
	Southc	Northwestc	Southc	Northwestc	Southc	Northwestc
One-year-old leys	287.3 (108.2)	145.5 (81.3)	78.6 (70.1)	61.9 (47.2)	365.8 (113.6)	207.4 (121.0)
Two-year-old leys	194.9 (86.6)	113.8 (83.8)	77.4 (54.4)	30.6 (27.6)	272.2 (115.1)	144.4 (109.0)
Three-year-old leys	NAd	67.8 (77.6)	NAd	18.2 (20.2)	NAd	86.0 (94.9)

a First and second cuts.

[b] Accumulated first and second cuts plus aftermath.

[c] South = southern coastal region, northwest = north-western coastal region.

d Not assessed due to termination subsequent to the second cut.

Calculated over the three annual growth cycles of one- and two-year-old leys, the coefficients of between- and within-field variation of SNF averaged 51.1 and 51.8%, respectively, being about twice as high as those of herbage production (not shown). The between- and within-field coefficients of variation of SNF decreased from the first to the second cut but increased with ley age. Whereas the variability of herbage production did not differ between the regions, the between- and within-field variations of clover percentages (not shown) and SNF were considerably higher in the northwest than in the south (for SNF: Tables 1 and 2). The lower was SNF on a field level, the higher was its within-field variation (not shown).

Tab. 2: Coefficients of within-field variation of symbiotic nitrogen fixation (SNF) in organically cropped red clover-grass leys in the coastal regions of Finland (averaged over two growing seasons)

	First cut (%)a		Second cut (%)a		Aftermath (%)b	
	Southc	Northwestc	Southc	Northwestc	Southc	Northwestc
One-year-old leys	40.8	87.2	32.2	52.7	33.4	58.2
Two-year-old leys	63.8	68.5	38.2	56.5	45.8	81.4
Three-year-old leys	102.4	101.0	63.6	106.1	NAd	117.6

a n = 79.

[b] n = 52.

[c] South = southern coastal region, northwest = north-western coastal region.

d Not assessed due to termination subsequent to the second cut.

Discussion

To ensure the establishment and the persistence of perennial legumes, attention has to be paid to the physiological requirements of the respective species (Dhont *et al.* 2002). However, between-field variation of SNF did not exceed its within-field variation, indicating that the variability of clover growth was caused by soil properties rather than by management (including fertilization practices).

The positive correlation between SNF and soil-CEC emphasized the importance of soil structure for red clover growth. CEC increases with clay and humus contents, i.e., factors that define porosity, and therefore water and gas transport in the soil, storage of plant-available soil water, mineralization of SOM by the decomposer population, chemical reactions, and penetrability of the soil by roots. To avoid soil compaction, the load of machinery, the number of passes, and the intensity of tillage ought to be reduced (Reintam *et al*. 2009).

Soil structure is enhanced especially by certain perennial crops and animal manure. Under green manuring where organic matter (OM) and plant nutrients are cycled within a narrow area, within-field variation will increase. In contrast, the re-cycling of OM and nutrients through harvest of forage and application of animal manure to the field decreases the heterogeneity of soil properties between and within fields. Application of animal manure also allows for a higher share of non-leguminous crops in the crop rotation, which helps breaking legume disease cycles.

Conclusions

The spatial variability of SNF between and within fields was high. Consequently, the preceding crop value of single ley crops needs to be assessed from case to case. Soil properties, especially soil structure, appeared to be decisive for the productivity of organic crop husbandry. Site-specific soil amelioration obviously offers a huge potential to increase crop yields on a field level. Within-field variation of soil properties can be reduced through an integration of crop and animal husbandry.

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Effects of Legume Cover Crops on Corn Growth and Soil Conservation in No-till

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Key words: Corn, Cover crop, Green manure, No-till

Abstract

Cover crops are used occasionally in no-till to help control weeds, prevent erosion and increase nutrients in the soil by using legumes. The objective of this study was to evaluate the effectiveness of living mulch as legume cover crops for supplying N to high-N-requiring crop, conserving soil and controlling weed in no-till corn cultivation. Emergence of corn sown due to living mulch of cover crops delayed the 2-3 days and survival rate was lower than that of conventional tillage. The ear yield of corn grown due to living mulch of hairy vetch and crimson clover without N supply attained 65 and 45%, respectively, compared to conventional, while biomass yield per plant in hairy vetch significantly higher than that of conventional tillage. Amount of runoff by rainfall in no-till corn field decreased by 77 and 87% in hairy vetch and crimson clover, respectively, so that the amount of soil erosion decreased by 97 and 99%. In addition, because of low soil temperature and light interception by cover crops, Stellaria aquatic L. as winter annual weed only occurred in cover crop field during corn growing season.

Introduction

With the population increasing in the world, the need to protect agricultural land and to stable food supply has become critical issue. Because agriculture is a soil-based industry that extracts nutrients from the soil, effective management practices for removal nutrients from soil and its returning to the soil will be required in other to maintain and increase crop productivity and sustainability of the arable land in the long term (Gruhn 2000). Around the world the concept of sustainable agriculture has been embraced to try to ensure that food supplies will continue to match demand. In order to maintain and improve soil fertility and achieve a sustainable agriculture, it is necessary to reduce mechanical soil preparation and keep a continuous cover of the soil. One of the methods for sustainable agriculture, use of cover crops can have stabilizing effects on the agroecosystem by holding soil and nutrients in place, conserving soil moisture with mowed or standing dead mulches, and by increasing the water infiltration rate and soil water holding capacity (Dabney *et al,* 2001). Also, cover crops recycle nitrogen in the soil, help to build soil organic matter, and improve soil structure to improve no-till crop yields. Long-term cover crops can boost yields while improving soil quality and providing environmental and economic benefits. Cultivation of winter cover crops as fallow crop in Korea and its soil cover for summer main crops in slope upland is very important in respect of soil conservation and weed suppression. The objective of this study was to evaluate the effectiveness of living mulch as legume cover crops for supplying N to high-requiring crop by using corn and conserving soil and controlling weed in no-till.

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Materials and methods

Two legume cover crops, hairy vetch and crimson clover were sown in the field with 10% slope at 10 October, 2009. In 2010, the field experiment for reduction of chemical fertilizer use included three treatments (0, 50 and 100%) of N fertilizer level with cover crops. The P and K fertilizers were applied at the recommended levels. Succeeding corn (*Zea mays* L.) under living mulch of two cover crops was directly sown with a plant density of 57,142 plants ha^{-1} on 4 May and 9 June, 2010. Corn yield was estimated by hand harvesting the center rows of each plot on 10 and 18 August according to sowing time, respectively. For investigation marketable yield, corn was selected based on more than 18-22 cm in length with straight row of kernels. In addition, amount of runoff and soil erosion was measured at the bottom of each drainage during corn growing season. Its equipment consists of a collecting gutter which was let into soil surface and connected to a collecting container on the downstream side. The distribution of weed was surveyed at 15 April, 1 June, and 20 August. Weeds sampled in a square meter quadrat were classified, counted and measured the weight.

Results

Emergence of corn in conventional tillage started 5 days after sowing and was completed 4 days later. Emergence of corn sown in living mulch of cover crops delayed the 2-3 days compared to conventional tillage (Table 1). The final survival rate of corn in living mulch was a lower than in conventional tillage. Compared to the conventional tillage, ear yield of corn grown with cover crops without N supply attained 65 and 45% in hairy vetch and crimson clover, respectively, while marketable value of corn was similar between conventional tillage and living mulch by using cover crops. However, biomass yield of corn in hairy vetch was 3% higher than in conventional tillage.

Table 1. Effects of legume cover crops on biomass and marketable ear yield in no-till corn sown on 9 June.

Cover crops	N Fertilizer levels (%)	Survival rate (%)	Biomass (Mg ha^{-1})	No. of marketable ear (1000 ea ha^{-1})	Yield index
Conventional		100	20.9	36.5	100
Hairy vetch	100	90	26.1	32.7	86
	50	59	21.5	22.3	61
	0	62	18.6	23.8	65
Crimson clover	100	66	19.6	21.6	59
	50	62	15.5	19.3	53
	0	79	18.1	16.4	45

During corn growing period in 2010, precipitation of rainfall was 475 mm. Amount of runoff by rainfall in no-till corn field decreased by 77 and 87% in hairy vetch and crimson clover, respectively, compared to conventional tillage (Fig. 1). Also, similiar trend was obsearved the reduction ratio of soil erosion by rainfall runoff, and the values were 97 and 99% in hairy vetch and crimson clover, respectively, compared to conventional tillage.

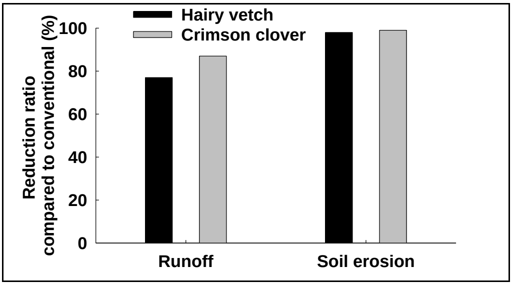

Fig. 1. Effects of living mulch as legume cover crops on runoff and soil erosion in no-till corn field.

The effect of living mulch of cover crops in no-till corn field on occurrence of weeds are shown in Table 2. At 15 April, the weed biomass in hairy vetch field was higher than in crimson clover field. The dominant weeds were *Capsella bursa-pastoris* L. and *Stellaria aquatica* L. in hairy vetch and crimson clover fields, respectively. At vegetative stage of corn, occurred weeds in hairy vetch and crimson clover fields were four and six species, respectively, while the weed was occurred with nine species in conventional tillage. Also, the dry weight of weed was decreased by 92 and 75% in hairy vetch and crimson clover fields compared to conventional tillage. After harvest of corn, on the other hand, weed occurred in hairy vetch, crimson clover and conventional tillage was five, four and five species, respectively.

Table 2. Effects of living mulch by using legume cover crops on occurrence and growth of weed species in no-till corn field.

Surveyed dates	No. of weed species (Species per m^2)			Dry weight (g m^{-2})		
	Conven-tional	Hairy vetch	Crimson clover	Conven-tional	Hairy vetch	Crimson clover
Apr. 15	-	4	3	-	61	94
Jun. 1	9	4	5	260	46	63
Aug. 20	5	5	4	232	134	152

Discussion

Several recent reports indicate that use of winter cover crops such as hairy vetch and crimson clover generally enhances soil fertility in no-till in spring-sown crop production (Dabney *et al,* 2001; Malhi *et al*, 2006). In this study, we examined the potentials of living mulch as legume cover crops for supplying N to high-N-requiring crop, conserving soil and controlling weed in no-till corn cultivation. Because soil temperature in living mulch covered was lower than in conventional tillage, emergence of corn sown due to living mulch of cover crops was delayed. Also, living mulch of cover crops has a little effect on the corn biomass production, while marketable ear yield was lower than that of conventional tillage. If low survival rate of corn sown in living mulch of cover crops is improved, the corn yield will increase because of a similar marketable value in all treatments. Benefits of **no till** system include reduced soil erosion, decreased labor and energy inputs, increased availability of water for crop production, and improved soil quality. In addition, using cover crop in no-till has improving soil structure and increasing infiltration, and reducing the flow velocity of water moving over the soil surface. In this study, living mulch by using cover crops was improved soil bulk density and the aboveground portion of covers also helps protect soil from the impact of raindrops. Consequently, runoff amount due to living mulch of hairy vetch and crimson clover decreased by 77-87% compared to conventional tillage, so that the amount of soil erosion significantly decreased. On the other hand, some cover crops suppress weeds both during growth and after death. At vegetative stage of corn, the dry weight of weed was decreased by 92 and 75% in hairy vetch and crimson clover fields, respectively, compared to conventional tillage. During growth these cover crops compete vigorously with weeds for available space, light, and nutrients, and after death they smother the next flush of weeds by forming a mulch layer on the soil surface (Blackshaw *et al*, 2001). Especially, *Stellaria aquatic* L. as winter annual weed only occurred in cover crop fields during corn growing season. It is these possibilities that low soil temperature and light interception by soil cover of legume cover crop. The results were considered that although using cover crop is effective for soil conservation and weed suppression, however, further research needs to evaluate cover crops for improvement of corn survival rate in no-till cultivation.

Conclusions

Living mulch of cover crops in no-till could significantly improved the soil physical and surpressed the weed during corn cultivation. In comparision to the conventional tillage, the amount of runnoff by rainfall in no-till corn field decreased by 80-85% in living mulch of cover crops, so that the amount of soil erosion decreased by 97-99%. Occurrence of weed during corn cultivation also be reduced by the living mulch of cover crops. However, the marketable ear yield of corn grown due to living mulch of cover crops was lower than that of conventional tillage, while the biomass yield of corn in hairy vetch was 3% higher. According to the results of this study, it is concluded that using cover crops could be an effective soil management for soil conservation and weed control in no-till. However, further research into the effective use of cover crops in cropping system needs to be carried out prior to the improvement of corn survival rate and nutrient turnover in soil.

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Forage quality for lactating cows in Latvian organic systems

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Key words: grass feed, quality, carotenoids

Abstract

Pasture grass, hay, silage and straw are the main sources of energy and feed materials for feeding of bovines in Latvia. Plants contain the feed materials required by animals including carotenoids which are to a certain extent passed over to animal products. Carotenoids play several important biologic roles, e.g., serve as pro-vitamin for vitamin A, act as boosters for the immune system, provide anti-carcinogenic and anti-oxidative impact, as well as improve the oxidative stability of products. Milk used for consumption or dairy processing should have a high anti-oxidative capacity to achieve high quality products. Feeding is one of the most significant factors influencing cow productivity, composition and quality of milk. It is expected that milk from cows fed silage have higher concentration of β-carotene and α-tocopherol than milk from cows fed hay. Therefore aim of the present study was analysed the content of total carotene in different forages in organic farming sistems. Results of investigation show that content of total carotenoids in pasture grass, clover and stem-grass samples decreased from June till August. The correlation between protein and total carotene content in organic pasture grass samples was calculated $r = 0.49$; $p < 0.05$. Feeding value dynamic of different sward changed more in time of vegetation than from fertilization designe and its dose.

Introduction

Currently, the organic farming products are produced 2.3% of the total number of farms in Latvia. Pasture grass, hay, silage and straw are the main sources of energy and feed materials for bovines fed in organic farms of Latvia. Moreover, it has been established in research that inclusion of a higher ratio of in-conversion feed in the feed ration of cows the milk harvested contains a higher ratio of the high-value ω-3 fatty acids and conjugated linoleic acid. Therefore, preparing the feed, attention should be paid to quality of the in-conversion feed. In the system of animals, carotenoids provide for several biologic functions: as a pro-vitamin to vitamin A and booster of the immune system and anti-oxidative impact, improving also the oxidative stability of products (Calderon et al., 2006) It can be concluded that depending upon the growing conditions of plants, preparation mode of the feed and the testing method used in the study, the carotenoid content in the same feed materials may be highly varied (Noziere et al., 2006). Natural grasslands and pastures of Latvia enjoy a high diversity of the plant species even rare and protected plants are found there. Under Latvian conditions, with long winter periods special attention should be paid to quality assessment of the in-conversion feed. Quite often dairy cows feed rations are calculated without taking in account of carotenoid content. Therefore, the purpose of our study is evaluation of the total carotenoid content in the feed materials most often used in nutrition of dairy cows in organic farm system.

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Materials and methods

Feed analyses were performed at Laboratory of Biochemistry and Microbiology of Research Institute of Biotechnology and Veterinary Medicine SIGRA LLU over the period 2009 - 2010. Under the trial, feed materials (silage n=37, haylage n=13, hay n=6, rapeseed cake n=3, carrots n=5) prepared for lactating cows in 6 organic farms. Silage samples were taken from silo bunkers from January till March. Comparison of grass yield, crude protein and fiber from May to July was made in one organic farm (n=12 without fertilizers) and one convencional farm (n=24) of Latvia. To assess the fluctuations of the carotene content of grasses and legumes over the grazing period, the following samples were tested: 11 pasture grass, 9 red clover (*Trifolium pratense L.)* and 9 cultivated grass mix samples (*Phleum pratense L.*,*Festuca pratensis Huds,Dactylis glomerata L., Lolium multiflorum Lam. et all)* , harvested over the period from June until September in one of the organic farms The indicators analysed were dry matter, protein, total fat and total carotenes. Dry matter content was established by drying the material in 60ºC for 18 hours; Kjeldahl method was applied for calculation of the protein content from nitrogen content multiplied by a relevant factor 6.25 pursuant to method LVS EN ISO 5983-1-2005; Total fat content was established with Soxslet method ISO 6492; Total content of carotenes was established by extracting them from a sample (3g) with 50 mL light petroleum and applying photometrics on FEK–56 M at 450 nm wavelength in accordance with ГOST 13496.17-95 method.The statistical processing of data was performed with the software program SPSS.

Results

It can be possible to get valuable grass feed without any supplemental fertilizers in organic farming system. The biochemical compositions of grasses in organic and convencional farming systems are compared in Table 1.

Table: 1 Changes of grass yield of and its DM content in timothy and red clover fresh mass

Time	NEL, MJ kg^{-1} in DM	Digestibility of nutrients, %	DM, g kg^{-1}	In DM, g kg^{-1}	
				Crude protein	fibre
1. Without fertilizers (organic farm)					
May 24	6.79	71.9	177.7	174.2	223.2
May 31	6.41	69.5	214.6	151.1	267.5
June 07	6.35	68.0	228.4	144.6	291.3
July 14	6.11	64.5	261.0	114.7	311.8
2. With Power 26-2-3 (70 kg/ha) (conventional farm)					
May 24	6.89	71.7	179.4	211.8	211.4
May 31	6.48	68.1	199.8	194.9	238.8
June 07	6.30	66.4	221.9	168.6	265.9
July 14	6.12	64.6	239.2	159.7	289.7
3. With Power 26-2-3 (100 kg/ha) (conventional farm)					
May 24	6.78	71.7	174.8	260.7	191.9
May 31	6.45	68.1	198.4	245.3	219.2
June 07	6.40	67.3	206.2	209.3	248.3
July 14	6.21	65.5	201.8	169.8	272.2

Changes of NEL are more connected with time of vegetation than with kind or dose of fertilizers Amount of fiber and digestibility of nutrients decrease in the time of vegetation.

The total carotene as well as protein and fat content in silage, haylage, hay, pasture grass, clover, stem-grass mix, rape seed meal and carrots is reflected in Table 2.

Tab.2: Content of total carotene in forage

Forage	n	Content of total carotene, mg kg^{-1} DM				Fat content %	Protein content %
		means	std. dev.	min	max		
		indoor season					
Silage	37	87.64	55.47	7.54	163.57	5.39	11.03
Haylage	13	7.57	7.13	0.42	12.84	3.74	12.00
Hay	6	1.78	1.82	0.01	3.60	1.87	6.58
Rapeseed cake	3	2.96	3.36	0.01	6.62	13.26	31.68
Carrots	5	138.95	83.04	13.35	221.75	0.24	0.87
		outdoor season					
Red Clover	9	47.13	30.23	10.05	88.21	3.56	17.82
Stem-grass	9	25.17	11.59	11.44	39.36	2.76	9.20
Pasture grass	11	24.06	15.58	10.28	46.34	3.12	12.79

Table 2 shows that in feeding technologies under animal confinement systems the carotene content in feed is established from 7.54 to 163.67 mg kg-1 of dry matter. Haylage contains considerably less total carotene - 0.42-12.84 mg kg-1 dry matter and hay where 4 samples of 6 indicated the total carotene content lower than 0.01 mg kg-1 dry matter. We should conclude that by feeding only hay and haylage, or silage with total carotene content under 20 mg kg-1 sufficient dose of β-carotene for dairy cows cannot be ensured. The current NRC recommendation for β-carotene intake -provide 300 mg per cow per day (NRC, 2001). The study allows coming to a conclusion that the carotene content in carrots is comparatively high even in March - 138.95 mg kg-1 dry matter on the average, however it should be noted that β-carotene makes up about 60% of the total carotenes in carrots. Changes of total carotene content in grass in outdoor season showed in figure 1.

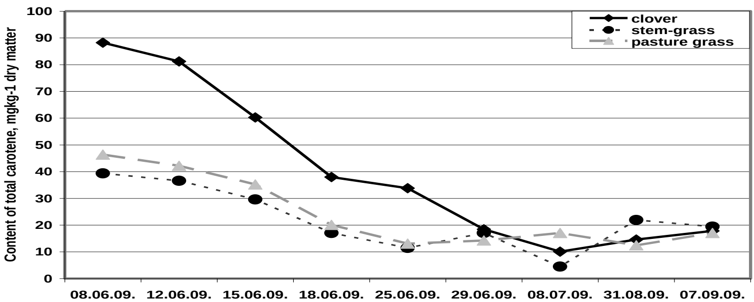

Figure1: Changes of total carotene content in grass

The carotene content in pasture grass was established at the level of 24.06 mg kg-1 dry matter on the average. Over the grazing season it fluctuates from 57.97 mg kg-1 at the start of June to 13.05 mg kg-1 in July. At the start of June, the carotene content in clover samples is about twice as high than that in cultivated grass mix samples, while in July the contents of these biologically active compounds does not significantly differ. The test results show a medium close correlation of the total carotene content (r = 0.49; p<0.05) to protein content in samples. Analysing the silage samples it is evident that the carotene content depends neither upon the fat nor the protein content. That could be explained by silage preparation technologies and different environment pH, which may influence the loss of biologically active compounds in storage.

Discusion

According to studies of Calderon and associates (2006) in their turn, the carotene content of the pasture grass of the Alps from June to October were fluctuating within the limits of 22.6-79.3 mg kg-1. Carotenoid contents indicated in scientific sources also closely correlates (r = 0.71) with protein content in grass samples and a close negative correlation exists (r = -0.73) with fibre contents in samples (Calderon et al., 2006). These results are similar to those obtained in our study and could be explained by sourcing the samples in natural pastures in organic farming systems. The scientific data regarding the plant carotene content over the season are contradictive, for the latter are largely influenced by the particular vegetation phase of the plants and changes in biochemical contents thereof, as well as the weather and soil conditions (conditioning with nitrogen fertilisers increases both, the protein and carotene content in green plants). It is possible that proteins promote the synthesis process of carotenoids (Park et al, 1983).

Conclusions

- Feeding value dynamic of different sward changed more in time of vegetation than from fertilization mode and its dose.
- At the start of June, the total carotene content in the red clover samples 88.21 mg kg^{-1} dry matter, while in stem-grass mix samples it was 39.36 mg kg^{-1} dry matter, in July the content of the biologically active compounds did not significantly differ (p<0.05).
- A medium close correlation of the total carotene content (r = 0.49; p<0.05) with the protein content in pasture grass samples was established.
- The total carotene content in silage samples was established at the level 7.54 to 163.57 mg kg^{-1} dry matter, while in hay samples - 0.01 to 3.60 mg kg^{-1}dry matter.

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Study on dry matter yields of forage plants using swine slurry in fallow paddy land located in the mid-mountain area

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Key words: Fallow paddy field, Cattle feedlot manure, Pasture

Abstract

This study was conducted to develop the technique for cultivation of grasses and forage crops using swine slurry (SS) in fallow paddy land (FPL). The field experiments were carried out from 2007 to 2009 on FPL at Kumsan, Chungbuk province in Korea. SS was prepared by mixing faeces and urine of swine in tank for 6 months. The experimental plots were consisted of seven treatments; tall fescue-based mixed pasture applied with chemical fertilizer (Control), mono-tall fescue pasture (MTFP), tall fescue-based mixed pasture (TFBMP), mono-Perennial ryegrass(MPR), mono-Italian ryegrass (MIR), mono-Red clover (MRC) and mono-Reed canarygrass (MRCG) applied with SS. Dry matter (DM) yields of forages and rates of grass coverage was higher in MTFP, TFBMP and MRCG as compared with other treatments and produced more than 15 tons per ha per.

Introduction

Koreans eating habits are continuing to become westernized. The consumption of rice has decreased and that of livestock product has increased. Also the cultivation area for rice is decreasing annually. KREI (2009) assumed the rice cultivation area was 1,072,000 ha in 2000, but decreased to 936,000 (87%) ha in 2008. Especially, FPL located in the mid-mountain area has increased in some regions of Korea. As a result, rice grower are obliged to change production from paddy rice to other crops. The introduction of grasses and forage crops system using FPL field can be a solution because it provide forage resources for livestock feed. Therefore, this study was conducted to develop the technique for cultivation of forage crops using SS in FPL.

Materials and methods

This study was conducted to develop the technique for cultivation of grasses and forage crops using swine slurry in FPL from 2007 to 2009 at Kumsan, Chungbuk province in Korea. The experimental plots were consisted of six treatments; tall fescue-based mixed pasture applied with chemical fertilizer (Control), mono-tall fescue pasture (MTFP), tall fescue-based mixed pasture (TFBMP), mono-Perennial ryegrass(MPR), mono-Italian ryegrass (MIR), mono-Red clover (MRC) and mono-Reed canarygrass (MRCG). Expect for the control, all treatments were applied with SS. The field of tall fescue-based pasture had been sown with a grasses mixture containing 'Fawn' tall fescue, 'Potomac' orchardgrass, 'Reveille' Perennial ryegrass, and ‘kenblue’ Kentuky bluegrass, 'Kenland' Red clover. Seeding rates were 16, 6, 4, 2 and 2 ha^{-1}, respectively.

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Results and Discussion

The mean DM yields of forages for 2 years increased in order to control > TFBMP > MTFP > MRCG > MPR > MIR. The DM yields of control was significantly higher than other treatments ($p<0.05$). In general much research has shown that the forage yield with chemical fertilizer were higher than those with SS(Vetter and Steffens, 1986, Ruppert et al., 1985).

Table 1: The dry matter yield (t ha^{-1}) of grass and legume species at paddy field by the application of swine slurry

Treatment		1st cut	2nd cut	3rd cut	4th cut	Total
Control (Tall fescue Mix)	'08	8.78	3.75	4.00	5.00	21.53a
	'09	12.72	4.38	3.52	5.99	26.61^{A}
	Mean	10.75	4.07	3.76	5.50	24.07^{a}
Tall fescue	'08	4.89	2.19	3.07	4.03	14.18b
	'09	4.36	3.80	4.52	3.51	16.19^{B}
	Mean	4.63	3.00	3.80	3.77	15.19^{bc}
Perennial ryegrass	'08	3.99	1.75	1.44	4.33	11.51b
	'09	2.67	3.25	–	0.87	6.79^{D}
	Mean	3.33	2.50	1.44	2.60	9.15^{d}
Tall fescue Mix	'08	4.10	2.57	3.03	3.84	13.54b
	'09	8.78	4.16	2.87	3.91	19.72^{BC}
	Mean	6.44	3.37	2.95	3.88	16.63^{bc}
Italian ryegrass	'08	4.84	2.14	–	–	6.98c
	'09	1.72	–	–	–	1.72^{D}
	Mean	3.28	2.14	–	–	4.35^{e}
Red clover	'08	7.61	6.74	4.48	3.04	21.87a
	'09	8.95	1.85	3.34	–	14.14^{C}
	Mean	8.28	4.30	3.91	3.04	18.01^{bc}
Reed canarygrass	'08	4.59	–	2.72	3.97	11.28b
	'09	5.45	2.80	4.22	3.06	15.53^{BC}
	Mean	5.02	2.80	3.47	3.52	13.41^{c}

* a~c, A~D and $^{a\sim e}$ Values with different letters are significantly different at the 5% level.

Like the results mentioned above, control plot had higher DM yield than SS, this might be due to temporary immobilization resulting from high C : N ratio of SS. Kissel et al. (1976) reported that 20% of nitrogen applied became immobilized by soil microorganisms and can be utilization efficiency resulting from competition between crops and soil microorganisms (Inbar et al., 1990). Mean DM yield of TFBMP, MTFP and MRCG were significantly higher than those of MPR and MIR ($p<0.05$).

Table 2: Grass coverage of grass and legume species at paddy field by the application of swine slurry (%)

Treatment		1st cut	2nd cut	3rd cut	4th cut
Control (Tall fescue Mix)	'08	95.0	90.6	82.0	77.5
	'09	94.6	91.2	90.4	98.3
	Mean	94.8	90.9	86.2	87.9
Tall fescue	'08	93.6	79.4	65.3	74.0
	'09	55.3	98.0	63.0	95.7
	Mean	74.5	88.7	64.2	84.9
Perennial ryegrass	'08	91.2	76.3	36.0	33.0
	'09	4.7	37.7	1.7	3.0
	Mean	48.0	57.0	18.9	18.0
Tall fescue Mix	'08	63.1	56.4	57.7	79.7
	'09	61.3	86.3	68.3	95.0
	Mean	62.2	71.4	63.0	87.4
Italian ryegrass	'08	99.1	94.6	-	-
	'09	-	-	-	-
	Mean	49.6	47.3		
Red clover	'08	89.1	84.6	58.0	88.3
	'09	100	96.7	8.3	-
	Mean	94.6	90.7	33.2	44.2
Reed canarygrass	'08	74.3	84.9	92.7	79.7
	'09	95.7	97.3	89.7	91.3
	Mean	85.0	91.1	91.2	85.5

This result means that FPL has contained with favorable conditions for growing grass, because forage productivity is more than 15 tons per ha per year in FPL which is higher productivity of grassland in mountainous area (Jung *et al.,* 2007). In addition, the farmer can save the trouble of repeated plowing and sowing every year, due to the introduction of perennial grasses. However, the farmer must conduct the re-seeding and practice the management methods for improving the persistence of red clover and perennial ryegrass. Therefore, we suggest that FPL may be the good land for forage production utilizing SS. SS can be applied on FPL without any negative effects on DM production and the property of soil. FPL of Korea can be better utilized by applying SS to the mono and/or mixed swards

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Select of green manure crops ‘Crimson clover (*Trifolium incarnatum* L.)’ for organic schisandra cultivation

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Key words: *Schisandra chinensis* B., Green manure, Crimsonclover (*Trifolium incarnatum* L.)

Abstract

In Schisandra, Creamsonclover as green manure crops cultivation(honghwacho) when using the soil pH, EC, the improvement of good growth and photosynthesis of Schisandra by a lively, brilliant color and fruit characteristics, there are similar mineral contents, and practices Compound fertilizer inputs by 25 % compared to the savings of material is fresh, the dry weight of Schisandra moderate increases as green manure crops suitable alternative to chemical fertilizers.

Introduction

Schisandra (*Schisandra chinensis* B.) is a deciduous vine of family of Schisandraceae cultivated as house-arch type, shelf type, fence type, and soil surface is covered with the non-woven, natural sod, thumper, straw, etc. for weed and soil. It is concerned that green manure crops in organic farming is important as an alternative of chemical fertilizers. Green manure crops on the biodiversity of soil provide predator’s habitat. Especially green manure crops can conserve soil on non-cropping upland. Thus while growing of *schisandra* or before planting, we examine the effect of green manure on crop yield.

Materials and methods

Selection of green manure crops

Selection test of green manure crops was conducted among total 3 plants; K-oats, Cleansolgo and Creamsonclover. Seeding was transplanted at the beginning of April.

Sites of test: field in Specialization Crop Research Institute and farmer’s fields.Test crops: *Schisandra chinensis* B. aged 1-2 years. Style of culture: house-arch type. Photosynthesis and contents of main elements were examined using portable photosynthesis measurement and HPLC.

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Results

Length of plant was the highest in Cleansolgo and the shortest in Crimsonclover. Yields of fresh and dry weights were ordered as Crimsonclover>Creansolgo>K-Oats. Rate of dry weights were 43.7 % in K-Oates, 34 % in Cleansolgo, and 40 % in Crimsonclover. Germination rate was 90% in Crimsonclover, and K-Oats was of higher (80 %) lodging rate. Lesser lodging rate in Crimsonclover may be caused by the shortest length and highest germination rate (Tab. 1 & 2).

Tab. 1: Growth characteristics different at green manure crops.

Grass species	Characteristics of Grass species			Stem		No. of branch (ea)
	family	Quantity of sowing (Kg/999㎡)	Seedtime	Length (cm)	Diameter (mm)	
k-Ots	Gramineae	10-15	Ear. 4	96.1	3.1	7.0
Cleansolgo	"	5	Ear. 4	153.0	5.2	5.4
Creamsonclover	Fabaceae	6-8	Ear. 4	54.8	2.7	3.0

Tab. 2: Growth and hervesting characteristics different at green manure crops.

Grass species	Weight of plant (kg/50㎠)	Weight of dry plant (kg/50㎠)	Lodging per cent (%)	germination per cent (%)
k-Ots	3.2	1.4	80	90
Cleansolgo	5.3	1.8	20	90
Creamsonclover	5.5	2.2	5	90

Tab. 3: Growth characteristics of *Schisandra chinensis*(2years) different at green manure crops.

Treatment	Stem			Leaf		Fruit		No. of main branch
	Length (㎝)	Diameter (㎜)	No./ branch	Length (㎝)	Diameter (㎜)	Length (㎝)	Diameter (㎜)	
k-Ots	212.0	4.2	3.2	7.4	4.3	3.7	2.1	1.4
Cleansolgo	212.0	4.0	6.2	7.5	4.3	4.0	2.1	1.8
Creamson-clover	188.0	4.8	3.8	7.7	4.6	4.3	2.1	1.6
Composite fertilizer	226.0	4.3	6.8	7.6	4.6	4.8	2.6	2.0

Fruit and shoot growth of *Schisandra* were highest in composite fertilizer, but growth of leaf was highest in Crimsonclover even only in 2 years of growing time (Tab. 3). Photosynthesis of *Schisandra* was the highest in Crimsonclover (Tab. 4). Therefore, it is considered that Crimsonclover is the most suitable as green manure crop for organic cultivation of *Schisandra* plant. Analysis of fruit of *Schisandra* showed that sugar content, acidity and color were not significantly different in green manure crops (Data omitted).

Tab. 4: Photosynthesis of *Schisandra chinensis* as affected by green manure.

Treatment	Photosynthesis different at measurement part(mg/m2)		
	Above (150㎝)	Middle (100㎝)	Below (50㎝)
k-Ots	44.67	36.38	41.70
Cleansolgo	40.66	40.94	37.14
Creamsonclover	48.34	40.74	37.66
Composite fertilizer	37.84	37.68	39.03

Discussion

This study was conducted about selection of green manure crop for organic farming of *Schisandra*. Low quality and productivity may cause distribution of organic farming because organic management of soil is difficult. Therefore, green manure crop, Creamsonclover, was selected for high productivity and quality of *Schisandra* as alternative to chemical fertilizers in this study.

Conclusions

Yield of green manure crop was ordered as Creamsonclover>Cleansolgo>K-Oats, and Creamsonclover was of the highest of germination rate (90 %), and the lowest lodging rate. Therefore, Creamsonclover was suggested as the best green manure crop for organic farming of *Schisandra* plant.

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Organic rice production

Effects of rice-winter cover crops cropping systems on the soil physical properties in no-tillage paddy

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Key words: No-tillage, Cover crop, Paddy field, Porosity, Bulk density

Abstract

The purpose of this study was to find out optimum conditions for no-tillage rice-winter cover crops cropping system. A field research was conducted to change of soil physical properties in rice-winter cover cropping systems at Doo-ryangmyeon, Sacheon, Gyeongsangnam-do, Korea from January 2005 to October 2006. The experimental soil was Juggog series (fine silty, mixed, mesic family of Fluvaquentic Eutrudepts). The rice cultivars were experimented under some different high residue farming systems, i.e. no-tillage no treatment (NTNT), no-tillage amended with rice straw (NTRS), no-tillage amended with rye (NTR), no-tillage amended with Chinese milkvetch (NTCMV), and tillage no treatment (TNT). Bulk densities of soil in 2005 and 2006 were the highest in the TNT, while porosities of soil in 2005 and 2006 were lowest in the TNT. The NTR treatment was high soil porosity than the other treatments. The soil microbial biomass C contents in 2005, and 2006 were the highest of 477 mg kg^{-1}, and 485 mg kg^{-1} in the NTCMV, followed by 413 mg kg^{-1}, and 484 mg kg^{-1} for the NTR and 363 mg kg^{-1}, and 445 mg kg^{-1} for the TNT, respectively. Generally, cover crop treatments were more increased soil porosity and soil microbial biomass C content than those of TNT. No-tillage treatments were lower penetration resistance than TNT in the top soil layers.

Introduction

Crop residue management and its impact on soil organic matter and nutrient cycling are increasing in importance with the current renewed focus on agricultural sustainability. And organic farming is rapidly expanding world widely. Plant growth in organic systems greatly depends on the functions performed by soil microbes, particularly in nutrient supply. In comparison with conventional farming, organic farming has potential benefits in promoting soil structure formation (Wright et al., 1999), enhancing soil biodiversity, alleviating environmental stress, and improving food quality and safety. Because nutrient supply and pest control largely depend on organic inputs and biological processes in organic systems, organic farming avoids the inputs of synthetic chemicals and their consequences. It is known that tillage methods, and placement of crop residues can affect physicochemical properties, microbial populations, and their activity in the soil. Shear and Moschler (1969) found

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no difference in bulk density values between no-tillage and conventional tillage systems. Gantzer and Blake (1978) reported an increase in bulk density and lower air-filled porosity in the surface of the no-till soil. In Great Britain, it was reported that there was an increase in bulk density in the surface 15 cm of the direct-drilled soil, as compared to plowed soils (Cannell et al., 1980). However, increased bulk density with no-tillage did not adversely affect crop yield. The mechanization of a no-till system on sandy Alfisols may only be successful in the long run if appropriate measures such as mulching, crop rotations and fallow systems can be applied to regenerate soil structure and to enhance macroporosity (Franzen et al., 1994). The purpose of this research is to find out the most productive cropping systems that evaluation of rice-winter cover crops cropping systems with the influences of the cropping systems on soil physical properties and microbial biomass.

Materials and methods

General description of the experimental site. A field research was conducted to evaluate soil physical properties in Rice-Winter cover cropping systems in Sacheon, Gyeongsangnam-do, Korea from January 2005 to October 2006. The soil employed was Juggog series (fine silty mixed, mesic family of Fluvaquentic Eutrudepts). Five cover cropping systems were arranged as sub plots. All of the treatments were replicated 3 times. The treatment combinations were NTRS (no-tillage amended with rice straw), NTR (no-tillage amended with rye), NTCMV (no-tillage amended with Chinese milk vetch), NTNT (no-tillage no treatment), and TNT (tillage no treatment).

Chemical properties of cover crops. Chemical properties of cover crops were determined using the SSSA method (1994) The cover crops were oven-dried at 70 ^oC for 72 hr. and then digested using H_2SO_4 for total nitrogen, and a ternary solution (HNO_3:H_2SO_4:$HClO_4$=10:1:4 with volume) for the determination of P, K, Ca, Mg, and Si in rice was determined after H_2SO_4-$HClO_4$ digestion. The nutrients of cover crops used in this experiment were shown Table 1.

Tab. 1: The nutrient amount (kg ha^{-1}) of plant cover used in this experiment

Year	Plant	Dry rate	T-N	SiO_2	P_2O_5	K_2O	CaO	MgO	C:N ratio
2005	NTRS†	6,120	43	523	12	18	12	16	125
	NTR	5,150	53	60	23	78	7	4	93
	NTCMV	6,810	139	41	42	210	59	28	45
	NTNT	2,540	24	64	17	52	5	4	99
2006	NTRS†	2,910	15	232	4	6	16	2	77
	NTR	3,790	18	46	12	73	9	3	92
	NTCMV	7,330	123	43	54	241	67	27	25
	NTNT	1,530	11	38	6	28	4	3	59

†NTRS ; no-tillage amended with rice straw, NTR ; no-tillage amended with rye, NTCMV ; no-tillage amended with Chinese milk vetch, NTNT ; no-tillage no treatment

Physical properties of soil. Bulk density and porosity were determined using the core method (Blake 1986) on May 18, 2005 and May 16, 2006, respectively. Prepared the soil surface with a knife and placed the 100 cm^3 cylinder against the soil with the sampler in place. In the laboratory, weighed the moistened soil sample after the oven dry for 24 hours at 105^oC. Then, samples were reweighed and were measured. Soil penetration resistance was measured by corn penetrograph (Eijkelkamp, Netherlands) from 0 cm to 80 cm soil depths after harvest of rice in paddy field.

Measurement of microbial biomass C. Microbial biomass C was measured before water irrigation and 20 days after submerging by chloroform fumigation-extraction methods (SSSA 1994).

Results & Discussion

Soil physical properties and microbial biomass C content were compared in Table 2. Bulk densities of soil in 2005 and 2006 were the highest in the TNT, while porosities of soil in 2005 and 2006 were lowest in the TNT. The NTR treatment was high soil porosity than the other treatments. The soil microbial biomass C contents in 2005, and 2006 were the highest of 477 mg kg^{-1}, and 485 mg kg^{-1} in the NTCMV, followed by 413 mg kg^{-1}, and 484 mg kg^{-1} for the NTR and 363 mg kg^{-1}, and 445 mg kg^{-1} for the TNT, respectively. Generally, cover crop treatments were more increased soil porosity and soil microbial biomass C content than those of TNT. These results gave evidence for the residual effects of cover crops.

Tab. 2: The characteristics of soil physical properties and soil microbial biomass C content

Plant cover	Bulk density g cm-3		Solid phase %		Porosity %		Soil microbial biomass C mg kg-1	
	2005	2006	2005	2006	2005	2006	2005	2006
NTRS†	1.28ab*	1.33a	48.4ab	50.0a	51.6ab	50.0b	401bc	473a
NTR	1.22b	1.24b	46.0b	46.8b	54.0a	53.2a	413b	484a
NTCMV	1.28ab	1.29ab	48.2b	48.7ab	51.8ab	51.3ab	477a	485a
NTNT	1.29ab	1.35a	48.7ab	51.0a	51.3ab	49.0b	404b	472a
TNT	1.37a	1.34a	51.7a	50.7a	48.3b	49.3b	363c	445b

†NTRS ; no-tillage amended with rice straw, NTR ; no-tillage amended with rye, NTCMV ; no-tillage amended with Chinese milk vetch, NTNT ; no-tillage no treatment, TNT ; tillage no treatment.

*Values within a column followed by the same letter are not significantly different at 5% level by DMRT

Figure 1 shows clear differences in the penetration resistance among cover crops treatments in no-tillage paddy field and TNT. The NTRS and TNT treatments in 2005 were lower penetration resistance than the other treatments in the 0-20 cm layers. On the other hand, those of all treatments were not significant in the 20-80 cm layers. However, no-tillage treatments in 2006 were lower penetration resistance than TNT in the top soil layers. Especially, NTR treatment was exhibited lowest values in the 0-20 cm layers. These results agree approximately with those obtained in Karamanos et al. (2004) research which was effects of reduced tillage practices on soil penetration resistance of upland soil. In conclusion, the results of this study showed that rice-winter cover crops cropping systems improved surface soil physical properties and soil microbial biomass C content.

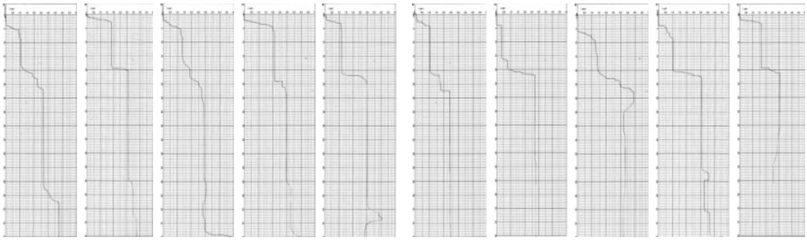

Figure 1: Change of soil penetration resistance after harvest of rice in 2005 and 2006. NTRS: no-tillage amended with rice straw, NTR: no-tillage amended with rye, NTCMV: no-tillage amended with Chinese milk vetch, NTNT: no-tillage no treatment, TNT: tillage no treatment

Acknowledgments

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Paddy weed control by residue management–in cold regions of Japan through Nature Farming

Iwaishi S.[1],Miki T., Abe D., Kato S. & Xu H. L.

Key words: Compost, Nature (organic) farming, Monochoria vaginalis (Burm. fil.) Presl var., Rice straw, Rice water weevil (Lissorhoptrus oryzophilus)

Abstract

A study on different applications of compost or rice straw suggested that in the cold regions of Japan, rice growth would be better and risk of weed and pest incidences would be lower if the accumulated soil temperature was higher during autumn ploughing and transplanting, which might avoid rapid decomposition of organic matter and high soil redox potential during the growth period. As a measure for paddy weed control, pre-decomposing of rice straw before transplanting is necessary and the adopting reasonable timing for ploughing and transplanting are key techniques. This is residue management, also called "soil breeding" that reduces risks of weed incidence by improving the ecosystem for stable growth of rice crops through understanding the ecological changes in paddy fields such as the cyclic oxidation and reduction.

Introduction

Rice plants bring changes in soil structure during growth by producing biomass such as straw and roots, which are used in soil formation and improvement. If applied to soil, 50% of the biomass of the rice straw would decompose into soil humus before the next cropping year (Kimura et al., 1980). In the cold or in the early cultivation in colder regions, a large quantity of organic materials remain in the puddled soil, and decompose under flooded conditions, resulting in damages to rice growth (Miki et al., 2009). Paddy rice cultivation with rice straw applied in right manner for managing the crop residues is called "Soil Breeding" as a basic technology in nature farming systems to improve productivity. Soil breeding is also considered a key technology to reduce harmful paddy weeds in organic paddy fields. Therefore, in the present experiment, the effect of ploughing practices and fertilization regimes on rice plant growth and germination of seed-borne weeds in a paddy field in Japan, sited in the cold regions was evaluated under field conditions.

Materials and methods

Field Experiment: The Experiment was conducted from autumn 2009 in a paddy field having a grey low land soil at the International Nature Farming Research Centre Experiment station located in Nagano Prefecture, Japan (N36º12', E137º51', 650 m above sea level). A factorial experiment was carried out with the treatments as follows: 1) Rice seedlings were transplanted on May 15 (Early tr) or June 3 (Late tr) , 2) Raw rice straw was applied into the paddy soil in autumn (RA) and in early spring (RES). Composted (CBW) and fresh rice straw (FBW) were applied immediately before water

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application in early 2010. Each plot (40 m^2) were separated by plastic panels and replicated 4 times in a Latin square design. Weed incidence was examined periodically during the season. Decomposition of rice straw was measured by the Mesh bag technique (Bocock & Gilbert, 1957). Rice grain yield was recorded in all plots.

Pot Experiment: Rice straw was mixed into the soil from the paddy field as described in the Field Experiment. The straw – soil mixture with a 60% water content was incubated at 30ºC for 30, 40, 45, 50, and 60 days. The incubated soils were used for pot culture of rice plants and plant growth and weed incidence were determined. Moreover, soils with and without straw mixed were incubated for periods of 10 to 60 days and the Redox potentials of the incubated soils were measured by a Glass electrode.

Results

Weed dominance and pest incidence as affected by rice straw decomposition in paddy field

The biomass of straw was reduced 60% by decomposing and a further half was reduced in the paddy soil (RA's). Rice straw incorporated into soils during autumn ploughing and before water immersion showed 40% decomposition and was further decomposed by 20% after water immersion. The soil mulched with straw (FBW) through winter to the spring reduced its biomass by 20% and was further reduced by 10% up to water immersion. Therefore, the biomass of the rice straw was reduced by 40% in plots (RES, FBW) ploughed in early spring and immediately before water immersion (Fig. 1). Due to the decomposition of the rice straw before water immersion, rice plant growth increased and weed flora ratio to biomass (WFR) decreased. When the transplanting was postponed for 19 days, rice straw was reduced by decomposition during the puddling period and the WFR decreased (Fig. 2). In plots with more tillers, the incidence of rice water weevil (RWW) as parasite in rice plants was lower (Fig .3). However, later transplanted rice plants were damaged to a greater extent by RWW when compared with the early transplanted plants as the later transplanting time corresponded to the egg laying time of the RWW.

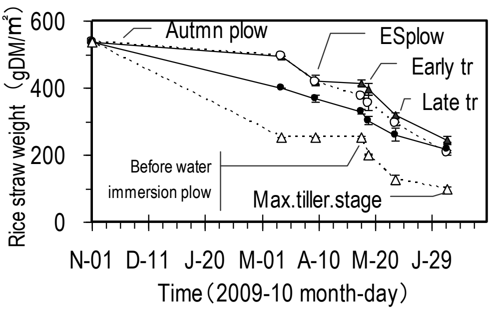

Fig.1 Rice straw weight with ploughing practice

FBW RES RA CBW

RA;Raw rice straw applied in Autumn ,RES;Raw rice straw applied in early Spring,CBW;Composted,FBW;Fresh rice straw applied immediately before Water immersion. The error-bars indicate standard error

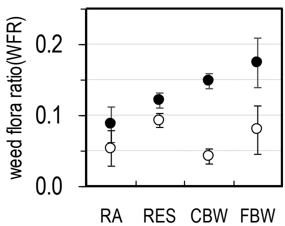

Fig.2 Weed dominance at HD

● Early tr. ○ Late tr.

WFR means dry mass ratio of weed /weed and rice at heading, The error-bars indicate S.E., Early tr.;early transplanting,Late tr.;late transplanting, RA,RES,CBW,FBW; as in Fig.1

Rice grain yield affected by rice straw decomposition

Grain yield was highest in plots RA where rice straw was decomposed to a greater extent and was comparable to yields of organic rice in the region. Yields declined in the order of plots - compost application (CBW) and plots ploughed immediately before water immersion (FBW), with the lowest in plots ploughed in early spring (RES). The growth and grain yield of both rice and weeds decreased in plots of RES (Tab.1). When comparing later transplanting with earlier transplanting, the grain yield was lower in plots with weeding but higher in plots without weeding (Tab.1).

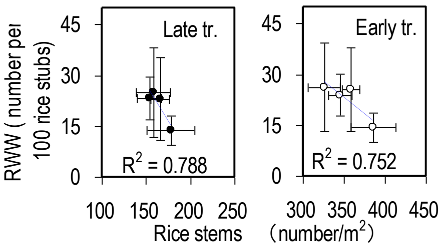

Fig.3 Parasite Number of RWW in rice plants

RWW means rice water weevil ,The error bars indicate S.E

Table 1 Rice yields under two factorial treatments (t/ha (SE))

plots	with Weeding	without weeding
RA	5.44 (0.16)	4.44 (0.24)
RES	4.99 (0.13)	3.84 (0.12)
CBW	5.29 (0.19)	4.24 (0.15)
FBW	5.03 (0.17)	4.12 (0.17)
Early tr.	5.35 (0.14)	4.02 (0.10)
Late tr.	5.02 (0.07)	4.30 (0.15)

RA,RES,CBW,FBW; Early tr,Late tr; Show the detail fig.1.

Soil redox potential and growth of rice and weeds as affected by soil incubation before water immersion

When soils were incubated at 30ºC for 900 day ºC, the soil redox process after water reduction was slow irrespective of mixing rice straw or not. The soils incubated for 0 to 300 day ºC showed a rapid increase in redox potential even without rice straw while that incubated for 600 day ºC did not show any redox process in the absence of rice straw. In contrast, there was a clear increase in redox potential if rice straw was mixed (Fig. 4). The biomass of weed was the highest in the pot where the soil had been incubated for 1350 day ºC. The biomass of rice was the highest in the pots where the soil had been incubated for 1800 day ºC but in the pots incubated for 900 day ºC was lower than that of 0 day ºC (Fig. 5).

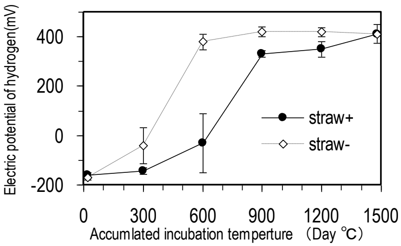

Fig.4 Redox potential of incubated soils 7days after immersion and puddling

The error bars indicate standard deviation

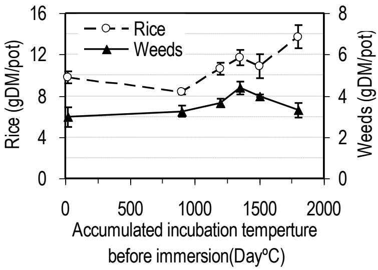

Fig.5 Rice and weeds growth under soil-incubation before immersion

The error-bars indicate standard error

Discussion and conclusion

If the straw was decomposed less during flooding in puddled paddy conditions after transplanting, weeds were reduced to a greater extent. The decomposing of rice straw before transplanting by autumn ploughing or composting and postponing transplanting could promote rice plant growth and reduce the flora ratio of weeds. The growth of both rice plants and weeds was low and the grain yield was depressed if the rice straw was applied immediately before transplanting. In plots with more tillers, the incidence of RWW was low , thus facilitating greater competitive ability of rice plants over weeds. Rice straw applications contributed to controls of weeds and pests. In plots ploughed in early spring, strong soil redox potentials occurred if the accumulated soil temperature (ACST) reached 600 day ºC. As suggested by the results, in the cold regions, the rice growth would be better and risks of weed and pest incidences would be lower if ACST was higher during the autumn ploughing and transplanting, which might avoid sharp decomposing of organic matter and develop a high soil redox potential. However, in addition to ACST , the soil moisture and percolation might limit the decomposition of the organic materials (Kubota, 1992). Thus, further studies are needed to promote the soil oxidation and redox buffer capacity by improving the conditions with optimum moisture with good drainage in the snowbound or poorly drained fields. Soil reduction occurs easily in organic paddy fields because of the presence of organic materials. This is the main reason for the incidence of *Monochoria vaginalis* (Saitoh *et al*., 2001). In conclusion, as a measure for weeds control, pre-decomposing of rice straw before transplanting is necessary and the selections of reasonable timing for ploughing and transplanting are the key techniques to obtain optimal rice yields (Iwaishi *et al.*,2010). Therefore, residue management, also called "soil breeding" reduces risks of weed incidence, and is defined as the transition of the conditions to suitable for stable growth of rice crops by understanding the ecological changes in paddy fields such as the cyclic oxidation and reduction over one year.

Acknowledgments

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Weed control in organic rice cultivation by applying organic materials such as rice bran

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Keywords: Organic rice cultivation, weed control, rice bran, rice straw, *Monochoria vaginalis*

Abstract

Weed control is one of the most important technical subjects when farmers tackle organic rice cultivation. Application of organic matter such as rice bran at transplanting is widely used in weeds control of organic rice cultivation, but its effect is unstable. In this study, we investigated the effective application of organic matter against paddy weeds in organic rice cultivation. The application of the organic matter of C/N ratio of 16 at the rate of 10 g N m^{-2} to soil surface increased rice yield by 35 % and reduced weed dry weight at harvest time by 93 % as compared with the incorporation of the organic matter of C/N ratio of 8 into soil at the rate of 5 g N m^{-2}. Although application of organic matter to soil surface reduced weed dry weight more effective than incorporation of organic matter into soil as described above, when organic matter was applied to soil surface where decomposed rice straw existed in the plow layer, weed dry weight was reduced by 80 % compared to that where raw rice straw existed in the plow layer. Our study showed that appropriate managements of the organic matter might play an important role to increase rice yield and suppress weed in organic rice cultivation.

Introduction

In extension of organic rice cultivation, weed control is one of the challenges and the most desirable solution (Riemens et al. 2006). In organic rice cultivation, measures of weeds control should be combined with various factors such as plowings with proper timing and practice, applications of rice straw, field management, seedling nurture etc. (Hasekawa 2008). In concept, this idea is consistent with the integrated weeds management that involves appropriate combinations of several weeds control techniques to retain the weeds incidence below the economic damage threshold (Zoschke and Quadranti 2002). As one of the measures to control weeds in organic rice cultivation, fresh organic materials such as rice bran are applied at the transplanting. Many organic rice farmers have practiced this method and many studies have been carried out to confirm the effectiveness in weed control by the application of fresh organic materials that have been practiced by farmer. As reported by Oba (2002), the shorter the period between organic materials application and seedling transplanting, the higher the effectiveness of the weeds control and the more the organic materials applied, the better the weeds control and the higher the rice grain yield in comparison with the control without weeds control. As reported by Nakayama (2002), with application of rice bran at 100 to 200 g m^{-2}, the weeds such as *Cyperus microiria*, *Callitriche verna*, *Rotala indica* and *Echinochloa crus-galli* were suppressed but this was not so effective in control of weeds like *Scirpus juncoides subsp. juncoides* and *Monochoria vaginalis*. Application of rice bran in shape of powder and

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pellets effectively suppressed the growth and development of *Echinochloa crus-galli* with higher effect when applied quantity is increased, but promoted growth of *Scirpus juncoides subsp. juncoides* (Muroi 2004). Application of alfalfa straw instead of rice bran also resulted in a good effect in paddy weeds control (Xuan et al. 2003). There are many other reports on paddy weed control by applying fresh organic materials such as rice bran. Actually, the effect in weeds control is not so stable when the fresh organic materials are applied in paddy field (Shimamune and Suzuki 2006). The reasons include the variations of cultivation conditions such as climate, soil type, and field and water managements. In addition, quantity, timing, position and quality of the organic matter application and decomposing extent of the crop residuals left from the former crop season also affect the effectiveness in weeds control. Therefore, in the present study, we examined the effect of the quantity, application position and C/N ratio of the applied organic materials on weed dry weight and rice grain yield as well as the effect of the decomposing extent and application practice of the applied organic materials on weeds incidence.

Materials and Methods

Experiment 1 (EX1): The experiment was conducted as 3-factorial design in a paddy field with a gray lowland soil in Matsumoto city (700 m above sea level), Nagnao, Japan. The total 16 plots, each with 9.7 m^2 areas, were arranged in complete random with 2 replicates. Organic mixture of rice bran and fish meal was applied to each plot. The treatments include: 1) Application rate at 10 or 5 g N m^{-2}; 2) Application position on soil surface or incorporated into the topsoil layer (5 cm); and 3) C/N ratio at 16 or 8. The C/N ratio was adjusted by organic mixture. Seedlings of rice (cv. Koshihikari) were transplanted in early June 2007. Soil mineralized nitrogen and available nitrogen were measured at the beginning and the stage of maximum tillering. The crop was harvested in early October with the weed dry weight and rice grain yield recorded. The quality of rice grain was measured by Near–infrared spectroscopy..
Experiment 2 (EX2): Rice (cv. Koshihikari) was grown in a/5000 Wagner's pots filled with the same soil as in EX 1. Treatments included 1) completely decomposed rice straw, 2) raw rice straw and 3) without straw. The rice straw was incorporated into the 0-5 cm topsoil layer. In addition to the 3 rice straw applications, organic mixture of rice bran and fish meal was 1) applied on soil surface, 2) incorporated into topsoil layer (0-5 cm) and 3) without rice bran application. Oxidation-reduction potential (Eh), Fe^{2+} ion, nitrate and ammonia were measured with intervals. Aboveground biomass of rice and weed was measured 26 days after transplanting.

Results

EX1: Concentrations of ammonia and available nitrogen during the tilering period were higher in plots of 10 g N incorporated application and C/N ratio 8 compared with plots of 5 g N surface application and C/N ratio 16 (data not shown). The weed dry weight at the harvest time was higher in plots of 5 g N incorporated application and C/N ratio 8 than in plots of 10 g N surface application and C/N ratio 16 (Fig. 2). The dominant weed was *Monochoria vaginalis* in this experiment. The rice gain yield was higher in plots of 10 g N combined with surface application than that of 5 g N combined with incorporated application (Fig. 1). There was no significant difference in grain yield between C/N ratios of the organic mixture (data not shown). The quality of rice grain was better in plots with C/N ratio of 16 than in plots with C/N ratio of 8. Differences in quality of rice grain was not found between organic application quantities or between application positions.

EX2: Soil Eh was higher and soil Fe^{2+} ion concentration was lower in plots with decomposed rice straw compared to raw rice straw (data not shown). Soil Eh in plots with decomposed rice straw suddenly decreased during the experiment period if organic mixture was applied. The dominant weed was *Monochoria vaginalis* in this experiment, too. The weed dry weight was higher in raw rice straw plots than in decomposed rice straw plots. The weed dry weight decreased in surface application plots but increased in incorporated application plots (Fig. 4). The decrement in weed dry weight caused by surface organic application was larger in decomposed straw plots than in raw straw plots. The rice grain yield was higher in surface application of organic mixture than incorporation application (Fig. 3).

Discussion

As shown by results from EX1, the integration of quantity, application position and C/N ratio of the organic mixture applied at the transplanting stage affected rice grain yield and weed dry weight. In the present study, the rice grain yield increased by 35% and the weed dry weight decreased by 93% in the plots of organic mixture with C/N ratio 16 applied to soil surface at the rate of 10 g m^{-2} than that of organic mixture with C/N ratio 8 incorporated into topsoil layer at 5 g m^{-2}. Therefore, in order to obtain a good effectiveness in weeds control and rice yield improvement by applying organic materials at transplanting stage, it is necessary to combine the application practices properly. *Monochoria vaginalis* causes the largest weed problem in organic paddy field (Shimamune and Suzuki 2006; Hasegawa 2008). Compared with other weed species, *M. vaginalis* needs less oxygen for its seed germination (Kataoka and Kim 1978) and the depth of soil for germination is shallow within 1 cm (Koarai 2004). One plant of *M. vaginalis*, if established at rice transplanting stage, would produce more than 7000 seeds, equivalent to 432,000 seeds per m^2 of soil (Hasegawa 2008). To reduce *M. vaginalis* with such properties as abovementioned, a management is needed to prevent exterme reductive condition in submerged soil because *M. Vaginalis* prefer reductive condition at the germination time.

As shown by the results from EX2, decomposed straw application in which weed dry weight was lower with higher Eh and lower Fe^{2+} ion concentration than raw straw application. In general, it is known that Fe^{2+} ion concentration increases when Soil Eh decreases because of getting reductive condition in submerged soil. Consequently, there was possibility that germination of *M. Vaginalis* which prefer reductive condition was suppressed under more oxidative condition in decomposed straw application than raw straw application. Furthermore, germination of *M. Vaginalis* was more suppressed by applying organic mixture to soil surface. As described above, *M. Vaginalis* germinates from shallow place of soil. These findings suggest that application of organic matter to soil surface was effective against *M. Vaginalis* (mulching effect). In the future, a weeds management to build a system whereby weeds incidence is reduced by integrated cultivation management will be expected by clarifying the impact of various management measures such as applications of organic materials and plowing practices on weeds incidence.

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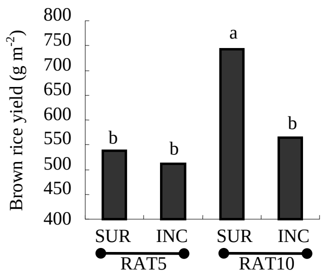

Fig. 1 Effects of interaction between application rate and placement method on rice yield in unweeded area in EX1. RAT5, application of organic mixture of rice bran and fish meal at the rate of 5 g N m^{-2}; RAT10, application of organic mixture at the rate of 10 g N m^{-2}; SUR, application of organic mixture to soil surface; INC, incorporation of organic mixture into soil at the depth of 0 to 5 cm. The values are the means of four replicates. Column with different letters are significantly different according to Tukey's test ($P < 0.05$).

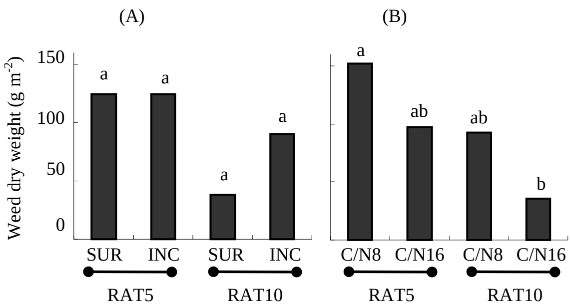

Fig. 2 Effects of interaction of (A) application rate and placement method and (B) application rate and C/N ratio of organic mixture on weed dry weight at heravest time in EX1. C/N8, application of organic mixture with C/N ratio = 8. C/N16, application of organic mixture with C/N ratio = 16. The other abbreviations in the figure are the same as Fig. 1. The values are the means of four replicates. Column with different letters are significantly different according to Tukey's test ($P < 0.05$).

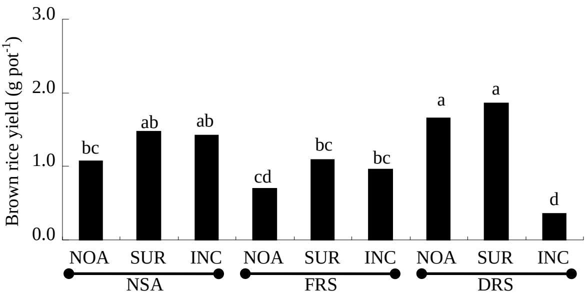

Fig. 3 Effects of interaction between placement method of organic mixture of rice bran and fish meal and decomposition degree of rice straw in topsoil layer on rice yield in EX2. NOR, no organic matter application; SUR, application of organic mixture to soil surface; INC, incorporation of organic mixture into soil at the depth of 0 to 5 cm; NSA, no rice straw; FRS, raw rice straw in topsoil layer; DRS, decomposed rice straw in topsoil layer. The values are the means of four replicates. Column with different letters are significantly different according to Tukey's test ($P < 0.05$).

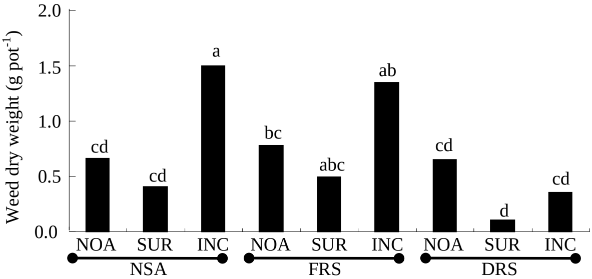

Fig. 4 Effects of interaction between placement method of organic mixture of rice bran and fish meal and decomposition degree of rice straw in topsoil layer on weed dry weight in EX2. Abbreviations in the figure are the same as Fig. 3. The values are the means of four replicates. Column with different letters are significantly different according to Tukey's test ($P < 0.05$).

Identifying proper application of compost produced in mixed crop-livestock farming for rice cultivation at Wanju Eco-Farming complex

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Key words: Organic, Farming, Organic material, Organic agriculture

Abstract

The test was carried out at a test field at the Wanju Eco-Farming Complex from 2009 to 2010 to figure out the proper application of fertilizers when growing rice at the Eco-Farming Complex. The result showed that when compared to the basal application of compost as fertilizer, applying supplementary compost after natural re-seeding of chinese milk vetch (CMV) helped balance soil nutrition and maintained rice yields.

Introduction

A large, environmentally sound farming complex was built in Wanju-gun, North Jeolla Province from 2006 to 2007, establishing a basis for organic farming such as Mixed Crop-Livestock Farming Center and Rice Processing Complex. Despite this, there has been no standard compost application in the Mixed Crop-Livestock Farming Center. Consequently, there have been concerns over soil-nutrition imbalance when cultivating organic rice. To address this concern, the present study aims to identify the proper application amounts of compost produced in the Mixed Crop-Livestock Farming Center.

Materials and methods

Chemical properties of the rice paddy and the composition of fertilizers used in the Wanju Eco-farming Complex were first analyzed. Basal fertilizer application and supplement application was applied at a ratio of 8:2. The basal fertilizers included only compost and compost after reseeding of Chinese milk vetch (CMV). They used oil cake as top dressing. The test was designed using four plots on the basis of 9kg/10a of nitrogen. The first rice plot was applied with compost as basal fertilizer and oil cake as top dressing. For the second plot, after applying CMV as basal fertilizer, compost and oil cake as top dressing was supplemented. The third plot was applied with chemical fertilizer. The forth plot was not fertilized.

Results

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Chemical properties of rice paddies and fertilizers at Wanju Eco-Farming Complex

Rice paddies at Wanju Eco-farming Complex had higher organic matter and phosphoric acid than conventional paddies that use chemical fertilizers and the amount exceeded the proper range (Tab. 1). The analysis of fertilizers showed that the nitrogen:phosphoric acid ration of the compost, CMV, and oil cake produced in the Mixed Crop-Livestock Farming Center was 1:1.9 , 1:0.1, and 1:0.5 (Tab. 2). The CMV can substitute 5.5kg/10a of nitrogen when it is returned to the field. (Tab. 3).

Tab. 1: Chemical properties of rice paddies at Wanju Eco-farming Complex (50 farms)

Properties	pH	EC	OM	Av.P_2O_5	Ex, Cation(cmol+ kg－1)			Av.SiO_2
	(1:5)	(dS m－1)	(g kg-1)	(mg kg-1)	K	Ca	Mg	(㎎/㎏)
Organic Farming	6.1	0.7	35	232	0.5	4.9	1.5	151
Conventional Farming	5.6	0.6	25	146	0.4	4.5	1.2	112
Adequate Range	5.5-6.5	-	25-30	80-120	0.25-0.30	5.0-6.0	1.5-2.0	157-180

Tab. 2: Fertilizer composition (%)

Fertilizers	T-N	P_2O_5	K_2O
Compost	1.4	2.7	2.1
Chinese Milk vetch	1.4	0.2	3.0
Oil Cake	4.0	2.0	1.0

Tab. 3: Reseeding CMV and the amount of fertilizer (kg/10a)

Fresh Weight(A)	Dry Weight(B)	B/A	N	P_2O_5	K_2O	CaO	MgO
2,317	383	16.5	5.5	0.8	11.5	2.4	0.9

Changes in rice yield and chemical properties of soil according to organic fertilizer applications

In the case of applying compost after reseeding CMV as basal fertilizer, phosphoric acid levels fell greatly when compared to the rice plot applied with compost only. The plot applied with chemical fertilizer had the highest amount of rice yield followed by the plot that used compost only and the plot that used compost after reseeding CMV.

Tab. 4: Chemical properties of soil before and after the test (2009-2010)

Application	Time	pH (1:5)	EC (dS/m)	OM (g/kg)	Av.P_2O_5 (mg/kg)	Ex. cations(cmol+/kg)		
						K	Ca	Mg
Compost after CMV as basal fertilizer	Before	6.3	0.2	28	251	0.34	3.2	0.73
	After	6.0	0.1	26	223	0.23	3.0	0.55
Compost Only as basal fertilizer	Before	6.2	0.1	27	210	0.30	3.0	0.64
	After	6.1	0.1	31	198	0.15	3.1	0.45
Conventional Application (Chemical Fertilizer)	Before	6.3	0.1	28	173	0.25	2.6	0.60
	After	6.0	0.1	26	161	0.15	2.4	0.43
No Fertilizer	Before	6.2	0.1	27	158	0.23	2.6	0.48
	After	5.9	0.1	24	136	0.13	1.9	0.33

Tab. 5: Rice Yield per Each Test Field (2009-2010)

Application	Brown rice (kg/10a)	Tiller's number	Leaf number	1000-brown rice weight (g)	Percentage of ripened grains (%)
Chinese milk vetch as basal fertilizer (N5.5kg/10a) and Compost (N1.7kg/10a)	455	14	80	25.0	75
Compost only as basal fertilizer (N7.2kg/10a)	464	14	80	24.6	77
Chemical fertilizer (9-3-3kg/10a)	472	14	81	24.6	77
No fertilizer	422	13	77	24.7	79

Discussion

Wanju Eco-farming Complex has used compost for organic farming by nitrogen application standard, so phosphoric acid level in the soil rose (Tab. 2). Concentrated phosphoric acid in soil can affect the aquatic systems of rural areas, threatening the ecosystem of rivers and lakes. Therefore, there is a need to apply green fertilizers such as CMV (Tab. 3) that has a low property of phosphoric acid as basal fertilizer and use compost as supplement. Rice yield was 2% higher under the compost-only plot, but taking into the economic factors such as fertilizer expenses, CMV reseeding supplemented with compost application is more profitable as it effectively reduces phosphoric acid levels in the soil.

Conclusions

When Wanju Eco-farming Complex uses compost produced in the Mixed Crop-Livestock Farming Center for organic rice cultivation, based on 7.2 kg/10a of nitrogen in basal fertilizer, reseeding CMV and applying compost is the most proper method for the rice production and soil environment.

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Effect on rice growth and change of inorganic nitrogen content in soil by application with rice bran and mixed expeller cake fertilizer on machine transplanting rice paddy field

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Key words: Rice bran, Mixed expeller cake, Soil physicochemical property

Abstract

This study was conducted to find a method using the application of rice bran and mixed expeller cake at machine transplanting rice paddy field. Different ratios of rice bran and mixed expeller cake were sprayed as substitute of chemical fertilizer (nitrogen 90kg ha^{-1}) before transplanting. Nitrogen content was highest in 30th day after transplantation, and in relation to treatments the order was the following: Rice bran 1,000kg ha^{-1} + Mixed expeller cake 1,374kg ha^{-1} > rice bran 2,000kg ha^{-1} + Mixed expeller cake 948kg ha^{-1} > rice bran 3,000kg ha^{-1} + Mixed expeller cake 522kg ha^{-1}. Number of panicle and spikelets per m^{-2} was higher in rice bran 1,000kg ha^{-1} + Mixed expeller cake 1,374kg ha^{-1} and rice bran 2,000kg ha^{-1} + Mixed expeller cake 948kg ha^{-1} than in rice bran 3,000kg ha^{-1} + Mixed expeller cake 522kg ha^{-1} and the yields was the highest in rice bran 1,000kg ha^{-1} + Mixed expeller cake 1,374kg ha^{-1}.

Introduction

Korean organic rice producers often use rice bran as a source of nutrients. The singular use of rice bran, however, results in lower plant height, number of tillers, and number of spikelets even when the same amount of nitrogen is supplied through rice bran as through chemical fertilizer (Kim et al., 2009). One of the reasons is because the efficiency of nitrogen fertilizer contained in rice bran is low. Also, nitrogen content contained in mixed expeller cake, another organic fertilizer, is more efficient and results in higher yield compared to the use of chemical fertilizer in an amount that can supply the same amount of nitrogen content (100%) (An et al., 2008). Therefore, it is believed that the combined use of rice bran and mixed expeller cake could improve the effectiveness of fertilization. This study tested the effectiveness of the combined fertilize at varying ratios.

Materials and methods

The test was carried out in 2008 in the experiment field of the Department of Rice and Winter Cereal Crop, National Institute of Crop Science located in Songhak-dong, Iksan-si, Jeollabuk-do using the Dongjin-1 rice variety. Considering the conventional application method (chemical fertilizer 90kg ha^{-1}), the amounts of rice bran and mixed expeller cake were decided at the level that supplies the same nitrogen content contained in chemical fertilizer 90kg ha^{-1}: rice bran (N: 2.16%, P: 3.78%, K: 1.43%) and mixed expeller cake (T-N Ratio 5.22%, N : 5%, P : 1%, K : 1%, KG Chemical).

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The tested mixing ratios of rice bran and mixed expeller cake are rice bran 1,000kg (nitrogen 21.3kg) ha^{-1} + mixed expeller cake 1,374kg (nitrogen 68.7kg) ha^{-1}; rice bran 2,000kg (nitrogen 42.6kg) ha^{-1} + mixed expeller cake 948kg (nitrogen 47.4kg) ha^{-1}; and rice bran 3,000kg (nitrogen 63.9kg) ha^{-1} + mixed expeller cake 522kg (nitrogen 26.1kg) ha^{-1}. As for the split application of fertilizer, the standard application method was used for chemical fertilizer. Fertilization using organic fertilizers followed the method used in the mixed expeller cake substation test (Yang et al., 2008) at the base to top dressing ration of 7:3. The base dressing was applied right before rotary tillage and the top dressing was applied 20 days prior to earing.

For this study, a single test field was created and the analysis was conducted on the test field three times with a 10-day interval with the first on the 20th day since transplantation of rice seedlings and the last on the 40th day. Wet soil collected in the depth of 10-15cm was analyzed to measure NH_4-N and NO_3-N contents. On August 9, which was before earing, the number of tillers and plant length were surveyed, and on October 10, which was during the ripening period, the yield and related properties were surveyed.

Results

The analysis of soil where three different ratios of rice bran and mixed expeller cake were applied showed that nitrogen content in soil was higher in the case of rice bran 1,000kg + mixed expeller cake 1,374kg ha^{-}1 until the 30th day after transplantation than in the case of chemical fertilizer. In the two other combinations in which the ratio of rice bran is higher, nitrogen content in the organically fertilized soil was lower than in the chemically fertilized soil throughout the study period (Tab. 1).

Tab. 1: Inorganic nitrogen in soil under different application rate of rice bran and mixed expeller cake

(Units: mg/kg)

Treatment	After 20DAT (July 1)	After 30DAT (July 11)	After 40DAT (July 21)	Heading stage (Aug 22)
Control	8.9	15.5	16.2	11.3
RB1,000kg+MEC1374kg ha^{-1}	14.9	19.0	12.4	11.7
RB2,000kg+MEC948kg ha^{-1}	11.8	12.0	9.5	11.9
RB3,000kg+MEC522kg ha^{-1}	8.9	12.2	9.2	13.4

RB: Rice bran; MEC: Mixed expeller cake; DAT: Days after treatment

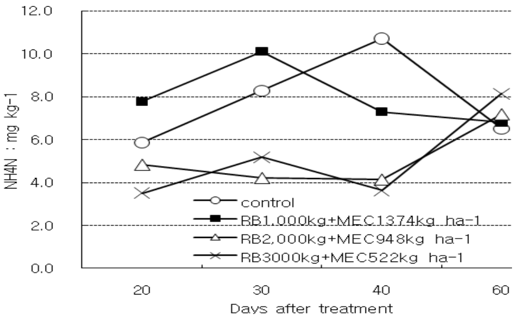

Figure 1: NH_4-N content in soil under different application rate of rice bran and mixed expeller cake

The analysis of NH_4-N content in soil showed a similar trend as that of nitrogen content. NH_4-N content in soil fertilized with the combination of rice bran and mixed expeller cake increased as the proportion of mixed expeller cake increased in the organic fertilizer (in the order of rice 1,000kg + mixed expeller cake 1374kg ha^{-1} > rice bran 2,000kg + mixed expeller cake 948kg ha^{-1} > rice bran 3,000kg + mixed expeller cake 522kg ha^{-1}) (Fig 1). No difference was observed in NO_3-N content between the different combinations analyzed.

Tab. 2: Rice yield and yield component under different application rate of rice bran and mixed expeller cak.

Treatments	No. of panicle per ㎡	No. of spikelets per ㎡	Percent ripened grain	1,000 grains weight	Milled rice yield	Yield index
	ea	×1,000	%	g	t/ha	
Control	304.4	38.0	74.6	20.8	6.23a	100
RB1,000kg+MEC1374kg ha^{-1}	317.2	40.3	73.2	20.8	6.26a	100
RB2,000kg+MEC948kg ha^{-1}	315.2	38,5	71.4	20.6	5.87b	94
RB3,000kg+MEC522kg ha^{-1}	284.2	35,1	79.4	20.3	5.75b	92

RB: Rice bran; MEC: Mixed expeller cake

The data was analyzed using SAS program(VER 9.2). Analysis of variance(ANOVA) was used to test the statistical significance, and Duncan's multiple range test was used to carry out significance of diffierence among means at P=0.05 probability level.

In terms of growth and development associated with the mixing ratios of rice bran and mixed expeller cake, the higher the proportion of mixed expeller cake, the greater the number of spikes per plant and the number of grains per㎡. The growth of rice was better in the soil fertilized by the mixture of rice bran 1,000kg + mixed expeller cake

1,374kg ha-1 and the mixture of rice bran 2,000kg + mixed expeller cake 948kg ha^{-1} than the soil fertilized by the mixture of rice bran 3,000kg + mixed expeller cake 522kg ha^{-1} and chemical fertilizer. The analysis of yield also showed a similar trend with the yield from the soil fertilized by the combination of rice bran 1,000kg + mixed expeller cake 1374kg ha^{-1} being the highest at 6.26MT ha^{-1} (Tab. 2).

Discussion

This study confirmed that the proportion of mixed expeller cake in the organic fertilizer consisting of rice bran and mixed expeller cake affects the growth, development, and yield of rice. The influence is believed to be due to the leaching characteristics of nitrogen fertilizer which differ from one organic fertilizer to another. Nitrogen content in the soil treated with the organic fertilizer where the proportion of mixed expeller cake is higher tends to be stable throughout the entire development period of rice, and accordingly nutrients were consistently supplied to the rice plants resulting in more tillers and grains. In the meantime, a number of different raw materials are used to make mixed expeller cake. Therefore, further analysis is advised to examine the speed of nutrient elution and effectiveness depending on the ratio of primary materials.

Conclusions

When the mixture of rice bran and mixed expeller cake is used as organic fertilizers for rice farming, nitrogen content in soil tends to remain stable when the proportion of mixed expeller cake is higher, and rice yield was the highest when the soil was fertilized with the mixture of rice bran 1,000kg + mixed expeller cake 1,374kg ha^{-1}.

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Effect of green manure biomass and rice yield on continuous cropping by different seeding rate of hairy vetch in paddy

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Key words: Hairy vetch, Seeding method, Green manure, Seeding rate, Rice.

Abstract

Green manure crops play an inportant role in organic farming. Field experiment was conducted at paddy soil (fine loamy, mixed, nonacid, mesic family of Aeric Fluvaquentic Endoquepts) in 2008/2009 to 2009/2010 at the National Institute of Crop Science (NICS), RDA, Suwon, Gyeonggi province, Korea. This experiment was carried out to evaluate the biomass of hairy vetch (Vicia villosa) and growth of rice (Oryza sativa) by different seeding rates. Seeding rates of hairy vetch consisted of 30, 60, and 90 kg ha^{-1} by broadcasting before rice harvesting. The biomass and nitrogen production of hairy vetch were not significantly different between 60 kg ha^{-1} and 90 kg ha^{-1} of seeding rates. Also, rice yield was not siginicantly differnt between seeding rate 60 kg ha^{-1} of hairy vetch and conventional pratice for two years. Therefore, we suggested that seeding rate of hairy vetch should be reduced by continuous cropping and incoportion of hairy vetch under rice-based cropping system.

Introduction

The cultivation of green manure crops is necessary for organic farming to replace chemical fertilizer in Korea. Especially hairy vetch is a good green manure for rice culivation as a legume crops. This crop has excellent winter survival and high content of nitrogen. Therefore, it is possible to cultvate this in a wide region in Korean penisula. However, seeds of hairy vetch has been imported from aborad at high cost because seed production of hairy vetch was so difficult due to economic and climatic conditions of Korea. Recently the reqeust of Korean cosumer has been increasing the production of organic farming as national income has increased (Jeon at al., 2006). So it is popular due to well-being in the coutry. Korean goverment (Ministry for food, agriculture, forestry and fisheries) has planed to increase the cultivation area of hairy vetch to 36% of green manure upto 2013. The seeding rate of hairy vetch is from 60 to 90 kg ha^{-1} and 30 kg ha^{-1} in paddy and upland soil, respectively in Korea. We suggested a hypothesis if hairy vetch has been contiuosly practiced under rice based cropping system, seeding rate of hairy vetch could be reduced as improving of soil environment. The effect of hairy vetch has been not studied in long-term of paddy soil as rice was cultivated to watering condition for long period. Therefore, this study was conducted to the effect of reduced seeding rate of hairy vetch on rice grwoth and yield by different seeding rates.

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Materials and methods

The experiment was conducted to find out the ruducing of seeding rate of hairy vetch under rice based cropping system at paddy soil (fine loamy, mixed, nonacid, mesic, family of Aeric Fluventic Haplaquepts) in NICS, Korea from September 2008 to October 2010 that had previously been planted hairy vetch for two years in a rice monoculture system. Climatic data during the two growing seasons of the experimentation are given in Table 1. Hairy vetch was seeded on the 3rd October and the 25th September in 2008 and 2009 by broadcasting before rice harvesting. The seeding rate cosisted of 30, 60, 90 kg ha^{-1}. Before 14 to 16 days of transplanting of rice seedling, the above ground portion of the plant was measured and then dried in an oven at 70°C, until a constant weight as obtained to measure the dry weight. Then, the total carbon (C) and total nitrogen (N) were measured using a CNS analyzer (Leco, USA). The harvested hairy vetch was used to cover the soil and was also incorporated into the soil for rice cultivation. Rice (*O. sativa* L. cultivar Wungang) seedlings that was 25 days old were transplanted on the 4^{th} June for 2 years using the transplanting machine at 30 x 14 cm density. The biomass of green manure, the soil chemical, physical characteristics and crop growth were investigated by standard methods of Rural Development Administration (RDA), Korea. Differences among treatments were estimated by one-way analysis of variance (ANOVA) using the SAS program (SAS institute, ver. 9.2, 2004) with Tukey's LSD. Differences were considered significant at $p< 0.05$.

Table 1. Monthly mean air temperature and total rainfall during the two growing seasons of experimentation at Suwon, Korea.

Mean monthly temperature (℃)				Total monthly rainfall (mm)		
Month	2008/2009	2009/2010	30-year average	2008/2009	2009/2010	30-year average
Sep.	22.3	21.6	20.2	101.9	56.3	133.5
Oct.	16.0	15.7	13.4	35.6	64.5	52.3
Nov.	7.4	6.9	6.1	18.5	68.2	51.0
Dec.	0.9	-0.7	-0.4	17.4	18.7	24.1
Jan.	-2.6	-4.4	-3.2	7.9	26.9	23.5
Feb.	2.4	1.4	-1.0	26.8	56.7	24.0
Mar.	6.1	4.6	4.5	59.5	78.7	47.0
Apr.	12.0	9.6	11.2	45.0	58.6	76.0
May	18.3	17.1	16.7	102.4	100.7	94.8
Jun.	22.1	23.1	21.4	118.8	116.1	133.2
Jul.	24.2	26.0	24.8	766.0	206.8	302.7
Aug.	25.7	26.9	25.2	207.1	372.8	305.8
Sep.	-	22.2	20.2	-	375.9	133.5

Results and Discussion

The biomass of hairy vetch plays a role using green manure under rice based cropping system. During two years of this experiment, fresh weight, dry weight and nitrogen production were evaluated before 14 to 16 days of rice seedling transplanting

(Table 2). During hairy vetch growing season, fresh weight, dry weight and N production were not significantly different between 60 and 90 kg ha^{-1} of seeding rate. It was estimated that hairy vetch was previously cultivated for two years. The cropping of hairy vetch was changed to soil environment such as chemical (Hatcher and Melander, 2003), physical (Jeon et al., 2008) and microbiological (Buyer et al., 2010) properties. Especially legumes such as hairy vetch are able to fix atmospheric nitrogen by microorganism (Clark et al., 2007; Schulz et al., 1999). It was indicated that hairy vetch root turnover and exudation during growing season had a positive effect on soil microbial activity (Buyer et al., 2010). However, the biomass of 30 kg ha^{-1} seeding rate was significantly lower than 60 and 90 kg ha^{-1}. The first year's biomass of hairy vetch was higher than second year's due to weather condition such as low temperature and much rainfall of growing season compared to the average year (Table 1).

Table 2. Biomass and N - uptake on of hairy vetch by different seeding rates.

Seeding rate (kg/ha)	2008/2009			2009/2010		
	Fresh weight (ton ha^{-1})	Dry Weight (ton ha^{-1})	N - Uptake (kg ha^{-1})	Fresh weight (ton ha^{-1})	Dry Weight (ton ha^{-1})	N - Uptake (kg ha^{-1})
30	14.6b	2.28b	67b	15.4b	1.60b	55b
60	26.6a	3.36a	118a	23.7a	2.35a	74a
90	26.9a	3.39a	116 a	27.3a	2.56a	93a

Rice yield and field lodging were conducted to investigate different seeding rate of hairy vetch as effective green manure (Table 3). In the first year, rice yield was not different between 60 kg ha^{-1} of seeding rate and conventional practice although 90 kg ha^{-1} increased yield compared to conventional practice. In the second season, 60 and 90 kg ha^{-1} of seeding rate did not show significant difference to conventional practice. Field lodging was occurred to this year because of typhoon. The 90 kg ha^{-1} of seeding rate showed serious lodging compared to conventional practice.

Table 3. Yield and field lodging of rice by different seeding rates of hairy vetch.

Seeding rate (kg/ha)	2008/2009		2009/2010	
	Rice yield (kg/ha)	Field lodging (0~9)	Rice yield (kg/ha)	Field lodging (0~9)
30	4751c	0	3949b	2
60	5000b	1	4537a	3
90	5352a	1	4578a	5
Conventional practice[1)]	5171ab	0	4325a	1

[1)] Applied to chemical fertilizers ($N-P_2O_5-K_2O$=90-45-57 kg ha^{-1}) and herbicide.

Green manure or cover crops can improve soil physical properties such as water infiltration and storage, and soil nutrients (Clark, 2007). Bulk density, porosity and carbon content of soil were investigated (Table 4) after rice harvesting. The bulk density and porosity of soil were improved at hairy vetch used plot compared to conventional plot. Carbon content was similar to bulk density and porosity.

Table 4. Bulk density, porosity and carbon content of soil after rice harvesting in 2010

Seeding rate (kg/ha)	Soil depth (0-10 cm)			Soil depth (10-20 cm)		
	Bulk density (Mg m^{-3})	Porosity (%)	Carbon content (%)	Bulk density (Mg m^{-3})	Porosity (%)	Carbon content (%)
30	1.02b	61.6a	1.70a	1.23b	53.7a	1.58a
60	1.07b	58.5a	1.82a	1.20b	54.8a	1.66a
90	1.15b	56.7a	1.84a	1.19b	55.0a	1.74a
Conventional practice	1.37a	48.5b	1.39b	1.34a	49.6b	1.54b

Conclusions

The cultivation of green manure is very important in organic farming. Hairy vetch usage replaces chemical fertilizer application under rice based cropping system. Field experiments were conducted to evaluate the effects of different seeding methods on the biomass and N production of hairy vetch and rice yield. The seeding rate of hairy vetch could be reduced to improving of soil physical and chemical properties in this system by continuous cropping.

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Fertilization Efficiency of Livestock Faeces Composts as Compared to Chemical Fertilizers for Paddy Rice Cultivation

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Key words: Livestock faces, Compost, Fertilization efficiency, Rice

Abstract

Soil NH_4-N content became higher in proportion to the increase in the urea application rate, while in livestock faeces compost (LFC) plots, it became lower than in urea plots and had no significant difference statistically among LFC plots. There was a close relationship between phosphate fertilization rate and the increment of soil available phosphate content after experiment resulting $y=0.1788x-6.169$ ($R^2=0.9425$) when applied fused superphosphate fertilizer, and $y=0.0662x-2.689$($R^2=0.9315$) when applied LFCs by the same amounts of phosphate (x: phosphate application, kg ha^{-1}, y: increment in soil available phosphate content, mg kg^{-1}). Plant height, number of stems, nutrients uptake by rice and rice yield showed higher levels in N 100, 150% application plots of chemical fertilizers, while every LFC plots exhibited lower values and no significant difference among them. Relative nitrogen fertilization efficiencies of LFCs compared to urea was 12.3% for cattle faeces compost (CaFC), 8.8 for swine faeces compost (SwFC) and 24.6 for chicken faeces compost (ChFC), respectively.

Introduction

In 2009, the Gyeonggi Province area surrounding Seoul produced livestock faeces amounting to about 8.3Tg which was 20% of the total production in Korea. Therefore, the environment-friendly management of livestock faeces is one of the greatest issues in order to preserve the rural environment in this area.

In Korea, there has been an application standard of LFCs for crop cultivation since 2000. This standard considers LFCs as a substitute for conventional manure. It recommends that the relative application rates of LFCs compared to that of conventional manure are CaFC 100%, SwFC 22% and ChFC 17%, respectively.

However, LFCs generally contain a high content of P, and therefore it could be a substitute for P fertilizers as described by Jakob et al. (2002). So in this paddy rice cultivation experiment, the fertilization efficiencies of N and K in LFCs as compared to chemical fertilizers were investigated to find out the proper application rate of them when LFCs are supposed to be applied as P fertilizer.

Materials and methods

Three application levels of LFCs were applied by the equivalent amounts of 50 (Com. N 50%), 100 (Com. N 100%) and 150% (Com. N 150%) of recommended N application rate by soil test, and also treated the same amounts of N, P, K with those of applied by LFCs using urea, fused superphosphate and potassium chloride (Fer. N

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50%, Fer. N 100%, Fer. N 150%). Three kinds of LFCs, CaFC, SwFC and ChFC, were made by mixing in the same proportion of sawdust and LFCs, and fermented thoroughly. The chemical properties of LFCs are shown in Tab. 1. Applied amounts of LFCs in N 100% treatment were 13.8 Mg ha^{-1} for CaFC, 10.3 Mg ha^{-1} for SwFC and 6.3 Mg ha^{-1} for ChFC and they were applied 7 days before transplanting date of rice seedlings.

Tab. 1: Chemical properties of livestock faeces compost used in the experiment

(Unit: fresh weight %)

Livestock composts	OM	T-N	P_2O_5	K_2O	CaO	MgO	Water
Cattle faeces compost	40.9	0.97	1.33	1.66	1.57	0.62	46.7
Swine faeces compost	38.6	1.26	3.99	2.76	4.36	1.52	41.3
Chicken faeces compost	45.8	2.11	2.96	2.49	6.03	1.19	31.7

Twenty-five day old rice seedlings (cv. *Chucheongbyeo,* Japonica type) were transplanted in a space of 0.3 by 0.14 m at 0.90 by 0.98 m confined plots with Seogcheon silty loam (coarse loamy, mixed, non-acid, mesic Fluventic Haplaquepts) on May 20 and harvested on Oct. 10, 2009. Selected chemical properties of the soil in the site are shown in Tab. 2. The recommended fertilization rates based on soil test were N 134, P_2O_5 75 and K_2O 47 kg ha^{-1}. All of the composts and fertilizers were applied as a basal fertilization. Plant height and tiller number were measured at main growth stages of rice such as tillering, active tillering, maximum tillering, panicle formation, heading and harvesting stage.

Tab. 2: Chemical properties of the soil used in the experiment

pH (1:5)	OM (mg g^{-1})	Av.P_2O_5 (mg kg^{-1})	Av.SiO_2 (mg kg^{-1})	Inorganic N (mg kg^{-1})	Ex. Cation (cmol kg^{-1})			CEC (cmol kg^{-1})
					K	Ca	Mg	
6.4	20.0	25	320	22.9	0.25	9.2	1.7	11.5

The surface soils collected at 15 cm depth from each plot were air dried, passed through a 2 mm sieve and used to determine soil properties by soil analysis method recommended by National Institute of Agricultural Science and Technology in Korea. Briefly, soil pH and EC were measured after mixing soil with H_2O at a ratio of 1:5. Soil organic matter and available phosphate were determined by Tyurin and Lancaster method, respectively. Exchangeable cations such as potassium, calcium and magnesium were analysed by extracting them with 1N ammonium acetate (pH 7) and determined by inductively coupled plasma spectrophotometer (ICP, GBC Integra XMP, Australia). Soil exchangeable ammonia level was obtained by Kjeldahl distillation from 2M KCl extracts. Soils were collected and analysed before experiment and at main growth stages of rice as mentioned above.

Results

Soil NH_4-N content became gradually higher in proportion to the increase in the fertilizer N (urea) application rate, while it was low in every LFC plot. P fertilizer raised the level of soil available P more than LFCs when the same amount of P was applied. LFCs application were less effective to increase soil exchangeable K than K fertilizer until the maximum tillering stage but this trend adversely changed after panicle formation stage or at harvesting stage showing more concentration of soil exchangeable K in LFC plots (Fig. 1).

○ NH_4^+-N content in soil

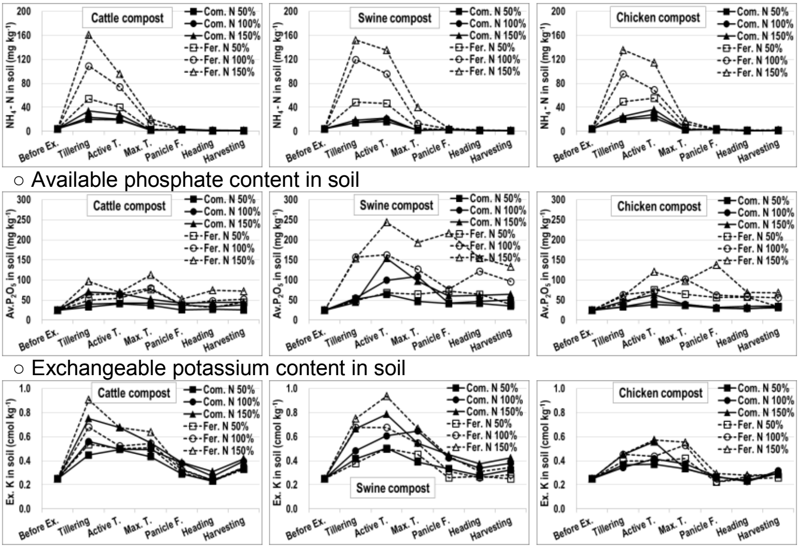

Figure 1: Changes of soil chemical properties at main rice growth stages by the application of livestock composts and chemical fertilizers

There were very close relationships between application rate of LFCs and soil organic matter increments after experiment and between phosphate fertilization rate and soil available phosphate increments after experiment. As for phosphate, the correlation was y=0.1788x-6.169 (R^2=0.9425) when applied fused superphosphate fertilizer, and y=0.0662x-2.689 (R^2=0.9315) when applied LFCs by the same amounts of phosphate with those in chemical fertilizer plots (x: phosphate application, kg ha^{-1}, y: increment in soil available phosphate content, mg kg^{-1}). But the relation between LFC application rates and the increments of soil exchangeable potassium content showed a low coefficient of determination (Fig. 2). Plant height, number of stems, nutrient absorption amount by rice plant and rice yield were high in 100, 150% N plots of chemical fertilizer, while every LC plot exhibited lower values and no significant difference among them (data not shown here).

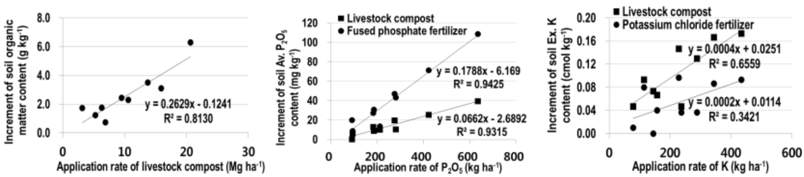

Figure 2: Correlation of fertilization rate and the increment of soil nutrients

Relative nitrogen specific fertilization efficiency of compost N as compared with urea N was 12.3% for cattle waste compost, 8.8% for pig waste compost and 24.6% for chicken waste compost, respectively (Tab. 3).

Tab. 3: Nitrogen fertilization efficiency of compost N and urea N

Treatment	Cattle waste compost			Swine waste compost			Chicken waste compost		
	Rice Yield (kg ha-1)	NFE †	NSE §	Rice Yield (kg ha-1)	NFE †	NSE §	Rice Yield (kg ha-1)	NFE †	NSE §
Compost N 50%	3,064	-	-	3,003	-	-	3,047	-	-
Compost N 100%	3,519	1.6	12.3	3,198	1.5	8.8	3,483	3.3	24.6
Fertilizer N 100%	5,021	12.8	100	5,289	17.1	100	4,963	14.3	100

† NFE; nitrogen fertilization efficiency, - NFE = (yield of treated plot – yield of untreated plot) ÷ N application rate, § NSE; nitrogen specific fertilization efficiency of compost N as compared with fertilizer (urea) N, - NSE = (NFE of compost N 100% plot ÷ NFE of fertilizer N 100%) × 100

Discussion

The high correlation between P application rate and increment of soil available P after paddy rice cultivation would be a clue to find out the proper P fertilization rate of LFCs, inferring that a little more amount of LFCs P is required to meet the need of paddy rice than chemical P. The N specific fertilization efficiencies of LFCs N to urea N ranged from 8.8 to 24.6%, therefore only a small portion of N put by LFCs application could be a substitute for fertilizer N and the rest has to be supplemented with proper N sources. This appears to be similar to the result of Sørensen et al. (1994). Average of soil exchangeable K concentration during the main rice growth stage was not different statistically between LFC plots and chemical ones (data not shown here). This result implies that LFCs K has an equivalent effect to fertilizer K. This research needs supplementary experiments because of the different fertilization method of all basal fertilization in this experiment from the optimal one which includes the topdressing of N and K. Nevertheless, this result offers a useful piece of information on developing the practical fertilization method for organic cultivation of paddy rice.

Conclusions

Gyeonggi Province is the birthplace of organic agriculture in Korea mainly due to the various regulations to preserve the water quality of Han river, a drinking water resource for over 11 million people. Since this area has the biggest livestock industry in Korea, faeces are the principal and renewable nutrient resources for organic farmers. Many growers of organic paddy rice in Korea have used oil cakes as a nitrogen source, and there were some experimental results on the optimum rate of oil cakes for rice cultivation, therefore optimizing the rate of oil cakes and such results from this experiment as the relative N, P, K fertilization efficiencies of LFCs, etc. would be informative to achieve the proper fertilization for organic cultivation of paddy rice.

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Effects of rice-green manure crop cropping systems on soil characteristics and rice yield in paddy field

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Key words: Green manure crops, Legume, Gramineae, Cropping system, Rice yield, Paddy soil

Abstract

Supplying rate of nitrogen at HV was 172.8 kg ha^{-1}, HV/B was 64.3 kg ha^{-1} and B was 38.6 kg ha^{-1}. The Rice yield was 7.05 ton ha^{-1} when the nitrogen supply was the largest with HV and 5.42 ton ha^{-1} was produced on HV/B. The chemical characteristics of soil have lower pH and exchangeable cations(Ca and Mg) at B, HV and HV/B, rather than at CF because green manure was applied at the former step. However, the physical characteristics of the soil and the porosity showed different tendency which was that it was better at the green manure crops than CF. Nitrogen nutrient balance was showed the most balanced at CF and field of application of green manure crops were required the appropriate management if future crops would be cultivated because nitrogen nutrient could be exhausted or accumulated.

Introduction

What environment friendly agriculture is the method using none of chemical materials such as pesticides and fertilizers and trying to use the organic matter which can be easily revolved back to the nature. Europe and the U.S. try to promote the soil fertility through rotation of cropping system for environment friendly agriculture and one of their representative exemplary crops is the green manure crop. The green manure crops are returned to soil when the plants are still green. The green manure crops plays the key role in reducing of chemical fertilizers, improvement of soil fertility, reduction of soil erosion, weed control and landscapes composition. Green manure crops are gradually spreading throughout the country with the governments 'Green Korea' policy and the increased price of chemical fertilizers. Typical green manure crops are barley green manure, hairy vetch, milk vetch and clovers. Usually green manure crops are cultivated at winter fallow fields and returned back to the soil at coming spring being used as green manure crops. Gramineae green manure that returned back to soil contains high C/N rate so that it has greater effect when it comes to improving soil characteristics rather than supplying fertilizers. Moreover, legume crops highly contain nitrogen and have low C/N rate therefore they can bring great effect of supplying fertilizers. Also, if gramineae crops and legume crops are mixed-planting, they can provide not only great effect of supplying fertilizers but also improving soil characteristics. Consequently, this study was conducted at Korea's typical soil, loamy soil, to figure out the effect of how barley green manure, hairy vetch and the mixed-planting hairy vetch with barley green manure affect on the yield of rice, usage of nutrient and soil characteristics.

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Materials and methods

A field study was conducted in sandy loam of paddy fields at Crop Environment Research Division farm, National Institute of Crop Science (NICS), Suwon, in Korea. Firstly hairy vetch and barley were cultivated in winter at experimental field and then applicated to the soil and cultivated rice (Unkwang byeo). Treatments were composed of hairy vetch (HV), barley (B), hairy vetch and barley (HV/B), custom fertilizing (CF) and none fertilizing (NF). Chemical fertilizers such as N, P_2O_5 and K_2O did not give all fertilizer except CF. Chemical Fertilizer was applied with N-P_2O_5 –K_2O=9-4.5-5.7kg/10a, and chemical fertilizer was used with urea for T-N, magnesium phosphate for P_2O_5 and potassium chloride for K_2O respectively based on the rate of split application. The green manure crops were sowed by machine of drill seeding at 14th of October, 2009 and applicated to soil at 17th of May, 2010. Rice transplantation was conducted by 30*15cm plant spacing on 7th of June. Right before application to soil, green manure crops of $1m^2$ was harvested and its fresh-weight was measured and then hot-air dryer for 24 hours at 100℃ were dried. After that, its dried-weight was measured. The nutrient contents of rice and green manure crops harvested two plants and hot-air dryer for 24 hours at 50℃ were dried and then we grinded it and analyzed T-N with CNS Analyzer (LECO CNS-2000). The measurement of Bulk density and porosity of the soil were collected by core samples and it was dried and weighed them. Soil pH was measured with a pH meter. Exchangeable cations and available phosphate of soil was measured with ICP (GBC SDS-270) and CNS Analyzer (LECO CNS-2000) was used to figure out amount of T-C.

Results and Discussion

Yield of the green manure crop was the largest at HV, 5.59 ton ha^{-1} and the yield of nitrogen was 172.8 kg ha^{-1} at this time. Yield of green manure of HV/B was 3.93 ton ha^{-1} and production of nitrogen was 64.3 kg ha^{-1} which was less than that of HV but more 1.7 times more than that of B. The yield of HV/B and B mixed-planting were similar, however, HV/B mixed-planting was higher in nitrogen production (table 1). The reason was that nitrogen contents were increased by cultivating a hairy vetch and barley at the same time.

Table 1: Yield of green manure crops and nitrogen according to treatments

Treatments	Dry yield of green manure crops (ton ha^{-1})	Yield of nitrogen (kg ha^{-1})
Barley (B)	3.44bc*	38.6c*
Hairy vetch (HV)	5.59a	172.8a
Hairy vetch/Barley (HV/B)	3.93b	64.3b

* Means within a column not followed by same letters are significantly different by DMRT 5%.

Yield of rice at HV was 7.05 ton ha^{-1} which was a lot more than any other green manure crops and the reason was that as a green manure crop the amount of nitrogen which was supplied was much more. HV/B produced 5.42 ton ha^{-1} which were less than that of HV but more than that of B. Moreover it produced longer Culm length, more number of spikelet per m^2 and number of spikelet/panicle than those of B but less than those of HV (table 2).

Table 2: Yield and components of rice as affected by treatments at harvest time

Treat-ments	Culm length (cm)	Panicle length (cm)	No. of panicles per m^2	No. of spikelet/ panicle (ea)	Percent ripened grain (%)	1000-grain weight (g)	Rough rice yield (ton ha^{-1})
B	58.8	17.1	204.8	102	92	27.5	4.69c*
HV	72.4	17.3	335.7	129	83	26.5	7.05a
HV/B	62.1	16.9	250.0	113	86	27.1	5.42b
CF	60.0	17.0	197.6	94	87	27.7	4.01d
NF	59.6	18.0	178.6	103	81	27.8	4.19cd

* Means within a column not followed by same letters are significantly different by DMRT 5%.

Soil of application of green manure crops showed lower pH contents than that of CF and among green manure crops, B showed the least amount which was 5.19. Exchangeable cations (Ca, Mg) showed lower amount with application of green manure crops than CF and there was no difference among green manure crops. Exchangeable K, T-C and Av.P_2O_5 hardly showed any difference also. Bulk density was 1.3~1.4 kg/m^3 showed no difference between any kinds of green manure crops at below table; HV/B and HV, contain characteristics of legume green manure crops, produced more porosity than B and CF(table 3).

Table 3: The changes of soil physico-chemical characteristics after examination

Treat-ments	pH (1:5)	T-C (g kg^{-1})	Av.P_2O_5 (mg kg^{-1})	Ex. Cations ($cmol^+$ kg^{-1})			Bulk density (Mg /m^3)	Porosity (%)
				Ca	Mg	K		
B	5.19	6.6	112	3.11	0.62	0.56	1.4	46.0
HV	5.63	6.4	112	3.01	0.58	0.59	1.4	49.0
HV/B	5.50	5.7	121	3.05	0.57	0.55	1.3	50.1
CF	5.72	6.3	111	3.71	0.72	0.59	1.4	47.0
NF	5.74	6.9	103	3.38	0.64	0.58	1.4	45.8

The total yield of rich was 14.64 ton ha^{-1} with HV, 14.54 ton ha^{-1} with HV/B which were more than other treatment. Usage of nitrogen was 61.7% with HV/B which was the highest. In HV, total yield of rice was highest as 14.64 ton ha^{-1} but the usage of nitrogen was low. The reason was that the amount of inputted nitrogen from green manure was 2.7~4.5 times more than in the other processes. Nitrogen nutrient balance was quite adequate with CF which was 2.9 kg ha^{-1}. Among green manure crops, 48.9 kg ha^{-1} of nitrogen with HV was accumulated on the soil meanwhile when it comes to HV/B, -38.5 kg ha^{-1} more than input was consumed (table 4). If you use long-term HV/B treatment in paddy soil, nitrogen shortage would be caused therefore it is quite advisable to supervise.

Table 4 : Usage of nitrogen and nitrogen balance as affected by treatments at harvest time.

Treatments	Total yield (ton ha^{-1})	Usage of nitrogen (%)	Nitrogen balance (kg ha^{-1})		
			N input	N output	Input-Output
B	8.91	4.7	38.60	64.9	▽26.3
HV	14.64	35.2	172.80	123.9	48.9
HV/B	14.54	61.7	64.30	102.8	▽38.5
Control(CF)	11.28	26.7	90.0	87.1	2.9
Control(NF)	8.50	-	-	63.1	▽63.1

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Cropping techniques cereals

New challenges to improve organic bread wheat production in Europe

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Key words: organic wheat, food-chain, baking quality, yield, farming system

Abstract

The total organic area in the EU-27 had an annual average growth rate of nearly 15% from 1998 to 2006 with winter wheat being the most important cereal crop. Wheat yield in organic farming is around 30% to 70% of yield of conventional farming but higher premia for organic wheat may to some extent compensate for this. Bread wheat is grown in a variety of crop rotations and farming systems and four basic organic crop production systems have been defined. Nitrogen deficiency and weed infestation are considered to be the most serious threat in organic wheat production. Organic wheat producers will have to fulfil the technological needs of bakers although the requirements differ widely from small artisan bakers to large enterprises handling the organic bread processing. To maintain and expand organic wheat production, there is a need to control weed population, manage nitrogen nutrition and maintain crop diversity in the cropping system. In order to obtain a share in the premium price of organic wheat products, farmers may involve in further processing and marketing.

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Introduction

Across Europe, the organic market is currently one of the most expanding sectors of the food industry but considerable differences exist across the Europe. Although organic grain production has rapidly progressed since the mid 90s, the growth has not matched the increasing demand in human nutrition and animal feed. The large demand of organic bread wheat for human nutrition has resulted in record-level prices and significantly increased imports. This sector should be secured from domestic sources when imports from outside Europe may introduce additional levels of economic risk associated with transportation and quality. The purpose of this communication is to underline main challenges of the organic bread wheat to improve production and quality in Europe and guarantee economic and environmental sustainability.

Materials and methods

The paper consists of results from a survey realised in 5 European countries (Austria, Denmark, France, Italy, Switzerland) which are quite representative for the diversity encountered in Europe. This survey is complemented with statistical data and literature reviews. Statistical data were collected from European database (Eurostat, IFOAM) and the national statistics of the selected countries. In these dataset, the area, share and growth of organic production, arable land and wheat production have been analysed. The main characteristics of the farming systems (crop rotation, type and size of animal husbandry, machinery used, list of technical problems, crop management of organic wheat, …) has been described both thanks to 26 interviews of farmers and/or key informants and national literature review.

Results and Discussion

Important growth of organic wheat in the EU

Wheat is the most important organic cereal in EU-27 with ca 400.000 ha in production. Durum wheat (117,686 ha) is particularly grown in Italy while large areas dedicated to the soft wheat production are found in Germany (45,000 ha), France (35,008 ha) and the United Kingdom (21,767 ha) (Eurostat, 2009). France and Austria recorded positive growth of more than 25% between the years 2000 and 2008. Denmark follows with a growth of 12%. The development of organic soft wheat in Italy and Switzerland is low or null while the organic share has largely increased for others products. Concerning the supply of organic products in Europe, Italy accounted for nearly 18% of all organic crops in the EU-27 while the others countries account far less like 9% for France, 6% for Austria and around 2% for Denmark.

Crop production systems in organic farming

Traditionally, organic farms included both crops and livestock production. From the beginning of the 1990s, organic agriculture has become much more specialized and crop rotations have been simplified in arable farming systems. Current organic cropping systems presented a large and continuous spectrum of diversification and intensification. These are characterised by different levels of inputs, crop diversity and crop management practices. Four basic types of cropping systems comprising soft wheat production were highlighted in the survey in five UE countries (Table 1). These four farming systems were i) mixed farming systems in temperate and Atlantic climate, ii) organic arable systems in western and central temperate regions, iii) irrigated grain systems in Mediterranean region and iv) extensive grain systems in Southern and Central Europe.

Table 1. Examples of organic wheat in the crop rotation

Farming Systems	Crop rotation	Duration of rotation	Proportion of wheat in the crop rotation	Fertilization type for wheat
Mixed farming systems	GC (2-4yr)- WW – SC – WC -	8-11 yr	20-30%	Slurry, compost
Highly specialised Arable systems	GL – WW – SC – RC – WW	6-8 yr	20-40%	Organic fertilisers
Irrigated grain systems	GL – WW – SC – GL - WC	4-6 yr	20-33%	Organic fertilisers
Extensive grain systems	GC (2) – WW – SC - WC	4-6 yr	0-33%	None or limited compost

WW winter wheat / GC Grass crops = Luzerne, Clover grass / SC Spring crops = Maize , Spring Barley, / RC Root crops = Sugar beet, Potatoes / GL Grain legumes= Pea, Soya

In general, organic grain systems with winter wheat are characterized by higher crop diversity and wider crop rotations compared to comparable conventional systems. Within a crop group, diversity is often higher, e.g. cereal patterns are less dominated by winter wheat and winter barley, than in conventional farming. Currently, weeds are considered to be the most serious threat in organic wheat production while diseases and pests are of relatively minor concern. Fear of ineffective weed control is also perceived by the farmers as one of the major obstacles for conversion from conventional to organic production. The productivity of organic wheat is also restricted by the limited supply of N. By choosing cultivars with good disease resistance, the organic farmer should be able to keep disease problems within acceptable limits. However, the choice of suitable cultivars for organic wheat is still limited, as plant breeding has been largely directed at providing cultivars adapted to conventional farming. Moreover, for the organic grower, disease resistance is only one aspect to be considered and choice of cultivars may be strongly influenced by other factors such as grain quality, ability to compete with weeds, N use efficiency and availability of organically produced seed.

Profitability of organic wheat in Europe

The economic viability of wheat production in Europe is clearly affected by the support payments policies, the technical performance but also by the existence of an adequate marketing structure. Even the climatic conditions are diverse in Europe, yield performance is largely explained by input and labour intensity (fertilization quantity, weed and soil management). Conversely, baking quality is linked with cultivar characteristics and climatic conditions. Table 2 illustrates yield variability in the countries participating in the survey where conventional wheat yields varied from 6 to 8.2 t ha-1 (source Eurostat). The direct support given to organic farmers via area payments or others subsidies is anticipated to have a substantial impact on the economic viability of organic production also in the future. The implementation of direct support for organic farming greatly varies amongst the different member countries and regions of the EU, both in terms of the levels of payments and eligibility for the programmes. Over the last five years, these premiums have fluctuated considerably over time in coherence with the large variation observed on the world cereal market. In the European Union, farmers are receiving premiums for organic wheat from 30% up to 200% depending on countries and sales channels. Prices for organic cereal used for human nutrition can reach 100% above conventional prices, whereas the price increase for animal feed is maximum 30%.

Table 2. Organic wheat yields ($t.ha^{-1}$) in the countries participating in the survey.

	France	Denmark	Austria	Italy	Switzerland
Grain yield Min value	2.5	1.0	3.0	3.5	3.0
Grain yield Max value	5.0	4.0	5.5	6.0	6.5

The premiums of organic wheat reported from Austria and France are above 150%, about 50% in Switzerland, where the price level for conventional wheat is high, and 30-40% in Denmark. The premium is around 80% in Italy where the domestic market for organic food is not consolidated. For the consumer, the premium of organic cereals is approximately 60% ranging from 40% for whole wheat to 75% for flour. The large gap between farm-gate and consumer price for organic products strongly limits the development and expansion of the organic cereal sector. The key question is whether the relative profitability of organic wheat will still be maintained if the premium paid by consumers is reduced. First, it depends on the combined growth in consumer demand and production level, which should result in upward price pressure on organic foods in comparison to the likely decline in production costs. Secondly, it is also determined by direct policy support compensating yield gap. Finally, the profitability of organic grains should be also guaranteed by the improvement of yield performance compensating the decline of the price premium. Organic products have been frequently associated with attributes such as local origin and supply, small-scale units of production and direct selling from producer to consumer. Nevertheless, nowadays organic markets are mainly based on highly industrialised and concentrated units of production, distributed through mainstream retail channels. The organic wheat and flour market has been diversified over time. Traditionally, direct sales from producer to consumer and specialised shops provided organic products for consumers interested in non-conventional products. The amount of organic wheat-based products sold through these channels was often small, with only few consumers being reached. In the beginning of the 2000s, the development was strongly supported by the wholesalers entering the organic market. Supermarkets became important actors in marketing.

Conclusions

To maintain and expand organic wheat production, the crop management needs to be optimized and the grain yield should be improved to become economically more attractive. First, there is a crucial need to maintain diversity within cropping system, to support ecological health, control weeds and improve N management by N fixing crops, while organic farmers are increasingly being pressured by forces of the market to re-adopt the factory principles of specialization and control. Bread wheat is grown in a variety of crop rotations and farming systems. It is essential to manage nutrient supply and efficiently control weeds. Premium price for special quality can be obtained by optimized choice of genotype, crop rotations and adjusted organic fertilizer inputs. To obtain premium prices for organic wheat products, farmers may get involved in further processing and marketing. Organic wheat producers will have to fulfil the technological needs of bakers; even if the requirements are diverse from small artisan bakers to large enterprises. Likewise there is a need to investigate the effect of growing regimes and technological processes on baking quality. Additional knowledge and references will be provided by the European AGTEC-Org project (www.agtec.coreportal.org).

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Mycorrhizal –wheat symbiosis effects on pigments content and water status parameters of different cultivars under drought stress

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Keywords: Arbuscular mycorrhiza, Chlorophyll, Drought, Triticum aestiv

Abstract

Drought causes considerable changes in biochemical characters, water content and induces damages in plants. Arbuscular mycorrhizal (AM) fungi are obligatory symbiotic soil microorganisms that colonize the plant roots and improve performance of plants in drought conditions. The effect of AM fungus, Glomus intraradices, on pigments content consisting total chlorophyll, chlorophyll a, chlorophyll b and carotenoid content, and also water saturation deficit (WSD) and shoot water content (SWC) of four Iranian wheat cultivars (Azar2, Darab2, Shiraz and Falat) were studied in pot culture under four water regimes including 100, 75, 50 and 25% field capacity (FC). Mycorrhizal inoculation caused increase in chlorophyll a (12.30%), total chlorophyll (11.33%) and carotenoid content (8.67%) but there was no significant different for chlorophyll b content. Inoculated plants had higher SWC (2.6%) and lower WSD (9.39%) than non-inoculated plants. Differences between inoculated and non-inoculated plants related to chlorophyll a/b and total chlorophyll/carotenoid ratios were not significant. The results indicated that inoculation can alleviate the unfavorable effects of water stress on wheat cultivars through enhancing WSD and declining SWC and also preventing the decrease of chlorophyll content.

Introduction

Colonization of arbuscular mycorrhizal (AM) and other beneficial fungi with plant roots increase productivity of crops under drought conditions through improving mineral nutritional uptakes (mainly P) and enhance drought resistance through improving water absorption (Augé, 2001; Arzanesh, *et al.*, 2011). The symbiotic interactions between AM fungi and host plants grown under drought conditions need to be studied in order to optimize beneficial effects of AM colonization (Al-Karaki, 1998). Drought is of the most important environmental stresses in agriculture and many efforts have been made to improve crop productivity under water-limiting conditions. Plant responses to water stress are complex mechanisms involving molecular and biochemical changes (Condon *et al*., 2004). Water deficit stress declines the photosynthesis of plants, causes changes in chlorophyll content and components and damage to photosynthetic apparatus and also inhibiting the enzymatic and photochemical activity in Calvin cycle (Iturbe-Ormaetxe *et al*., 1998). The objective of the present study was to evaluate the effect of four drought stress levels in mycorrhizal inoculation condition on changes in pigments and water content parameters in four wheat cultivars.

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Materials and Methods

The surface layer of soil (0-30 cm) was collected from Bajgah (29°44´ N, 52°37´ E, 1810m), Fars, Iran. Applied soil was air dried, passed through 2mm sieve and mixed uniformly and its physical property was sandy loam with 25.3% field capacity.

Experimental procedures: The pot experiment was carried out in the greenhouse of Crop Production and Plant Breeding Department in College of Agriculture, Shiraz University, Shiraz, Iran, in 2010. A factorial experiment based on completely randomized design with three replications was used to evaluate the effect of three factors. The studied factors were as follow: 1-water stress at four levels (100, 75, 50 and 25% of field capacity (FC) of soil); 2-four wheat cultivars (from the Seed and Plant Improvement Institute, Karaj, Iran) differing in drought tolerance including; a resistant cultivar (Azar2); a semi-resistant cultivar (Darab2) and sensitive cultivars (Shiraz and Falat) (all obtained from research program of Shiraz University) and 3-mycorrhizal inoculation. The mycorrhizal fungus used in the experiment was *Glomus intraradices* Schenck & Smith and provided by the Department of Soil Science in Shiraz University, Shiraz, Iran.

The pots were filed with 5kg soil and then about 5cm soil of each pot was removed and in mycorrhizal treatments, 50g inoculums (containing spore numbers of 8 g^{-1}substrate and root colonization of 85 percent) was placed and incorporated with the remained soil and then 3cm of removal soil was added again pots, after that eight seeds were placed in pots with the equal distances. Also whole residual of removal soil was added to the pots. After germination, seedlings were thinned to four plants in each pot. The pots were daily weighted and according to decreasing weight of each pot, decalcified water was poured up to FC until the starting of the drought treatment. Drought stress treatments were applied at tillering stage, then pots related to each water regime were daily weighted and water treatments were performed.

Pigments and water content measurement: To determine the shoot water content (SWC) and water saturated deficit (WSD), 22 days after initiating the water treatments, a randomly selected plant in each pot was sampled and SWD and also WSD were recorded based on the following formulas: $\mathrm{WSD} = 1 - \left(\frac{\mathrm{FW-DW}}{\mathrm{TW-DW}}\right) \times 100$, $\mathrm{SWC} = \frac{\mathrm{FW-DW}}{\mathrm{DW}} \times 100$ (FW: fresh weight; TW: turgid weight; DW: dry weight). Pigments content of plants were determined by Arnon method (1949).

Results

Mycorrhizal inoculation caused increase in chlorophyll a (12.30%), total chlorophyll (11.33%) and carotenoid content (8.67%) but there was no significant difference for chlorophyll b content. Although differences between inoculated and non-inoculated plants for chlorophyll a/b and total chlorophyll/carotenoid ratios were not significant but inoculated plants showed higher SWC (2.6%) and lower WSD (9.39%) than non-inoculated plants. Water stress decreased all measured pigments consist of chlorophyll a, chlorophyll b, total chlorophyll and carotenoid content and also decreased SWC of plants but WSD was increased. The highest content of chlorophyll a (45.24 mg/ml), chlorophyll b (14.71 mg/ml), total chlorophyll (59.95 mg/ml) and carotenoid (20.23 mg/ml) were observed in 100% FC and the lowest ones (23.59, 5.09, 28.68 and 9.96 mg/ml, respectively) were in 25 % FC water regime. Chlorophyll a/b and total chlorophyll/carotenoid did not show definite changes under different water regimes but highest value for both was observed in 25%FC. Water regime of 100% FC also showed highest percent of SWC (86.40%) and lowest percent of WSD (18.13%). Highest values of chlorophyll a (38.49 mg/ml), chlorophyll b (10.96 mg/ml) and total chlorophyll (49.46 mg/ml) were recorded for Azar2 but there were no significant difference among cultivars for carotenoid content. Azar2 also showed highest chlorophyll a/b (4.079) and total chlorophyll/carotenoid (3.33) ratios but differences for chlorophyll a/b were not significant. The maximum shoot water content (84.37%) and the minimum water saturation deficit (29.66%) were obtained for Azar2. The only significant difference among interactions was observed for drought × cultivar for chlorophyll b (Table 1).

Tab. 1: Mean comparison and ANOVA for pigments and water content parameters.

	Ch a (mg/ml)	Ch b (mg/ml)	Ch T (mg/ml)	Car (mg/ml)	Ch a/b	Ch t/car	SWC %	WSD %
Mycorrhiza								
Inoculated	34.043	9.9844	44.027	16.198	3.8124	2.8391	82.55	27.00
Non- Inoculated	30.313	9.2316	39.545	14.905	3.8114	2.7790	80.46	29.80
LSD5%	2.6269	0.8171	2.7179	1.5446	0.6749	0.3503	1.660	1.450
Drought stress levels								
100% FC	45.239	14.712	59.951	20.231	3.0972	3.0141	86.40	18.13
75% FC	32.585	11.255	43.84	17.572	3.0549	2.6894	81.93	20.65
50% FC	27.295	7.3743	34.669	14.444	3.9245	2.4888	79.83	29.92
25% FC	23.594	5.0899	28.683	9.961	5.1711	3.0440	77.86	45.13
LSD5%	3.7150	1.9355	3.8436	1.9844	0.9544	0.4954	1.840	2.040
Cultivars								
Azar2	38.497	10.963	49.46	15.528	4.079	3.3297	84.37	29.66
Darab2	32.274	9.4375	41.436	16.254	4.039	2.7404	83.04	29.63
Falat	31.756	9.1617	41.194	15.068	3.795	2.5915	79.92	28.07
Shiraz	26.185	8.8695	35.054	15.357	3.334	2.5746	78.70	26.46
LSD5%	3.9090	1.1555	2.9843	2.1844	1.0533	0.7974	2.34	2.294
Analysis of variance								
Mycorrhiza (M)	0.006*	0.070	0.001	0.099	0.997	0.733	0.014	0.0001
Drought stress (D)	0.0001	0.0001	0.0001	0.0001	0.0001	0.083	0.000	0.0001
Cultivars (C)	0.0001	0.002	0.0001	0.734	0.386	0.010	0.0001	0.006
M ×D	0.601	0.551	0.431	0.851	0.871	0.963	0.907	0.223
M × C	0.983	0.932	0.966	0.999	0.990	0.786	0.806	0.934
D × C	0.940	0.020	0.521	0.445	0.706	0.522	0.550	0.102
M × D × C	0.914	0.997	0.889	0.999	0.999	0.992	0.996	0.924
C.V%	20.02	20.85	15.95	24.35	23.41	30.58	14.98	12.45

*P-Value obtained in analysis of variance

Ch a: chlorophyll a content; Ch b: chlorophyll b content; Ch T: total chlorophyll content; Car: Carotenoid content; SWC: shoot water content; WSD; water saturation deficit; C.V: coefficient of variation.

Discussion

Pigments content were significantly reduced in drought stress due to suppression of specific enzymes responsible for the synthesis of photosynthetic pigments in wheat. Spectrophotometrically measurement of total chlorophyll content showed higher chlorophyll and carotenoid content for inoculated than non-inoculated plants. Higher chlorophyll content of inoculated plants is likely due to alleviating water stress by mycorrhizal symbiosis and increased water and mineral uptakes and higher pigments content resulted in higher growth in wheat. Higher chlorophyll causes higher photosynthesis and consequently higher yield and dry mater production. Increased chlorophyll content in leaves of mycorrhizal plants under drought conditions has been reported (Hajiboland et al., 2010). The results of present study showed that in inoculated plants, traits SWC and WSD were significantly higher and lower compared with control plants regardless of water regime and cultivars respectively. Higher SWC and lower WSD of inoculated plants is due to higher water uptake by mycorrhizal hyphae or phosphorus uptake that can induce some cellular changes in wheat under the water stress condition. Drought stress decreased SWC and increased WSD of all cultivars while resistant (Azar2) and semi-resistant (Darab2) cultivars showed higher SWC than sensitive cultivars, because of their ability to uptake higher amount of water by their roots or preventing water loss in their shoots. Safir et al. (1972) concluded that AM symbiosis affects the water relations in plants indirectly through improved phosphorus (P) nutrition. There are reports that AM symbiosis may postpone declines in shoot and leaf relative water content and change water relationships in wheat cultivars dealing with water limited conditions. In general, the results indicated that inoculation with AM fungi can alleviate the unfavorable effects of water stress on wheat cultivars through declining WSD and enhancing SWC and also preventing chlorophyll content decrease. According to our results, it can be proposed that its beneficial effects on crop growth indicate that using arbuscular mycorrhizal fungus in field would result in increased wheat productivity.

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Producing organic wheat with high grain protein content: the significance of intercropping and the need for diagnostic tools

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Key words: grain protein content; N-status; wheat; chlorophyllmeter; organic farming.

Abstract

Grain quality of wheat is one of the major concerns of organic farming production. Cereal-legume intercropping may be of significance in this regard as it enhances the yield productivity and the grain protein content (GPC) of the intercropped wheat. However, fitted tools are needed for the diagnosis and management of such interspecific canopies. Our main objectives were i) to analyse the effect of intercropping and N-management on organic farming performances and ii) to analyse the relationships between N-status indicators and GPC of intercropped wheat. These objectives were assessed in winter pea–wheat intercrops in 2007 and 2009 in western France. Our study confirmed the significance of intercropping in the production of wheat with high GPC. We showed that tools for diagnosis, fitted for sole crops to manage grain yield and GPC (N nutrition index, chlorophyll meter), can be used on intercropped wheat.

Introduction

Organic farming may be a way to improve the sustainability of agroecosystems by limiting the use of non-renewable resources and chemical inputs. However, the yield and the quality of crops are often lower in organic farming than in conventional agriculture. Two major constraints explain the low and variable yields and GPC of organic arable systems which are a deficient N nutrition (Berry et al. 2002) and weeds competition (Bond & Grundy 2001). Intercropping, the simultaneous growing of two or more species in the same field, is gaining interest in Europe in the context of organic farming. Intercropping is known to enhance productivity compared to sole cropping (Jensen 1996). Moreover, a higher GPC in the intercropped cereal has also been observed when compared to sole crops (Jensen 1996). These advantages are assumed to be linked to the complementary use, in time and space, of resources by the intercropped species (Jensen 1996). According to Gooding *et al.* (2007), the effect of intercropping on the GPC of wheat is a result of i) the low competitiveness of legumes for mineral N compared to the cereals and ii) the competition for light between the species, limiting the intercropped cereal biomass compared to sole crops.

However, the performances of organic cereal-legume intercrops are highly variable, and there is a lack of diagnostic and management tools for such interspecific canopies. Indeed, tools used to establish the N status of crops were built for sole cropped wheat and must be tested before widespread use in intercropping. The aim of this study is i) to analyse the effect of intercropping and N-management on organic farming performances and ii) to analyse the relationships between N-status indicators and GPC of intercropped wheat.

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Materials and methods

Tab.1: Treatments, experimental conditions and N fertilisation

Reference of experiment	Year of harvest	Crop design	Treatments	Planned densities (gm^{-2}) Pea	Wheat	Stage of wheat at the date of N-fertilisation (ZGS)	Time of N-fertilisation	Rate of N-fertilisation ($kg\ N\ ha^{-1}$)
A	2007	W100	A-SC N0	—	330	—	—	0
		W100	A-SC N	—	330	ZGS30	15 March 2007	570
		P50W50	A-IC1	45	165	—	—	0
		P30W70	A-IC2	27	231	—	—	0
		P50W50	A-IC3	45	165	ZGS32	13 April 2007	380
		P30W70	A-IC4	27	231	ZGS32	13 April 2007	380
B	2009	W100	B-SC N0	—	330	—	—	0
		W100	B-SC N	—	330	ZGS30	7 April 2009	40
		P50W50	B-IC5	45	165	—	—	0
		P30W70	B-IC6	27	231	—	—	0
		P50W50	B-IC7	45	165	ZGS30	7 April 2009	40
		P30W70	B-IC8	27	231	ZGS30	7 April 2009	40
		P50W50	B-IC9	45	165	ZGS32	28 April 2009	40
		P30W70	B-IC10	27	231	ZGS32	28 April 2009	40

W100: wheat sole crop; P30W70 and P50W50: substitutive intercrops of pea and wheat; SC and IC: sole cropped and intercropped design, respectively, with or without N-fertilisation; ZGS: Zadoks growth stage scale.

Field experiments were carried out in 2007 (Exp A) and 2009 (Exp B) (organic farming in western France). Winter wheat (*Triticum aestivum* L., cv Apache) was grown as a sole crop and as an intercrop with winter peas (*Pisum sativum* L., cv Lucy) (Table 1). Pests were not controlled and no irrigation was provided. Crops were grown without and with N-fertilisation (chicken feather meal: high levels in Exp A and moderate levels in Exp B) (Table 1). At the end of the winter, the soil contained about 98 and 112 kg N ha^{-1} in the 0-75 cm layer in 2007 and 2009, respectively. Crops were sown on 02/11/2006 and 19/11/2008 (randomised complete block design; n=4) and were harvested near the flowering of wheat (observed on 10/05/2007 and 25/05/2009) and at maturity (on 04/07/2007 and 10/07/2009).

The N status of both sole cropped (SC) and intercropped (IC) wheat was assessed at flowering by calculating the N nutrition index (NNI) (Justes *et al.* 1997). The NNI of IC wheat was calculated as the ratio between the measured concentration of N in the shoot of IC wheat and critical Nc determined from the total aboveground dry matter of the intercrop (DMic = IC wheat DM + IC pea DM; as proposed by Cruz & Soussana (1997) for mixed crops) as per Justes et *al.*'s (1997) equation for wheat: if DMic < 1.55 t ha^{-1}, Nc = 5.35 %; if DMic > 1.55 t ha^{-1}, $Nc = 5.35 \times (DMic)^{-0.442}$. As proposed by Prost & Jeuffroy (2007), SPAD readings for wheat were taken at flowering (ZGS65) with a chlorophyll meter (SPAD 502, Minolta). The SPAD index was calculated as the ratio of the SPAD reading on one treatment to that of the SC N-fertilised treatment in the same experiment, after checking that the NNIs of this treatment were equal to 1 to confirm that it had a non-limiting N status. Analysis of variance was performed (α=5 %) and the means were compared using Tukey's HSD tests (α=5 %) (R software).

Results and discussion

Total grain yield of unfertilised or N-fertilised intercrops (varying from 400 to 666 gm^{-2}) was rarely significantly different from that of unfertilised or N-fertilised SC (varying from 400 to 632 gm^{-2}). This was consistent with the previous results which demonstrated that N-fertilisation did not increase the total grain yield of intercrops (Jensen 1996; Naudin *et al.* 2010). With the exception of B-IC5, unfertilised and N-fertilised intercrops resulted in an insignificant difference in the grain yield of wheat than the unfertilised SC wheat (from 343 to 617 gm^{-2}) (Table 1). With the exception of A-IC2, the GPC of unfertilised or N-fertilised IC wheat (varying from 8.1 to 11.5%) was always higher than that of unfertilised SC wheat (7.3%). Moreover, as shown by Naudin *et al.* (2010), the GPC of N-fertilised IC wheat was not significantly different from that of N-fertilised SC wheat, irrespective of the level of N-fertilisation (above 11% and 9% in Exp A and Exp B, respectively). In Exp A, intercropping increased the NNI of wheat (varying from 0.45 to 0.74) in comparison with unfertilised SC wheat (0.38), but the NNI of IC wheat (with or without N-fertilisation) remained significantly lower than that of N-fertilised SC wheat (0.97). In Exp B, the NNI of wheat was not significantly different, irrespective of crop design or N-fertilisation, and never exceeded 0.65. Irrespective of the treatment, weed dry matter was not significantly different. Thus, weeds are not the cause of differences between the yields or the GPC of wheat.

Tab.2: Grain yield and grain protein content of SC and IC wheat at maturity; N status of wheat and weeds dry matter at wheat flowering.

	Total grain yield of crops (g m-²)			**Grain yield of wheat** (g m-²)			**GPC of wheat** (%)			**NNI of wheat**			**Weeds DM** (g m-²)		
	mean	±SE	HSD	**mean**	±SE	HSD	**mean**	±SE	HSD	**mean**	±SE	HSD	**mean**	±SE	HSD
A-SC N0	**400**	±38.0	b	**400**	±38.0	b	**7.3**	±0.15	c	**0.38**	±0.03	e	**67**	±28.3	---
A-SC N	**598**	±20.3	a	**598**	±20.3	a	**11.9**	±0.28	a	**0.97**	±0.03	a	**83**	±13.4	---
A-IC1	**547**	±35.5	a	**348**	±18.4	b	**8.9**	±0.27	b	**0.57**	±0.03	cd	**82**	±22.7	---
A-IC2	**400**	±35.5	b	**343**	±29.4	b	**7.1**	±0.36	c	**0.45**	±0.05	de	**75**	±25.6	---
A-IC3	**565**	±32.0	a	**359**	±7.9	b	**11.5**	±0.25	a	**0.74**	±0.04	b	**82**	±22.3	---
A-IC4	**541**	±20.8	ab	**437**	±12.2	b	**11.0**	±0.11	a	**0.70**	±0.04	bc	**90**	±7.8	---
B-SC N0	**580**	±34.9	---	**580**	±34.9	a	**7.3**	±0.32	b	**0.48**	±0.02	---	**25**	±11.3	---
B-SC N	**632**	±34.8	---	**632**	±34.8	a	**8.9**	±0.71	ab	**0.54**	±0.05	---	**23**	±7.1	---
B-IC5	**511**	±55.1	---	**398**	±39.4	b	**8.4**	±0.32	ab	**0.50**	±0.03	---	**58**	±21.7	---
B-IC6	**666**	±42.8	---	**617**	±48.6	a	**8.1**	±0.23	ab	**0.59**	±0.07	---	**28**	±18.4	---
B-IC7	**644**	±18.6	---	**510**	±24.1	ab	**9.4**	±0.18	a	**0.63**	±0.04	---	**54**	±18.3	---
B-IC8	**651**	±33.1	---	**604**	±33.7	a	**9.0**	±0.21	a	**0.65**	±0.07	---	**37**	±4.8	---
B-IC9	**649**	±20.0	---	**589**	±25.7	a	**9.1**	±0.19	a	**0.64**	±0.01	---	**28**	±10.5	---
B-IC10	**628**	±33.3	---	**594**	±36.3	a	**9.1**	±0.29	a	**0.59**	±0.06	---	**40**	±15.0	---

SC and IC: sole cropped and intercropped design, respectively, with or without N-fertilisation; GPC: grain protein content; DM: dry matter. Values are means (*n*=4). Analysis of variance (α=5 %) was carried out for each experiment, and treatments with the same letter or symbol ("---") are insignificantly different (Tukey's HSD test; α=5 %).

The GPC of wheat at harvest was highly correlated with the NNI of wheat at flowering, irrespective of the crop design (Figure 1a). This confirms that, in a sole cropping or an intercropping system, a high N status of the wheat enhances its GPC. A negative correlation between the efficiency of accumulated N to produce grain number of wheat and the NNI confirmed that a decrease in the grain number favours grain quality by concentrating N in the grains (Figure 1b). SPAD readings may also contribute to build a good indicator of N status for IC wheat (Figure 1c), as shown by Prost & Jeuffroy (2007) in case of SC wheat. Furthermore, as the GPC of wheat was highly correlated with the SPAD index (Figure 1d), the SPAD index may be a very interesting diagnostic tool to manage the GPC of IC wheat. Moreover, as SPAD readings depend on the cultivar (Prost *et al.* 2007), the SPAD index may be more significant than the SPAD readings so as to replace the NNI. However, more experiments with additional calculations of the SPAD index similar to our study are required.

Conclusions

Our study confirms the significance of intercropping to produce high-quality wheat grains. The present study demonstrates that the tools of diagnosis, previously fitted for

SC wheat to manage grain yield and GPC (namely the NNI or the SPAD index), can be used on IC wheat. Further studies are needed for testing these tools using various cultivars under various climatic conditions.

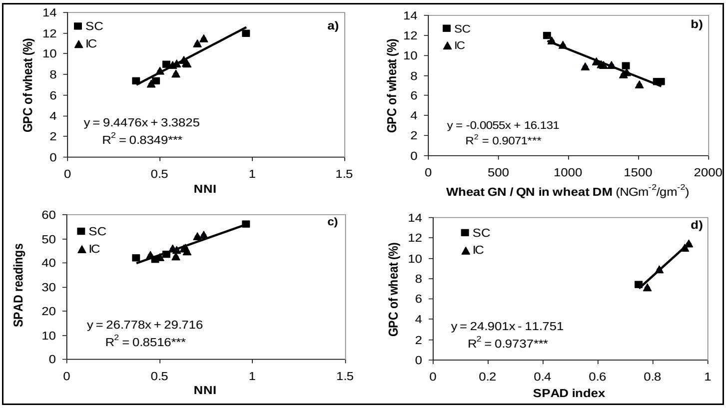

Figure 1: N status indicators and grain protein content of wheat

SC and IC: sole cropped and intercropped design, respectively, with or without N-fertilisation; GPC: grain protein content; NNI: N nutrition index; GN: grain number; QN: accumulated N in shoot; DM: dry matter. *** significant for P<0.001.

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Crop rotation and crop management effects on cereal yields in arable organic farming in Denmark

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Key words: Cereals, manure, catch crops, grass-clover, weeds

Abstract

One of the main challenges in organic crop production is to ensure high and stable crop yields. In this study we used data from a 12 year old crop rotation experiment in Denmark to estimate the contribution of various management factors to yields of winter and spring cereals. The experiment included three factors in two replicates: 1) Grass-clover green manure crop (with and without), 2) catch crop (with and without), and 3) animal manure (with and without). Animal manure was the most important factor for increasing grain yield of cereal crops, but also grass-clover and catch crop contributed considerably to increasing yields. The grass-clover had a larger long-term effect on grain yields on the sandy loam soils than on the sandy soil. Yields were significantly reduced by weeds, and maintaing stable yields requires good weed control and prevention measures.

Introduction

An expansion of organic crop production requires increased crop production, which calls for high and stable crop yields if this is to take place without expanding agricultural area. This must be achieved while ensuring integrity of the organic crop production, placing less reliance on external and non-renewable resources and reducing environmental effects of the production system. Studies undertaken in Europe have pointed to restricted nitrogen (N) supply and poor weed control as being the primary reasons for low yields in organic cereal crops (Olesen et al., 2007, 2009). Improving the crop rotation design through inclusion of green manure crops and catch crops may contribute to a sustainable increase of cereal crop yields. In this study we used data from a 12 year old crop rotation experiment in Denmark to estimate the contribution of various management factors to yields of winter and spring cereals.

Materials and methods

An experiment on organic arable crop rotations was conducted at three sites in Denmark from 1997 to 2008 (Olesen et al., 2000). The experiment included three factors in two replicates: 1) Grass-clover green manure crop (with and without), 2) catch crop (with and without), and 3) animal manure (with and without). Four year crop

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rotations were used (Table 1), and all crops in the rotations were represented every year. The experiment was placed at three sites with different soil and climatic conditions: Jyndevad (sand), Foulum (loamy sand) and Flakkebjerg (sandy loam). Crop rotation O1 was only used at Jyndevad in 1997-2004 and was replaced by O4 in 2005-2008. Where manure was applied this corresponded to about 40-60% of the recommended rates in conventional farming.

The content of ammoniacal N (NH_4-N) in the applied manure was determined. Grain yields were determined for each plot by combine harvester. Samples of above ground biomass were taken in each plot at ear emergence in the cereals, and the samples were separated into cereal, catch crop and weeds for assessing weed pressure.

The harvested dry matter grain yields were related to applied ammoniacal N in the manure and to the assessed weed pressure (percent weed of total biomass). Additional effects of grass-clover and catch crops in the rotation was also included in the statistical analyses. For winter cereals it was possible to separate the effect of grass-clover in a direct pre-crop effect and in a longer-term effect of having grass-clover in the rotation. All analyses were performed using a mixed regression model and applying the MIXED procedure of the SAS statistical analysis system. The model included linear effects of applied ammonium in manure and of percent weeds present, categorical effects of grass-clover as pre-crop or in the rotation and of catch crops.

Tab. 1: Organic crop rotations during 1997 to 2009 at Jyndevad, Foulum and Flakkebjerg.

Course	O1	O2	O4
1st course	S. barley/ley	S.barley/ley	S.oatCC
1997-2000	Grass-clover	Grass-clover	W. wheatCC
	S. wheatCC	W. wheat	W. cereal1 CC
	LupinCC	Pea/barleyCC	Pea/barleyCC
2nd course	S. barley/ley	S.barley/ley	W. wheatCC
2001-2004	Grass-clover	Grass-clover	S. oatCC
	S. oatCC	W. cereal2	S. barleyCC
	Pea/barleyCC	LupinCC	Lupin
3rd course		S.barley/ley	S. barleyCC
2005-2008		Grass-clover	Faba beanCC
		Potato	Potato
		W. wheatCC	W. wheatCC

[1] Triticale at Foulum, wheat at Flakkebjerg, [2] Rye at Jyndevad, otherwise wheat
[CC] Catch crop

Results and discussion

The largest effect of manure application was achieved at Foulum for the winter cereals (Table 2), but at Jyndevad for the spring cereals (Tables 3 and 4). At Foulum and Flakkebjerg similar effects of manure application were achieved in all cereal crops. The applied rates of manure application in the experiment were mostly around 50 kg NH_4-N/ha. This manure rate gave yield increases of 0.9 to 1.4 Mg DM/ha in winter cereals, 0.9 to 1.5 Mg DM/ha in spring barley and 1.1 to 1.7 Mg DM/ha in spring oats.

Tab. 2: Effects of animal manure, grass-clover, catch crops and weeds on dry matter yields in winter cereals (winter wheat, winter rye and winter triticale).

	Jyndevad		Foulum		Flakkebjerg	
Manure (kg DM/kg NH_4-N)	19	***	28	***	17	***
Grass-clover pre-crop (kg DM/ha)	1312	**	626	***	858	***
Grass-clover in rotation (kg DM/ha)	162	NS	600	***	778	***
Catch crop in rotation (kg DM/ha)	37	NS	60	NS	105	NS
Weeds (kg DM/% weed)	-14	**	-66	***	-37	**

Levels of significance: NS: P>0.05, *: 0.05>P>0.01, **: 0.01>P>0.001, ***:0.001>P.

Tab. 3: Effects of animal manure, grass-clover, catch crops and weeds on dry matter yields in spring barley.

	Jyndevad		Foulum		Flakkebjerg	
Manure (kg DM/kg NH_4-N)	29	***	18	***	19	***
Grass-clover in rotation (kg DM/ha)	6	NS	384	***	274	**
Catch crop in rotation (kg DM/ha)	603	***	689	***	433	***
Weeds (kg DM/% weed)	-36	***	-72	***	-29	*

Levels of significance: NS: P>0.05, *: 0.05>P>0.01, **: 0.01>P>0.001, ***:0.001>P.

Tab. 4: Effects of animal manure, grass-clover, catch crops and weeds on dry matter yields in spring oats.

	Jyndevad		Foulum		Flakkebjerg	
Manure (kg DM/kg NH_4-N)	33	***	22	***	23	***
Catch crop in rotation (kg DM/ha)	42	NS	838	***	729	***
Weeds (kg DM/% weed)	-91	**	-64	*	-31	NS

Levels of significance: NS: P>0.05, *: 0.05>P>0.01, **: 0.01>P>0.001, ***:0.001>P.

Grass-clover in the rotation gave only small yield increases at Jyndevad. This may be explained by the large loss of N accumulated in the grass-clover crop by N-leaching following ploughing of the grass-clover ley (Askegaard et al., 2005). However, the grain yield effects of grass-clover as a pre-crop to winter cereals was larger at Jyndevad than at the other two sites. The combined effect of grass-clover as a pre-crop and grass-clover in the rotation on winter cereal grain yield was 1.5, 1.2 and 1.6 Mg DM/ha at Jyndevad, Foulum and Flakkebjerg, respectively. This is similar to the effect of applying manure at a rate of 50 kg NH_4-N/ha. However, the amount of N recycled in the grass-clover was about 300 kg N/ha, resulting in a lower N use efficiency of the grass-clover N than for N applied in manure (Olesen et al., 2009). Both the N use efficiency and the cereal grain yields may be increased through better recycling of the grass-clover N, e.g. through biogas treatment of the grass-clover crops (Stinner et al., 2008).

The rotation effects of grass-clover could not be determined for oats due to the experimental design. For spring barley the effect of grass-clover in the rotation was a yield increase of 0 to 0.4 Mg DM/ha. This is less than for winter cereals, where the effect varied from 0.2 to 0.8 Mg DM/ha. The smallest effect was found at Jyndevad, probably due to increased organic matter turnover and higher rates of N leaching on this sandy soil. The larger effect of grass-clover in the rotation on winter cereals compared with spring cereals can be attributed to a shorter time (2 years) between grass-clover and winter cereals versus 3 years between grass-clover and spring barley in rotation O1 and O2. This indicates that the residual effect of grass-clover on grain yields only lasts a few years.

Catch crops gave no significant yield increase in winter cereals, although the estimated effects were all positive. However, it should be noted that the crop rotations with grass-clover (O1 and O2) only allows for a small proportion of catch crops in the rotation thus reducing the overall effect of having catch crops in the rotation. The estimated yield effects of catch crops in spring barley varied from 0.4 to 0.7 Mg DM/ha, and similar effects were obtained in spring oats (Tables 3 and 4). This is larger than the effect of including grass-clover as green manure in the crop rotation, but less than for application of manure.

Weeds were estimated to reduce crop yields for all crops and at all sites. The average amounts of weeds assessed as weed dry matter at anthesis in proportion of total above-ground bioomass across all treatments and years were 6.5, 3.7 and 6.3% at Jyndevad, Foulum and Flakkebjerg. This gives average yield reductions from weeds of 0.1 to 0.2 Mg/ha in winter cereals, 0.2 to 0.3 Mg/ha in spring barley and 0.2 to 0.6 Mg/ha in spring oats. These effects are considerably smaller than the beneficial effects of manure application, green manure crops and catch crops. This shows that the weed control in general has been sufficient and acceptable in the experiment. However, poor weed control can easily double weed pressure and also double the yield losses from this weed pressure.

Conclusions

Animal manure was the most important factor for increasing grain yield of cereal crops, but grass-clover and catch crop also contributed considerably to increasing yields. Yields were significantly reduced by weeds, and maintaing stable yields requires good weed control and prevention measures.

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Spring forms of spelt landraces (*Triticum spelta* L.) and their suitability for Organic Farming

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Key words: spelt, characteristics of landraces, spring form, organic farming

Abstract

Organic farmers are interested in the growing of spring spelt wheat forms (Triticum spelta L.). Therefore, the important agronomical characteristics and baking quality of six spring spelt wheat landraces were studied and evaluated. The studied and evaluated cultivars were inclined to lodging and wheat diseases. Their yield rate is determined by the length of the spike and the weight of one thousand grains. The grain yield and the crude protein yield per hectare achieved the same level in organic farming. The spring spelt wheat forms stand out in high protein content and wet gluten content; the gluten was, nevertheless, weaker and less swollen.

Introduction

Spelt wheat (*Triticum spelta* L.) is a relatively common crop in current organic farming and a valuable material for the production of favourite cereal organic products. When comparing it with common wheat (*Triticum aestivum* L.), we appreciate a higher proportion of proteins, fibres and some mineral elements (zinc, selenium, lithium, phosphorus, magnesium) in the spelt wheat plants (Abdel-Aal & Hucl 2005). It tolerates worse environmental conditions and thus provides a more stable yield rate, even in less favourable areas for farming (Rüegger *et al*. 1990). Concerning the growing of spelt wheat, it has some advantages which determine it to be a suitable crop for the organic farming system. Thanks to a better ability to form tillers and sprouts (Suchowilska *et al*. 2009), it competes well against weeds. However, thanks to this ability, it may form a higher number of unproductive tillers and sprouts (Abdel-Aal and Hucl 2005). The good health of plants is another positive trait of spelt wheat (Schmid *et al*. 1994). Varieties (a group of varieties) have to be studied very carefully as there may be more or less resistant varieties to the most important wheat diseases (Abdel-Aal & Hucl 2005). For example, an inclination to lodging is one of the disadvantages of spring wheat forms (Suchowilska *et al*. 2009). Winter spelt wheat forms are more common in Europe (Abdel-Aal & Hucl 2005). However, spring wheat forms are becoming more interesting too as they could substitute damaged wheat crop stands in winter. This article presents the results of an analysis of particular agronomically significant traits and the baking quality of six landraces of spring spelt wheat.

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Materials and methods

Precise small-plot trials were established in three replications on a certified organic parcel of the University of South Bohemia (Faculty of Agriculture) in České Budějovice (JU ZF) in 2008 and 2009. From the genetic resources were selected six spring spelt accesions. Common wheat varieties - Jara (an obsolete Czech cultivar), Granny and SW Kadrilj (modern top spring varieties) were chosen as the control. Lucerne was used as a forgoing crop. The treatment of the crop stands respected the principles of organic farming in the growing period – the crop stands were harrowed in the tillering period. An evaluation of the crop stands was carried out during the growing period and also after the harvest. Post-harvest analyses of the plants and spikes were carried out as well. The evaluation was based on a specific methodology by Konvalina *et al*. (2008). Standard methods were applied in the analysis of baking quality (proportion of nitrogenous elements in the dry matter of grains – CSN/ISO norm 1871, wet gluten content in the dry matter of grains - CSN/ISO norm 5531, and gluten index, SDS test by Axford CSN 46 1100-2. A statistical evaluation of the data was carried out in the Statistica 9.0 program (an elementary statistical evaluation and the Tukey HSD test).

Results and Discussion

Concerning common wheat diseases, the resistance to brown rust (*Puccinia recondita*) and mildew (*Blumeria graminis*) were studied and evaluated. All the spelt wheat varieties were as or less tolerant to these diseases than SW Kadrilj, a control variety (Table 1). The spring spelt wheat forms were much longer and taller (138 - 146 cm) than SW Kadrilj (100 cm). Therefore, the spelt wheat plants better competed against weeds than the control variety (Eisele & Köpke, 1997). Meanwhile, they were inclined more to lodging (it was also confirmed by the Tukey HSD test) (Table 1). There were negligible differences between the varieties. The degree of the inclination to lodging was in a negative correlation to the harvest index (r=0,56) which was caused by the fact that plants having weak stalks achieve higher values of the harvest index but they are more lodged, on the other hand. Concerning spike productivity, the varieties were characterised by sparse spikes and all productivity was enhanced by the length of the spikes. The weight of grains in the spikes was lower than the ones of the control varieties (Table 1). The harvest index rate was similar to one of the control varieties. The modern common wheat varieties were characterised by a reduced harvest index which was provoked by a lack of accessible nutrients (the nutrients of nitrogen) in the soil. A plant forms conditions for better production of phytomass at the beginning, but the nutrients contained in the plant are not further distributed to grains (Baresel et al. 2005). The grain yield rate achieved the same level as the control varieties (Tukey HSD test) (Table 2). The comparison of the crude protein yield per hectare also showed very interesting findings (the spelt wheat varieties achieved the same crude protein yield per hectare as the control bread wheat varieties, on average). As a lot of authors have confirmed (Abdel-Aal & Hucl 2005, for example), spring and winter spelt wheat forms contain a high proportion of protein in the grain. As our research showed, a mean difference in the proportion of protein in the grain between the spelt and common wheat, achieved 4.2 % in favour of the spelt wheat (Table 2). The spelt wheat plants also contained more wet gluten (35 – 48 %) than the plants of the control varieties (21 - 33%). The gluten index was reduced in the spring spelt wheat plants (GI = 37 - 50) so the gluten was weaker and it was more difficult to work it by baking. Concerning the swelling of proteins (it is expressed by the SDS test), there were more significant differences in the spelt wheat plants (39 - 66 ml) than in the plants of the control common wheat varieties (58 - 83 ml). Scientific literature also makes remarks about the worse swelling of the spring spelt wheat forms

(Abdel-Aal & Hucl 2005). Therefore, a mixture of spelt wheat flour (weaker and less swelling gluten, high proportion of proteins) and common wheat flour (more solid gluten, more swelling proteins, low proportion of proteins) is considered as a prospective material for the production.

Table 1: Selected Agronomic Traits of Spelt Landraces (mean/standard deviation) (2 years, 3 replications)

Variety	Rust1	Mildew1	Plant height (cm)	Index of lodging1	Weight of grains per spike (g)	Spike length (cm)	Spike density2
Spelta (Triticum spelta L.)							
SP1	6,5±1,6ab	6,2±0,5de	146±2,6bc	6,6±0,7a	0,7±0,1a	11±1,3a	13±0,3b
SP2	7,1±1,4ab	8,1±0,7ab	140±2,9abc	6,8±1,0a	0,7±0,2a	9±0,6b	16±0,9bc
SP3	7,0±1,3ab	8,8±0,3b	136±4,4ab	6,9±0,5a	0,7±0,1a	9±0,2b	15±0,8ab
SP4	6,5±0,8ab	5,9±0,3d	146±2,1c	7,0±1,2a	0,8±0,2a	11±0,3a	14±0,3ab
SP5	5,8±0,8a	7,8±0,6ac	140±2,1abc	6,9±0,5a	0,9±0,1a	11±0,6a	14±0,5ab
SP6	6,8±1,4ab	7,8±0,6ac	138±4,8abc	6,5±0,8a	0,8±0,2a	9±0,5bd	16±0,8ac
Control – Bread wheat (*Triticum aestivum* L.)							
Jara	7,5±0,8ab	7,1±0,5ce	130±13,6a	8,5±0,6b	1,3±0,2b	10±0,2cd	18±3,2c
Granny	5,5±0,8a	8,8±0,5ab	96±0,8d	9,0±0,0b	1,3±0,4b	10±0,1ac	18±0,9c
Kadrilj3	8,5±0,8b	8,6±0,3b	100±0,8d	9,0±0,0b	1,1±0,1ab	7±0,3e	22±2,1d

19 = resistant or no lodging; [2]number of spikelets.$10cm^{-1}$; [3]SW Kadrilj; $P < 0.05$; Different letters document statistical differences between varieties for Tukey HSD test, $P < 0.05$

Conclusions

Some of the tested and evaluated varieties are suitable for the organic farming system. Material resistant to brown rust and mildew has to be chosen carefully for growing in organic farming. The resistance to lodging should be one of the most important criteria of selection. The selection of the varieties being characterised by a high weight of one thousand grains may contribute to an enhancement of the spike productivity (and enhance the yield formation). Spring spelt wheat forms provide the same grain yield, but after the dehulling of grains, total yield will be lower. But spelt grain have better quality (a high proportion of the crude protein in grain). The spelt wheat grains are valuable materials for the production of healthy regional and local products.

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Table 2: Economic Traits and Baking Quality of Spelt Landraces (mean/standard deviation) (2 years, 3 replications)

Variety	Harvest index	Grain yield (t.ha-1)	Protein yield (t.ha-1)	Protein content (%)	Wet gluten content (%)	Gluten index	SDS test (ml)
Spelta (Triticum spelta L.)							
SP1	0,39±0,0a	3,0±1,2a	0,52±0,2a	17,9±0,8a	47±0,2ab	50±11,0a	39±1,5c
SP2	0,39±0,0a	3,4±1,6a	0,64±0,3a	18,6±0,4a	48±2,4b	50±26,6a	65±0,8a
SP3	0,38±0,0a	3,2±2,1a	0,61±0,4a	18,8±0,1a	47±2,9ab	49±39,2a	66±1,7a
SP4	0,38±0,1a	2,5±1,2a	0,43±0,2a	17,9±0,9a	35±12,4abc	37±5,7a	39±4,2c
SP5	0,40±0,0a	3,5±2,5a	0,65±0,5a	18,5±0,4a	39±13,5ab	41±8,9a	51±9,7c
SP6	0,43±0,1a	3,4±2,4a	0,62±0,4a	18,0±0,1a	47±4,5ab	43±25,2a	56±55,8bc
Control– Bread wheat (*Triticum aestivum* L.)							
Jara	0,38±0,0a	3,9±2,3a	0,57±0,3a	14,7±0,4b	32±9,8ac	68±6,9a	58±4,7abc
Granny	0,38±0,1a	3,9±3,1a	0,52±0,4a	13,2±0,5c	21±13,1c	53±15,8a	63±16,7ac
Kadrilj1	0,42±0,0a	4,7±2,5a	0,65±0,3a	14,3±0,9b	33±1,3abc	71±9,9b	83±1,5e

[1]SW Kadrilj; Different letters document statistical differences between varieties for Tukey HSD test, $P < 0.05$

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Fusarium mycotoxins and wheat productivity in ecological and integrated arable systems in Central Europe

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Key words: wheat, *Fusarium* mycotoxins, farming systems

Abstract

A long-term trial comparing ecological (ECO) and integrated (INT) farming systems was carried out in western Slovakia, with grain yield of winter wheat, concentration of mycotoxins being reported here. The ECO system had lower yields (12 – 31 %) in most, but not all years. There was no difference in yield between farming systems during drier years. The greater productivity of the INT system was achieved with significantly lower nutrient efficiency for nitrogen, phosphorus and potassium inputs. The results indicate increased drought tolerance in the ECO system. Concentration of DON was lower by 46 % in ECO system compared with INT. The level of ZON was affected by the weather conditions.

Introduction

Productivity is usually considered the ultimate bench-mark when comparing the performance of agricultural systems. Conversion to organic management from these conditions usually means considerably drop of yields, during two to tree years of conversion. In the medium and long term, when soil fertility recovers, yields are slightly lower or comparable to the pre-conversion yields (Dierauer *et al.* 2006). The presence of mycotoxins, especially deoxynivalenol (DON) and zearalenone (ZON) is a major concern for grain growers using any system (Moss 1991). Review of the literature suggests, that the mycotoxin content of cereals is highly variable, regardless of the farming system. This paper reports on the effects of ecological and integrated farming systems, fertiliser inputs on the yield of winter wheat and mycotoxins contamination in a log-term field trial.

Material and methods

Rotation and cropping system field experiments were carried out at Dolná Malanta, Western Slovakia from 1999 to 2008. The ecological system was composed of a six course crop rotation: beans + lucerne – lucerne – winter wheat – peas – maize – spring barley. The integrated system consisted of the crop rotation: winter wheat – peas – winter wheat – maize – spring barley – lucerne (3 years at the same plot). Subplots were fertilised (+fert) and unfertilised treatments (-fert).
The +fert treatment in ECO system was based on 40 tonnes of manure per rotation (192 kg N; 40 kg P; 208 kg K), while the INT system also received 40 tonnes of

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manure plus synthetic fertilisers. In INT system fungicide Tango super (1,0 l per ha) was applied. Treatments were replicated four times. In order to compare the efficiency of the two farming systems, the yield parameters, kernel count (KC), 1000 grain weight (TGW) and grain yield were divided by the volume of fertilisers added (kg.ha^{-1} of N, P and K) in the +fert treatments. The second winter wheat crop in INT was taken into evaluation. Crop management and climatic data for winter wheat are shown in Table 1. The concentration of deoxynivalend (DON) and zearalenone (ZON) was detected in the w. wheat grain samples from ECO and INT systems, +fert and –fert variants by using of HPLC. Analysis of variance was used to identify significant treatment effects. Significantly different means were separated using contrast analysis.

Tab. 1: Crop management data for w. wheat, 1999 – 2008; rainfall and average temperature calculated for the vegetative period of the crop; synthetic fertiliser inputs applied in the INT system.

Year	Sowing date	Harvest date	Rainfall (mm)	Average temperature (°C)	Nitrogen (kg.ha^{-1})	Phosphorus (kg.ha^{-1})	Potassium (kg.ha^{-1})
1999	23/10/98	20/07/99	435	8,1	23,8	15,0	31,6
2000	28/09/99	3/07/00	301	9,5	25,3	5,0	18,3
2001	29/09/00	20/07/01	408	10,4	29,0	5,8	23,3
2002	4/10/01	6/07/02	310	9,0	44,2	15,8	16,6
2003	9/10/02	30/06/03	264	7,7	34,2	21,6	26,6
2004	2/10/03	21/07/04	450	8,2	39,8	19,1	16,6
2005	1/10/04	19/07/05	398	8,2	49,2	22,5	10,0
2006	7/10/05	20/07/06	522	7,9	58,3	22,5	0,0
2007	2//10/06	2/07/07	347	10,0	58,0	28,3	56,6
2008	9/10/07	28/07/08	467	8,9	57,5	28,3	21,6

Results and Discussion

The effects of years and farming systems on winter wheat yield parameters were significantly different with the year x system interaction also being significant. In general, average grain yield was lower in the ECO system by about 25 % and ranged from 0 % to 31 %, (Tab. 2). In drier years (2000, 2002, 2003, 2007) the yield difference was not significant. The average kernel count was also lower in ECO system by 12,4 %.

Tab. 2: Grain yield (t.ha^{-1}) for winter wheat grown in ECO and INT farming systems. Means and standard errors shown.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
ECO	6,2 ±0,54	5,4 ±0,06	5,1 ±0,32	5,4 ±0,35	4,6 ±0,09	5,3 ±0,8	4,9 ±0,55	6,8 ±0,37	5,2 ±1,4	5,1 ±1,4
INT	8,3 ±0,35	5,7 ±0,29	6,5 ±0,44	5,7 ±0,45	5,0 ±0,32	7,7 ±0,42	6,6 ±0,13	8,9 ±0,7	4,7 ±0,23	5,1 ±0,16

The variation in TGW between systems was lower, and TGW was greater in the INT system by 3 %. The lack of differences in drier years may be related to increased nutrient cycling, water – holding capacity (Lotter *et al.* 2003), higher soil organic matter content, soil fertility (Macák *et al.* 2008) in ECO system, or the inability of wheat to use the extra fertiliser in the INT system. The efficiency of the two farming systems was compared by relating yield parameters to fertiliser inputs. The ECO system was significantly higher per unit of nutrient added for all yield parameters (Tab. 3). This finding has important economic and environmental implications, were resources such as water and energy reliant fertilisers need to be used efficiently with regard to cost and off-farm impacts.

Tab. 3: Efficiency of fertiliser inputs on winter wheat yield parameters (10 years average). Means and standard errors shown

Yield parameters	Nitrogen ($kg.ha^{-1}$)		Phosphorus ($kg.ha^{-1}$)		Potassium ($kg.ha^{-1}$)	
	ECO	INT	ECO	INT	ECO	INT
Kernels (pc . m^{-2})	418 ±15	213 ±9	2014 ±69	694 ±50	385,8 ±13	294 ±21
1,000 grain weight (g)	1,28 ±0,031	0,59 ±0,024	6,11 ±0,150	1,93 ±0,134	1,18 ±0,029	0,79 ±0,034
Grain yield ($kg.ha^{-1}$)	168,8 ±6	89,9 ±5	806,4 ±27	292,0 ±21	155,7 ±5	123,1 ±9

The effects of farming systems, years, fertilisation on DON concentration in winter wheat grain were significantly different. Average DON concentration in INT system was 361,6 $\mu g.kg^{-1}$, in ECO system its concentration was lower by 46 % and reached an average of 192,4 $\mu g.kg^{-1}$ (Tab. 4). Fertilisation treatments significantly enhanced the level of DON.

Tab. 4: Concentration of DON and ZON ($\mu g.kg^{-1}$) in winter wheat kernels

System / Treatment	DON	ZON
Integrated	361,6b	7,4 n. s.
Ecological	192,4a	7,8 n. s.
Fertilised	420,5b	7,7 n. s.
Unfertilised	189,9a	7,4 n. s.
2007	198,7a	12,9b
2008	411,7b	2,3a

Numbers with different letters are significantly different (P = 0,05)

Not only farming system, but within INT system also pre-crop effect on DON concentration was revealed. Peas, as pre-crop for winter wheat, significantly enhanced the concentration of DON. Weather conditions during two consecutive growing seasons significantly influenced levels of DON in winter wheat samples. More humid and warm weather during June and July in 2008 caused significantly higher production of DON than it was in 2007, with prevalence of very warm and dry periods. Statistical analysis of ZON concentration in winter wheat grain showed significant effect of years. The effects of farming system and fertilisation were not significant.
During 2006 - 2007 growing season, warm and dry weather, namely in June and July supported the production of ZON, whereas more humid and warm weather in 2008 was less favourable for ZON. Detected levels of DON and ZON in both systems did not exceed the max. levels according to EU regulation 1881/2006, 750 $\mu g.kg^{-1}$ of DON and 75 $\mu g.kg^{-1}$ of ZON in cereals for human consumption.
Our experiments may confirm the results of Döll *et al.* (2002), that in the absence of fungicides, organic wheat was more tolerant to *Fusarium* infection than conventional. The type of fertility management is more important for the extent of *Fusarium* infection than the use of pesticides. The relatively low and/or slow nutrient supply in organic farming helps to trigger the plants´ natural defenses against infections. If a plat is allowed to grown unusually fast by providing it with an abundance of nutrients, the accumulation of defense compounds is reduced, as well as resistance to diseases and pests (Brandt & Molgaard 2006).

Conclusions

The greater productivity of the INT system was achieved with significantly lower nutrient efficiency than in the ECO system. No difference in yield between the systems was determined during drier years. The ECO system was able to produce higher yields than integrated per unit of nutrient applied, with significantly higher output/input ratio for nitrogen, phosphorus and potassium. ECO system have the potential to achieve consistent, moderate yields with a significantly lower reliance on external inputs. Mycotoxin contamination (DON, ZON) in wheat was below the level considered safe for consumption. In ECO system, the concentration of DON was lower by 46 % compared with INT system. Within INT system, pre-crop effect on DON concentration was determined, when peas enhanced the level of DON in w. wheat grain. Level of ZON was influenced by weather conditions. Drier and warmer weather supported the production of ZON, more humid and warm weather enhanced the level of DON.

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Organic crops

Organic production of tropical tuberous vegetables: An eco-friendly approach for sustainable production, tuber quality, soil health and economic returns

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Key words: Alternative farming, root crops, productivity, soil quality index, economics

Abstract

Global awareness of health and environmental issues has stimulated interest in alternative agricultural systems like organic farming. Elephant foot yam and yams (Dioscorea sp) are ethnic starchy vegetables with high energy, nutritive and medicinal values. Field experiments were conducted at the Central Tuber Crops Research Institute, Thiruvananthapuram, India during 2004-2010 to assess the agronomic, nutritional and economic advantages of organic farming over conventional system in these crops. Organic farming produced significantly higher yield (15–30 %) over conventional practice. In elephant foot yam a profit of Rs 215776 ha^{-1} (US $ 4849) was obtained. Elite and local varieties responded equally well to organic farming, which lowered the bulk density by 2.3%, improved the water holding capacity by 28.4% and the porosity of soil by 16.5%. There was significant increase in pH (0.64-0.77 unit), exchangeable Mg, available Cu, Mn and Fe, higher soil organic matter (11-19%), available N, P and K, bacterial and fungal populations, N fixers, P solubilizers and dehydrogenase enzyme activity of soil. Organic farming scored significantly higher soil quality index (1.930) than conventional practice (1.456). Tuber quality was improved with higher dry matter, starch, crude protein, K, Ca, and Mg and lower oxalate contents. Cost effective technologies were field validated.

Introduction

Worldwide concerns regarding the food safety, anthropogenic degradation of the environment and the threats to human health have generated interest in sustainable alternative agricultural systems (Carter *et al*.1993). According to the UN millennium ecosystem assessment "land degradation" is one of the world's greatest environmental challenges. About 40% of the world's arable land is seriously degraded and 11% of such land is in Asia. The land quality for food production contributes to future peace. Hence "Organic farming" is essential for sustainable production, improved conservation of soil and vegetation besides restoration of degraded land.

Tropical tuber crops form important staple or subsidiary food for about 500 million of the global population. Elephant foot yam and yams are high energy tuberous vegetables with good taste and medicinal values. They are food security crops in tropical countries mainly West Africa, South East Asia, Pacific Islands, Papua New

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Guinea islands and the Caribbean.There is ample scope for organic production as they respond well to organic manures.There is a great demand for organically produced tuberous vegetables among affluent Asians and Africans living in Europe, USA and Middle East. This paper explores the comparative advantages of organic farming over conventional practice in terms of yield, quality, economics as well as soil physico-chemical and biological properties under elephant foot yam and yams.

Materials and methods

Three field experiments were conducted during 2004-2010 at the Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram, Kerala, India, in an acid Ultisol (pH: 4.3-5.0). The impact of conventional, traditional, organic and bio-fertilizer farming was evaluated in elephant foot yam (EFY) for 5 years in randomized block design (RBD) with 5 replications. Comparative response of 4 varieties of elephant foot yam (2 elite (Gajendra, Sree Padma) and 2 locals) under organic and conventional farming was evaluated in split plot design.Three species of edible *Dioscorea* (white yam :*D. rotundata* (var. Sree Priya), greater yam: *D. alata* (var. Sree Keerthi) and lesser yam: *D. esculenta* (var. Sree Latha)) were evaluated under conventional, traditional and organic farming systems in split plot design. In split plot design, varieties/species were assigned to main plots and production systems to sub plots and replicated thrice. Under National Horticulture Mission funded programme, on farm trials were conducted at 10 sites/replications (covering 5 ha in Kerala) in RBD with 3 treatments, conventional, organic and traditional, to validate the organic farming technology.

Chemical inputs were not used in the test site for an year before the experiments. In "conventional plots" the package of practices recommendations (farmyard manure (FYM) + NPK fertilizers) was advocated. Farmers practice of using FYM and ash was followed in "traditional plots". In "organic farming plots", FYM inoculated with *Trichoderma harzianum*, green manure, ash and neem cake were used. In "bio-fertilizer farming", FYM, mycorrhiza, *Azospirillum* and phosphobacterium were applied. Organically produced planting materials were used.

Pooled analysis of yield data was done. Proximate analyses of tubers for dry matter, starch, total sugar, reducing sugar, crude protein, oxalates and total phenols, mineral composition of tubers viz., P, K, Ca, Mg, Cu, Zn, Mn and Fe contents, chemical parameters of soil viz., soil organic matter (SOM), pH, available N, P, K, Ca, Mg, Cu, Zn, Mn and Fe status, physical characters of the soil such as bulk density, particle density, water holding capacity (WHC) and porosity, plate count of soil microbes viz., bacteria, fungi, actinomycetes, N fixers, P solubilizers and the activity of dehydrogenase enzyme were determined by standard procedures. Economic analysis was done; net income and benefit cost ratio were computed. The soil quality index (SQI) was computed based on the method of Karlen and Stott (1994). The three main steps in this technique include the selection of minimum data set of soil quality indicators, scoring of the indicators based on their performance of soil functions and integrating the scores into a comparative indicator of soil quality.

Results

1. Elephant foot yam (Amorphophallus paeoniifolius)

Organic farming favoured canopy growth and corm biomass, lowered collar rot disease and mealy bug infestation in storage. All the varieties responded equally well to organic farming. Organic farming resulted in 20% higher yield over conventional practice and generated additional profit of Rs. 47,716 ha^{-1} (US $ 1072) over chemical based farming. Organic corms had significantly higher dry matter and starch and lower oxalate contents (Table 1). The content of K, Ca and Mg was higher by 3-7% in organic corms. After 5 years, pH was significantly higher (by 0.77 unit) and SOM (by 19%) available N, P and K status of the soil were higher in organic plots. Exchangeable Mg, available Cu, Mn and Fe contents were significantly higher. WHC was significantly higher (14.11%), bulk density (1.544 g cm^{-3}) and particle density (2.289 g cm^{-3}) were slightly lower and porosity (36.5%) higher. The population of bacteria, fungi and N fixers was higher by 41%, 20% and 10% respectively in organic plots. The dehydrogenase enzyme activity (1.625 µg TPF formed g^{-1} soil h^{-1}) was promoted by 23% in organic plots. The organic system scored significantly higher SQI (1.930), closely followed by the traditional system (1.913). SQI of conventional (1.456) and biofertilizer systems (1.580) were significantly lower (Figure1). The SQI was driven by WHC, pH and available Zn followed by SOM. The on farm trials confirmed the superiority of onstation developed organic farming technology (FYM @ 36 t ha^{-1} (cowdung + neem cake mixture (10:1) inoculated with *Trichoderma harzianum*), green manuring with cowpea to generate 20-25 t ha^{-1} of green matter in 45-60 days, neem cake @ 1 t ha^{-1} and ash @ 3 t ha^{-1}).

Tab.1: Yield, quality and economic benefits of organic farming in EFY

Production system	Corm yield (t ha-1) (Pooled mean)	Dry matter (%)	Starch (% FW basis)	Oxalate (% DW basis)	pH	Soil organic matter (SOM) (g kg-1)	Net income ha-1		B:C ratio
							Rs	US $	
Conventional	47.61	19.93	14.68	0.234	4.55	20.32	1,68,060	3777	1.79
Traditional	44.96	20.72	16.51	0.217	5.45	20.11	1,40,880	3165	1.64
Organic	57.10	21.41	16.54	0.186	5.32	24.19	2,15,776	4849	1.90
Bio-fertilizers	42.07	21.67	16.40	0.204	4.68	22.15	1,20,288	2703	1.56
CD (p=0.05)	3.55	1.06	0.94	0.026	0.28	NS			

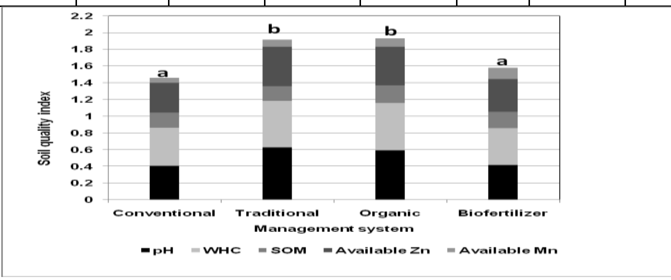

Figure 1: Soil quality index for different management systems in EFY

2. Yams (Dioscorea* species*)

Organic farming produced significantly higher yield in yams (24.44, 21.02 and 19.03 t ha^{-1} for white yam, greater yam and lesser yam respectively). The yield increase in these species was 25%, 15% and 27 % respectively. Lowering of bulk density and improvement in water holding capacity (by 19%) and porosity of soil were observed in organic plots. The population of bacteria, fungi and P solubilizers were higher by 23%, 17% and 22% respectively. There was significant increase in pH under organic farming (by 0.64 unit). The soil organic matter improved by 11% and dehydrogenase enzyme activity by 14%. Organic tubers had significantly higher Mg content (139 mg $100g^{-1}$), slightly higher dry matter (33.56%) and crude protein contents (1.92%).

Discussion

Yield under organic farming is determined by the intensity of external input use before conversion (Stanhill 1990). Elephant foot yam and yams are traditionally grown with low external inputs using organic wastes and manures available in the homesteads.The higher yield in these crops may be due to the overall improvement in soil physico-chemical and biological properties under the influence of organic manures (Clark *et al*.1998, Colla *et al*. 2000, Stockdale *et al*. 2001). The pH increase under organic management may be due to elimination of NH_4 fertilizers, addition of cations especially via green manure applications, decrease in the activity of exchangeable Al^{3+} ions in soil solution due to chelation by organic molecules and Ca content of the manures. Higher soil organic matter status of organic plots might be attributed to the large addition of organic manures particularly green manure cowpea. Available N, P and K were higher under organic management due to the direct result of inputs and constituents of various manures. The higher microbial load and dehydrogenase enzyme activity in organic plots may be due to higher decomposition of organic matter due to addition of organic manures like FYM, green manure, neem cake etc. to replace the chemical fertilizers. The higher tuber quality is similar to the reports of Rembialkowska (2007) that organic crops contain more dry matter and minerals, especially Fe, Mg and P by 21%, 29% and 14% over conventionally produced ones.

Conclusions

Organic farming is a feasible option in tuberous vegetables for sustainable yield of quality tubers, higher profit and maintaining soil quality.

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Growth and yield by planting distance in organic and semi-forced greenhouse cultivation of leaf perilla

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Keywords: Organic cultivation, Leaf perilla, Growth, Yield.

Abstract

With regard to organic greenhouse cultivation of leaf perilla, this study aims to identify the growth and yield of leaf perilla by planting distance. During the cultivation period, the total usage of organic fertilizer, inclusive of base manure and supplementary manure, amounted to 12.7kg of T-N, 10.6kg of P_2O_5 and 4.7kg of K_2O per 10a. As for growth patterns of leaf perilla, lower planting density resulted in an increase in plant height, stem diameter, leaf length, leaf width, and leaf weight. The total yield of leaf perilla recorded 2,599 kg/10a in an area with the span of 10×7cm, which represented 11% higher than that of conventional farming while exceeding other processing methods.

Introduction

In Korea, recent growth in meat and raw fish consumption has expanded overall consumption of lettuce and leaf perilla as raw vegetables. As over 20 crops (i.e. leaf perilla, lettuce, and chicory) are grown as environmentally friendly certified items in 173 production complexes, such clustering of cultivation area is gaining considerable momentum nationwide. So, technological breakthroughs for environmentally friendly cultivation methods have emergeed as a pressing challenge amid the recent boom in well-being and functional foods (Kim et al., 2010).

Materials and methods

In this study, we classified the planting distance into four types: 10×5cm (192,500 plants/10a), 10×7cm (137,500 plants), 10×9cm (106,900 plants), 10×11cm (87,500 plants). Manchoo was chosen as the item under cultivation.

We applied 162kg/10a of mixed organic fertilizer (N-P-K=3.2:4.2:1.1) as base manure, and the same fertilizer of N1.5kg/10a diluted with 5.0 ton of water as supplementary manure every ten days.

The cultivation period totaled 88 days from March 5, 2009 through May 31, 2009.

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[8] Same as above

Results and discussion

In leaf perilla cultivation, we applied 12.7kg of T-N, 10.6kg of P_2O_5 and 4.7kg of K_2O per 10a. With regard to the growth of leaf perilla by planting distance, lower planting density led to an increase in plant height, leaf length, leaf width, leaf weight, and chlorophyll content (Tab. 1).

Tab. 1: Leaf perilla growth by planting distance in organic greenhouse cultivation

Treatment Type	Plant Height (cm)	Leaf Length (cm)	Leaf Width (cm)	Leaf Weight (g/unit)	Chlorophyll (SPAD)
10 × 5cm	37.2c	13.3d	11.4d	2.0b	34.2d
10 × 7cm	38.2bc	14.4c	12.2c	2.1ab	36.5c
10 × 9cm	39.4b	15.2b	13.4b	2.2ab	37.6b
10 × 11cm	47.3a	16.3a	14.4a	2.3a	38.6a

CV (%) --- 1.5 ---- 1.0 ------ 1.9 ----- 3.4 ------- 0.6

* Means followed by same letters in a column are not significantly different ($P<0.05$).

With regard to leaf perilla yield per harvesting period, higher planting density lowered the yield of superior output whereas increasing the yield of inferior output. In the total quantity of superior output, the plot with the span of 10×7cm produced higher yields of 374kg-666kg/10a than other three plots (Fig. 1).

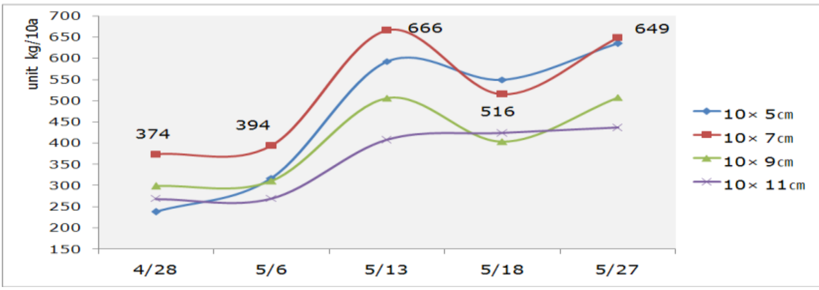

Figure 1: Leaf perilla yield by harvesting period during organic greenhouse

The total number of superior output was 1,293,000 leaves from the area with the span of 10×7cm, which was 5% higher than the area with the span of 10×5cm, 26% higher than the area with the span of 10×9cm, and 33% higher than the area with the span of 10×11cm. In the area with the span of 10×5cm, total yield remained relatively higher, but being accompanied by larger number of inferior output. In the area with the span of 10×7cm, total quantity of superior output stood at 2,599kg/10a, and the rate of superior output stood at 83%, which was an 11% increase from the conventional level, which illustrated its higher economic feasibility.

Tab. 2: Quantity by planting distance in organic greenhouse cultivation

Treatment Type	Quantity per 10a							Superior Output Index
	Number of Leaves (thousand)			Quantity (kg)				
	Total	Superior Output	Inferior Output	Total Quantity	Quantity of Superior Output	Quantity of Inferior Output	Rate of Superior Output	
10×5cm	1,747	1,228	519	3,320	2,334	986	70	100
10×7cm	1,549	1,293	256	3,113	2,599	515	83	111
10×9cm	1,183	989	194	2,426	2,028	398	84	87
10×11cm	1,019	861	158	2,140	1,808	332	84	77

LSD(5%) 169kg

C.V(%) 5.4

Conclusions

In organic greenhouse cultivation of leaf perilla, the area with the planting distance of 10×7cm generated the largest increase in the quantity and quality of yield.

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Yield and yield attributes of sesame (*Sesamum indicum* L.) sown after sunflower (*Helianthus annuus* L.) in an organic crop rotation system

Olowe, V.I.O.[1], Alebiosu, M.A[2] & Adeyemo, Y.A[3]

Key words: sesame, sunflower, yield, yield attributes, crop rotation

Abstract

There is an increasing demand for organic sesame seeds in the international market. Sesame was sown after sunflower in an on-going organic crop rotation scheme involving sesame, sunflower, soybean and maize in 2009 to assess the yield performance of an improved early maturing variety (E8) of sesame. The experiment commenced in 2008 and was laid out in a randomized complete block design and replicated four times. Treatments being evaluated include continuous, rotational and conventional cropping systems. Sesame plants grown under conventional cropping system produced significantly ($p<0.05$) higher number and weight of capsules per plant, weight of seeds per plant, number of branches per plant and grain yield than those under continuous and rotational cropping systems in 2009. Sesame under rotational cropping system however, produced slightly higher grain yield in 2009 than 2008.

Introduction

Crop rotation scheme is very germane to sustainable organic farming because it guarantees some level of biodiversity, breaks weed and pest life cycles and provides complementary fertilization to crops in the scheme. The organic sesame (*Sesamum indicum* L.) market is now a fast growing market with an annual growth rate of 50% (Export Promotion of Organic products from Africa [EPOPA], 2005). Sesame as an annual crop has great potentials as a component crop in crop rotation because it conditions the soil by reducing cotton root rot and nematodes thus lowering the risk on succeeding crop, loosens the soil with its tap root and provides a dense network of roots in the upper layer, retains soil moisture better for planting the next crop and composted leaves of sesame left on the soil binds the soil (Langham and Schwarz, 2008). Despite these natural attributes of sesame, the crop is still predominantly cultivated as a small holder crop that is often relegated to marginal soils in the troipics and as such is under-exploited (Olowe *et al*, 2009). In order to develop a production package for some staple and commercial food crops which can guarantee availability of wholesome and affordable food that can be formulated into rich human diets, a crop rotation scheme was initiated consisting of four component crops with export potentials (soybean, sunflower, sesame and maize) in 2008. The objective of the study is to evaluate the performance of the component crops in rotation relative to continuous and conventional cropping systems.

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Materials and methods

The crop rotation scheme involving four component crops (soybean, sesame, sunflower and maize) is being carried out at the Organic plot of the Teaching and Research Farm of the University of Agriculture, Abeokuta (7^o 15' N, 3^o 25' E, altitude 140 m.a.s.l). The study started in 2008 during the late cropping season (July – November). Rainfall and mean monthly temperature values are shown on Figure 1. Details of the rotational cropping system are shown on Table 1. The test crops will be grown on the the same plots for the continuous and conventional cropping systems throughout the study. The four rows in Table 1 depict the sequence the test crops will follow in the phased rotation scheme. The soil of the experimental field is oxic Paleudulf (Adetunji, 1991). The test variety of sesame is E-8 (an improved early maturing variety). The experimental design is randomized complete block design (RCBD) with four replicates. Treatments evaluated were continuous (sesame after sesame), rotational (sesame after sunflower in 2009) and conventional cropping systems (use of agro-chemicals). The plots of the conventional cropping system were located about 15 m away from the organic plots to avoid commingling. The continuous and rotational cropping systems will receive organic fertilizers in subsequent years (i.e. 2010 and beyond). The row spacing adopted for sesame under the three cropping systems was 60 x 5 cm and each plot measured 6.5m by 6.0m ($39m^2$). Sowing of sesame seeds was done on 28 August, 2008 and 2 July, 2009 by hand. Thinning was carried out three weeks after sowing (WAS) to secure one plant per stand. No herbicides or fertilizers were applied on the continuous and rotation plots. However, pre-emergence herbicides (Galex and Gramoxone) was applied imediatetly after sowing and fertilizer combination (60 kgN/ha and 56 kg P_2O_5/ha) at 4 WAS on the conventional plots. Harvesting was done at physiological maturity (Olowe et al., 2009). Data collected on yield and yield attributes included number of branches and capsules per plant, weight of capsules and seeds per plant, 1000 grain weight, harvest index and grain yield. Data collected were subjected to analysis of variance and means of significant traements were separated using the least significant difference method as described by Steel and Torrie (1984).

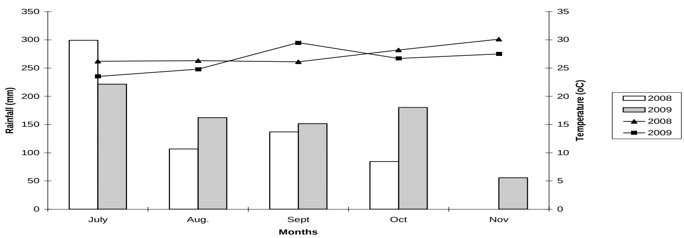

Figure 1: Monthly rainfall and mean monthly temperature during the late cropping season of 2008 and 2009.

Rainfall distribution varied markedly in both years. Since sowing was delayed till third decade in August because of the heavy downpour in July - early August, 2008, sesame only received 52.2% of total rainfall during the late cropping season.

Tab 1: Phased rotation scheme involving sesame, sunflower, soybean and maize

2008	2009	2010	2011	2012
Sunflower	Sesame	Maize	Soybean	Sunflower
Sesame	Soybean	Sunflower	Maize	Sesame
Maize	Sunflower	Soybean	Sesame	Maize
Soybean	Maize	Sesame	Sunflower	Soybean

Tab 2: Grain yield and yield attributes of sesame in 2009

Cropping systems	No. of branches per plt.	No. of capsules per plt.	Wt. of capsules per plt (g)	Wt. of seeds per plt. (g)	1000 grain wt (g)	Harvest index (%)	2008 Grain yield (kg/ha)	2009 Grain yield (kg/ha)
Continuous	2	20	3.04	0.92	2.48	7.8	-	246.0
Rotational	2	21	3.43	1.06	2.38	7.7	256.0	283.4
Conventional	3	39	6.38	2.71	2.48	8.8	281.0	723.4
$LSD_{5\%}$	0.50	13.09	2.51	1.15	ns	ns	ns	305.6

ns – not significant

Results and discussion

Crop rotation scheme as a vital strategy in managing soil fertility in tropical agriculture is not very common because it requires special management or additional planning skills. During the first year of the study (2008), no significant difference was observed between sesame grown under organic and conventional cropping systems even though conventional sesame yield was slightly higher by 9.7%. This could be attributed to the fact the study site is located on a field that was under fallow for three years before the commencement of the study. In general, organic farming systems depend largely on soil fertility for nutrient supply and this can only be achieved by using an integrated approach involving crop residue incorporation, manure application and crop rotation, unlike the short term practice of applying fertilizers as in conventional agriculture. In 2009, growing sesame under conventional cropping system resulted in significantly higher number and weight of capsules per plant, weight of seeds per plant, number of branches per plant and grain yield relative to the continuous and rotational cropping systems. The superior performance of sesame under conventional cropping system could be attributed to the availability of nutrients applied through fertilizer. No organic fertilizer was applied in 2009 since it was the first year continuous and rotaional cropping systems were introduced in the study. Supply of N has been recognized as a major limiting factor in the productivity of arable crops in organic farming (Olesen et al., 2007). Cropping system did not affect harvest index and 1000 grain weight. The range of 1000 grain weight recorded (2.38 – 2.48g) is lower than the required 3.0g which is one of the premium qualities required for export (Burden, 2005). Sesame under rotational cropping system that thrived only on incorporated sunflower plant residue (preceding crop) recorded grain yield that was 15.6% superior to the sesame under continuous cropping system, though not significant. Only sesame under conventional cropping system produced grain yield higher than the world average of 0.46 ton/ha (FAO,2004). It is envisaged that the performance of sesame under continuous and rotational cropping systems will be enhanced with the application of organic fertilizer in 2010.

Outlook

The performance of sesame across the three cropping systems will be further monitored in the crop rotation scheme.

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Biochemical Changes, Nitrogen Flux and Yield of Maize due to Organic Sources of Nutrients

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Key words: Organics, nutrients, biogas slurry, panchagavya

Abstract

Field experiments were conducted during June 2004 and 2005 at Tamil Nadu Agricultural University, Coimbatore to evaluate the organic sources of nutrients and Panchagavya spray on the biochemical changes, nitrogen flux(N uptake) and yield of maize. The experiment consisted of six treatments comprising four treatments of organic sources of nutrients with and without Panchagavya (blend of five products obtained from cow) foliar spray; one treatment was recommended dose of fertilizers (RDF) and one control (neither-manured or fertilizer applied).The treatments were fitted in a randomized block design replicated four times. The study revealed that increased soluble protein content and Nitrate reductase (NRase) activity of maize was estimated with Biogas slurry, a by-product of biogas plant (BGS) and it was comparable to RDF. Higher yield of maize was recorded under BGS with Panchagavya. Increased nitrogen uptake was observed under BGS with Panchagavya

Introduction

Heavy use of chemicals in agriculture has weakened the ecological base in addition to degrading the soil, water resources and quality of the food. At this juncture, a keen awareness has sprung on the adoption of “organic farming” as a remedy to cure the ills of modern chemical agriculture (Kunnal, 1997). It is essential to develop a compatible package of nutrient management through organic resources for crops based on scientific facts and economic viability (Kannaiyan, 2000). *Panchagavya* is a foliar nutrition prepared and used for various crops. In Sanskrit, *Panchagavya* means a combination of five products obtained from cow. *Panchagavya* is used as foliar spray, soil application along with irrigation water, seed or seedling treatment etc.

Crops produce essential amino acids and other nutrients when the soil is healthy to sustain the microbial population (Kannaiyan, 2000). Scientific studies are limited under irrigated conditions to report about the biochemical changes that can be achieved through pure organic sources of nutrient supply. Hence the present study was taken up to evaluate the effect of organic sources of nutrients and *Panchagavya* on the yield of maize.

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Materials and methods

Field experiments were conducted during June 2004 and 2005 at Tamil Nadu Agricultural University, Coimbatore. There were six treatments viz, T_1 - Bio-gas slurry (a by-product of biogas plant from 3 milk yielding (milch) animals) (BGS) applied as wet slurry to the field and incorporated , T_2 -T_1 + *Panchagavya* spray, T_3 - *Sesbania aculeata* as intercrop incorporated *in situ* on 45 DAS, T_4-T_3 + *Panchagavya* spray, T_5-Recommended NPK fertilizers (RDF) and T_6-Control (Neither manures nor fertilizers). The treatments were fitted in a randomized block design replicated four times.

The inorganic fertilizer treatment received full dose of recommended NPK (135: 62.5: 50 kg ha^{-1}) for which all the recommended package of practices were followed. For the organic nutritional treatments the recommended dose of N alone was substituted through organic sources such as biogas slurry and *Sesbania aculeata* and no P and K were applied. No agro chemicals were used for these treatments.

Panchagavya was prepared using biogas slurry / cow dung (5 Kg), cow's urine (3 L), cow's milk (2 L), cow's curd (2 L), cow's clarified butter / ghee (1 L), sugarcane juice (3 L), tender coconut water (3 L) and ripe banana (12 Nos). All the above items were added to a wide mouthed mud pot and kept open under shade. The contents were stirred twice a day for about 20 minutes, both in the morning and evening to facilitate aerobic microbial activity. After fifteen days of incubation, a three per cent spray solution was prepared from the *Panchagavya* stock solution. The spray solution (500 liters ha^{-1}) was sprayed on 15, 30, 45 and 60 DAS using hand-operated sprayer with high pore size nozzle in T_2 and T_4 treatments.

The soil of the experimental field was moderately deep, well-drained sandy clay loam (*Typic Ustropept*), with a pH of 8.3. The soil was low (175 kg ha^{-1}), medium (20 kg ha^{-1}) and high (975 kg ha^{-1}) in available N, P and K, respectively.

Table 1. NRase activity (on 45 DAS), N Flux and yield of maize as influenced by organic sources of nutrients

Treatments	NRase activity (µ moles NO_2 h-1 g-1)	N uptake (kg ha-1)	Grain yield (t ha -1)
T_{1} - Bio-gas slurry (BGS)	847	244.6	7.49
T_{2} - T_1 + *Panchagavya* spray	892*	274.7*	8.20*
T_{3} - *Sesbania aculeata* as intercrop incorporated *in situ* on 45 DAS	810	197.9	6.52
T_{4} - T_3 + *Panchagavya* spray	837	230.1	6.87
T_5 - Recommended NPK fertilizers (RDF)	870*	269.7	7.90*
T_{6} - Control	737	127.1	4.03
SEd	9.18	0.55	0.14
CD (P=0.05)	19.46	1.18	0.30

Statistically significant

Results and discussion

NRase activity: Nitrate reductase (NRase), a molybdoenzyme that reduce nitrate (NO_3) to nitrite (NO_2), was higher under BGS + *Panchagavya*. Presence of growth promoting substances such as IAA and GA in *Panchagavya* coupled with fast N mineralization in the soil supplied with BGS might have influenced more N uptake and hence more NRase activity.

Nitrogen flux of crops: Higher nitrogen (N) uptake by maize was recorded under BGS + *Panchagavya* and this might be due to the increased availability of all macro and micro nutrients under BGS coupled with nutrition through sprays of *Panchagavya*. Similar increased N uptake with BGS was observed by Reddy and Reddy (2000) in maize.

Yield: BGS + P*anchagavya* recorded the highest mean grain yield of 8.20 t ha^{-1}. Better nutrient uptake under this treatment and the resultant increased growth and yield parameters might have increased the yield of maize.

Conclusions

The study revealed that increased NRase activity, increased nitrogen uptake and higher yield of maize were recorded under BGS with *Panchagavya* indicating the superiority of organic source of nutrients.

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Assessing suitability of potato cultivars for organic farming: Nitrogen use, yield potential and weed suppression

Haase, T.[1], Schulz, H., Kölsch, E. & Heß, J.

Key words: crop N status, tuber yield, growth rate, ground cover

Abstract

A randomized field experiment with eighteen potato cultivars was conducted in order (1) to find cultivars with a pronounced late blight (*P. infestans*) tolerance and high nitrogen (N) use efficiency, (2) to examine different methods for the assessment of crop N status under conditions of organic farming and (3) to study canopy growth characteristics favourable in terms of ground cover and - possibly - weed suppression. Results from two experimental seasons (2009 and 2010) suggest that even in years with moderate late blight epidemics (2009), a clear differentiation regarding tolerance to late blight can be made among cultivars and within maturity groups. Most cultivars gave higher tuber FM yields in 2010, the season with higher mineralized nitrate-N in spring and less late blight during the season, yet the effects cannot be separated, since no copper fungicides were applied. Future research should consider potential interactions of genotypic N use efficiency and different N supply as a function of crop rotation and/or organic manuring. Total tuber fresh matter (FM) yield of cultivars in 2009 was not correlated with the specific severity of the course of late blight, i.e. cultivars with the same area under disease progress curve, gave signgicantly different total tuber FM yields. This genotype-specific tuber yield potential may be considered by organic potato growers when choosing a cultivar. Chlorophyll content of the youngest fully-expanded leaf assessed by using the YARA-N-tester were reasonably well correlated with N concentration in these leaves. In both years, we found negative correlations between weed density just before mature harvest of the crop and ground cover duration. Interestingly, even some early cultivars gave comparatively high values for ground cover duration.

Introduction

Economic return of organic potato production is affected by the percentage of marketable tuber yield within total tuber yield. Tuber size is mainly determined by nitrogen (N), which affects the length of the tuber bulking period and rate (Möller et al. 2007), but also by cultivar (Hagman et al. 2009). Minimum tuber size grades should have been exceeded for the majority of tubers by the time the period of tuber bulking has ended due to either depleted soil mineralized N resources or due to late blight (*Phytophthora infestans*). Since organic growers can hardly influence N mineralization, it is vital to have cultivars with a high potential for an efficient use of available N. Besides, we hypothesize that genotype-specific earliness of ground cover and duration of canopy growth may affect the competitive ability of potato cultivars towards weeds. This study aimed (1) to find cultivars with pronounced late blight tolerance, high yield potential and high N use efficiency, (2) to examine different methods for the assessment of crop N status under conditions of organic farming and

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(3) to study canopy growth characteristics favourable in terms of ground cover and - possibly - weed suppression.

Materials and methods

The study was conducted during 2009 and 2010 at the Hessische Staatsdomaene Frankenhausen (51.4 N; 9.4 E), the organic research farm (since 2001) of the University of Kassel, Germany, located 230 m asl. Soil type of the experimental field was a Haplic Luvisol, soil texture a silt loam. The preceding crop in both years was grass-clover followed by a non-leguminous catch green manure crop ploughed in before subsequent seed bed preparation in April. All seed tubers were graded 35-55 mm and pre-sprouted for approximately six weeks. Layout of the field experiment was a two factorial (factor A: time of harvest; factor B: cultivar) strip design with four replications. Potato seed-tubers of 18 different cultivars (ranging from very early to late maturity type) were planted in plots of four rows with 20 tubers per row for final harvest at maturity. The same 18 cultivars were planted four times in adjacent single row plots of 16 seed-tubers for four randomized samplings at 60, 70, 80 and 90 days after planting. In order to answer the above mentioned questions the following measurements and calculations were conducted: (1) Plant-available nitrate-N in the soil profiles of 0-30 and 30-60 cm was determined seven times at crop emergence (BBCH09 after Hack et al. (1993)), at 60 to 90 days after planting and at final harvest (mature crop; BBCH99), using 1% K_2SO_4 as an extractant. Incidence of late blight was estimated accoding to the scheme provided by James (1971). In 2009, Area-Under-Disease-Progress-Curve (AUDPC) was caluated from regular assessments of the disease in the field according to the equation provided by Shaner and Finney (1977). The potato crop was lifted with a one-row harvester and picked up by hand. Tubers were weighed and counted after sampling from single rows (16 plants) at early harvests (60, 70, 80 and 90 days after planting) and the inner two rows at BBCH 99 (40 plants) at final harvest. Samples of whole aboveground biomass and the youngest fully-expanded leaves (>100 g FM per plot) were taken for analysis of total N concentration from a sub-sample in the laboratory. Nitrogen use efficiency (NUE) was defined as the ratio of the unit (kg) nitrogen taken up by the whole crop until maximum biomass accumulation (canopy and tubers) and the unit (100 kg) of total tuber yield. (2) We determined leaf chlorophyll concentration in the youngest fully-expanded leaf conducting 30 measurements per plot, using a hand-held YARA-N-Tester® (Agri Con, Ostrau). Samples of these leaves (>100 g FM per plot) were taken for analysis of total N concentration from a sub-sample in the laboratory. (3) Digital photographs of the canopy were taken from about 1.5 m above the ground from an area of 0.75 m * 1.05 m. Digital photographs were subjected to a software (Optimas 6.5) yielding data on percentage of canopy ground cover (Pforte 2010). Area-Under-Ground-Cover-Duration Curve was calculated according to the method applied for AUDPC. Weed ground cover was estimated plot-wise in plots for final harvest of the crop. Statistical analysis was conducted with a General Linear Model using software SAS 9.2. Regression analysis was done using software SPSS 17.

Results and Discussion

Nitrate-N availability in the soil profile (0-60 cm) assessed early in the season (mid May) differed between the two seasons (2009: 37; 2010: 83 kg/ha) and may have been one reason for the different average final total tuber yields at harvest of the mature crop in the two individual seasons (2009: 31 t/ha; 2010: 34 t/ha). In 2010, incidence of late blight was negligible and certainly not yield-limiting. One-year results

(2009) indicate that very-early cultivars that are often regarded to be less resistant to late blight than later maturing genotypes (Colon et al., 1995) do not necessarily show a more severe progress of the disease in the field (Table 1). Within individual maturity types we found a large variation among cultivars concerning the course of late blight in the field. The same applies for total tuber fresh matter yield.

Table 1: Area-Under-Disease.Progress-Curve (AUDPC), total tuber fresh matter yield (TTFMY) and nitrogen use efficiency (NUE) of the 18 examined cultivars, 90 DAP

Cultivar		AUDPC	TTFMY [t/ha]		NUE [kg N/100 kg tuber DM]	
	MT	2009	2009	2010	2009	2010
Anuschka	ve	268	33,17	35,92	1,63	1,40
Salome	ve	286	27,50	29,03	1,66	1,38
Biogold	ve	18	28,78	30,96	1,68	1,32
Merida	e	-	27,03	34,84	1,75	1,33
Agila	e	309	35,97	32,82	1,48	1,22
Belana	e	156	30,54	35,45	1,65	1,25
Princess	e	432	32,22	37,60	1,62	1,32
Mirage	e	166	25,45	30,22	1,71	1,46
Elfe	e	315	33,26	36,14	1,46	1,29
Primadonna	e	438	32,12	36,10	1,53	1,28
Francisca	e	483	35,83	38,33	1,51	1,20
Miranda	e	532	26,70	33,54	1,61	1,26
Vitabella	e	16	30,62	30,60	1,62	1,32
Finessa	me	191	31,40	-	1,44	-
Ditta	me	172	29,41	34,03	1,34	1,02
Allians	me	61	29,72	29,95	1,37	1,25
Adelina	me	39	30,53	34,34	1,23	1,20
Jelly	mll	68	28,71	32,58	1,36	1,09

MT=maturity type: ve=very early; e=early; me=medium early; mll=medium late to late

Total tuber fresh matter yield of the cultivars (Table 1) differed significantly among the examined cultivars but also within maturity types and between years. Accordingly, a significant two-way interaction (cultivar x year) was established. Still, nine out of seventeen cultivars (examined over two years) consistently yielded total tuber FM over 30 t/ha. Results also show that under growth condtions of limited N, nitrogen use efficiency may vary considerably among the examined cultivars and between seasons. Chlorophyll content of the youngest fully-expanded leaf assessed by using the YARA-N-tester were reasonably well correlated with N concentration in these leaves (2009: R^2=0.60; 2010: R^2=0.34). In both years, we found negative correlations between weed density just before mature harvest of the crop and ground cover duration (2009: R^2=0.52; 2010: R^2=0.41). Interestingly, even some early cultivars gave comparatively high values for ground cover duration.

Conclusions

Cultivar choice based on late blight tolerance, yield potential and nitrogen use efficiency (NUE) may be a useful tool for organic potato gowers to utilize the limited nitrogen. Further research should examine if there is an interaction between NUE and different levels of N supply from soil as a response to the type of preceding crop and/or the amount of organic manures applied. Assessing the canopy N status by YARA-N-Tester® in the field may have the potential to replace the destructive and time consuming sampling of leaves for following expensive laboratory N analyses. Future research should focus on the development of canopy (here: youngest fully-expanded leaf) N status critical levels, underneath which copper applications would be refrained from, since the N status of this season will already have been exploited. Finally, organic potato growers may consider the genotypical potential to suppress weeds, especially when growers intend to cultivate a subsequent cash crop with a rather low weed competitiveness.

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Effects of organic composts on soil and yield characteristics of boxthorn (*Lycium chinense* Mill.) organic cultivation

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Key words: Boxthorn, Organic cultivation, Organic Compost, Rain shelter

Abstract

For the development of Boxthorn organic cultivation techniques, we investigated the effect of several organic composts as foundation and growing plant fertilizer. And we adopted partly opening rain shelter greenhouse to protect anthracnose. When the organic composts were applied, yield was best in 'mixed organic compost' treatment. However, betaine content of dried fruit was best in 'mixed organic compost and nitrogen guano' treatment. Chlorophyll contents and 100 fruit weight were also better than other treatments.

Introduction

The Boxthorn is one of the prominent herbal crops in Korea. It could be taken every day for healthcare according to traditional remedy. In taxonomic classification Boxthorn plant in Korea is *Lycium chinense* Mill.(Lee, 1998) but *Lycium barbarum* L. is widely cultivated in China. And it can be used as a medicine almost every part of plant such as fruit, leaf, root cortex, flower, sprout.

There are five diseases on Boxthorn plant. Among them Anthracnose was the most serious one(Lee *et al*., 1986). The predominant species of Anthracnose was *Colletotrichum acutatum* with 86.7% of isolation rate and the second one was *C. dematium* (Pers.) Grove with 10% isolation rate. And there were the other miner species like *C. gloeosporioide*s and *Glomerella cingulata*(Lee, 2004). Rain shelter greenhouse can protect outbreak of Anthracnose(Choi *et al*., 1996) but there are some technical subjects to be solved like ventilation methods for enhancing growth of Boxthorn and good designs to avoid natural disaster like heavy snow and typhoon.

In Korea there are about forty pesticide-free Boxthorn cultivation farmers and about three organic Boxthorn farmers. Most of pesticide-free farmers are planning to change to organic cultivation but they are considering yield decrease. Therefore, it is necessary to find new composts to recover yield decrease.

Materials and methods

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Cultivars and composts

'Jang-myeong' and 'Cheong-un' Boxthorn cultivars were planted on 'Mixed organic compost(organic matter : 58%, oil seed hull : 25% and micro-organisms *etc*., NPK:3-2-1)', 'Oil seed hull compost(NPK:3.7-2.2-1.1)' and 'Nitrogen guano(NPK:9-9-6)' treated field. But according to yield and growth analysis oil seed hull and nitrogen guano single treatments were worse than mixed organic compost so we combined two treatments next for two years. So the treatments were 'Non-treat', 'Mixed organic compost(10ton/ha)', 'Mixed organic compost(10ton/ha) for foundation and Oil seed compost(1.6ton/ha) for growing plant compost' and 'Mixed organic compost(10ton/ha) and Nitrogen guano(0.7ton/ha)'. We have investigated the characteristics of yield and growth and analyzed contents of Betaine, Fructose and Glucoses in Boxthorn fruits.

Cultivation method

Rain shelter greenhouse is essential cultivation technique in Boxthorn organic farm to avoid anthracnose. There are generally three ventilation types. Among them we adopted partly opening rain shelter greenhouse which is superior to other types in ventilation efficiency and natural disaster resistance. It has partly opened roof in which plastic film was fastened upper 1/3 part of each side and could be opened over 1/2 of it. We let it open all the times except rainy day of fruit setting and ripening seasons. According to previous research tree type cultivation can produce more yield by 20~30% than traditional method. So we cultivated by boxthorn tree type.

Results

Effects of compost on Boxthorn organic cultivation

In the first year the yield of 'Mixed organic compost' treatment was better than other treatments. So we changed two inferior single foundation compost treatments into double treatments of foundation and growing plant composting. In second year, yield characteristics of 'Mixed organic compost' treatment was the best but according to dried fruit betaine content analysis, 'Mixed organic compost and nitrogen guano' treatment was the best and it's chlorophyll and 100 fruit weight were also better than other treatments.

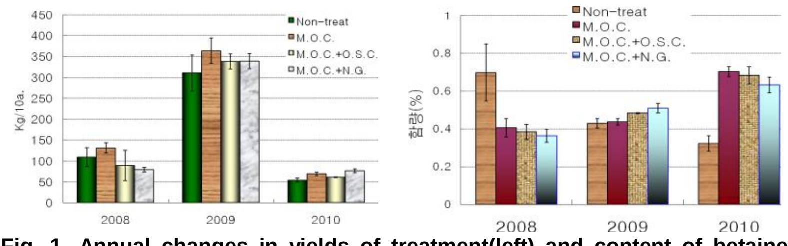

Fig. 1. Annual changes in yields of treatment(left) and content of betaine in fruits(harvested in September, right).

And the last year we could harvest only one time because of typhoon 'Kompasu' and bad weather conditions. So yields of all the treatments decreased sharply but 'Mixed organic compost and nitrogen guano' treatment was the best in yield, chlorophyll content and 100 fruit weight. Betaine content of dried fruit was increased year by year in all the organic compost treatments.

Tab. 1. Yield and growth Characteristics of three compost treatments in 2009

Treatment	Chlorophyll content	100 fruit weight	Number of fruits	Yield (Kg/10a)	Yield Index(%)
Non-treat	54.2 b	24.0±0.86	868.5±169.02	310.3±43.36	100
Mixed compost	58.3 a	24.2±0.46	1,069.9±49.24	363.3±30.22	117
Mixed compost + Oil seed hull compost	58.0 a	23.9±0.03	967.6±99.77	337.7±18.37	109
Mixed compost + Nitrogen guano	59.8 a	25.2±1.10	947.0±106.61	338.6±17.84	109

* Chlorophyll content : Minolta SPAD-502 measured value(-9.9~199), DMRT 5%

Tab. 2. Yield and growth Characteristics of three compost treatments in 2010

Treatment	Chlorophyll content	100 fruit weight	Number of fruits	Yield (Kg/10a)	Yield Index(%)
Non-treat	40.2±1.8	9.3±0.4	198.3±36.7	54.1±4.8	100
Mixed compost	45.6±1.8	9.4±2.1	359.4±103.1	68.8±4.1	127
Mixed compost + Oil seed hull compost	49.1±2.2	11.0±1.9	298.4±71.9	61.1±1.3	113
Mixed compost + Nitrogen guano	49.5±1.9	11.3±0.8	316.0±41.6	76.2±4.7	141

* Chlorophyll content: Minolta SPAD-502 measured value(-9.9~199)

Soil changes after application of composts

According to soil analysis of second year soil pH value was neutral in most of organic matter treatments but Mixed compost + Nitrogen guano treatment was about 6.4. In the content of organic matter all treatments were about 20mg/kg. The available phosphorus content was significantly exceeded and the content of exchangeable cations was slightly greater than the optimum value.

Tab. 3. Organic matter, pH, exchangeable cations of four compost treated soils in 2009

Treatment	pH (1:5)	EC (dS/m)	Organic matter (mg/kg)	available phosphate (Kg/10a)	Exchangeable cation(cmol/kg)		
					Ca	K	Mg
Non-treat	7.0±0.26	2.7±1.34	21.3±2.65	888.5±92.96	8.4±0.52	0.6±0.16	2.3±0.17
Mixed compost	7.0±0.03	2.6±0.86	19.3±2.35	980.1±48.47	8.4±1.17	0.55±0.14	2.7±0.24
Mixed compost + Oil seed hull compost	7.0±0.07	1.3±0.55	20.8±1.10	980.1±48.47	6.5±0.54	0.5±0.05	2.3±0.12
Mixed compost + Nitrogen guano	6.4±0.27	3.3±0.82	21.8±3.35	909.9±44.74	7.8±0.58	0.9±0.15	2.5±0.14

In third year's soil analysis pH value was higher than that of previous year but EC level was decreased greatly. In non-treatment organic matter content decreased but in organic compost application treatment it had a tendency to increase. Available phosphorus content of the organic compost application was greatly excessive and increasing. Exchangeable cations generally showed slight increase in the pattern.

Tab. 4. Organic matter, pH, exchangeable cations of three compost treated soils in 2010

Treatment	pH (1:5)	EC (dS/m)	Organic matter (mg/kg)	available phosphate (Kg/10a)	Exchangeable cation(cmol/kg)		
					Ca	K	Mg
Non-treat	7.6±0.12	0.9±0.14	19.8±3.09	859.7±85.8	8.3±0.66	0.5±0.12	3.1±0.12
Mixed compost	7.5±0.07	1.4±0.43	21.1±2.35	1100.0±115.6	7.6±0.60	0.63±0.12	3.9±0.28
Mixed compost + Oil seed hull compost	6.9±0.30	1.3±0.37	21.8±3.10	1025.7±123.9	5.8±0.42	0.8±0.17	3.5±0.11
Mixed compost + Nitrogen guano	7.3±0.10	1.3±0.61	22.9±1.30	1044.3±156.1	6.4±0.23	0.7±0.27	3.6±0.41

Discussion

According to this study it was better with ‘Mixed organic compost’ as a foundation compost and ‘Nitrogen guano’ as a growing plant fertilizer. However, in the soil analysis available phosphorus content was greatly excessive and increasing so we have to find out available phosphorus reducing method. And Betaine content of dried fruit increased year by year in all the organic compost treatments.

Conclusions

Mixed organic compost as a foundation fertilizer and Nitrogen guano as a growing plant fertilizer were useful materials and technique for Boxthorn organic cultivation. But excessive available phosphorus reducing program was needed to be developed.

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Relative Effectiveness of Organic and Inorganic Nutrient Sources in Improving Canola Yield and Nutrient Uptake

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Key words: Amendments, canola, inorganic, organic, nutrient uptake, yield

Abstract

A field experiment was established in 2009 on a Gray Luvisol loam at Star City, Saskatchewan to compare the relative effectiveness of organic and inorganic amendments on yield and nutrient uptake of canola. In 2009 and 2010, in treatments receiving only organic amendments, thin stillage produced the highest yield and nutrient uptake, and it was similar to the NPS balanced fertilizer treatment. Compared to the control, fish food and distiller grain dry produced higher yield and nutrient uptake, followed by moderate increase from compost, alfalfa + canola meal pellets, alfalfa pellets and wood ash, with little increase from distiller grain wet and wood ash granulated, and a slight reduction from glycerol. In treatments receiving organic amendments in combination with fertilizers, application of N fertilizer increased yield and nutrient uptake substantially in wood ash and glycerol treatments. Rapid release elemental S produced yield and nutrient uptake similar to gypsum, when applied with N and P fertilizers. In conclusion, the implications of the findings are that some organic amendments can be used to improve crop yields under organic production. The findings also suggest the potential of some inorganic amendments (e.g., rapid release elemental S and gypsum) in preventing S deficiency in organic crops, provided other nutrients are not limiting in soil.

Introduction

There is great interest and demand for organically-grown food and fiber products in Canada and internationally (Macey 2005), but maintaining soil fertility is an important production issue facing organic agriculture in the semi-arid region of the Canadian Prairies (Jans 2001). The N deficiency on organic farms can be minimized by growing N-fixing legume crops in the rotations (Buhler 2005), but in soils deficient in available P, K, S or other essential nutrients, the only alternative is to use external sources because synthetic fertilizers can not be applied to prevent nutrient deficiencies and increase yield in organic crops. Manure/compost can provide these nutrients, but often there is not enough manure to apply on all farm fields, and the cost of transporting manure to long distances is uneconomical in remote areas. On such soils, rock phosphate fertilizer, elemental S fertilizer, gypsum, wood ash, or other amendments may be used to correct deficiencies of these nutrients, and field experiments on the feasibility of these products in preventing nutrient deficiencies under organic farming are underway. Information on comparisons of organic and inorganic nutrient sources in the same experiment is lacking. The objective of this study was to determine the relative effectiveness of organic and inorganic nutrient sources in increasing yield and nutrient uptake by preventing nutrient deficiencies in crops.

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Materials and methods

A field experiment was established in 2009 on a Gray Luvisol (Typic Haplocryalf) loam soil at Star City, Saskatchewan. Soil at this site has shown severe S deficiency in canola in previous years. A randomized complete block design was used to lay out the treatments in four replications. Each plot was 7.5 m long and 1.8 m wide. Amendments were broadcast on surface and then incorporated into soil to about 10 cm depth a few days prior to seeding with a double-disc press drill at 17.8 cm row spacing. Seed yield was determined by combine harvesting a 7 m long and 1.2 m wide strip in each plot. Seed and straw samples were analyzed for total N, P, K and S to calculate nutrient uptake, to assess the availability of nutrients from amendments. The data were subjected to analyses of variance using GLM procedure in SAS (SAS Institute Inc. 2004) and $LSD_{0.05}$ was used for mean separation. The 31 treatments were; 1. Control (no amendment), 2. Compost @ 20 Mg ha^{-1}, 3. Wood ash @ 2 Mg ha^{-1}, 4. Alfalfa pellets @ 2 Mg ha^{-1}, 5. Alfalfa + canola meal pellets @ 2 Mg ha^{-1}, 6. Distiller grain (wheat) – wet @ 2 Mg ha^{-1}, 7. Distiller grain (wheat) – dry @ 1 Mg ha^{-1}, 8. Thin stillage @ 20,000 L ha^{-1}, 9. Glycerol @ 1 Mg ha^{-1}, 10. Fish food additive @ 1 Mg ha^{-1}, 11. Triple superphosphate @ 20 kg P ha^{-1} + 80 kg N ha^{-1} + 20 kg S ha^{-1}, 12. *Penicillium bilaiae* + 80 kg N ha^{-1} + 20 kg S ha^{-1}, 13. Rock phosphate granular (International Compost) @ 20 kg P ha^{-1} + 80 kg N ha^{-1} + 20 kg S ha^{-1}, 14. Rock phosphate finely-ground (International Compost) @ 20 kg P ha^{-1} + 80 kg N ha^{-1} + 20 kg S ha^{-1}, 15. Rock phosphate granular (BC Mines) @ 20 kg P ha^{-1} + 80 kg N ha^{-1} + 20 kg S ha^{-1}, 16. Rock phosphate finely-ground (BC Mines) @ 20 kg P ha^{-1} + 80 kg N ha^{-1} + 20 kg S ha^{-1}, 17. Gypsum @ 20 kg S ha^{-1} + 80 kg N ha^{-1} + 20 kg P ha^{-1}, 18. Rapid release elemental S @ 20 kg S ha^{-1} + 80 kg N ha^{-1} + 20 kg P ha^{-1}, 19. Glycerol @ 1 Mg ha^{-1} + 80 kg N ha^{-1}, 20. Wood ash @ 2 Mg ha^{-1} + 80 kg N ha^{-1}, 21. Distiller grain (corn) – dry @ 1 Mg ha^{-1}, 22. Treatment 15 + *Penicillium bilaiae*, 23. Treatment 16 + *Penicillium bilaiae*, 24. Rock phosphate + humates granulated (BC Mines) @ 20 kg P ha^{-1} + 80 kg N ha^{-1} + 20 kg S ha^{-1}, 25. Treatment 24 + *Penicillium bilaiae*, 26. Rock phosphate [powder] (BC Mines) @ 20 kg P ha^{-1} + 80 kg N ha^{-1} + 20 kg S ha^{-1}, 27. N + S - 80 kg N ha^{-1} (using 34-0-0) + 20 kg S ha^{-1} (using 0-0-51-17), 28. Wood ash – granulated @ 200 kg ha^{-1} (applied side band), 29. Wood ash – granulated @ 200 kg ha^{-1} (applied side band) + 80 kg N ha^{-1}, 30. N + P - 80 kg N ha^{-1} (using 34-0-0) + 20 kg P ha^{-1} (using 0-45-0), and 31. N only - 80 kg N ha^{-1} (using 34-0-0).

Results and discussion

In 2009, combined application of N, P and S chemical fertilizers (NPS) produced considerably higher seed yield of canola compared to the unfertilized control (Table 1). In treatments with only organic amendments, thin stillage produced the highest seed yield, and it was similar or even slightly higher than the NPS balanced fertilization treatment. Compared to the control, fish food, or distiller grain dry of both wheat and corn produced significantly higher seed yield, followed by moderate (but non-significant) increase in seed yield with compost, alfalfa + canola meal pellets, alfalfa pellets, or wood ash - fly ash, with little or no increase in seed yield from distiller grain wet of wheat, or wood ash granulated, and reduction in seed yield with glycerol. In 2010, response trends of seed yield of canola to amendments were generally similar to 2009 (Table 1).

In 2009, in treatments where chemical fertilizers were also applied in addition to organic amendments, application of N fertilizer increase seed yield substantially in both wood ash treatments (especially in fine/powder/fly ash - wood ash), suggesting lack of N in these treatments (Table 1). Application of N also increased seed yield in glycerol treatment, but much less than the gypsum along with N + P fertilizer treatment, suggesting lack of both N and S. Application of RRES along with N + P fertilizer also produced seed yield similar to gypsum + N + P treatment, but both treatments produced seed yields considerably higher than the unfertilized control. In 2010, seed yield responses to combined organic and/or inorganic amendments were similar to 2009 (Table 1). This soil is deficient in available S, and has shown severe S deficiency in canola always in previous years, and considerable reduction in canola seed yield in 2010 when only N was applied without any S fertilizer due to N and S imbalance in plant. Based on the history of this site in relation to S deficiency in canola in previous years and seed yields in 2010, the findings suggest that RRES has the potential to provide available S to the crop to the same level as gypsum.

The response trends of straw yield to all organic and inorganic amendments were generally similar to seed yield (data not shown). Seed + straw yield with thin stillage similar to or even slightly higher than the NPS balanced fertilization treatment suggests a great potential of thin stillage as an organic amendment to prevent any nutrient deficiencies and subsequently increase crop yield. The significant increase in seed +straw yield with fish food, or distiller grain dry of both wheat and corn compared to unfertilized control also suggest the potential of fish food, and distiller grain dry of wheat or corn amendments in improving yield of organic crops. The response trends of total N and other nutrients (P, S and K) uptake in seed + straw to all organic and inorganic amendments were generally similar to seed yield (Table 1).

Conclusions

Some amendments showed potential for improvement in organic crop production. In some other cases highest seed yields were produced when both organic and chemical amendments were applied together. The findings suggest the importance of integrated use of organic and inorganic nutrient sources to optimize crop yields. , the implications of the findings are that some organic amendments can be used to improve crop yields under organic production. The findings also suggest the potential of some inorganic amendments (e.g., rapid release elemental S and gypsum) in preventing S deficiency in organic crops, provided other nutrients are not limiting in soil.

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Tab. 1: Seed yield and N uptake of canola with various amendments applied in spring 2009 at Star City, Saskatchewan (S-deficient soil)

Amendments[z]	Seed yield (kg ha-1) 2009	Seed yield (kg ha-1) 2010	Total N uptake in 2009
Control (no amendment)	809	463	38.5
Compost @ 20 Mg ha-1	997	534	45.3
Wood ash @ 2 Mg ha-1	985	453	44.8
Wood ash granular @ 200 kg ha-1	887	362	40.5
Alfalfa pellets @ 2 Mg ha-1	985	563	45.1
Alfalfa + canola meal pellets @ 2 Mg ha-1	1029	458	48.8
Distiller grain (wheat) – wet @ 2 Mg ha-1	831	396	41.2
Distiller grain (wheat) – dry @ 1 Mg ha-1	1422	540	64.3
Distiller grain (corn) – dry @ 1 Mg ha-1	1340	396	60.8
Thin stillage @ 20,000 L ha-1	1976	853	85.7
Glycerol @ 1 Mg ha-1	663	512	32.7
Fish food additive @ 1 Mg ha-1	1451	541	64.2
Gypsum @ 20 kg S + 80 kg N + 20 kg P ha-1	1965	714	93.5
RRES @ 20 kg S + 80 kg N + 20 kg P ha-1	1960	615	94.7
Glycerol @ 1 Mg ha-1 + 80 kg N ha-1	1559	308	72.0
Wood ash @ 2 Mg ha-1 + 80 kg N ha-1	2015	834	92.1
Wood ash granular @ 200 kg + 80 kg N ha-1	1869	563	89.5
TSP @ 20 kg P + 80 kg N + 20 kg S ha-1	1842	835	80.3
N only - 80 kg N ha-1 (using ammonium nitrate)	ND	230	ND
N + P - 80 kg N + 20 kg P ha-1 (using TSP)	ND	491	ND
N + S - 80 kg N + 20 kg S ha-1 (using K_2SO_4)	ND	680	ND
Penicillium bilaiae + 80 kg N + 20 kg S ha-1	1808	616	84.2
RP gran (IC) @ 20 kg P + 80 kg N + 20 kg S ha-1	1769	652	80.3
RP fine (IC) @ 20 kg P + 80 kg N + 20 kg S ha-1	1806	711	83.6
RP gran (BC) @ 20 kg P + 80 kg N + 20 kg S ha-1	1842	638	83.8
RP fine (BC) @ 20 kg P + 80 kg N + 20 kg S ha-1	1843	698	83.3
RP gran (BC) @ 20 kg P + 80 kg N + 20 kg S ha-1 + *Penicillium bilaiae*	1987	568	90.4
RP fine (BC) @ 20 kg P + 80 kg N + 20 kg S ha-1 + *Penicillium bilaiae*	2034	702	92.0
RP + humates gran (BC) @ 20 kg P + 80 kg N + 20 kg S ha-1	1869	552	85.9
RP + humates gran (BC) @ 20 kg P + 80 kg N + 20 kg S ha-1 + *Penicillium bilaiae*	2055	667	91.4
RP fine (BC) @ 20 kg P + 80 kg N + 20 kg S ha-1	1850	689	85.1
$LSD_{0.05}$	250	193	12.7
SEM	88.7***	68.5***	4.53***

[z]TSP = Triple superphosphate; RP = Rock phosphate; Gran = Granular; Fine = finely ground.

** and *** refer to significant treatment effects in ANOVA at P ≤ 0.05 and P ≤ 0.001.

Organic vegetables

Microclimatic change and growth status by soil-covering material in organic garlic cultivation

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Key words: Garlic, Rice bran, Rice hull, Saw dust, Organic farm

Abstract

This study was carried out to investigate the effect of soil covering materials such as rice bran, rice hull and saw dust on garlic growth through a field experiment in wintertime. Rice bran was the smallest in term of particle size, but it recorded the highest level of bulk density. The missing plant rate after winter season was relatively high, 59.3%, and that of soil covering materials stood at the low level of 10%. Other growth factors recorded the highest level during application of rice bran. In terms of chemical properties of soil-covering materials, rice bran recorded the highest level of 1.84, 2.34 and 0.16% in the content of N, P, and K, respectively. The subsoil temperature was higher by application of rice bran as compared to that of other materials which stood at the lowest temperature (-9^{o}C).

Introduction

In double-cropping areas in Gyeongsangbuk-do, organic cultivation of garlic as a major source of winter crop is threatened by backward technological methods for quality output due to the restricted use of input materials such as chemical fertilizer and livestock manure. In particular, winter crops including garlic are vulnerable to climate disasters such as cold snap, thus more stable production technology remains quite a pressing challenge for winter crops. Against this backdrop, we applied easily available organic materials (rice bran and hull, saw dust) to the soil-covering during the planting of garlic. Under the same soil conditions, we investigated changes in the microclimate and growth of garlic to verify the optimal effect of soil-covering materials.

Materials and methods

We experimented with the 2005 Euisung garlic variety, which was planted on November 2, 2005, in a cultivation plot inside the Gyeongsangbuk-do Agricultural Research & Extension Services. According to conventional cultivation methods, we used a transparent polyethylene film (0.03mm thickness) as a mulching material for garlic cultivation. The entire cultivation plot was classified into four sections: Rice bran, rice hull, and saw dust treatment plots plus a non-treatment plot, for examination of garlic growth and microclimatic changes. We applied 700 kg/10a of rice bran, 700 kg/10a of rice hull, and 1,150 kg/10a of saw dust to three treatment plots, and these plots was arranged in a randomized block design with three replications with the area of each individual plot of 6m^2 (planting 190 stocks). We applied soil-covering materials after furrowing and sowing. Then, a PE film was used for soil mulching to entice the budding for next spring. From December 15, 2005 through March 7, 2006, we measured daily soil temperature around the area 10cm underground via a thermometer (Hobo, Onset). We looked into garlic growth on March 9 after the re-growth period, and then we harvested crops on June 14. We analyzed both soil and plant pursuant to the Rural Development Administration's method for analysis of soil and plant (1988) and physicochemical properties of organic soil-covering materials pursuant to the Rural Development Administration's method for examination of fertilizer quality (1998).

Results

According to analysis of physical properties of organic soil-covering materials, rice bran recorded the highest density of 0.28g/cm^3, whereas rice hull pointed to the lowest density of 0.10g/cm^3 (Tab. 1). Such results are clearly due to particle size. Rice bran generated the highest level of residue after passage of particle with the size of 1mm, being followed by saw dust and rice hull respectively. Thus, both size and density of particle seem to influence the level of dissolution when it is put into the soil.

Tab. 1: Physical properties of organic soil-covering materials

Classification	Density (g/cm^3)	Passage into mesh (g/10g)			
		5♪	10	16	Residue
Rice Bran	0.28	0.00	0.06	2.29	7.65
Saw Dust	0.23	0.42	1.95	3.41	4.22
Rice Hull	0.10	0.00	3.92	4.73	1.35

♪:mm = 16/mesh

Tab. 2 compares the chemical properties of organic soil-covering materials. Application of rice bran showed higher content of N, P, and K than saw dust and rice hull, and its lower carbon-nitrogen ratio confirmed that rice bran excelled in nitrogen supply more than saw dust and rice hull. Rice hull had higher nitrogen content of 0.56% than saw dust, but it recorded lower content of other minerals.

Tab. 2: Chemical properties of organic soil-covering materials

Classification	T-N	T-C	C/N	P_2O_5	K_2O	CaO	MgO	Fe	Mn	Cu	Zn
	-------- (%) --------							----- (mg/kg) ----			
Rice Bran	1.84	45.4	24.7	2.34	0.16	0.01	0.44	32.0	131.3	4.1	46.9
Saw Dust	0.24	50.2	209.3	0.05	0.02	0.12	0.03	14.2	162.5	3.1	3.0
Rice Hull	0.56	45.5	81.2	0.06	0.05	0.02	0.02	17.9	127.6	2.7	15.8

According to analysis of garlic growth during the re-growth period (Tab. 3), the non-treatment plot generated lower occurrence rate of nearly 50% after the winter season, and it also displayed slightly poor growth patterns in terms of leaf number, stem diameter, and plant height. There was no outstanding disparity in garlic growth by organic soil-covering material, but their application resulted in excellent occurrence rate of around 90% and favorable growth patterns compared with the non-treatment control. As shown in Fig. 1, such results are also mirrored in the analysis of daily changes of soil temperature by soil-covering material during the winter season. According to examination of daily changes in soil temperature for February 3-4, the coldest time in wintertime, soil temperature in the non-treatment plot dropped to -5℃ around 7 a.m. on February 4. However, soil temperature stood at 0℃ or higher in other three plots for application of organic soil-covering materials. Consequently, the lowest soil temperature displayed a gap of around 4-5℃ by organic material, and it exerted the biggest influence over the occurrence rate and growth patterns during the re-growth period. Therefore, we should give top priority to the rise in soil temperature for stable production of quality winter crops.

Tab. 3: Growth patterns by organic soil-covering material during the re-growth period (as of March 9, 2006)

Classification	Plant Height (cm)	Stem Diameter (mm)	Number of Leaf (leaf/stock)	Occurrence Rate (%)
Non-treatment	11.6	4.8	4.0	49.7b
Rice Bran	13.1	5.7	4.4	89.3a
Saw Dust	13.5	4.8	4.0	87.4a
Rice Hull	13.1	5.2	4.1	85.8a

DMRT (Duncan's Multiple Range test) 0.05

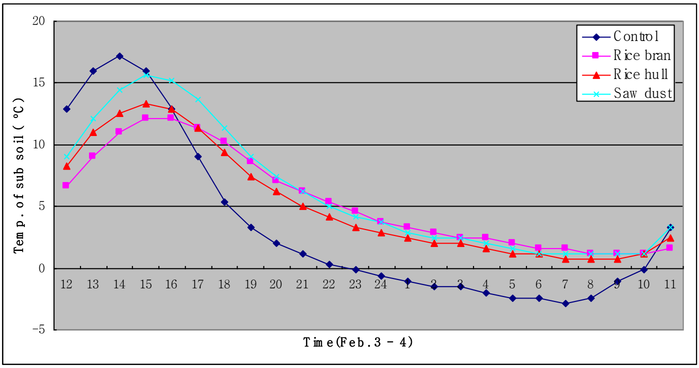

Figure 1: Change in daily soil temperature in wintertime by organic soil-covering material

We examined the growth patterns of garlic during the harvesting season to analyze the effect of organic soil-covering materials (Tab. 4). Application of rice bran recorded the largest bulb weight of 44g, being followed by saw dust and rice hull, and the non-treatment case generated a bulb weight of 37g which was similar to that of rice hull.

Tab. 4: Growth status in the harvesting season by organic soil-covering material

Classification	Bulb Weight (g)	Plant Height (cm)	Stem Diameter (mm)	Bulb Diameter (mm)	Weight of Upper Ground Part (g)
Non-treatment	36.9 b	67.5a	11.1a	47.7b	34.1a
Rice Bran	43.8 a	71.4a	10.8a	51.3a	41.7a
Saw Dust	38.9ab	70.5a	10.1a	48.9b	36.0a
Rice Hull	37.2 b	70.5a	9.1a	48.1b	33.3a

DMRT (Duncan's Multiple Range Test) 0.05

Discussion

With the aim of utilizing easily available organic materials for safe, high quality farm products, we looked at the impact of soil-covering materials such as rice bran, saw dust, and rice hull on garlic growth. Accordingly, we examined how these mulching materials influenced soil temperature for February 3-4, the coldest time in wintertime.

During the application of rice bran and saw dust with smaller particle size and higher nitrogen content, soil temperature remained at 0℃ or higher unlike the non-treatment control plot. It seemed effective for a stable occurrence rate and heavier bulb weight during garlic cultivation after wintertime, thereby being recommended as an efficient tool to garlic cultivators.

Conclusions

In organic garlic cultivation, the use of rice bran and saw dust for soil-covering can boost stable production of quality garlic crop through prevention of frost damage and expansion of bulb weight amid an overall rise in soil temperature.

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Organic pot culture of selected vegetables using compost and a microbial inoculant

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Key words: Compost, pot culture, vegetables, toxicity, Microbial inoculant

Abstract

Pot culture of vegetables in households is becoming important in urban cropping due to multiple benefits. Thus studies were carried out to determine the impact of different rates of homemade compost for growing beans and tomatoes, with and without a popular microbial inoculant (EM). Soil chemical parameters and water holding capacity were enhanced with increasing rates of compost and the impacts were accentuated by EM. Crop yields were highest at compost rates equivalent to 6 MT.ha-1, and declined with increasing rates. Crop yields were also promoted by EM and rates of yield decline were lower with the inoculant. The potential of indoor vegetable culture with compost and inoculants is presented.

Introduction

Urban gardening, especially in high rise buildings is becoming a popular practice and hobby. It is a leisure practice, and is used to grow leafy and even fruit vegetables for daily needs and satisfaction (Relf 2009). Growing vegetables in this manner supplies fresh vegetables and organic principles could be used for such projects. Containers with vegetable plants could provide safe, tasty and nutritious vegetables at lower costs in an environmentally friendly manner (Relf 2009). However scientific literature (e.g. Web of Knowledge) does not provide information on indoor household vegetable production using containers, even on a conventional or organic basis.

Compost is popular manure in organic cropping although high rates of this material causes toxicity problems (Erhart & Hartl 2010). Most urban homes make compost using wastes from the household and gardens which could be used in indoor vegetable cultivation. Due to the paucity of such studies, a project determined the impact of different rates of compost when added with or without a microbial inoculant (EM) to accelerate its breakdown, on soil properties and yields of two popular tropical vegetables, over three cropping cycles.

Materials and methods

The study was carried out in a plant house of the Faculty of Agriculture, University of Peradeniya, Sri Lanka (8^o N, 81^oE, 421 m.asl) in 2007/8 using plastic containers of dimensions 10 x 30 cm, filled with 5 kg of a soil to which fertilizers had not been added for at least 4 years. The characteristics of the soil were pH (pH1:2.5 H_2O) 6.4 $\pm$ 0.2, Total organic C 11.8 $\pm$ 1.2%, Water Holding Capacity (WHC) of 19.5%.

The characteristics of the compost made of home and garden waste (Leaf) were: - Total organic C 30.5 $\pm$ 2.6%; Total N 2.86 $\pm$ 0.6%; Available P 22 $mg.kg^{-1}$, Exchangeable K 720 $mg.kg^{-1}$,C: N ratio 15.3, pH 7.3$\pm$ 0.5, and did not contain any inert material such as glass or plastic.

The pots were filled with sieved soil, and compost added at rates equivalent to 0, 3, 6, 9 or 12 $Mt.ha^{-1}$ (0, 6.5, 13, 19.5, 26 $g.pot^{-1}$). The microbial inoculant (EM) was applied at a rate equivalent to 5 litres. ha^{-1}, diluted 1:500 times to 50% of the pots, the others received similar quantifies of water. At 14 days after adding compost and EM or water, uniform seeds of beans (*Phaseolus vulgaris* L. – var. Wade) or tomato (*Lycospersicon esculentum* L var. Thilina) were planted at a rate of one seed or seedling per container. The two crops were arranged as separate trials in a completely randomized design with 5 replicated per treatment. The plants were maintained in weed free conditions and no chemicals were added. At 4 day intervals 200 ml of water was added per pot. At crop maturity, pods of beans or ripe fruits of tomato were harvested and yields per plant determined. After harvest, the soils were analysed for Organic C, Total N, Available P, Exchangeable K and WHC using standard techniques. This process was carried out over three cycles using new soil and new compost made in the same manner. Due to similarities the data was pooled for statistical analysis using a GLM procedure of the SAS statistical package and significance of observed differences were determined using probability values.

Results and Discussion

Compost increased mean soil organic C (Table 1); enhanced rates of compost has a marginal impact on this parameter. The greatest impact of increasing soil organic C was with compost equivalent to 3 $Mt.ha^{-1}$, indicating the benefits of adding organic matter to these degraded soils, even for indoor gardening, confirming similar reports by Morra *et al*. (2010) using urban waste compost. The highest increases in organic C were with the first two increments of compost. EM had no significant impact on soil C, thus this solution has no detrimental impact on organic C in soils, especially when used with organic matter. Using EM alone tends to reduce soil C, thus illustrating that this process is not conducive for maintaining soil quality

Application of increasing rates of compost increased soil nutrients significantly. The lowest impact was observed with P, which is generally a non-labile. In terms of N, the increment with rates of compost and EM was significant, especially up to 9 $Mt.ha^{-1}$ of compost. This high increment could be due to the high mineralization of organic N, which could continue after the harvest (Diacono & Montemurro 2010). In all applications of compost the increment was highest with N, which is generally limiting in tropical soils, and thus this compost could supply this nutrient to the growing pot cultured crops in household gardening programs.

Although increasing rates of compost enhanced P and K, the impact was not as evident as with N. However both these essential nutrients were increased, signifying the importance of compost applications in pot culture of organic vegetables.

EM increased the availability of all three nutrients significantly, due to the role of EM in accelerating processes of decomposition of organic matter (Jilani *et al*. 2007). EM would increase the nutrient availability to the crops and hence promote growth, and hence could be recommended for indoor organic pot cultures as done for organic field projects (Jilani *et al*. 2007).

Composts increased the WHC of soils significantly due to the impact of the organic matter on aggregate stability (Diacono & Montemurro 2010). This occurs due to slaking. Addition of the inoculant (EM) increased the WHC, due to the greater microbial activity, and the processes are to be determined, although it reduces water requirements. However this study confirms field projects where composts and organic matter have improved soil physical and chemical parameters (e.g. Dorado *et al*. 2003) and EM has enhanced the process.

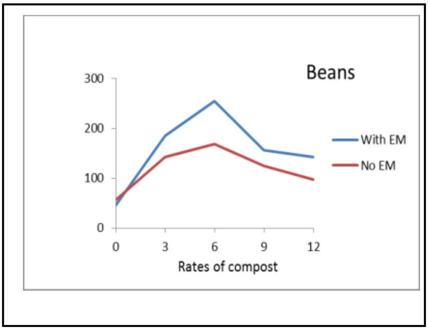
Table 1. Soil parameters as affected by rates of compost and EM (mean of 3 crop cycles)

Rate of compost ($MT.ha^{-1}$)	EM	Organic C (%)	Total N (%)	Avail P $mg.kg^{-1}$	Exch. K $mg.kg^{-1}$	WHC (%)
None	No	12	1.04	42	524	18.4
	With	08	0.75	43	505	18.5
3	No	24	2.25	44	614	19.6
	With	23	3.14	46	631	19.9
6	No	28	3.42	47	628	20.4
	With	28	3.96	49	652	21.5
9	No	30	3.72	50	631	20.9
	With	31	4.15	54	662	22.4
12	No	35	4.14	52	624	21.5
	With	34	4.46	52	615	23.4
Probability	Compost rate	0.034	0.021	0.004	0.011	0.033
	Inoculant	0.047	0.005	0.019	0.005	0.037
	Interaction	NS	*	*	NS	*

*/NS indicate significance/non significance at p= 0.05.

The harvest is the most vital component in any cropping program and the addition of compost increased yields of beans and tomato up to certain levels, after which yields declined (Fig.1). In beans and tomato, compost up to a rate equivalent to 6 $Mt.h^{-1}$ (i.e. 6g per pot) increased yields, and declined thereafter. This is due to the possible toxic effects of compost through development of substances such as phenols (Gomez-Brandon *et al*. 2008). Thus excessive use of compost would be detrimental in indoor organic vegetable pot culture.

The microbial inoculant did not facilitate the greater use of compost for higher yields in both crops (Fig.1). However it had the possibility of increasing yields at all rates of compost. In the bare soil, it marginally reduced yields, again implying that such solutions and inoculants should not be used without organic matter. With compost, at all rates it promoted yields, which could be due to greater nutrient release from compost and increasing WHC (Table 1). With increasing compost rates the beneficial effects of the inoculum declined although the yields of both species were greater. With tomato, using EM with compost at a rate equivalent to 9 Mt.ha-1 did not reduce yields significantly when compared to 6 Mt.ha-1 This implied that for longer duration crops such as tomato, EM offers the possibility of using greater quantities of compost with marginal harmful effects, and this would have positive long term effects on the soils.



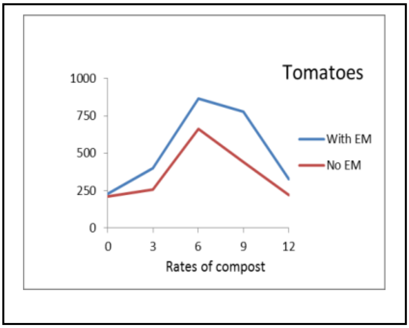


Figure 1: Impact of rates of compost (Mt.ha^{-1}) on yields (g.plant^{-1}) of beans and tomatoes as affected by EM (Mean of 3 crops) [Y AXIS PRESENT YIELDS]

Conclusions

The study on indoor organic pot culture of vegetables illustrate that very high quantities of compost are detrimental for yields due to possible toxic and allelopathic effects. The use of microbial inoculants such as EM would help overcome these detrimental effects by breaking down the organic matter and thus and providing greater yields and possibly reducing the toxicity effects, which require further study.

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Effect of organic materials on seedling growth and yield of red pepper

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Key words: Organic, Red pepper, Seedling growth, Yield

Abstract

In this study, growth of pepper seedlings was testedby treating organic materials in a plastic green house in Ssangok-ri Dogok-myeon, Hwasun-gun, Jeollanam Province from February 3, 2010 to April 19, 2010. The raised seedlings were planted to the organic planting area with an interval of 70cm×55cm on April 20 in Deogam-ri Gogeum-myeon Wando-gun and red peppers were harvested at 7 times from July 22 to September 29. Before planting, the plant length of the overgrowth of seedlings was reduced by 26.8% using plant powder treatment as compared to the control group. The red pepper yield was 27% higher than in the control group when 20g of bone ash powder and 20g of plant powder were mixed. The yield tended to increase in other treatments compared to the control group.

Introduction

Generally, seedling transplanting cultivation method is used by raising seedlings and transplanting them to the field. Thus, raising seedlings is a critical part of cultivating peppers. With regard to organic cultivation, the use of chemical fertilizer and pesticides is strictly prevented. Consequently, the management of bed soil, nutrients and pests are required. As plug seedlings are widely used, spindly growth prevention using DIF (difference between day and night temperature) method (Lim, et al., 1997), moisture, nutrient, ultraviolet light control (Bae, et al., 1998), *light* quality and temperature control, spindly growth prevention using growth regulator (Liberth, 1990), growth retardant and salt (Zang, 2002) and watering using deep ocean water have been used in nursery for solving the overgrowth problem. Currently, triazole compounds which are produced and sold as antimicrobial agents are mostly used in Korea. Triazole compounds are used for sterilizing and inhibiting growth (Bae, et al., 1998). Such agents are known to be effective in inhibiting the length of the embryonal axis, uprooting, reducing leaf size, increasing leaf thickness and stem diameter, increasing root thickness and reducing length. However, as these such as plant powder and bone ash powder to find out the appropriate treatment for avoiding overgrowth of organic seedlings and to investigate the impact on yield.

Materials and methods

In this study, growth of seedling was studied by treating organic materials in a plastic green house dedicated for seedling growth in Ssangok-ri Dogok-myeon, Hwasun-gun, Jeollanam Province from February 3, 2010 to April 19, 2010. The raised seedlings were placed in experimental plots with 4 times of randomized block design and

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planted to the organic planting area with an interval of 70cm×55cm on April 20 in Deogam-ri Gogeum-myeon Wando-gun and red peppers until September 29. PR Mujeok was used for the experiment and the organic bed soil (moisture 45%, capacity to retain water 38%, bulk density 0.15mg/㎥, pH(1:5,v/v) 6.4, EC(1:5,v/v) 0.32ds/m, P_2O_5 265㎎/l, NH4-N 227㎎/l, NO3-N 127㎎/l, CEC 27cmol+/kg) was provided by Seoul Bio. Bed soils were filled with 50 nursery boxes and one pepper seed was planted to each cell and covered with soil. Then, the green house temperature was maintained at 26-28℃ during the day and 15-16℃ during the night. T1 was control group, and treatment groups were T2 plant powder 20g/box, T3 bone ash powder 20g/box, T4 activated carbon powder 20g, T5 plant powder 20g+ activated carbon powder 20g/box, T6 bone ash powder 20g+ activated carbon powder 20g/box, and T7 plant powder 20g+ bone ash powder 20g+ activated carbon powder 20g/box. The treatment groups were distributed 7 days after seeding when no water was added. Watering was carried out daily or every other day according to the condition of the soil. Sufficient amount of organic liquid fertilizer were added once in 2-5 days from 2 weeks after seeding. The seedling quality was tested by looking at plant height, leaf length, leaf width, leaf number, stem diameter and dry weight. The yield of pepper was estimated by harvesting red peppers at 7 times from July 22 and drying them with investigation according to the research standard of the RDA. Experiments were arranged in a RCB design with 4 repetitions evaluated with SAS.

Results and considerations

The plant height of pepper was reduced by 26.8% in plant powder, 12.8% in bone ash powder, 14.4% in activated carbon powder, 10.4%in plant powder + activated carbon powder, and 18.8% in bone ash powder + activated carbon powder as compared to the control group. This result shows that when the seedling box was treated with 20g of plant powder, the overgrowth was the most efficiently prevented. It can be assumed that less nitrogen is absorbed by plants during the seedling raising stage, thus the plant height was decreased (Navetiyal, et al., 1989; Chartzoulkis, 1992). Plug seedlings overgrow as they are cultivated with 5-10 times higher density than conventional seedlings and tend to lose quality such as aging of leaf and root. Therefore, growth management techniques are very important.

Tab. 1: Comparison of treatment by dry red pepper yield

Treatment	Stem diameter (mm)	Plant length (cm)	Dry weight (g/Plant)		
			Shoot	Root	Total
T1. Control group	3.35	25.0	0.364	0.220	0.584
T2. Plant powder 20g/box	2.75	18.3	0.312	0.185	0.496
T3. Bone ash powder 20g/box	2.92	21.8	0.295	0.190	0.484
T4. activated carbon powder 20g/box	3.10	21.4	0.332	0.142	0.474
T5. Plant powder 20g+activated carbon powder 20g	2.97	22.4	0.341	0.150	0.491
T6. Bone ash powder20g+activated carbon powder 20g	2.84	20.3	0.282	0.161	0.443
T7. Plant powder 20g+Bone ash powder20g+activated carbon powder 20g	3.32	24.7	0.330	0.160	0.490

CV (%) -- 5.78 ------------------------------ 2.62

LSD (1%) --- 2.25 ----------------------------- 0.23

The analysis on the mineral elements in the seedling plant showed that T-N content was low in the plant powder and bone ash powder treatment and high in the activated carbon powder (which was treated both separately and together with other materials). That was the same for P_2O_5 content. Except for activated carbon powder treatment, K_2O content was higher than in the control group in all treatments. The content of CaO was higher than in the control group when plant powder was used. MgO content was the same for the control group and plant powder treatment but lower in other treatments.

Tab. 2: Comparison of treatment by red pepper seedling mineral element content (%)

Treatment	T-N	P_2O_5	K_2O	CaO	MgO
T1. Control group	3.39	0.56	4.14	1.45	1.06
T2. Plant powder	3.24	0.45	4.50	1.51	1.06
T3. Bone ash powder	3.11	0.45	4.47	1.31	0.97
T4. activated carbon powder	4.08	0.61	3.93	1.29	0.90
T5. Plant powder +activated carbon powder	3.31	0.57	5.83	1.67	1.03
T6. Bone ash powder +activated carbon powder	3.57	0.47	4.32	1.47	0.88
T7. Plant powder+Bone ash powder+activated carbon powder	3.78	0.54	5.96	1.43	0.92

The red pepper yield was 27% higher in T6 (Bone ash powder + activated carbon powder) than in the control group and tends to increase in the other treatments compared to the control group. Shin (2001) reported that the higher the fertilizer concentration is during the seedling raising stage, the higher the yield of red pepper, which is consistent with the result of this study.

Tab. 3: Comparison of treatment by red pepper seedling quality (Harvesting duration: Jul. 22-Sept. 29)

Treatment	Harvested fruit (No./plant)	Avg. fruit weight (g/ No)	Red pepper yield (kg/10a)
T1. Control group	92.6	12.5	2199
T2. Plant powder 20g/box	98	10.9	2138
T3. Bone ash powder 20g/box	101.3	9.1	1967
T4. activated carbon powder 20g/box	107.2	10.6	2187
T5. Plant powder 20g+activated carbon powder 20g	95.4	11.3	2122
T6. Bone ash powder 20g+activated carbon powder 20g	109.1	11.5	2,444
T7. Plant powder 20g+Bone ash Powder 20g+ activated carbon powder 20g	94.8	11.5	2161

CV (%) -- 3.53

LSD (1%) -- 156

Conclusions

To summarize, when 22g of plant powder or bone ash powder was added to each nursery box during the seeding raising stage (7 days from seeding) of organic pepper, plants did not overgrew. Rather, the plants grew relatively well. Therefore, such organic materials can be used for plug seedling production of organic peppers.

The plant height of pepper was reduced by 26.8% in plant powder, 12.8% in bone ash powder, 14.4% in activated carbon powder, 10.4%in plant powder + activated carbon powder, 18.8% in bone ash powder + activated carbon powder as compared to the control group. This result means that when the seedling box was treated with 20g of plant powder, the overgrowth was the most efficiently prevented.

The analysis on the mineral elements in the seedling plant showed that T-N and P_2O_5 content was low in the plant powder and bone ash powder treatment and high in the activated carbon powder (which was treated both separately and together with other

organic materials). Except for the activated carbon powder treatment, K_2O content was higher in all treatments as compared to the control group. The content of CaO was higher than in the control group when plant powder was used.

The red pepper yield was 27% higher in the treatment of 20g of bone ash powder and activated carbon powder each than control group and tends to increase in other treatments as well.

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Response of greenhouse grown cucumber to organic fertilizer

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Key words: compost, cucumber, Marketmore

Abstract

Between February and June 2008 at the University of Agriculture Abeokuta, Nigeria the optimum organic fertilizer rate for organic cucumber was investigated in a greenhouse. Cucumber cv. Marketmore was grown in a sandy loam soil fertilized with compost at 1.25, 2.5 and 5.0g kg soil^{-1}. Control plants received no compost. Compared with 0 or 12.5g compost kg soil $^{-1}$, application of 2.5 or 5.0g compost kg soil^{-1} significantly increased the growth and fruit yield of cucumber. The effects of 2.5 or 5.0g compost kg soil $^{-1}$ often did not differ significantly thus, compost rate of 2.5gcompost kg soil $^{-1}$) is recommended for greenhouse organic cucumber production in south-western Nigeria.

Introduction

There is an increasing demand for organic fruits and vegetables by health conscious Nigerians. Cucumber (*Cucumis sativus* L.) is one of the vegetables in high demand all-the-year round. Cucumber contains alkaline-forming minerals and is an excellent source of vitamin C and A (anti-oxidants), folate, manganese, molybdenum, potassium, silica, sulphur, and lesser amounts of vitamin B complex, sodium, calcium, phosphorus and chlorine. The need to cut out pesticide application for compliance with organic standards has made protected cultivation a possible solution to producing organic cucumbers. Although cucumber features prominently, in protected organic cultivation systems (Niu *et al*.2011), protected cultivation is relatively new among Nigerian cucumber growers. Whereas there is a fertilizer recommendation for field grown organic cucumbers (Aiyelaagbe *et al*. 2007), none exists for greenhouse grown cucumbers. This study was undertaken to determine it as part of a larger study for the development of a production protocol for greenhouse grown organic cucumber.

Materials and methods

The study was conducted in the tropical greenhouse of the University of Agriculture Abeokuta Nigeria between February and June 2008. Two seeds of 'Marketmore' cucumber were planted in plastic buckets containing 6.5kg loamy sand with pre-cropping nutrient content as follows: 1.32%OM, 0.17% total N, 7.18 mg/kg av. P, 0.79 Cmol/kg K and 1.65mg/kg Mg. The soil had twelve weeks earlier received compost derived from poultry manure, wild Mexican sun flower (*Tithonia diversifolia*) and wood ash (2:1:1 v/v) which contained 2.81% N, 27.4% av. P, 38.5% K and 6.64% Mg. The compost application rates corresponded to , 2.5, 5.0 and 510t/ha. No compost application served as control. Rates were assigned following a completely randomised

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design with four replicates. Two weeks after sowing, plants were thinned to one per pot, and trained unto polyethylene strings. The plants received a mean of 1 litre water/plant/week to support growth. Growth and yield data is presented at 9 weeks after sowing. Treatment means were separated using Fischer's Least Significant Difference at 5% probability.

Results

Compost rate significantly influenced growth and fruit production of cucumber. Application of 2.5 or 5.0g compost kg soil $^{-1}$ significantly increased vegetative growth, total dry matter accumulation and fruit production of cucumber compared with control (Table 1, Fig .1). The effects of 2.5 or 5.0g compost kg soil^{-1} on vegetative growth and fruit yield often did not differ significantly. Similarly, Foliar nutrient content increased significantly with rate of compost application and peaked at 5.0g compost kg soil^{-1}, (Table 2).

Table 1: Growth response of cucumber to compost

Compost rate (g kg soil-1)	Vine length (cm/plant)	Leaf area (cm2/plant)	Branches (no/plant)	Total dry weight (g/plant)
0	125	247	1.5	5.87
1.25	175	500	2.8	8.12
2.5	178	510	3.1	8.06
5.0	223	640	3.4	9.39
LSD (0.05)	70	150	1.3	2.50

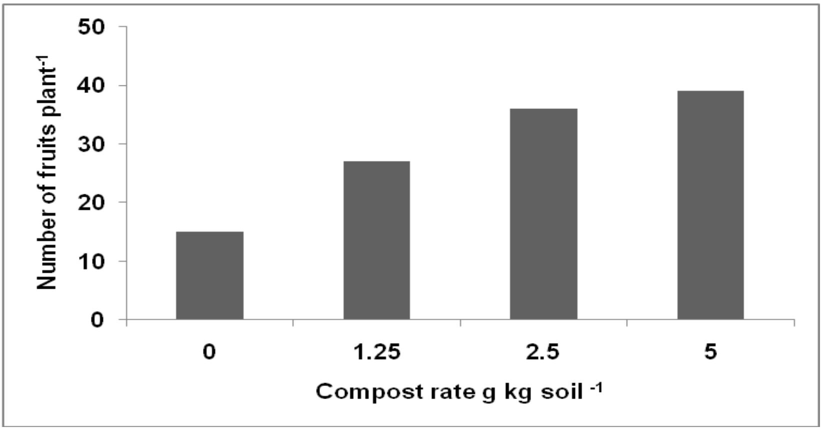

Figure 1: Fruit yield of cucumber in response to compost

Table 2: Foliar nutrient content of cucumber in response to compost rates

Compost rate (g kg soil^{-1})	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
0	7.29	13.46	11.40	10.87	16.52
1.25	24.21	28.99	20.68	22.88	22.00
2.5	30.96	31.04	32.015	29.94	30.09
5.0	47.45	43.04	36.69	34.22	35.45
LSD (0.05)	3.45	2.30	2.10	3.52	2.82

Discussion

Application of 5.0g compost kg soil^{-1} increased foliar nutrient content of cucumber without significantly increasing fruit yield probably because the high N content promoted vegetative growth at the expense of reproductive development. This suggests that 2.5g compost kg soil^{-1} provided enough nutrients to support the growth and fruiting in cucumber, while 5.0g compost kg soil^{-1} is excessive.

Application of 2.5g compost kg soil^{-1} corresponds to 5tcompost ha^{-1} or 140 kg N ha^{-1} which falls within the range recommended by and Amer *et al*., (2009).Higher rates of application would lead to luxurious consumption of nutrients with the risk of leaching of unused N in form of nitrate into the soil. This could pollute underground water and well as create health hazards in produce (Kotsiras *et al*.2002, Ju *et al*. 2007, Guo *et al*.2010). Furthermore, in highly developed urban and peri-urban production systems where organic fertilizers are not free, application of excessive amounts could lower profit margins by increasing cost of production.

Conclusions

Thus, application of 2.5g compost kg soil^{-1} is recommended for greenhouse production of one crop of organic cucumbers in south western Nigeria.

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Red Pepper Cultivation Using a Native Legume Cover Crop in Korea

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Key words: cover crop, *Vicia tetrasperma*, red pepper

Abstract

Four seed vetch **(***Vicia tetrasperma***)***, a biennial native leguminous plant, was used for a cover crop with different quantity of sowed seeds. Weed suppression and yield were evaluated for the red pepper cultivation in the following year of the vetch seeding. Seeding of 1.0, 2.0, 3.0, 4.5, and 6.0 kg 10 a*$^{-1}$ *suppressed weed occurrences until late in the growing season of the red pepper. Consequently, red pepper in the cover cropping system with seeding of 3.0, 4.5, and 6.0 kg 10 a*$^{-1}$ *had a similar yield to the conventional red pepper. The ideal seed rate in four seed vetch was 3.0 and 4.5 kg 10 a*$^{-1}$ *in terms of reducing weed occurrence as well as increasing growth and yield in red pepper.*

Introduction

Biennial native leguminous plants have been used **as** a winter cover crop in Korea. Four seed vetch belongs to the leguminous *Vicia spp*., grows approximately 50 cm long in a height, spreads throughout Korea, and can be used for a suitable cover crop due to its withering under the hot temperature in summer when cash crops are actively growing (Cho *et al*, 2009). In this research, we verified the potential of four seed vetch to be used cover crop during the following period, in terms of weed suppression and red pepper establishment.

Materials and methods

This study was conducted on the Experimental Farm of National Academy of Agricultural Science in Suwon, Korea in September of 2007 to 2008. Before the four seed vetch was seeded, there were shallow tillage and preparing furrows in September 6 of 2007. Seed rate was 1.0, 2.0, 3.0, 4.5, and 6.0 kg 10 a^{-1}, and the seeding was arranged with three replicates in a randomized block design. Red pepper was transplanted in May 20 of the following year. Uncropped strips and PE mulch were refereed as a control and conventional treatments, respectively. Coverage rate was visually observed at the time of seeding of four seed vetch (Oct 19 of 2007), pre-transplanting of red pepper (May 15 of 2008), and post-transplanting of red pepper (June, July, and August 20 of 2008). Weed weight was counted on July 20 of 2008, and growth and yield in red pepper were measured after harvesting.

Results and Discussion

Four seed vetch with seed rate of 3.0, 4.5, and 6.0 kg 10 a^{-1} covered ground more than 70% before winter in 2007 and showed most coverage on the ground in May of 2008 when the red pepper was transplanted (Table 1). Consequently, weed suppression more than 90% was observed on the cover cropping system with seed

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rate of 3.0, 4.5, and 6.0 kg 10 a^{-1} in 60 days after transplanting (Table 2), resulting in taller height, thicker diameter, and higher yield in red pepper compared with those of control or similar to the conventional red pepper (Table 3). Hairy vetch, one of the main cover crops in Korea, overcomes the cold weather and provides large amounts of organic mulches, which has been used for a green manure (Seo *et al*, 2005). Several cuts or early dead of the winter cover crop (four seed vetch) reduced the potential competition with the pepper for the availability of water and nutrients (Hollander *et al*, 2007) as well as provided nutrients for the red pepper establishment and growth since the growing period between the two plants were not overlapped.

Tab. 1: Coverage rate as affected by seeding rate of four seed vetch in a red pepper field in 2007

Seeding rate (kg 10 a-1)	Coverage rate (%)				
	Oct. 19 2007	May 15 2008	June 20 2008	July 20 2008	Aug. 20 2008
1.0	16.6	40.7	37.1	11.8	6.9
2.0	31.8	69.5	54.2	34.3	19.3
3.0	69.9	85.5	87.8	78.3	62.0
4.5	70.5	97.9	95.7	84.9	68.7
6.0	80.9	97.8	97.9	93.1	78.1

Tab. 2: Number and fresh weight of weed and weeding as affected by seeding rate of four seed vetch in a red pepper field in July 20 of 2008

Seeding rate (kg 10 a-1)	No of pl m-2	Fresh weight (g m-2)	Weed control rate (%)
1.0	61.2	1,604	49.7
2.0	66.7	1,359	57.4
3.0	12.5	225	92.3
4.5	11.3	88	97.2
6.0	9.6	62	98.1
Uncropped strips	102.9	3,191	-

Tab. 3: Growth and yield of red pepper as affected by seeding rate of four seed vetch in a red pepper field in 2008

Seeding rate (kg 10 a-1)	Plant height (cm)	Diameter (mm)	Yield (kg 10 a-1)
1.0	96.6	12.2	148.3 b*
2.0	100.1	13.8	186.5 b
3.0	106.1	13.3	292.8 a
4.5	103.7	13.6	274.8 a
6.0	100.1	14.1	264.0 a
Uncropped strips	75.9	8.3	36.9 c
PE film mulch	101.7	15.7	308.9 a

* : 0.05 DMRT

Conclusions

We observed that four seed vetch, biennial native legume, have been shown as a sustainable approach which enables us to control weeds better and to obtain a high pepper production as observed by Guldan and Martin(1996).

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Germplasm evaluation and selection of lettuces (*Lactuca sativa* L.), edible chrysanthemums (*Chrysanthemum coronarium* L.) and mallows (*Malva verticillata*) for organic farmers

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Abstract

We collected and examined germplasm resources of lettuces, edible chrysanthemums and mallows for organic farmers. We found that 3 genotypes (OL-51, OL-52, and OL-63) are suitable for organic cultivation. The main use of treatment for grey mold among eco-friendly pest control methods is helpful to increase efficiency of seed-gathering after collecting and evaluating a total of 64 kinds of lettuces- collected 43 South Korea local varieties, 8 kinds cultivated by the Highland Agriculture Research Center, 4 kinds of cultivated lettuces, and 9 kinds for sales- to choose appropriate kinds of lettuces for organic cultivation in South Korea. We chose those with more than 300 leaves (OC-18, OC-44, and OC-51) after evaluation of yield characteristics of a total of 62 edible chrysanthemums. We covered each genotype of seed of edible chrysanthemums when gathering the seeds by ourselves so as not to decrease the purity of each genotype. We chosed OM-38, OM-39, and OM-40 for their yield performance and germination rates among the total 41 genotypes of mallows. We selected 9 genotypes of lettuces, editable chrysanthemums and mallows with possibility of organic cultivation and found that they can be used permanently through self seed-gathering on organic farms.

Introduction

Demand for environmentally friendly agricultural products is on the rise as society is increasingly interested in health and food safety, and consumer awareness of the environment has increased. Research on cultivation has been undertaken on a large scale as shown in publication of Guidelines to Organic Cultivation (2006: National Institute of Agricultural Science and Technology, 2007: Jelloabuk-do Agricultural Research and Extension Services, 2010: Jeonnam Agricultural Research and Extension Service) but research on varieties suitable for organic cultivation and ways for seed-gathering is weak. 138,000 tons of lettuces were produced on 4,574ha, reaching KRW 115.9 billion in production volume as of 2008 in South Korea. 26,000 tons of edible chrysanthemums were produced on 1,079ha. Edible chrysanthemums are an important vegetable with its amount of production on bare ground reaching KRW 36 billion (2009: Ministry of Agriculture and Forestry). Mallow is not shown in statistics yet, but it is becoming a vegetable mainly used for soups in South Korea.

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Use of native seeds is critical for organic cultivation which meets international standards but most farms use commercial seeds due to the lack of distribution of seed-gathering technology. Efforts to search varieties suitable for organic cultivation such as those for lettuces, edible chrysanthemums, and mallows are weak and organic farmers have gathered seeds by themselves or planted and harvested general genotypes consequently until now. Some genotypes suitable for organic cultivation, which had already been reported, were introduced in the Manual for Organic Cultivation of Lettuces (2006: National Institute of Agricultural Science and Technology), Manual for Eco-friendly Cultivation of Lettuces (2007: Jeollabuk-do Agricultural Research and Extension Services) and Technology Handbook for Organic Cultivation of Lettuces (2010: Jeonnam Agricultural Research and Extension Service) but such introduction is insufficient compared to that of general cultivation.

In addition, research on ways which help organic farms gather seeds by themselves and use them permanently has in fact not been done. This research intended to look for crops whose seeds farms can gather by themselves and use, especially promising resources in lettuces, edible chrysanthemums, and mallows, and other resources appropriate to organic cultivation.

Material and methods

As for lettuce, we gathered 43 traditional genotypes we collected in South Korea and abroad, 8 genotypes cultivated by the Highland Agriculture Research Center, 4 cultivated genotypes and 9 genotypes for sales and made them public. We separated organic and conventional management in lettuce by using an high altitude cool region organic field in Daegwanryeong and conducted characteristics research until late October after sowing on April 30, 2008 and planting on June 3. We publicized a total of 62 genotypes (57 traditional genotypes, which the agriculture gene bank and resource center of Rural Development Administration had distributed to us, and 5 genotypes for sales we gathered in the market) and made comparison in growth and yield in the case of organic cultivation to choose genotypes of edible chrysanthemums for organic cultivation. We made a total of 41 genotypes (37 traditional genotypes from the agriculture gene bank and resource center of Rural Development Administration, and 4 genotypes for sale that we gathered in the market) and compared their yield performance in the case of organic cultivation. We evaluated their characteristics and yield performance as in the case of general edible chrysanthemums. We used SAS 9.12 for statistical evaluations.

Results and discussion

Lettuces

Germination rates of collected traditional genotypes varied ranging from 0 to 100%. Their number of leaves was similar or more when they were organically harvested than when they were generally harvested. Differences between leaves (leaf length, leaf width) were large but leaf shape (proportion of leaf width/leaf length) was consistent. We found that collecting OL-63 have higher yields than other genotypes when it comes to organic cultivation of Chima type lettuce (Tab. 1). However, genotypes of red leaf ('Geocgchugmyeon' type) lettuces were found to have noticeably low yield in organic cultivation compared to general cultivation and we found that differences in growth are attributable to organic cultivation of lettuces according to leaf shape. In addition, collecting OL-51 is the only genotype which saw a higher yield than other genotypes of red leaf lettuces when it comes to organic cultivation (Tab. 2).

Tab.1: Comparison of growth and yield in organic and general cultivation of 'Chima' type leaf lettuces (*Lactuca sativa*)

Collecting No.	Organic cultivation				Conventional management			
	No. of leaves (each/plant)	Leaf length (㎝)	Leaf width (㎝)	Yield (ton/ha)	No. of leaves (each)	Leaf length (㎝)	Leaf width (㎝)	Yield (ton/ha)
OL-47x	40.9 c	13.5 b	9.0 bc	3.6 c	54.4 b	15.2 bc	10.5 a	9.7ab
OL-48x	39.1 c	11.3 cd	7.4 cd	3.0 c	35.9 c	16.8 abc	13.1 a	8.8 b
OL-53x	28.7 d	10.3 de	7.3 d	1.5 c	47.3 bc	16.0 abc	12.4 a	10.6 ab
OL-56x	40.3 c	13.2 bc	10.0 ab	6.4 b	44.7 bc	19.3 b	13.8 a	12.4 ab
OL-63y	65.7 a	16.7 a	11.3 a	11.8 a	71.1 a	17.8 ab	12.7 a	16.6 a
OL-64z	56.4 b	14.7 b	9.7 ab	7.1 b	51.7 bc	18.4 ab	12.0 a	9.6 ab
LSD (5%)	7.03	1.87	1.65	4.68	16.38	3.77	3.35	16.52
CV	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14

xJeogchima; yCheongchima; zHeugchima

Tab.2: Comparison of growth and yield in organic and general cultivation of 'Geocgchugmyeon' type leaf lettuces (*Lactuca sativa*)

Collecting No.	Organic cultivation				Conventional management			
	No. of leaves (each/plant)	Leaf length (㎝)	Leaf width (㎝)	Yield (ton/ha)	No. of leaves (each)	Leaf length (㎝)	Leaf width (㎝)	Yield (ton/ha)
OL-45	26.6 b	10.7 a	11.2 a	3.5 bcd	30.9 ab	16.2 ab	15.9 abc	8.8 ab
OL-46	25.2 b	11.2 a	12.5 a	3.0 cd	26.4 abc	12.9 d	14.8 c	5.0 b
OL-49	28.6 b	11.1 a	11.8 a	22.7 d	29.9 ab	13.5 cd	14.6 c	7.3 ab
OL-50	22.7 b	11.5 a	13.6 a	4.4 b	28.8 abc	13.7 bcd	15.2 bc	5.8 b
OL-51	40.0 a	12.4 a	12.6 a	8.1 a	32.0 ab	15.0 bcd	15.7 bc	10.3 ab
OL-54	22.3 b	10.7 a	13.0 a	4.4	26.3 abc	14.6 bcd	17.7 abc	9.9 ab
OL-55	22.4 b	10.7 a	13.5 a	3.3 bcd	23.4 bc	13.9 bcd	18.1 ab	12.0 a
OL-59	15.0 c	11.1 a	12.6 a	3.8 bcd	33.2 a	16.0 abc	17.0 abc	12.4 a
OL-60	15.2 c	11.8 a	13.1 a	2.6 d	19.8 bc	18.1 a	19.0 a	8.9 ab
LSD (5%)	6.62	1.99	2.82	2.60	9.56	2.69	3.30	10.77
CV	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10

Edible chrysanthemums

Most of the collected traditional genotypes germinated, except for two cases, but their germination rate tended to be generally low. 40 genotypes have less than 40% germination, 16 genotypes showed 41-70%, and only 4 genotypes had more than 70% germination rate. Growth characteristics showed that 4 genotypes (OC-17, 42, and 44) have more than 70 % of initial germination rate after being planted, 10 genotypes (OC-9, 13, 16, 18, 31, 37, 51, and 60) have more than 200g of yield performance, and OC-44 was the only one genotypes which has more than 70% germination rate and more than 200g of weekly yield performance. We could choose 3 genotypes (OC-18, 44, 51) as promising varieties for organic cultivation (Tab. 3).

Tab. 3: Selected of good sprouting rate, late bolting and yield of edible chrysanthemum (*Chrysanthemum coronarium*)

Collecting No.	Sprouting rate (%)	Plant height (cm)	No. of leaves (each/plant)	Leaf length (㎝)	Leaf width (㎝)	Total weight (g/plant)	Yield (ton/ha)	Budding days after sowing
OC 18	14	24.3	380.0	11.6	4.7	242.9	13.5	89
OC 44	74	27.8	428.6	12.4	5.8	361.7	20.1	-z
OC 51	37	23.4	375.3	12.5	5.5	293.3	16.3	78
Control	61	25.3	375.9	11.7	5.3	250.2	13.9	-
LSD 5%	-	NS	218.9	-	-	146.2	8.11	
CV	-	2.0	2.0	-	-	2.0	2.0	

zDead in field before budding.

Mallows

Six of the collected traditional varieties did not germinate and most of them germinated but germination rates tended to be low on the whole. 37 genotypes had less than a 40% germination rate. 8 genotypes saw germination rates of 41-70%. Only 6 genotypes had more than 70% germination. Growth characteristics after being planted showed that 5 genotypes (OM-36, 37, 38, 39 and 40) have more than 70% of initial germination rate, 11 genotypes (OM-13, 17, 34, 36, 37, 38, 39 and 40) have more than 100g of yield performance, and 4 genotypes (OM-36, 38, 39, and 40) have more than 70% of germination rate and 100g of weekly yield performance. We could choose 3 genotypes (OM-38, 39 and 40) as promising germplasm resources for organic cultivation among those collected germplasm resources based on comprehensive consideration of growth and yield performance (Tab. 4).

Tab. 4: Selected of hood sprouting rate, late bolting and yield of mallow (*Malva verticillata*)

Collecting No.	Sprouting rate (%)	No. of leaves (each/plant)	Leaf length (㎝)	Leaf width (㎝)	Petiole length(cm)	Total weight (g/plant)	Yield (ton/ha)
OM 38	89	65.4	15.9	17.3	2.0	120.1	6.8
OM 39	100	67.3	15.9	17.7	3.6	115.0	6.4
OM 40	74	67.5	16.5	18.6	2.2	118.7	6.6
Control	100	58.8	15.9	18.7	2.7	109.4	6.1
LSD 5%	-	23.8	4.0	4.3	2.4	62.6	3.48
CV	-	2.0	2.0	2.0	2.0	2.0	2.0

Conclusions

Based on our research, we chose 9 promising genotypes for organic cultivation including lettuces, edible chrysanthemums and mallows and found that organic farmers can gather their seeds by themselves and use them permanently.

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2009 Statistics of greenhouses for vegetables grown in facilities and performance of Agricultural Research and Extension Service, Environmental-friendly Agriculture Research Center of Chonnam National University.

Evaluation of domestication possibility of *Thymus transcaspicus* Klokov under low input cropping system

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Keywords: Irrigation interval, Manure; Khorasan thyme; phytochemical characteristics

Abstract

In order to evaluate the possibilities of cultivation of Khorasan thyme (Thymus transcaspicus), an experiment was conducted in the years 2006 and 2007 under field conditions at the Research Station of the Faculty of Agriculture, Ferdowsi University of Mashhad, Iran. Irrigation intervals (2, 3 and 4 weeks as main plots) and cattle manure (10, 20 and 30 t ha-1 as subplots) were employed within a split-plot design with three replications. Plant biomass and its components as proportion of leaf, stem and flowers and also essential oil percentage and yield were measured at final harvest. Phenological cycles were recorded during the two years of the experiment. Results indicated that increasing application of organic manure beyond 10 t ha-1did not show any significant effect on plant biomass. Increasing irrigation intervals in the second year of trial, significantly reduced plant biomass. This was also true for stem, leaf and flower content in dry matter. Essential oil content and yield in response to organic manure and irrigation showed no particular trend. Phenological cycles were completed in 192 days equivalent to 3300 degree-days in 2006 and 172 days equivalent to 3050 degree-days in 2007. The constituents of essential oil were 25 components which was 43.1% of the total essential content with thymol as the main constituent.

Introduction

In order to conserve medicinal and aromatic plants communities on the basis of sustainability, there are different strategies including domestication and cultivation practices as a means to conserve the species within the human domain. For cultivation of medicinal and aromatic plants under field conditions, different management practices are required including method of propagation, time of planting, plant density, nutrient and water requirements and competition with weeds. However, among these practices, nutrient and water requirements, which may interact with plant secondary metabolites, should be dealt with cautiously. It has been noticed that higher amount of available nutrient in the form of mineral fertilizer may reduce the content of these metabolites. Therefore to supply the amount of nutrient needed, organic fertilizers may be more appropriate for this type of plants. Although water is a limiting factor for plant production, a mild water stress has been shown to increase secondary metabolites in medicinal and aromatic plants. Today, production of these metabolites under low input and organic cropping systems has been considered. *Thymus transcaspicus* (Lamiaceae), is native to the North-East of Iran and Turkamanistan and

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is used widely by the local communities for different purposes such as curing illnesses, spice and condiment. The aim of this study was to evaluate performance of *T. transcaspicus* plants growth and its suitability for domestication under low input and organic cropping systems.

Materials and methods

This study was conducted in 2006 and 2007 growing seasons at Research Station of Faculty of Agriculture, Ferdowsi University of Mashhad, Iran. Seeds were sown under glasshouse conditions and then the 66-day-old seedlings were transplanted in the field on 10 May 2006 as spring cultivation with 5 seedlings m^{-2} in plots of 4 m^2 on rows 50× 40 cm distances. All treatments were arranged in split-plot design with three replications in which irrigation intervals (2, 3 and 4 weeks Intervals) were allocated in main plots and composted cattle manure (10, 20 and 30 t ha^{-1}) as subplots which was applied three months prior to transplanting. Experimental plots were irrigated up to field capacity (26.5% θ) with1.5 cm of water (675 l) in each irrigation. Phenological observations were carried out in each plot. The field was managed organically, with no application of chemicals including fertilizers and pesticides. At full blooming stage, from 0.5 m^2 area in each plot, plants were cut at a height of 10 cm above soil level and dried under shaded conditions. Dry matter yield and plant parts (leaf, stem and flower) proportions, except at the second harvest in the second year when the flower number was low and ignored, were determined. Essential oils from the dried aerial parts were isolated by hydro-distillation method using a Clevenger-type apparatus and stored for further gas chromatography analysis and gas chromatography-mass spectrometry. Data analysis was made using SAS statistical software (SAS Institute 2002) and means were compared by Duncan’s Multiple Range test at $P < 0.05$.

Results

Crop development: Our observations showed that the total duration of plant growth and development from transplanting to maturity was 192 days equivalent to 3300 GDD in 2006. However, in 2007, up to the second cut when the growth was initiated, from the established plants of first year, it lasted 172 days equivalent to 3050 GDD. Established plants of the second year showed longer reproductive growth duration, from early flowering to the end of plant life-cycle, both in days and GDD measures, compared to the first year plants.

Plant biomass: Increasing the amount of applied organic manure more than 10 t ha^{-1} showed a negative effect on biomass production in the first year and similar results obtained in the second year (Table 1). Plant biomass was higher in the second year of the experiment particularly at the first cut. Increasing the irrigation intervals showed no significant ($P>0.05$) effect on plant biomass in the first year and the first cut of the second year, except the second cut of the year 2007. In this cut, with increasing the irrigation intervals, the plant biomass was reduced (Table 1). In general, higher irrigation intervals resulted in lower plant biomass, although not significant; but the negative impact of longer irrigation intervals was more than the negative impact of higher amounts of manure. It is expected that with increasing plant irrigation intervals, the proportion of stem in total dry matter increases and accordingly the proportion of leaves and flowers decrease. This type of effect has been reported for forage and rangeland crops; however, we did not realize such an effect on medicinal and aromatic plant like Khorasan thyme (Figure 1).

Oil production: Essential oil yield was not affected by cattle manure nor irrigation intervals (Table 1). Increasing irrigation interval from 2–3 weeks decreased the oil percentage; however, a further increase of irrigation interval from 3–4 weeks increased the oil content. Decreasing the irrigation interval from 4 and 3 to 2 weeks showed the highest positive interaction of the two treatments on foliage biomass in both years). At the second cut of 2007, increasing the applied manure more than 10 t ha^{-1} increased the production of biomass as the irrigation intervals decreased. At the first cut of both years, the oil percentage and total oil production increased as the irrigation interval increased from 2–4 weeks across all manure levels. This result was not consistent for the second cut of year 2007. Thymol (43.1%) and carvacrol (8.7%) were the main constituents of the essential oil in Khorasan thyme.

Table 1. Interactive effects of irrigation interval and manure on herbage biomass and oil production of *T. transcaspicus* in two years of experiment (2006–2007).

II(week)	2006			First cut 2007			Second cut 2007		
	M (t ha-1)								
	10	20	30	10	20	30	10	20	30
Dry matter (g m-2)									
2	37.2ab	29.6ab	19.9ab	61.2a	63.9a	57.8a	36.9a	37.6a	38.3a
3	38.9ab	11.8b	19.3ab	51.0a	51.7a	50.4a	27.3ab	19.1ab	34.2ab
4	47.7a	19.6ab	18.5ab	54.8a	46.5a	44.6a	15.1ab	12.4ab	3.5b
Essential oil (%)									
2	2.4a	2.0a	1.8a	0.9ab	1.1ab	1.1ab	0.8a	1.1a	0.9a
3	1.9a	1.9a	2.1a	0.8b	0.9ab	0.9ab	0.7ab	0.7ab	0.7ab
4	2.2a	2.1a	1.9a	1.2a	1.0ab	1.1ab	0.1c	0.3bc	0.1c
Essential oil yield (g m-2)									
2	0.9ab	0.6ab	0.3ab	0.5a	0.7a	0.6a	0.8a	0.8a	0.7ab
3	0.7ab	0.2b	0.4ab	0.4a	0.4a	0.4a	0.4ab	0.3ab	0.5ab
4	1.2a	0.4ab	0.3ab	0.7a	0.5a	0.5a	0.31ab	0.2ab	0.05b

*Means in each column followed by the same letter are not significantly different (P<0.05), using Duncan's Multiple Range Test. II: Irrigation interval, M: Manure

Discussion

Among various concerns of using fertilizers, including their optimum rate, time and location of application and their interaction with other environment and management factors, our field observation indicated plants loss mostly due to root decay at higher rates of manure application. It may be postulated that the high amount of organic manure in the first year, which is the period of plant establishment with smaller root structure, might have had a negative effect on the plant growth. This has been also reported for other similar plants (Koocheki *et al.* 2004). In another experiment with *Nepeta binaludensis* there was no difference of plant biomass with the application of 10, 20 and 30 t ha^{-1} organic manures (Najafi 2006). Therefore, it appears that this species is not able to tolerate high organic matter in the soil, particularly where irrigation water is limited. Water stress reduced growth and yield of plants and this has been associated with lower photosynthetic rate due to reduced stomatal conductance. There are many reports which confirm the negative effect of water stress on dry biomass production of medicinal and aromatic plants such as *Rosmarinus officinalis* (Delffine *et al.* 2005), and *N. binaludensis* (Najafi 2006). Although essential oil yield was not affected by cattle manure in present study, but this was somehow in contradiction with some literature in which a positive effect of organic fertilizers on essential oil percentage and yield has been previously reported (Najafi 2006;). Ram *et al.* (2006) reported that increasing water availability reduced essential oil percentage of *Mentha arvensis* but total essential oil yield was increased due to the positive effect of available water on plant biomass, i.e. a dilution effect. It seems that after the first cut, the plants are not able to tolerate any water deficit and increasing irrigation interval more than two weeks would result in biomass reductions, oil percentage and total oil production across all manure levels (Table 1). In general, these results revealed that *T. transcaspicus* has good potential for domestication under low input and organic cropping systems.

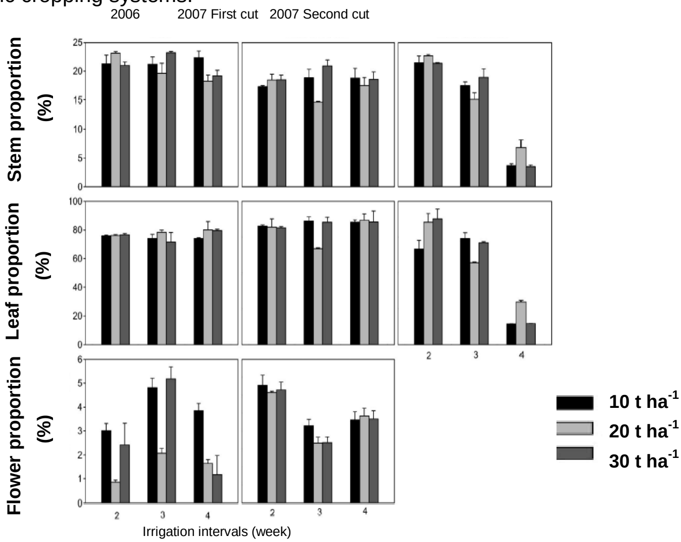

Figure 1. Effects of irrigation intervals and manure on plant part proportion (%) in years 2006 and 2007 (error bars indicate the standard errors).

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Digested and not digested solid fraction of pig slurry as N source for organic lettuce production

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Key words: organic horticulture, lettuce, anaerobic digestion, pig slurry.

Abstract

In organic farming, the re-use of on-farm internal resources, such as livestock manure stabilized by composting or anaerobic digestion, able to supply N after mineralization process on short term, represents a good approach to organic fertilization in horticulture. The aim of our study was to evaluate the N fertilization of organic lettuce with a digested (D) and not digested (ND) solid fraction of pig slurry. In a greenhouse, in a loamy (A) and a sandy (B) soils, lettuce was fertilized under organic conditions with D, ND and urea (mineral fertilization) at 200/400 KgN hasoil-1, also for evaluating the potential phyto-toxicity of high N input. Lettuce fresh weight, leaves' number, leaf area, NO3- content in leaf tissues, stem height, soil N-NO3- and N-NH4+ were determined at the end of the crop cycle.

Lettuce fresh weight and total leaf area were higher in A respect to B. D application gave parameters comparable to those obtained with 200 KgN hasoil-1 urea, with a decrease of NO3- content in lettuce leaves. Highest rate of D and ND gave highest residual N-NO3- in A, but not in B. In relation to N-NH4+, it was higher in both soils treated with D and ND respect to urea treatments.

Introduction

The massive use of mineral fertilizers is incompatible with the conservative approach of organic farming, which suggests the re-use of on-farm internal resources to ensure the protection of the natural environment and the maintenance of soil fertility on long term (Wood *et al*. 2006, Canali *et al*. 2009). Sometimes, organic fertilization collides with the need to ensure high N supply at the early phenological stages of horticultural crops characterized by short-term phenological cycle (Tesi & Lenzi 1998): the livestock manure, being an on-farm resource, is an answer to the this need, particularly when previously underwent to a stabilization process such as anaerobic digestion.

In the proposed greenhouse experiment conducted under organic conditions, the solid fractions of pig slurry, anaerobically digested or not digested, were tested at different doses on lettuce production in comparison with conventional fertilization with urea, with the aim to verify the effect of different fertilization approaches on lettuce yield and quality. The pot trial was conducted on two soils, characterized by different texture and fertility, in order to evaluate also the role played by the soil properties onto the N availability to crop.

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[2-3-4] As Above

Materials and methods

In a greenhouse, lettuce (*Lactuca sativa* L., cv Romana) was transplanted into 16 cm diameters pots containing two soils from Central Italy (Monterotondo - Rome): a medium fertility - loamy soil (A) and a low fertility - sandy soil (B). The experiment was conducted from April to June, 2009 (temperatures range: 15-26°C). Before lettuce transplanting, soils were fertilized by adding D (N_{tot}: 0.39%) and ND (N_{tot}: 0.47%) at 200 and 400 Kg_N ha^{-1} doses, the last one for evaluating the effect of high N input on lettuce growth, the potential phyto-toxicity (Abdullahi *et al.* 2008) and the nitrate assimilation by leaf tissues. Granular urea was applied at the same doses (conventional fertilization), while unfertilized soils were taken as controls. Treatments were arranged in a randomized complete-block design with six replicates. Irrigation was managed in relation to plant water-demand. After 6 weeks, lettuce fresh weight (g), total leaf area (cm^2), number of lettuce leaves per plant, stem height (cm) and leaf nitrate concentration (mg Kg^{-1}) were recorded. At the end of the cropping cycle, soils were sampled at 0-30 cm (5 sub-samples per pot) and soil $N\text{-}NO_3^-$ and $N\text{-}NH_4^+$ (Kg ha^{-1}) were determined by extraction in a 0.2N KCl solution and colorimetric determination by Autoanalyzer Technicon II. Data were evaluated by ANOVA to verify the statistical differences of the tested parameters in relation to the different fertilization treatments. Average values and the related standard errors are reported in the graphs.

Results

Results obtained in relation to fresh weight, total leaf area, numbers of leaves and stem height are reported in Figure 1.

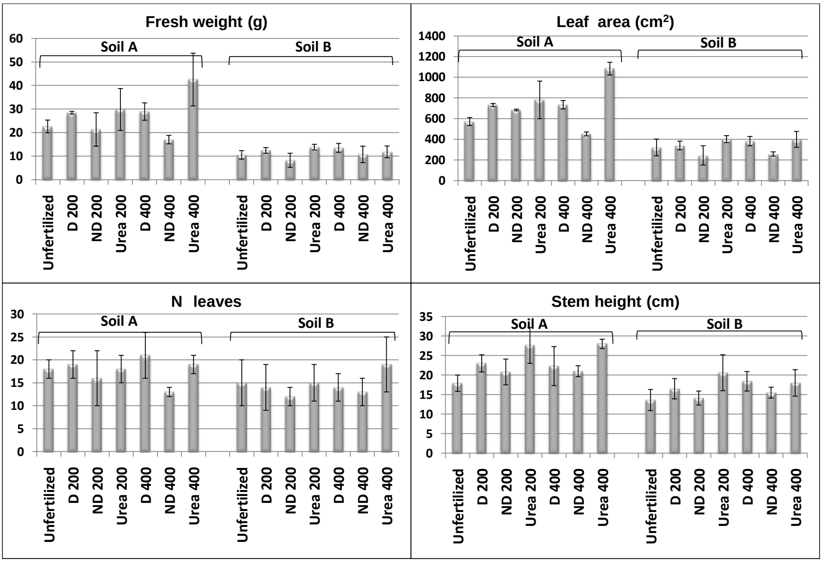

Figure 1: Fresh weight (g $plant^{-1}$), total leaf area (cm^2), number of leaves and stem height (cm) of lettuce fertilized at 200 / 400 Kg_N ha^{-1} with digested (D), not digested (ND) solid fraction of pig slurry and urea in A and B soils, compared to unfertilized treatments.

Lettuce fresh weight ($P<0.0001$) and total leaf area ($P<0.005$) were significantly influenced by soil characteristics: in B soil, with a sandy texture and low biological fertility, lettuce production and leaf area were about two times lower respect to that recorded in A, a loamy soil characterized by higher biological fertility. Besides, in A the fertilization effect is clearly evident, giving the urea treatments the highest yield and leaf area at 400 Kg_N ha^{-1} dose. At 200 Kg_N ha^{-1}, the digested solid fraction of pig slurry gave the same fresh weight and leaf area obtained by applying urea at the same dose. No significant differences were noticed in soil B in relation to the treatments. Soil characteristics influenced also the stem height ($P<0.05$), which was higher in soil A than in soil B, but no fertilization effect was noticed.

Fertilization affected significantly nitrate concentration in lettuce leaves ($P<0.005$): highest values of nitrate content in lettuce leaves were found after urea treatments, while D and ND limited the nitrate translocation from soil to the edible part of the plant (Table 2). However, in soil B, the use of D and ND determined a significant decrease of soil $N\text{-}NO_3^-$ pool respect to the corresponding mineral fertilization. As far as the soil exchangeable $N\text{-}NH_4^+$ concerns, at the end of the cropping cycle, it was generally higher for D, ND and urea treatments at 200 Kg ha^{-1} respect to that obtained after 400 Kg ha^{-1} fertilizers' addition, in both the A and B soils (Table 2).

Tab. 2. Nitrate concentration in lettuce leaves (mg Kg^{-1}), residual soil $N\text{-}NO_3^-$ and $N\text{-}NH_4^+$ (Kg ha^{-1}) in both the A and B soils, in relation to the different treatments (average values ± standard errors).

Soil		NO_3^- conc. in leaf tissues (mg Kg^{-1})	Soil $N\text{-}NO_3$ (Kg ha^{-1})	Soil $N\text{-}NH_4$ (Kg ha^{-1})
A	Unfertilized	420 ± 23 a	10.4 ± 2.7	4.5 ± 2.1
	D 200	620 ± 35 a	10.5 ± 5.2	3.7 ± 2.6
	ND 200	305 ± 16 a	8.8 ± 1.5	4.7 ± 0.7
	Urea 200	12416 ± 75 d	12.1 ± 5.3	3.9 ± 0.4
	D 400	917 ± 38 b	22.0 ± 6.5	2.9 ± 0.2
	ND 400	1441 ± 29 b	16.3 ± 8.4	1.6 ± 1.2
	Urea 400	11352 ± 93 c	14.8 ± 3.0	1.4 ± 1.3
		P< 0.005		
B	Unfertilized	238 ± 24 a	4.4 ± 0.9 a	2.3 ± 0.3
	D 200	80 ± 17 a	4.7 ± 1.7 a	4.2 ± 2.6
	ND 200	122 ± 14 a	4.4 ± 1.2 a	5.3 ± 0.7
	Urea 200	9529 ± 61 b	10.5 ± 6.0 b	1.8 ± 0.8
	D 400	148 ± 17 a	4.6 ± 0.7 a	2.2 ± 1.5
	ND 400	234 ± 22 a	4.6 ± 0.6 a	0.1 ± 0.1
	Urea 400	18263 ± 131 c	20.9 ± 9.4 c	0.8 ± 0.6
		P< 0.005	**P<0.01**	

Discussion

In the Annex I of Reg. (EC) N°. 889/2009 on organic production, liquid animal excrements are inserted as allowed organic fertilizers, but only after controlled fermentation or appropriate dilution. The use of slurry in lettuce fertilization is not usual, because of the risk of phytotoxicity on seed germination, due to a low C/N ratio: anaerobic digestion could properly overcome this problem, producing a good quality fertilizer. Results obtained showed that organic fertilization with 200 Kg_N ha^{-1} of D gave a crop yield comparable to that obtained with urea fertilization, while ND was not an adequate source of N in the first phenological phase, particularly at 400 Kg_N ha^{-1}, probably for the mentioned phytotoxic effect.

In organic farming, soil characteristics represents a key factor for vegetable growth and quality, being N availability strongly influenced by soil biological fertility: in soil B, effectiveness of all the fertilizers were reduced (probably for N loss by leaching from the pot micro-environment). In the loamy soil A, with higher biological fertility and higher water retention, the N inputs were better utilized. The remarkable increase of nitrate accumulation in lettuce leaves treated with urea (whose limit superimposed by E.C. 563/2002 Regulation for fresh product is 3,500 mg Kg^{-1} for the cultivation periods April-to-September) could be justified by the pot system, which is a confined environment in which the effect of the translocation of available N from soil to plant is clearly emphasized when huge amounts of mineral N are supplied with the fertilizer. The findings attested that the organic fertilization could limit this unfavourable effect, by ensuring at the same time good quality plant production. The differences in soil $N\text{-}NO_3^-$ pool in relation to the alternative fertilizations, particularly high when the D was added at the highest dose, could depend from the biological attitude of the soils to oxidize nitrogen coming from fertilizer: in soil A, a clay soil characterized by medium fertility, the nitrification activity played by the microbial biomass proceeded faster, while in soil B, the lower biological fertility probably constituted the “limiting factor” for the previous mineralization activity and consequently for the concentration of free nitrate in the soil liquid phase. Anyway, the comparison between nitrate content at the end of the experiment in soil B confirmed that the organic fertilization with ND or D, based on N supply in the $N\text{-}NH_4^+$ form, determined a reduction of the risk of nitrate leaching from soil, especially in the sandy-textured one, so to constitute another positive aspect to the organic approach.

Conclusions

Organic fertilization with digested solid fraction of pig livestock manure at both the tested doses gave good results in relation to lettuce yield, comparable to those obtained with conventional fertilization with urea. The quantification of soil N pools suggested that both digested and the not digested biomass could be applied as N fertilizers, but at a rate not higher than 200 Kg_N ha^{-1}, thus limiting soil available nitrate concentration and reducing the risk of nitrate leaching also in sandy poor soils. The recorded higher quality of lettuce produced through organic fertilizers use respect to the conventional one attested the proposed itinerary as an alternative environmental-friendly approach to ensure a sustainable horticultural crop yield and, on parallel, a safety and healthy food to be proposed to consumers. A critical point in the use of fertilizers from slurry in organic agriculture is the origin of material which, in any case, cannot derive from factory farming.

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Effect of green manure on yield and soil nutrient balances in organic lettuce cultivation

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Key words: Green manure, Lettuce, Nutrient balances

Abstract

The yield characteristic and soil nutrient balances through the study on organic lettuce cultivation of by using green manure crops, Crotalaria juncea and Sorghum bicolor and organic fertilizers + compost are summarized as follows. The dry weight and the amount of nutrients of Sorghum bicolor *was higher than* Crotalaria *juncea as a whole. In the first year of planting green manure, there was no difference between yield of lettuce. But in 2nd years and 3rd years, the yield of lettuce increased on* Crotalaria juncea *and organic fertilizers + compost in comparison of untreated control and Sorghum bicolor. The nutrient balance of N, P and K was the appropriate level on* Crotalaria juncea*, but nutrient balance of Sorghum bicolor and organic fertilizers + compost showed surplus in all nutrients and N and P respectively.*

Introduction

The crop rotation and green manure should be the basis of soil management of organic farming, but on domestic organic farming, the soil nutrient was mainly managed by external inputs such as organic fertilizers and compost. Therefor this study was carried out to investigating the effects of green manures for improving the problems of soil management by using organic fertilizers and compost, and analysing nutrient balance in soil used green manures at summer season and cultivated lettuce on plastic house at spring and winter season for three years.

Materials and methods

The study was performed in 2007 ~ 2010 at plastic greenhouse of Jeollanamdo Agricultural Research and Extension Services, situated in south-western Korea. The experimental layout was in a single block design. The plot size was 3.5 m x 12 m.

The treatments of the nutrients sources by green manure, organic fertilizers and compost

The treatments were the following: T1, growing *Crotalaria juncea* and inputting to soil by cutting and tillage at summer season(Jun. ~ Aug.), and then cultivating lettuce of winter cropping(Oct. ~ Mar. in next year) and summer cropping(Mar. ~ Jun.), three times for four years from 2007 to 2010, and the duraton of growing green maure was 60 days, 45 days and 48 days in 2007, 2008 and 2009 respectively.; T2, growing *Sorghum bicolor* and cultivating lettuce by the same method as T1; T3, no inputting any nutrients sources to soil for for four years from 2007 to 2010, but cultivating lettuce by the same method as T1; T4, not growing green manures but Inputting organic fertilizers + compost to soil before planting lettuce of winter and spring cropping for three years from 2008 to 2010.

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Results

The nutrients amount and growth characteristic of green manure

In the 1st yerars, the dry and fresh weight of green manure tended to be higher because of the higher fertility of the soil on plastic house and difference of the duraton of growing green maure. The dry weight of *Sorghum bicolor* was higher than *Crotalaria juncea*(Tab. 1).

Tab. 1: The fresh **and d**ry weight **by kinds of green manure**

Kinds of green manure		Above ground part(kg/m2)		Underground part(kg/ m2)	
		Fresh weight	Dry weight	Fresh weight	Dry weight
Crotalaria juncea	1st years('07)	6.31	1.48	0.27	0.66
	2nd years('08)	3.61	0.45	0.37	0.11
	3rd years('09)	3.25	0.86	0.19	0.05
Sorghum bicolor	1st years('07)	13.18	2.94	2.01	0.58
	2nd years('08)	6.35	1.40	1.50	0.28
	3rd years('09)	7.67	1.22	1.32	0.39

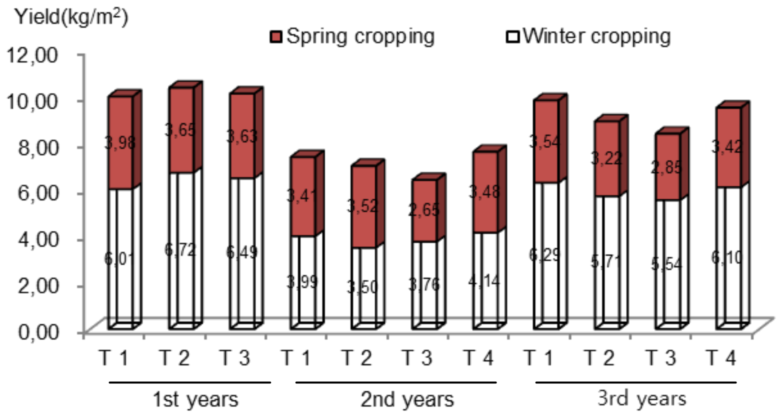
Chemical content of green manure crops were higher in *Sorghum bicolor in* comparison of *Crotalaria juncea* because of the higher dry and fresh weight(Tab. 2).

Tab. 2: The amount of nutrients inputted to soil by green manure and organic fertilizers + compost

Nutrients sources		T-N (g/ m2)	P_2O_5 (g/ m2)	K_2O (g/ m2)
Crotalaria juncea	1st years('07)	47.9	10.3	55.1
	2nd years('08)	13.2	8.0	6.7
	3rd years('09)	21.6	4.5	14.8
Sorghum bicolor	1st years('07)	61.7	24.5	127.6
	2nd years('08)	20.0	9.6	36.1
	3rd years('09)	36.4	9.4	24.4
fertilizers + compost	2nd years('08)	79.2	24.4	15.4
	3rd years('09)	79.2	24.4	15.4

Yield characteristic of lettuce

In the first year of planting green manure, there was no difference between yield of lettuce. But in 2nd years and 3rd years, the yield of lettuce increased on *Crotalaria juncea* and organic fertilizers + compost in comparison of untreated control and *Sorghum bicolor*(Fig. 1).



* T1 : *Crotalaria juncea* ; T2 : *Sorghum bicolor* ; T3 : Untreated control ; T4 : Organic fertilizers + Compost

Figure 1: The yield of lettuce affected by kinds of green manure and organic fertilizers + compost

Nutrient balances in soil

The nutrient balance of N, P and K was the appropriate level on *Crotalaria juncea*, but nutrient balance of *Sorghum bicolor* and organic fertilizers + compost showed surplus in all nutrients and N and P respectively(Tab. 3).

Tab.3: Nutrient balances of lettuce cultivated in soil amended with kinds of green manures and organic fertilizers + compost

Treatm-ents	Input(g/ m2)			Output(g/ m2)			Balance(g/ m2)		
	T-N	P_2O_5	K_2O	T-N	P_2O_5	K_2O	T-N	P_2O_5	K_2O
T1	83	23	77	68	22	74	15	1	3
T2	118	44	188	63	18	62	55	25	127
T3	0	0	0	55	18	62	-55	-18	-62
T4	158	49	31	38	10	39	117	39	-8

* T1 : *Crotalaria juncea* ; T2 : *Sorghum bicolor* ; T3 : Untreated control ; T4 : Organic fertilizers + Compost

Discussion

For using green manure crops on organic lettuce cultivation, leguminous green manure such as *Crotalaria juncea* showed a stable and high yield of lettuce. But, in gramineous green manure *Sorghum bicolor*, the amount of N, P and K inputted to soil was sufficient, but yield of lettuce decreased more than. These results are considered to be caused by unstable yield because high C/N ratio of gramineous green manure. In addition, the temporary input of a large amount of green manure as well as the application of organic fertilizers and compost could be the cause of soil environmental pollution by nutrient leaching and accumulation, etc. Therefore, these problem for utilization of green manure is considered to be studied.

Conclusions

For lettuce of `Ssam` vegetable main crop, leguminous green manure crops such as *Crotalaria juncea* were replacements of organic fertilizer, the yield of lettuce was similar to that on cultivation practices using organic fertilizers + compost. But long-term use of green manures in terms of the use of nutrient cycling will be needed continual review.

Acknowledgments

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Phenotypic evolution of different spinach varieties grown and selected under organic conditions

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Key words: spinach, phenotypic evolution, on-farm, participatory plant breeding.

Abstract

Organic agriculture needs flexible varieties that can buffer environmental stress and adapt to the needs of farmers. We implemented an experiment in order to investigate the evolutionary capacities of a sample of spinach varieties based on phenotypic traits. After 2 cycles of cultivation and on-farm mass selection, all the varieties tested (population varieties) showed an evolution of the traits and thus flexibility which could be used for on-farm adaptation. However, the response to selection observed on station was not always in the direction desired by farmers.

Introduction

Population varieties are still predominantly used in developing countries and they are gaining interest in developed countries, especially for organic farmers (Wood and Lenné 1997). Indeed, organic agriculture needs flexible varieties to buffer the variability of cultivation conditions, to enhance the self-regulation capacity of organic farming systems (Lammerts van Bueren, 2002) and to adapt to the requirements of each farmer (specific markets for example). More and more farmers also look for such varieties in order to achieve seed self sufficiency. Participatory plant breeding is a selection method that can respond to these different needs. In this experiment (in the framework of the European project Farm Seed Opportunities), we investigated the evolutionary capacities of spinach varieties for phenotypic traits of interest for farmers. While diversity among spinach varieties based on molecular markers has been studied (Hu *et al.* 2007), there have not been published studies of the diversity of phenotypic traits which are of direct relevance to farmers.

Materials and methods

The evolution of different spinach (*Spinacia oleracea* L.) population varieties was explored during a 3-year experiment (2007 to 2009). The plants were cultivated and selected by organic farmers in contrasting environments (two farmers in Western France and one in The Netherlands). The evolution was assessed by comparison of the original seed sample with the variety cultivated and selected on-farm for two cycles of cultivation and selection (Figure 1).

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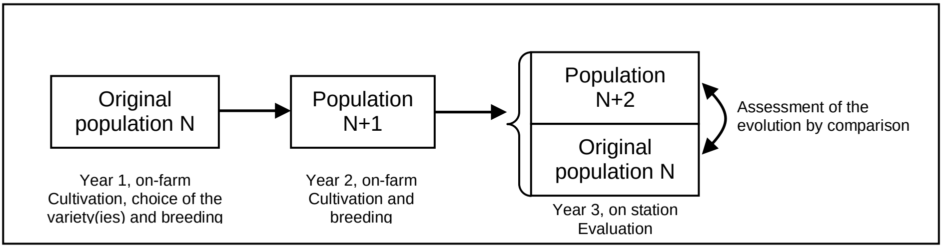

Figure 1: Scheme of the experiment

The varieties tested were European populations of spinach which were historically registered in the European variety catalogue but which have been removed. Seeds came from national gene banks (CGN – The Netherlands - and GEVES - France).

The experiment was performed in 3 steps: (i) 2007, selection among varieties: cultivation by each farmer of about 20 varieties, with farmers choosing at least one variety to be grown and selected on their farm for the following years; (ii) 2007 and 2008, selection within varieties: on-farm mass selection within the chosen variety(ies); (iii) 2009: evaluation of all the varieties chosen and selected by the farmers in a common trial (one location, Le Rheu, Brittany, France). To avoid intercrossing on farm, the varieties were multiplied individually under cages. On-farm, the plots' size was at least 100 plants and 5 m² per variety. Selection was carried out differently according to farmers. One farmer (MC) eliminated the non-desirable plants, one other (AVO) choose the plants corresponding to its criteria and transplanted them separately for seed multiplication and the last (FD) decided to multiply all the plants of the variety chosen, just putting out the spiny seed at harvest (the variety chosen had no spiny seeds). The common trial of the third year was a split-plot design with 3 replicates of 32 plants each. Sub-blocks were composed of the different versions of one variety, i.e. population N from the gene bank and population(s) N+2 from farmer(s). Different phenotypic traits were measured on 15 plants per replicate for each version of each variety. They were observed on one well-developed and representative leaf of each plant (except for bolting index, observed at the plot level).

Trait observations:
(1) petiole length, (2, 3) leaf blade length and width: in mm,
(4, 5, 6) leaf colour, measured with a chromameter-Minolta (average of 3 measurements per leaf: 2 lateral measurements and one on the "top" of the leaf, each measurement gives 3 parameters: L (light saturation), A (yellow-blue axis) and B (green-red axis) (Hunter Labs, 1996)),
(7) anthocyanin on the stem: 1-presence, 2-absence,
(8) petiole attitude: 1-horizontal, 2-semi-erect, 3-erect,
(9) leaf blade attitude: 1-semi-pendulous, 2-horizontal, 3-semi-erect, 4-erect,
(10) leaf blade blistering: 1-absent or very weak, 2-weak, 3-medium, 4-strong, 5-very strong,
(11) leaf blade shape of apex: 1-acute, 2-obtuse, 3-rounded,
(12) leaf blade thickness: 1-very fine, 2-fine, 3-medium, 4-thick, 5-very thick,
(13, 14, 15) bolting index: 0-not bolted (0%), 1-little bolted (1 to 25%), 2-medium bolted (25 to 75%), 3-bolted (75 to 100%) (index observed 3 times: May 22, May 29, June 4, 2009)

The traits chosen were phenotypic traits which interested farmers. Most of them are UPOV descriptors (CPVO 2010) and thickness was added after farmers' proposition. Diseases were not evaluated because not observed during the experiment.

The growing conditions and selection criteria of the farmers were also recorded.

Statistical analyses were performed with R software (R Development Core Team, 2009). Each variety was analysed separately. ANOVA tests were performed for quantitative traits Y (i.e. petiole length, leaf blade length and width and leaf colour), according to the model: $Y_{ijk} = \mu + replicate_i + version_j + \varepsilon_{ijk}$. Chi² tests of the version effect were performed on the distributions of the semi-quantitative traits (i.e.

anthocyanin, petiole and leaf blade attitude, leaf blade blistering, shape of apex and thickness) after pooling the data of the 3 replicates. For both ANOVA and Chi² tests, we chose a significance threshold of 5%.

Results

Table 1: Mean values and statistical significance values of the evolution of varieties after 2 years of cultivation and selection in the common experiment at Le Rheu in 2009: m_N / m_{N+2} where m_{N+2} is the mean of the farmers' version after 2 growing cycles and m_N is the mean of the original seed lot

Variety	MLS	ALW	SUP	VER	VIK	VMA	EDR	
Traits / Farmer	AVO	MC						FD
Petiole length	m_N = 84/ m_{N+2} =75 *	76/ 90 ***	80/ 71	85/ 92	68/ 70	89/ 95	110/ 102	110/ 99
Leaf length	164/ 154	143/ 156 *	150/ 141	166/ 169	146/ 143	152/ 174 **	150/ 160	150/ 147
Leaf width	135/ 127	119/ 118	138/ 124 *	127/ 136	139/ 140	113/ 123	112/ 118	112/ 109
Colour "L"	42.8/ 42.3	40.9/ 41.5	39.5/ 40.4	43.3/ 43.1	41.3/ 42.8 **	41.7/ 41.8	42.5/ 43.8 *	42.5/ 42.8
Colour "A"	-14.3/ -14.1	-12.8/ -13.4***	-12.4/ -12.9	-14.8/ -15.4 **	-13.4/ -14.3 *	-14.4/ -14.4	-13.3/ -13.7	-13.3/ -12.6
Colour "B"	-20.7/ -19.9	-18.2/ -19.2***	-16.7/ -17.1	-22.1/ -23.0 *	-17.9/ -19.3 *	-20.3/ -20.6	-18.5/ -20.4 **	-18.6/ -18.3
Anthocyanin 0 - 1	1.00/ 1.00	1.00/ 1.00	1.00/ 1.00	1.44/ 1.49	1.00/ 1.00	1.04/ 1.07	1.21/ 1.37 *	1.21/ 1.45 *
Petiole attitude 1 - 3	1.82/ 1.84	1.91/ 2.27 *	1.98/ 1.64	2.18/ 2.16	2.41/ 2.06 **	2.22/ 2.32	2.26/ 2.30	2.26/ 2.21
Leaf attitude 1 - 4	2.00/ 1.93	2.02/ 2.09	1.80/ 2.07 *	1.73/ 1.67	2.74/ 2.81	1.87/ 1.52	1.84/ 1.67	1.84/ 1.59
Shape of apex 1 - 3	2.39/ 2.21	2.95/ 2.79	2.63/ 2.58	2.05/ 1.93	2.93/ 2.94	2.48/ 2.07	2.37/ 1.90 *	2.37/ 1.79 **
Thickness 1 - 5	4.20/ 4.02	3.96/ 3.89	3.43/ 3.48	4.36/ 4.09	3.68/ 3.44	3.44/ 3.95	3.74/ 4.30 *	3.74/ 3.79
Blistering 1 - 5	2.82/ 2.69	3.04/ 2.96	3.18/ 3.11	2.71/ 2.78	3.01/ 3.43 *	2.27/ 2.48	1.74/ 1.63	1.74/ 1.66
Bolting index (0 to 3) May 22, 2009	1.00/ 0.67	0.67/ 2.33***	0.67/ 1.00	1.67/ 1.67	0.33/ 0.67	2.67/ 3.00*	2.00/ 2.50*	2.00/ 2.50 *
Bolting index (0 to 3) May 29, 2009	1.33/ 0.33 *	1.33/ 2.00 ***	1.67/ 2.00	3.00/ 3.00	2.67/ 2.33	3.00/ 3.00	3.00/ 3.00	3.00/ 2.50 *
Bolting index (0 to 3) June 4, 2009	2.67/ 2.67	3.00/ 3.00	0.75/ 0.88 *	3.00/ 3.00	3.00/ 3.00	3.00/ 3.00	3.00/ 3.00	3.00/ 3.00

Varieties: Alwaro (ALW), Monarch Long Standing (MLS), Supergreen (SUP), Verbeterde Hollanda (VER), Viking (VIK), Viking Matador (VMA), Eté de Rueil (EDR)

p-value (p) of ANOVA or Chi2 (for qualitative traits, in italic) for the difference $m_{N+2} – m_N$:

* p <0.05, ** p<0.01, *** p<0.001

All varieties showed statistically significant evolution: some varieties evolved for only one or few traits (Monarch Long Standing, Verbeterde Hollandia and Viking Matador), whereas others evolved on more numerous traits (Alwaro, Viking or Eté de Rueil) and they differ on traits on which they evolved (Table 1). For example, Monarch Long standing evolved only on petiole length and 2 bolting indexes and Verbeterde Hollandia evolved only on 2 colour parameters. Petiole length and attitude, leaf length, colour (parameters A and B) and 2 bolting indexes have evolved for Alwaro and the 3 colour parameters, petiole attitude and blistering have evolved for Viking. All measured traits showed significant evolution for at least one variety. When the same trait evolved for 2 varieties, in most cases it was in the same direction. Colour of the leaves and bolting index on June 22 evolved for many varieties, whereas leaf width, attitude, thickness and blistering evolved each only for one variety.

Discussion

The results obtained by statistical analysis confirm some visual observations. For example, petioles of Alwaro N+2 (cultivated at MC) are 9 mm (17.6%) longer than Alwaro N, Eté de Rueil N+2 versions had a lower mean note for leaf shape of apex than the N version (more leaves with an acute apex), and all this was clearly visible in the field. Evolution observed on the varieties is linked with natural adaptation (environmental selection pressure) and farmers' selection. MC and AVO applied directional selection pressure but FD let the variety evolve on its own. The type of selection (natural or human) does not seem to have an influence on the intensity of evolution (number of traits and p-values). Indeed, evolution of FD version of Eté de Rueil is comparable to the evolution of the MC version and even to the evolution of the other varieties. However, a more thorough experimentation would be needed to compare the intensity of human and natural selection (the same varieties, selected and not selected, compared in contrasted environments).

Conclusions

The results show evolution of the spinach populations evaluated after only 2 years of cultivation and breeding in organic conditions. Such information points to the flexibility of such varieties and their interest for participatory plant breeding because of their potential for differential evolution. On-farm conservation and selection is one strategy to maintain or increase cultivated biodiversity, in connection with farmers' needs (each farmer having his/her own breeding objectives). These results are also relevant to help policy-makers to adapt the European seed legislation to recognize on-farm breeding and to accommodate evolving populations.

Acknowledgements

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Cultivar evaluation for red pepper under organic crop management in Korea

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Key words: disease resistance, evaluation, organic management, red pepper cultivar, yield.

Abstract

To screen several promising red pepper cultivars, may be adaptable to organic cultivation conditions, seventy six F1 hybrids commercial and eight local purebred red pepper cultivars were tested. Comparing the infection rate of phytophthora blight between commercial (F1 hybrid) and local (Purebred) cultivars, average infection rate of commercial cultivars was 9.8% and that of local cultivars was 17.8%. But the infected fruits rate of anthracnose in field were similar as 3.3% in commercial (F1 hybrid) and 3.1% in local (Purebred) cultivars. In yield characteristics, average yield of commercial cultivars was 2.89 t ha^{-1} and that of local cultivars was 2.22 t ha^{-1}. For organic pepper farmers it is more favourable to cultivation purebred cultivars because they can save to the same quality plant next year's crop. In this study among the local purebred cultivars, two cultivars are promising that their yield near to 3 t ha^{-1} and have disease field resistance.

Introduction

Red hot pepper is one of the most important vegetable crops for seasoning foods in Korea. The need for sustainability of performance in pepper was increased, particularly in organic agriculture in Korea. But it is limited by the lack of varieties adapted to organic conditions (Wolfe *et al.* 2008). In future, the requirement for organically cultivated vegetable will be increasing steadily; therefore many organic growers are searching for certified organic seed and adaptable cultivars for organic environments. In America, smaller seed companies have produced the majority of organically produced seed to date (Bonina *et al.* 2004). Lammerts Van Bueren *et al.* (2002) already suggested the general variety characteristics on the basis of the agro-ecological approach to enhance the self-regulating ability for the main components of organic farming strategies. The general criteria for variety characteristics are adaptation to organic soil fertility management, weed suppressiveness, crop health, seed health and yield and yield stability.

Therefore, in the present study we tried to screen several promising red pepper cultivars, which may be adaptable to organic cultivation conditions. Especially resistant to most problem diseases like pepper anthracnose and blight, and have high yield capacity in organic cultivation.

Materials and methods

Eighty four red pepper cultivars were tested to select for organic cultivation (Table 1). Sixty F1 hybrid commercial cultivars are resistant to blight disease, sixteen F1 hybrid

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commercial cultivars are medium resistant to phytophthora blight disease and eight local purebred cultivars are medium resistant to blight disease. For this study, the green manure crops were fall-seeded in last year and before transplanting compost of 10 ton per ha was applied. On May 10, eighty four kinds of seedlings were transplanted in 100 cm rows. The red peppers were harvested three times and the capsaicin contents were analyzed.

For selecting disease resistant cultivars, the inoculation was conducted in laboratory. In phytophthora blight resistance test, each cultivar was inoculated with 5ml suspension by dispenser at concentration of 1x 103 and 1x 105 zoospore/ml on sixty-day old pepper seedlings in pot. After inoculation, it was investigated three times at every 7 days (Figure1). In anthracnose resistance test, the inoculation was divided into green and red pepper fruits. Inoculation was conducted on three parts (top, middle, tail) of pepper fruit with concentration of 2 x 106 conidia/ml by pinning as a wound-inoculation method. Ten days after inoculation, the lesion area was measured as diameter (Figure 1). These inoculation results of anthracnose were compared to infected fruits rate in field (Figure 2).

Tab. 1: Sources of evaluated cultivars in present study

Item	Resistance to blight*	Fixation	Number
Commercial cultivar	R	F1 hybrid	60
	M	F1 hybrid	16
Local cultivar	M	Purebred	8

* R: resistant to blight disease, M: medium resistant to blight disease

Results

Figure 1 shows the frequency distributions of the most troublesome diseases on peppers. In this year, it was difficult to select resistant cultivars in field because the whether is somewhat better that the phytophthora blight disease did not occur severely. In laboratory Inoculation, 83.4% of cultivars were less than 20% infection, 14.4% of cultivars were between 30~50% infection and 2.4% of cultivars were more than 60% infection. For the infection fruits of anthracnose in field, 78.6% of cultivars were infected less than 5%, 12% of cultivars were infected 6~10% and 8.4% of cultivars were infected more than 10%. Comparing the infection rate of phytophthora blight between commercial (F1 hybrid) and local (Purebred) cultivars, average infection rate of commercial cultivars was 9.8% and that of local cultivars was 17.8%. But the infected fruits rate of anthracnose in field were similar as 3.3% in commercial (F1 hybrid) and 3.1% in local (Purebred) cultivars.

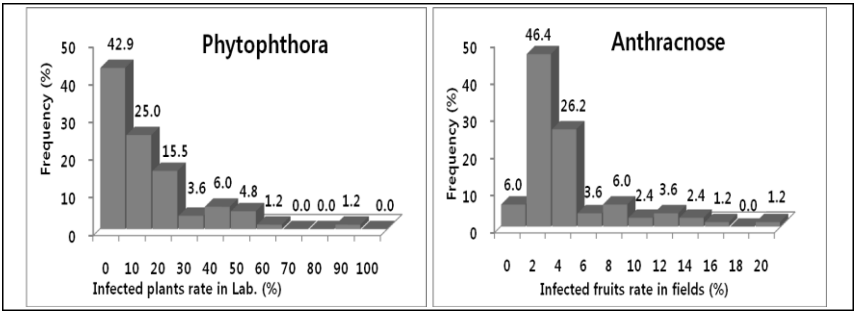

Figure 1: Frequency distribution of inoculated pepper plants rate of phytophthora blight in laboratory and infected fruits rate of anthracnose in field (n=84). Inoculation concentration of blight was 1 x 10^5 zoospores ml^{-1} in laboratory.

Figure 2 shows the relationship between infected lesion size of pepper fruit by inoculation in laboratory and naturally infected fruits rate by anthracnose in field. Between inoculation of green and red fruits, the correlation coefficient of green pepper was higher and signicant than that of red fruits, suggesting easier infection on the green pepper fruit than red one.

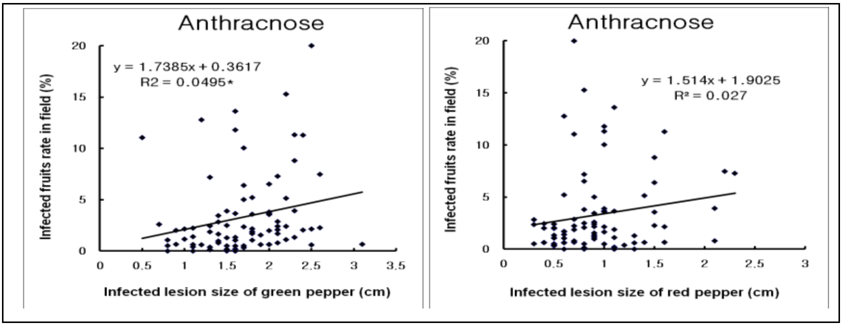

Figure 2: The relationship between infected anthracnose lesion size of pepper fruits and infected fruits rate in the fields (n=84). Inoculation concentration of anthracnose was 2 x 10^6 conidia ml^{-1} in laboratory.

Figure 3 shows the frequency distribution of dried red pepper yield (t ha^{-1}) and capsaicin contents. For the yield distribution, 10.7% of cultivars were 2 t ha^{-1}, 89.2% of cultivars were 2.5~3.5 t ha^{-1} and 9.6% of cultivars were more than 4 t ha^{-1}. For the capsaicin contents distribution, 78.7% of cultivars were less than 60 mg g^{-1}, 16.7% of cultivars were 80~120 mg g^{-1} and 4.8% of cultivars were more than 140 mg g^{-1}. Comparing the yield between commercial (F1 hybrid) and local (Purebred) cultivars, average yield of commercial cultivars was 2.89 t ha^{-1} and that of local cultivars was 2.22 t ha^{-1}.

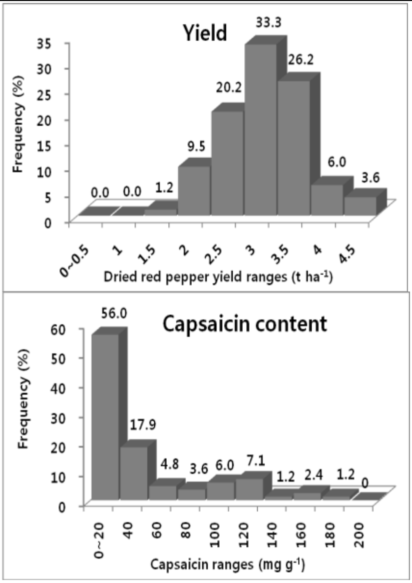

Figure 3: Frequency distribution of dried red pepper yield (t ha^{-1}) and capsaicin contents (mg g^{-1}) (n=84).

Discussion

On principle, organic pepper farmers have to use organically produced seeds and planting materials. However actually the organic pepper seeds are limited and it is difficult to obtain, because almost commercial seeds are treated post harvest with chemical-synthetic fungicide or pesticide. To obtain good seeds, it is needed to select better cultivars adapted to organic farming systems. Many organic farmers want to grow hybrid cultivars, because the seeds must be the offspring of two parents that differ in one or more heritable characteristics and have heterosis. In present study, the yield of F1 hybrid commercial cultivars is higher than that of purebred cultivars, and general resistance to disease of commercial cultivars are also stronger. However, the seeds collected from a grown hybrid commercial cultivars will not be true to type when replanted and thus cannot be saved to plant next year's crop (Kirschenbaum 2000). Thus it is necessary to introduce the disease resistant gene to the local pepper cultivars which are genetically fixed purebred. In Korea, because of severe anthracnose disease outbreak after summer season, early maturing cultivars which can avoid that season also adaptable to organic crop management. In this study among the local purebred cultivars, two cultivars are promising that their yield near to 3 t ha^{-1} and have disease field resistance.

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Optimizing nutrient inputs in organic horticulture: exploring the potential for using organic extracts as fertilizers

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Key words: organic extracts, liquid fertilizers, organic vegetable production

Abstract

In intensive organic horticulture, a major challenge is to ensure sufficient supply of nutrients for rapid plant growth. Contrary to solid organic manures, water-soluble compounds, when applied, go directly in the soil solution, increasing the pool of readily available plant nutrients. The use of liquid organic fertilizers containing plant nutrients in soluble form can improve yields of organically grown vegetables and reduce the risk of losses through split applications. Organic extracts are used in many countries, with differences in raw materials, production process, application method and purpose. The paper presents a collection of the available information and our findings on the effect of starting material and extraction method on the nutrient quality of plant extracts.

Introduction

Organic certification in vegetables is increasing all over the world, reaching 35 million hectares overall in 2008 (Willer & Kilcher 2010). However, due to the increase in population and the limited availability of land, agriculture - including organic - will need to intensify the production. In intensive organic horticulture, ensuring sufficient supply of nutrients for plant growth is a major challenge, particularly for N (Giller 2001). This may encourage over-fertilization, an inefficient way of using resources which can lead to environmental pollution.

Besides the certified one, there is much production which is in fact organic because synthetic fertilizers are not used for lack of access or economic constraints, especially in developing countries (IFOAM 2009). In these countries, vegetable production has an important role in improving the livelihood conditions of small-scale and resource-poor farmers, since it constitutes both an opportunity for diet improvement and a source of income (AVRDC 2006).

In both cases, economic and environmental advantages can be achieved by a better nutrient use efficiency (NUE) of the fertilizers.

A better synchronization between plant nutrient requirement and nutrient supply can be done through split applications of the fertilizer. As most vegetable production systems are dependent on irrigation, the use of liquid fertilizers offers a unique opportunity to provide the plants with additional nutrients during the growth cycle, adjusting inputs according to the immediate crop need. Moreover, organic N sources might play an important role in organic horticultural cropping systems, as the ability of some cropped plants to use also organic forms of nitrogen has been demonstrated (Paungfoo-Lonhienne *et al.* 2008). The use of organic liquids as top-dressing fertilizers could potentially overcome some of the constraints of organic horticulture, since they would provide some soluble, easily available nutrients to the crop in split applications

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through irrigation. If produced with organic waste products, they would also provide a means for recycling nutrients and reduce the dependency of organic horticulture on external sources of animal manure.

Organic extracts are used as fertilizers in many countries, with differences in feedstock, production processes, application methods and purposes (El-Naggar et al., 2010). However, there is still very little scientific knowledge regarding these liquids, especially under a plant nutritional point of view. A few studies were made to test some liquids on plants, but none or very few – to our knowledge – deal with their nutrient content and transfer from the raw materials to the solution, and with the nutritional effects of these liquids on plants. Some claim that through a fermentation process of the extracts, nutrient transfer in solution and nutrient availability would positively increase. This paper aims at reviewing the available information about organic liquids used in horticulture and at discussing some of the results from explorative trials.

Materials and methods

Literature about organic liquids was collected through peer reviewed articles, articles from magazines, websites and books. Information on feedstock, preparation and application practices was also collected through direct and indirect fieldwork.

Explorative trials - aimed at studying the nutrient transfer from feedstock to solution - were performed through producing some extracts from various plant sources and plant derived waste materials through two processes: one continuously provided oxygen in the solution, while the second left the solutions fermenting by going anaerobic. Sample screenings of the main plant nutrients both in the soluble fraction (under 0.45 µm) and in the liquid fraction (under 200 µm) were performed, and nutrient mass balances calculated. Similar trials are currently ongoing, although results are still not available. Phytotoxic effects of the extracts, and their effects as biostimulators through hormone-like activity are being explored.

Results and discussion

Organic liquids are used in horticulture in many countries, including Korea, USA, Australia, Cambodia, Egypt, Brazil, Kenya, Thailand, Peru, Nigeria. The variety of names used to call them is extremely broad and no common terminology is used. Some examples of the names used for products that – although different – are used as organic liquid fertilizers are: bio-organic liquid, compost extract, compost leachate, compost tea, earth juice, fermented fruit juice, fish emulsion, garden tea, herbal tea, humic acid foliar fertilizer, protein or fish hydrolyzates, liquid compost, liquid green manure, liquid humate, liquid manure, liquid organic fertilizer, liquid microbial organic fertilizer, manure tea, organic foliar feeding, organic foliar fertilizer, organic tea, seaweed extracts, vermicompost leachate, vermi-leachate, and weed tea.

These liquids are used for various and often multiple purposes: pest control, fertilization, biostimulation, enhancement of microbial community, increased availability of micronutrients etc. They are produced from a variety of sources (both plant or animal derived, and both fresh or composted) and processes (mainly aerobic extraction or fermentation). Sometimes a microbial inoculum is used. There is also a big variety of commercial products available in the market mainly for home-garden use. These products are very diverse, but they usually claim to feed the crop while enhancing the microbial community of the soil. When home-made, these extracts are available at almost no costs (often the only cost is the one for the container). However, the availability of raw material to produce these extracts is limited, so that their extended use could potentially be difficult.

Some of our main results from experimental trials showed that for most nutrients there is no significant difference in nutrient transfer in solution between aerobic and fermented process (fig.1). P and Fe were an exception because they did show a higher transfer in the soluble fraction (<0.45 µm) when produced through fermentation. However, this could not correspond to higher nutrient availability but it could be the result of formation of precipitates which are not available to plants.

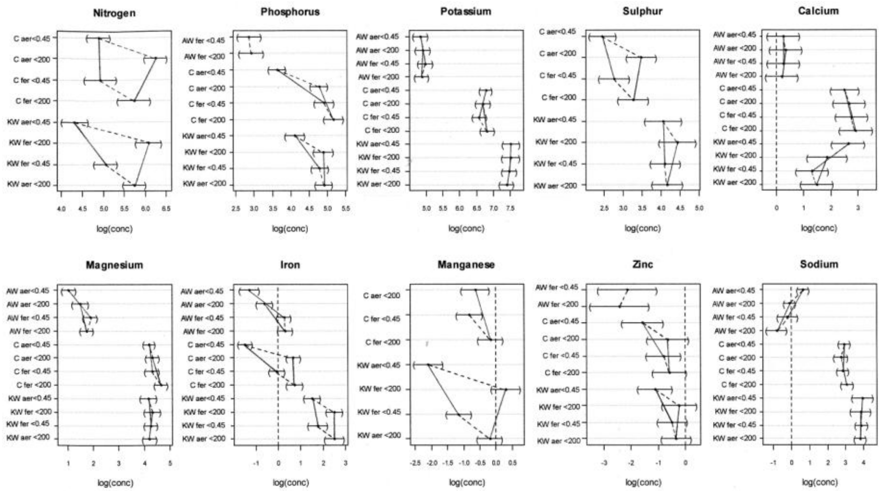

Fig. 1: Nutrient concentration of organic extracts. Points indicate estimated average values (on log scale), while lines within brachets indicate the 95% confidence interval. AW: apple waste; C: clover; KW: kitchen waste; aer: aerated; fer: fermented; <200: liquid fraction (<200 µm); <0.45: soluble fraction (<0.45 µm). Solid lines indicate trends between aerated and fermented process, and dashed lines trends between soluble and liquid fraction. Points are missing where data did not have statistical significance.

The difference in concentration between liquid and soluble fractions gives an idea of the nutrients which are still organically bound in solution. N, P, S, Fe and Mn are present both as small and larger (thus organically bound) molecules, whilst K, Ca, Mg, Zn and Na are only present in form of small molecules. For some nutrients, like N, the organically bound fraction is less available to plants than the soluble fraction, while generally the situation is opposite when dealing with P and Fe. Regarding N, one of the main nutrients considered in fertilizers, about 18-40% of the N contained in the feedstock is transferred in the liquid fraction, of which about 10-15% in mineral form, dominated by ammonium, while NO_3^- tends to disappear from the system. N losses are around 20%, but with high variability.

Raw materials behave differently and nutrients are not always transferred in the soluble fraction proportionally to their concentration in raw materials. Therefore, the selection of the raw materials to be used should be done according to the target nutrients and their transfer. Table 1 shows how many kilograms of soluble nutrients would be possible to obtain by processing 1 ton of different fresh feedstock.

Table 1: Raw materials' nutrient content and potential amount of nutrients obtainable in plant extracts

	Nutrient concentration in raw material, per unit of dry weight								Potential amount of nutrients obtainable in the soluble fraction in extracts produced through fermentation, per unit of fresh material							
	(mg/g DW)						(µg/g DW)		(kg/t FW)						(g/t FW)	
Raw material	N	P	K	Ca	Mg	S	Fe	Na	N	P	K	Ca	Mg	S	Fe	Na
Apple waste	8.3	0.9	4.3	0.8	0.3	0.4	8.3	0.9	0.7	0.1	0.7	0.1	0.0	0.0	9.0	16.0
Clover grass	36.2	4.3	23.5	15.2	2.7	1.9	36.2	4.3	0.6	0.5	1.5	0.6	0.2	0.0	2.9	35.7
Kitchen wastes	20.3	3.3	41.8	5.2	2.2	2.0	20.3	3.3	0.3	0.2	2.3	0.1	0.1	0.1	11.2	62.8

Conclusions

Organic extracts should be used as top-dressing fertilizers, not as base fertilizers. They are not meant to substitute organic practices like soil organic matter addition but, when used in addition to them, they might help increasing the productivity of organically grown vegetable crops. The major advantage of home-made organic extracts is that they can be locally produced at very low costs, reducing the dependence of the farmers from external inputs. However, their variability in nutrient content can be very high. Although plant extracts contain substantial amounts of nutrients, they tend to have high salt content as well and therefore there is risk for salt toxicity when they are used for plant fertilization. Besides the nutritional aspect, however, these extracts can contain biostimulants, so that they might have a positive effect even when they are used in small doses and at high dilutions. The results presented in this paper are preliminary and research is still needed in order to assess whether the use of liquid organic fertilizers can be a viable way to solve some of the nutritional problems encountered in organic horticulture, both under technical and economical points of view.

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Effect of sea water treatment on growth and yield of chinese cabbage (*Brassica rapa ssp. campestris*) and radish (*Raphanus sativus* L)

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Key words: *Brassica rapa ssp. campestris, Raphanus sativus* L, fresh weight, hypocotyls, salt stress

Abstract

This study was undertaken to assess the effect of sea water (SW) on growth and yield characteristics of Chinese cabbage (Brassica rapa L. ssp. campestris) and radish (Raphanus sativus L.) from August to October, 2010. Chinese cabbage cv. 'CR Kaulbaechu' and Radish cv. 'Chamjoa' were grown under plastic house and treated with diluted sea water (2.5%, 5%, 10%, 20%, 50% and 100% v/v) using leaf spray and root application while control plants were treated with normal water. Results indicated that Chinese cabbage showed better growth and higher shoot fresh weight (635.6 g) under the 50% SW spray treatment, while crop treated with 10% SW exhibited better growth and fresh weight (602.8 g) when applied at the root. Radish showed better leaf weight (100.0 g) and hypocotyls weight (65.0 g) per plant under the 20% SW leaf spray treatment. Using the root application, radish showed the best growth and yield characteristics under the 10% SW treatment. Chinese cabbage and radish showed tolerance to salt stress up to 50% and 20%, respectively, using the leaf spray. Further research on the effects of sea water on mineral composition in both crops is recommended.

Introduction

Chinese cabbage (*Brassica rapa* L. ssp. c*ampestris*) is a common vegetable crop and its worldwide production was estimated 53 million tonnes in 2007 (Lee *et al*., 2010). Chinese cabbage is used as the major raw ingredient for *kimchi* and various dishes and its estimated annual production was measured 2.39 million tonnes in Korea (Cheigh and Park, 1994). Year-round production of Chinese cabbage in Korea has increased the annual income of famers as well as provided employment opportunities. Chinese cabbage is frequently grown in both open fields and plastic houses following the harvest of the main crops, and it is considered as a salt removal crop.

Radish (*Raphanus sativus* L.), another income-generating crop in Korea, is used commonly for preparing *Kimchi* as well as for fresh consumption. In Korea, the estimated radish production area is 37,304 ha with a total annual production of 1,564,374 tonnes (Swiader, 1998). In Korea, farmers have been growing the radish in open field and in greenhouse during the autumn and winter season, respectively. Due to short growing period, farmers have considered the radish farming as a lucrative enterprise.

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Sea water has been used to irrigate the crops since World War II (Boyko, 1967). Recent studies of sea water have been undertaken across a variety of crops. Miao (2003) reported the highest yield of spinach using electrodialyzed deep seawater at 5 dS/m. Sgherri et al. (2008) reported that the fruits picked from tomato plants irrigated with diluted seawater, produced berries with a higher nutritional value. Though sea water is rich in mineral nutrients, its application has not received much interest in growing vegetables in Korea.

Sea water contains 11 mineral nutrients out of 13 essential nutrients. However, its high concentration of sodium chloride causes salt stress to the plants. Therefore, the present study evaluates the effects of sea water treatment on the growth and yield characteristics of Chinese cabbage and radish.

Materials and Methods

Seeds of Chinese cabbage cv. 'CR Kaulbaechu' and Radish cv. 'Chamjoa' were sown in plastic 128 plug trays (54 cm in length x 24 cm in width) containing horticultural soil (High, Punong, Korea) in August 10, 2010. Seedlings of both crops were transplanted in the planting bed under plastic house in August 27, 2010 at KNU. Plant to plant distance was maintained at 30 cm and 15 cm in Chinese cabbage and radish, respectively. Sea water was taken from Goseung, Kangwon-Do with its electrical conductivity (EC) being 55 dS/m. Sea water was diluted at different concentrations (2.5%, 5%, 10%, 20%, 50% and 100% in v/v) with double distilled water (Millipore Elix 5). Sea water was applied to both crops using leaf spraying and root placement in every two weeks interval. Out of 20 plants per treatment, 10 plants were treated using leaf spray and the remaining 10 plants were treated using root application. For leaf spray, 50 ml and 30 ml of each treatment was applied in Chinese cabbage and radish, respectively. For root application, 200 ml and 100 ml of each treatment was applied in Chinese cabbage and radish, respectively.

Chinese cabbage and radish were harvested after 60 days of transplanting. In Chinese cabbage, growth characters including plant height (cm), leaves per plant (no.), leaf size (length and width, cm) and shoot fresh weight (g) per plant were measured. In radish, leaves number per plant, leaf length (cm), leaf weight (g) per plant, hypocotyls length and width (cm), hypocotyls weight (g) per plant and total root length (cm) were measured. The measurement of growth and yield characteristics were taken in 10 plants in both crops and descriptive statistics (mean and standard deviation) was used to analyze data (Microsoft Excel, Version 10).

Results and Discussion

Effect on growth and yield characteristics of Chinese cabbage

Sea water (SW) treatment on Chinese cabbage leaves affected its growth and yield characteristics (Table 1). Plant height was measured highest (30.3 cm) in 20% SW treated plants followed by 2.5% and 50% SW treated plants. Leaves number per plant was counted the highest (46.3) in 50% SW treated plants and the lowest (35.3) in control. The highest (36.3 cm) leaf length was measured in 50% SW treatment followed by 2.5% SW treatment (36.0 cm). Likewise, the highest (24.7 cm) leaf width was measured in plants treated with 5% SW followed by the plants grown under 50% (23.0 cm). Variation on shoot fresh weight per plant observed among the treatments. With increasing concentration of SW up to 50%, shoot fresh weigh was increased.

The shoot fresh weight per plant was highest (635.7 g) under 50% treated plants group and lowest was in control (398.0 g). Highest shoot fresh weight per plant in 50% SW treatment might be due to increase in leaf number and size promoted by enhanced mineral supplement through the stomatal aperture.

Table 1. Effect of sea water (SW) treatment in leaves on growth and yield of Chinese cabbage (*Brassica rapa* L*. ssp. campestris*)

Treatment	Plant height (cm)y	Leaves / plant (no)y	Leaf length (cm)y	Leaf width (cm)y
Control	29.3 ± 1.2	35.3 ± 5.5	32.0 ± 1.8	19.5 ± 0.5
2.5% SW	30.0 ± 2.0	39.6 ± 3.8	36.0 ± 3.5	19.5 ± 2.3
5% SW	28.3 ± 0.5	40.3 ± 1.2	35.5 ± 1.5	24.7 ± 4.1
10% SW	28.8 ± 0.5	39.6 ± 1.2	36.0 ± 1.5	20.8 ± 4.1
20% SW	30.3 ± 2.5	41.3 ± 5.1	33.9 ± 2.2	20.7 ± 0.3
50% SW	30.0 ± 1.0	46.3 ± 2.3	36.3 ± 3.2	23.0 ± 1.7
100% SW	28.6 ± 0.5	41.3 ± 6.4	35.8 ± 1.3	20.5 ± 1.3

yMean ± SD (n = 10)

Sea water treatment using root application and its effect on growth characters and fresh yield of cabbage are presented in Table 2. The highest plant height (28.3 cm) and leaves number (43.6) were recorded at the plants grown under 10% SW. Similarly, the highest leaf length (37.1 cm) and leaf width (21.1 cm) were measured under the plants treated with 10% SW. Shoot fresh weight per plant varied in all the treatments. Plants under 10% SW group produced the highest shoot fresh weight (602.9 g) per plant, whereas the lowest (398. 0 g) was in control (Table 2).

Table 2. Effect of sea water (SW) treatment in roots on growth and yield of Chinese cabbage (*Brassica rapa* L*. ssp. campestris*)

Treatment	Plant height (cm)y	Leaves / plant (no)y	Leaf length (cm)y	Leaf width (cm)y	Shoot fresh weight/plant (g)y
Control	26.3 ±1.2	35.3 ± 5.5	32.0 ± 1.8	19.5 ± 0.5	398.0 ± 60.0
2.5% SW	27.0 ± 1.0	40.3 ± 1.5	35.5 ± 1.8	21.1 ± 0.3	492.2 ± 34.7
5% SW	27.3 ± 1.2	36.6 ± 2.1	33.3 ± 1.5	20.0 ± 2.0	444.7 ± 33.8
10% SW	28.3 ± 3.2	43.6 ± 1.5	37.1 ± 1.3	21.1 ± 1.9	602.9 ± 42.5
20% SW	26.3 ± 4.9	40.0 ± 3.6	35.5 ± 4.1	20.0 ± 1.7	391.8 ± 60.2
50% SW	24.5 ± 1.5	41.3 ± 1.5	33.5 ± 0.5	18.5 ± 0.5	400.3 ± 72.3
100% SW	25.7 ± 1.5	38.3 ± 4.2	34.8 ± 2.0	18.7 ± 1.2	277.2 ± 63.8

yMean ± SD (n = 10)

Effect on growth and yield characteristics of radish

Spraying sea water in radish leaves also affected its growth and yield characters (Table 3). Leaf number per plant was highest (15.2) in 2.5% SW treated plants followed by control (15.0). The highest leaf length (39.6 cm) and leaf weight (100.0 g) per plant measured at 20% SW (100.0 g) treated groups. The highest hypocotyls length (7.5 cm) and width (4.7 cm) were recorded at 20% SW treated group. Hypocotyls weight per plant varied in all the treatments. The highest weight (65.0 g) of hypocotyls per plant was measured in 20% SW treatments followed by 2.5% (57.2 g) treatment. The total root length was the highest (28.8 cm) in 20% SW treated plants and the lowest (14.8 cm) in 2.5% treatment.

Table 3: Effect of sea water (SW) treatment in leaves on growth and yield of radish (*Raphanus sativus* L).

Treatment	Leaf number	Leaf length (cm)	Leaf weight/ plant (g)	Hypocotyl length (cm)	Hypocotyl width (cm)	Hypocotyl wt (g) /plant	Total root length (cm)
Control	15.0 ± 1.9	38.0 ± 3.3	96.4 ± 23.3	6.5 ± 1.3	3.9 ± 0.6	53.5 ± 25.9	21.2 ± 2.4
2.5% SW	15.2 ± 1.3	37.8 ± 4.6	86.7 ± 43.6	5.6 ± 1.8	3.7 ± 1.4	57.2 ± 25.7	14.8 ± 2.7
5% SW	14.0 ± 1.0	38.9 ± 2.1	90.3 ± 27.5	6.1 ± 1.2	3.7 ± 1.3	45.5 ± 31.5	18.9 ± 4.5
10% SW	14.8 ± 2.4	37.2 ± 3.5	88.9 ± 47.2	6.1 ± 2.0	3.0 ± 1.4	40.2 ± 33.1	15.7 ± 5.4
20% SW	14.8 ± 1.5	39.6 ± 3.6	100.0 ± 34.1	7.5 ± 3.0	4.7 ± 1.4	65.0 ± 35.0	28.8 ± 5.5
50% SW	14.0 ± 0.7	35.7 ± 1.8	83.8 ± 18.1	6.0 ± 1.3	4.0 ± 1.2	49.6 ± 28.7	15.1± 1.0
100% SW	14.0 ± 2.8	38.9 ± 4.0	89.2 ± 43.9	6 .0± 2.1	3.7 ± 1.6	46.2 ± 32.5	16.8 ± 3.0

yMean ± SD (n = 10)

Root application of sea water in radish and its effect on growth and yield are presented in Table 4. In all the treatments, 10% SW treatment showed the highest (14.6) leaf number per plant and leaf length (41.8 cm). Variation in leaf weight per plant noticed in all the treatments. The highest (102.4 g) leaf weight was recorded in 10% SW treatments followed by 5% (89.0 g). With increasing level of sea water treatment up to 10%, leaf weight was progressively increased.

Table 4. Effect of sea water (SW) treatment in root on growth and yield of radish (*Raphanus sativus* L).

Treatment	Leaf number	Leaf length (cm)	Leaf weight/ plant (g)	Hypocotyl length (cm)	Hypocotyl width (cm)	Hypocotyl wt /plant (g)	Total root length (cm)
Control	12.4 ± 0.5	39.3 ± 1.9	68.8 ± 16.1	8.0 ± 1.0	5.1 ± 1.2	108.2 ± 54.2	22.0 ± 4.5
2.5% SW	13.0 ± 3.9	41.2 ± 3.7	74.5 ± 34.3	8.2 ± 2.8	4.9 ± 1.4	54.7 ± 48.9	20.0 ± 6.9
5% SW	12.8 ± 1.9	39.9 ± 6.3	89.0 ± 31.2	7.7 ± 1.0	5.0 ± 1.3	104.0 ± 44.9	21.2 ± 3.7
10% SW	14.6 ± 0.9	41.8 ± 2.7	102.4 ± 26.6	8.6 ± 2.2	5.4 ± 1.3	129.4 ± 71.3	22.8 ± 4.0
20% SW	12.8 ± 2.0	40.4 ± 3.0	87.86 ± 25.5	7.5 ± 1.5	4.7 ± 0.4	83.3 ± 30.8	20.0 ± 3.3
50% SW	12.8 ± 1.3	37.8 ± 3.7	74.6 ± 22.5	7.7 ± 1.8	4.5 ± 1.2	84.5 ± 68.8	18.2 ± 1.8
100% SW	12.2 ± 1.3	38.3 ± 4.9	71.6 ± 20.1	6.5 ± 1.2	3.7 ± 0.6	41.52 ± 26.1	19.6 ± 2.7

yMean ± SD (n = 10)

Similarly, the highest hypocotyls length (8.6 cm) and width (5.4 cm) were measured in plants under 10% SW treatments. Hypocotyls weight per plant varied among the treatments. Sea water treatment with 10% in radish produced the highest (129.4 g) hypocotyls weight followed by control (108.2 g).

Conclusion

This study investigated the diluted sea water effects on growth and yield characteristics of Chinese cabbage and radish crops. Using leaf spray, Chinese cabbage and radish crops grown with 50 % and 20 % SW showed better vegetative growth and yield. SW exceeding the 50% and 20% concentration in Chinese cabbage and radish, respectively, tend to cause salt stress to the plants. In both varieties, 10 % diluted SW exhibited better growth and yield using root application. In sea water treatment, supplement of mineral nutrients through leaf surface to the both crops might increase the growth and yield. In addition, further study on the effects of sea water on mineral composition and qualitative characters in both crops is recommended.

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Effect of seawater on growth of four vegetable crops
- Lettuce, leaf perilla, red pepper, cucumber –

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Keywords: Organic agriculture, seawater, salt tolerance, salinity, vegetable crops

Abstract

The effects of seawater on growth of lettuce(Lactuca sativa L.), leaf perilla(Perilla frutescens var. japonica Hara), red pepper(Capsicum annuum L.) and cucumber(Cucumis sativus L.) seedlings were investigated in the glass greenhouse. These effects were studied on seedlings, and diluted seawater (1%, 5%, 10%, 20%, 50%, 100% v/v) was sprayed enough on leaves. The tested four vegetable crops have well grown up to 10% diluted seawater, but the tested vegetable crops were damaged from increasing salt levels. Of these, lettuce was provided salt-tolerant vegetable crop and red pepper was considered salt-sensitive vegetable crop. The salt tolerance of vegetable crops is different between crops and complicated because of additional detrimental effects caused by accumulated ions or specific ion toxicities in their leaves. These results show that agricultural use of seawater may be benefit crop cultivation in organic farming system as well as in conventional farming system.

Introduction

Since 2000, Korean government was planned to achieve environmental-friendly agricultural production goal of 10% by 2015. Organic farmers utilized also a various harmless natural resources for all natural organisms in all kind of environments. Of all natural resources on earth, seawater does not reduce and it is also easily available anywhere around the world. More than 70% of the earth surface is covered by seawater (Natasa et al., 2008). Saline water was previously considered unusable for plant cultivation, but new research during the past two decades has helped bringing into practice some irrigation (Hamdy et al., 1993; Qadir et al., 2001). There are many plants such as rice and other halophytes that grow under saline conditions. In seawater, sulphur (S), magnesium (Mg), kalium (K), calcium (Ca) and many other trace elements with biological significance are highly contained. These nutrients are essential to plant growth. Korean farmers were used salt and seawater to improve quality of agricultural products and to control weed especially in orchard. In recent, agricultural use of seawater or solid is rapidly increased for crop growth regulation and pest control. The experimental research work in Korea was started in 2010. We will here discuss the results of first year's experiments about effects of seawater on growth of major four vegetable crops in Korea – Lettuce, leaf perilla, red pepper and cucumber.

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Materials and methods

This experiment was conducted from September to October 2010 under glass greenhouse at the National Academy of Agricultural Sciences. The seawater used in this experiment was sampled from the Yellow Sea. The properties of seawater have been presented in Table 1. Seawater from Yellow Sea was diluted at six different concentrations of 1%, 5%, 10%, 20%, 50% and 100% in v/v. The diluted seawater was prepared direct before the start of seawater treatment. These diluted seawater was sprayed 3 times to four vegetable crops - lettuce (*Lactuca sativa* L.), leaf perilla(*Perilla frutescens var. japonica* Hara), red pepper(*Capsicum annuum* L.) and cucumber(*Cucumis sativus* L.) - on leaves in every 7 days interval. The seedlings are prepared in the greenhouse. They are grown in plastic pots for 2 ~3 weeks to obtain 2 leaves.

Table 1. Chemical properties of seawater in March 2010 (unit: ㎎/ℓ)

Sample site	pH	EC ($dS \cdot m^{-1}$)	T-N	NH_4-N	NO_3-N	T-P	PO_4-P	Na^+	Cl^-	SO_4^{2-}
Seosan	7.92	44.7	1.9	n.d*	0.99	0.121	0.044	10,174	16,696	2,440

*n. d : non detected

Four vegetable crops were harvested by cutting down after 1 weeks treated with 3 times spray on leaves, and then we observed crop damage and measured plant height(cm) and fresh weight(g plant^{-1}) as a impact factor on crop growth.

Results and discussion

The plant height and fresh weight yields are shown in Table 2. There are six different levels to utilizing seawater. Growing vegetable crops with diluted seawater are depending on the salt levels.

Table 2. Effect on the growth of four vegetables treated with four dilutions of seawater

Seawater	Plant height (cm)				Fresh weight (g plant^{-1})			
	lettuce	Perilla	Red pepper	Cucumber	lettuce	Perilla	Red pepper	Cucumber
0%	14.0a	9.8a	16.0a	21.3a	9.07a	4.26a	3.95a	7.87a
1%	13.7a	11.5a	11.5bc	17.4a	9.41a	6.41b	2.68b	10.09b
5%	14.3a	10.3a	13.5b	21.2a	10.16a	5.53b	3.38a	11.27b
10%	14.3a	9.2a	15.3a	18.2a	9.38a	3.75a	4.22a	10.13b
20%	14.2a	7.5b	15.5a	21.2a	8.85a	3.35a	4.06a	10.77b
50%	14.0a	-	12.b	19.5a	7.25b	-	3.62a	5.93c
100%	14.3a	-	8.5c	-	6.06b	-	1.95b	-

Values within each columns denoted by same letter are not significantly different at *p* = 0.05%

The relative salt-sensitive crops are leaf perilla(*Perilla frutescens var. japonica* Hara) and cucumber(*Cucumis sativus* L.). These crops cann't utilize seawater at higher salt levels. However, lettuce(*Lactuca sativa* L.) has high salinity tolerance. This crop in the 100% seawater treatment reached a height of 14.3cm better than a height of 14.0cm by control plot. The fresh weight yield, however, results in an increase up to 10% diluted seawater, but in a reduction from over 20% diluted seawater. Leaf perilla(*Perilla frutescens var. japonica* Hara) was an increase in the growth and yield up to 5% seawater concentration, and then decreased with increasing salt levels. Leaf perilla seedlings were died over 50% seawater concentrations. The plant growth of red pepper(*Capsicum annuum* L.) and cucumber(*Cucumis sativus* L.) seedlings are decreased in all diluted seawater concentration, whereas the fresh weight yield was increased up to 20% seawater levels. The use of water with still higher salt levels and even exceeding that of seawater for irrigation of various food and crops has been reported by many scientists including Aronson(1989), Shahida and Naghma(1989), Yensen(1988), and others. Salinity generally affects the growth of plants by either by producing an ion excess or by water deficits in the expanded leaves(Greenway and Munns, 1980).

Conclusion

Organic vegetable cultivation using seawater should be considered that for diluted concentration. Salt tolerance is different depending on vegetable crops. High significant interaction between vegetable growth and seawater concentrations was observed. Crop growths are generally inhibited by extreme high concentration of seawater, but promote crop growth by optimal range of diluted seawater.

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Optimum application rate of mixed organic fertilizer for organic cultivation of welsh onion under greenhouse conditions

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Key words: welsh onion, organic cultivation, organic fertilizer

Abstract

This study was conducted to investigate the optimum application rate of mixed organic fertilizer (MOF) for the organic cultivation of welsh onion under greenhouse conditions. MOF was applied to 0%, 50%, 100% and 150% levels of recommended nitrogen by soil testing compared with chemical fertilizer (nitrogen, phosphate and potash respectively). Available P_2O_5 (Av. P_2O_5) and electrical conductivity (EC) of soil after the experiment was increased in proportion to the increase of MOF, and NO_3-N was especially lowered to a level of 50% as opposed to 100% of chemical fertilizer. The rates of nitrogen utilization with welsh onion plants, at 150 days after transplanting, were decreased in proportion to the increase of MOF. Thus the rate of a level of 150% was lower than any other treatments. Fresh yield by MOF application showed no significant differences compared with chemical fertilizer, but the 50% level of MOF showed a tendency to decrease by 8%. Finally, with respect to Av. P_2O_5, EC and NO_3-N in the soil after experiment and resulting fresh yield, optimum application rates of MOF under greenhouse conditions were almost at the level of 100%.

Introduction

Recently, consumer appreciation of organic farming and vegetables is changing. Consumers' demands on environment-friendly products are increasing as well. Organic agriculture equates to farming technology in which no synthetic or artificial chemicals, such as chemical fertilizer or organic synthetic agricultural chemicals, are used (MAFF, 2008; Choi, 2006). The cultivation acreage of the certified environmentally friendly agriculture of Gyeonggi-do was, in 2006, 5,173ha and this increased to 6,117ha in 2007, and then to 6,652ha in 2008 (NAQS, 2008). The cultivation acreage is due to commensurately increase in the future, and large amounts of organic fertilizers are needed to control plants growth and related intensive farming. Application of organic fertilizer over the optimum/maximum rate causes environmental pollution, and can also result in misuse of organic fertilizer with extra farm expenditure in addition. The optimum application rate and effects of organic fertilizer regarding organic cultivation are necessary, in respect of soil management for sustainable and environmentally friendly precision agriculture. Studies have also been conducted on the effects of organic fertilizer on lettuce and crown daisy (Kim *et al*., 1987), radish and chinese cabbage (Lim *et al*., 1979; Lim *et al*., 1992), however the effects of organic fertilizer on welsh onion had not as yet been investigated.

Materials and methods

Mixed organic fertilizer (MOF) was applied to 0%, 50%, 100% and 150% levels of recommended nitrogen by soil testing from plot of chemical fertilizer (CF) - mixed nitrogen, phosphate and potash. Also, chemical fertilizer without nitrogen (CFWN) which means not applied nitrogen, non fertilizer were treated for N uptake amount, and N utilization rate (%). The application rate of nitrogen in plot of MOF 100% and plot of chemical fertilizer were the same as each other. MOF was applied as a basal dressing without chemical fertilizer. The chemical ingredients of MOF consisted of nitrogen 45.6g kg^{-1}, phosphate 21.5g kg^{-1}, potash 13.1g kg^{-1}, and organic matter 783g kg^{-1}, respectively (Tab. 1).

Tab.1: Chemical properties of the mixed organic fertilizer used

T-N (g kg-1)	P_2O_5 (g kg-1)	K_2O (g kg-1)	OM (g kg-1)	OM/N	Water content (g kg-1)
45.6	21.5	13.1	783	17.2	147

* MOF consisted of castor meal 70%, rice bran meal 15%, and amino acid by-products 15%, respectively, and that was allowed for organic cultivation in Korea

Test variety "Heukgeumjang" was transplanted on April 30th 2008 to a greenhouse after mulching with punched (20*20) black P.E. film, and harvested September 30th 2008. Transplanted welsh onion seedlings were raised in 200 hole plug trays for a duration of 50 days.

Results and Discussion

In the greenhouse cultivation, the rates of nitrogen utilization on welsh onion plants after 150 days after transplanting decreased in proportion to the increase of the MOF 50% level to 150% level (Tab. 2). As a result the rate of the 150% level was lower, with 18.6%, than any of the other treatments which ranged between 23.8-28.4%. The rate of nitrogen utilization on MOF N 100% was similar to chemical fertilizer.

Tab. 2: N utilization rates of welsh onion under greenhouse condition

Treatments	Dry weight (kg ha-1)	N contents of dry matters(%)	N uptake amount(kg ha-1)	N utilization rates (%)
MOF N 50%	6,820	2.22	151.3 b	28.4
MOF N 100%	7,430	2.23	166.0 a	25.2
MOF N 150%	7,500	2.26	169.6 a	18.6
CF	7,400	2.22	164.2 a	23.8
CFWN	6,450	2.05	132.3 c	-
Non fertilizer	6,420	2.03	130.4 c	-

* N utilization rates : ((N uptake amount of treatments-N uptake amount of CFWN)/N applied amount of treatments) x 100

Plant height, stem length, stem width, and fresh yields of welsh onion consequent to MOF treatments showed no significant differences compared to those treated with chemical fertilizer (Tab. 3). But, plant height, stem length and stem width of MOF treatment was inclined to increase in proportion to the MOF increment. Fresh yields showed a tendency to increase from 4,994kg in MOF N 50% level to 5,511kg in MOF

N 150% level. Also, the 50% level did show a tendency to decrease by 8% compared to that of chemical fertilizer.

Tab. 3: Growth parameters and yields of welsh onion

Treatments	Plant height (cm)	Stem length (cm)	Stem width (mm)	Weight per 1plant (g)	Marketable yield (kg ha-1)	Index
MOF N 50%	84.3	29.0	16.4	122.4	49,940	92
MOF N 100%	86.2	29.9	17.1	133.1	54,580	101
MOF N 150%	87.6	30.3	17.3	134.4	55,110	102
CF	85.8	29.3	17.2	132.5	54,270	100
CFWN	82.0	27.0	15.7	116.0	47,160	87
Non fertilizer	82.3	27.9	15.2	115.8	46,960	87

Av. P_2O_5, EC and NO_3-N of after-experiment's soils were increased in proportion to the increase from MOF N 50% to MOF N 150% level (Tab. 4). Av. P_2O_5 of after-experiment's soils was lower in MOF 50% level than that of before experiment, and that was similar in MOF 100% level to that of before experiment. EC of after-experiment's soils was inclined to increasing in proportion to the increase of MOF and NO_3-N was especially lower in 50% level with 38mg kg^{-1} compared to those of 100% level with 66 mg kg^{-1} and chemical fertilizer with 79 mg kg^{-1}.

Tab. 4: Chemical properties of soil after experiment

Treatments	pH (1:5)	OM (g kg-1)	Av. P_2O_5 (mg kg-1)	Ex. Cations (cmol kg-1)			EC (dS m-1)	NO_3-N (mg kg-1)
				K	Ca	Mg		
Before experiment	6.7	17	304	0.97	9.1	3.3	0.28	8
MOF N 50%	6.5	17	290 c	0.13	9.4	3.1	0.65 bc	38 c
MOF N 100%	6.5	17	301 b	0.19	9.0	3.1	0.73 b	66 b
MOF N 150%	6.4	17	334 a	0.26	9.0	3.2	1.12 a	122 a
CF	6.3	17	310 b	0.37	8.8	2.9	0.83 b	79 b
CFWN	6.6	17	307 b	0.34	9.0	2.9	0.59 c	23 c
Non fertilizer	6.6	17	277 d	0.11	8.7	2.8	0.56 c	26 c

Conclusions

The rate of nitrogen utilization was lowest in N 150% level than in any other treatments, and that of MOF N 100% was similar to the chemical fertilizer. NO_3-N particularly decreased in the 50% level compared with the MOF N 100% level and chemical fertilizer. Thus the MOF N 50% level was supposed to cause deficiency about the supply capacity of nitrogen. Fresh yields of MOF levels were inclined to increase in proportion to the increase of MOF, but MOF N 50% level showed a tendency to decrease by 8% compared to that of chemical fertilizer. Considered of Av.

P_2O_5, EC and NO_3-N of after-experiment's soils and fresh yields of welsh onion, optimum application rate of mixed organic fertilizer was suggested that it may be nearly MOF N 100% level under greenhouse cultivation and the calculation formula for the optimum application of MOF was as follows: NARST ÷ NCMOF/100, NARST : Nitrogen application rate (kg 10^{-1}) by soil testing, NCMOF : Nitrogen content (%) of MOF.

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Chinese cabbage varieties resistant to clubroot in Korea

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Keywords: Chinese cabbage, Clubroot, Resistant variety

Abstract

Clubroot is prevalent in continuous cropping area of Chinese cabbage and radish. The resistance test to clubroot was performed for the screening of resistant varieties among major varieties of domestic and overseas origins from 1998 to 2000. The results are summarized as follows: Three Chinese cabbage varieties including 'CR607' showed resistance to clubroot in 1998, two Chinese cabbage varieties including 'CR902' had resistance to clubroot in 1999, and six Chinese cabbage varieties including 'CR power' were resistant to clubroot in 2000.

Introduction

Recently, clubroot (pathogen: *Plasmodiophora brassicae* Wornin) began to wreak havoc on Chinese cabbage crops in several major producing districts including Yeoncheon, Yangju, and Pyeongtaek. In Korea, an initial record of clubroot goes back to 1920 (Report on Studies on the Central Agricultural Examination Station, 1928). Clubroot had never caused such grave concern until its outbreak gathered considerable momentum 5-6 years ago, and it is now widely seen as the most serious disease to threaten domestic cultivation of Chinese cabbage and radish. Since the late 1990s, domestic studies on clubroot, albeit on a small scale, have been mainly centered upon resistance tests or selection of preventive medicine (Ryu, J. D. et al. 1995, Oh, J. H. et al. 1997, Kim, D. W. et al. 1997 & Sim, H. S. et al. 1998). Currently, there is almost no study specifically geared towards the screening of resistant variety against clubroot. To expand our understanding of the outbreak and prevention of clubroot among Chinese cabbage, we conducted resistance tests for three years from 1998 through 2000 in conjunction with the National Academy of Agricultural Science, Gyeonggi-do Agricultural Research & Extension Services, and Gangwon-do Agricultural Research & Extension Services, with the following results regarding the screening of Chinese cabbage varieties resistant to clubroot.

Materials and methods

From 1998 through 2000, we undertook a clubroot resistance test in Pyeongtaek and Yeoncheon, two major Chinese cabbage production centers in Gyeonggi Province. In 1998, we tested 18 varieties of domestic and foreign origins (i.e. bezoar) among spring crops under greenhouse cultivation in Pyeongtaek and 36 varieties of domestic and foreign origins (i.e. precocious chuseok cabbage) among autumn crops under open field cultivation in Yeoncheon. In autumn 1999, we tested 16 varieties (strains) such as CH208 under greenhouse cultivation in Pyeongtaek and under open field cultivation in Yeoncheon. In spring 2000, we tested 12 varieties such as CR

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power under greenhouse cultivation in Pyeongtaek, and then in autumn we examined the same varieties under open field cultivation in Yeoncheon. In 1998, we directly collected varieties from a leading domestic seed company, but in 1999 and 2000 our seed collection was collectively sourced from the Dept. of Pathology at the National Academy of Agricultural Science. The seedling period amounted to 30 days for spring cultivation and 25 days for autumn cultivation. For identification of disease outbreak, we checked the distribution rate of knot on a 30-week-old root around 60 days after the formal planting of Chinese cabbage, which was classified into five levels (Shim, H. S. et al. 1998): 0- no knot, 1- 1-10% of knot per head of cabbage (weight: 10), 2- 11-30% of knot per head of cabbage (weight: 30), 3- 31-60% of knot per head of cabbage (weight: 60), and 4- 61-100% of knot per head of cabbage (weight: 100). We calculated the degree of disease outbreak according to the following formula: ∑ (The sum of populations per level × weight)/number of populations under examination.

Results and discussion

In 1998, we looked at the outbreak of clubroot by variety or strain in Pyeongtaek and Yeoncheon, and the result is as shown in Tab. 1. There were no perfect resistant varieties, but CH211 and CR607 strains, bezoar, and Kigokoro 65 (黃ごころ65, Japanese variety) were resistant to clubroot in Pyeongtaek while 19 varieties such as Sinhwang showed resistance to clubroot in Yeoncheon. CR607 strains, bezoar, and Kigokoro 65 had resistance to clubroot in both areas, and those varieties under massive domestic cultivation were all susceptible to clubroot. The outbreak of clubroot by variety in 1999 is as shown in Tab. 2. In Pyeongtaek, CR 902 and CR green were among the resistant varieties despite regional prevalence of clubroot. In Yeoncheon, 10 varieties (strains) such as CH 240 showed resistance to clubroot. Overall, CR 902 and CR green proved to be resistance varieties in both areas.

Tab. 1: Clubroot outbreak by variety (strain) in different cultivation areas (1998)

Variety & Strain	Pyeongtaek		Yeoncheon		Variety & Strain	Pyeongtaek		Yeoncheon	
	Outbreak Degree	SD	Outbreak Degree	SD		Outbreak Degree	SD	Outbreak Degree	SD
Sinhwang	24.1	41.37	1.5	1.80	Black Pearl Cabbage	-	-	55.4	27.87
Hwanghwang65	12.5	19.52	27.2	26.88	Black Rose Cabbage	-	-	44.0	12.94
CD3	32.3	49.45	3.5	3.91	Gold Pearl Cabbage	-	-	34.7	27.46
CD4	29.3	40.51	3.3	3.25	9400789	-	-	1.6	1.01
CD5	23.6	33.49	0.3	0.58	CR570	-	-	4.6	0.51
CD6	12.8	18.84	0.7	0.58	CR11	-	-	3.8	4.16
CH179	21.9	26.29	6.2	3.63	CR12	-	-	3.8	3.21
CH208	32.7	54.23	2.3	2.44	CR13	-	-	4.9	3.27
CH211	3.7	3.20	47.8	2.57	CR14	-	-	5.3	7.14
Gusung	59.3	25.32	53.8	16.18	Tasty Cabbage	-	-	47.3	14.28
CR1	10.9	17.78	2.6	2.12	Autumn Yellow Cabbage	-	-	36.8	11.02
CR2	24.1	39.54	5.1	4.35	Olympic Cabbage	-	-	49.6	8.79
CR607	6.5	6.22	2.7	1.54	CH240	-	-	46.3	13.16
Uhwang	4.7	3.73	9.6	9.81	CH242	-	-	58.9	19.29
Kigokoro 65	5.3	6.67	3.2	2.55	60-day-old Cabbage in Late Autumn	-	-	51.3	13.70
012 Napa Cabbage	37.1	49.56	4.8	7.10	Precocious Garak Cabbage	-	-	56.5	13.97
Alpine Summer Cabbage	75.6	16.48	46.1	12.93	Garakshin Cabbage No. 1	-	-	62.3	6.82
Yellow Spring Cabbage	55.6	48.29	-	-	Samjin Cabbage	-	-	66.3	18.00
Gangse Cabbage	71.3	39.62	-	-	Geumgarak Cabbage	-	-	36.5	31.50

The outbreak of clubroot by Chinese cabbage variety (strain) in 2000 is as shown in Tab. 3. CR power, CR ansim, CR green, CH208, CR 481, and CR singsing had resistance to clubroot in Pyeongtaek and Yeoncheon. During the three-year experiment, CH 208 displayed a considerable variation in its resistance to clubroot depending upon the year and test place. In Pyeongtaek and Yeoncheon, CR green belonged to resistance strains for 1999 and 2000, thus it deserves to be listed among the resistant varieties.

Tab. 2: Clubroot outbreak by variety (strain) in different cultivation areas (1999)

Variety & Strain	Pyeongtaek		Yeoncheon	
	Outbreak Degree	SD	Outbreak Degree	SD
CH208	15.2	13.23	10.5	16.93
CH211	36.4	33.07	2.9	2.85
CH240	53.7	32.59	0.0	0.00
CH242	49.7	17.62	0.7	1.21
80018	17.4	14.79	0.0	0.00
80028	26.0	18.40	2.9	3.44
80082	44.6	22.30	40.3	47.94
70553	14.8	18.47	1.1	1.91
70556	11.3	13.21	0.7	1.15
CR Singsing	15.1	24.27	14.7	23.65
CR 902	5.5	7.15	9.9	6.60
CR green	2.0	2.63	0.0	0.00
Gaenari	60.2	35.26	10.4	11.59
Hucgangmi	69.1	18.48	9.9	9.24
CCX 01	39.6	40.55	12.2	11.11
CCX 02	23.7	17.95	51.9	27.20

But, such resistance can be disrupted by regional race, and clubroot resistance is reported to vary according to regional race (Kuginuki et al. 1999). In a three-year study on the outbreak and prevention of clubroot, such disparity in regional race was found among major consecutive cultivation areas in Gyeonggi Province, and this study also confirms such gap in disease resistance according to regional race. There is no perfect variety resistant to the entire race, thus it is necessary to screen a resistant variety suitable for regional race.

Tab. 3: Clubroot outbreak by variety (strain) in different cultivation areas (2000)

Variety & Strain	Pyeongtaek		Yeoncheon	
	Outbreak Degree	SD	Outbreak Degree	SD
CR Power	1.1	1.96	0.9	1.01
TB-801	1.1	1.03	77.0	8.84
CR Ansim	0.6	0.67	0.0	0.00
CR Hagae	18.8	31.93	0.0	0.00
CR Green	6.0	10.45	0.0	0.00
CR Saerona	0.3	0.52	67.9	14.90
CH 208	9.5	13.80	0.0	0.00
DH 001	15.6	18.39	84.6	13.51
DH 003	12.9	12.10	1.4	1.27
DH 002	8.4	10.58	97.0	0.42
CR 481	2.2	3.06	0.5	0.44
CR Singsing	0.4	0.75	3.2	4.44

Resistance to clubroot is controlled by a single dominant gene (Kuginuki et al. 1999 and Kim, D. W. et al. 1999), and the CR (Japanese clubroot-resistant) strains usually show resistance to clubroot.

Conclusion

From 1998 through 2000, we undertook a clubroot resistance test to major varieties of domestic and foreign origins for effective prevention of clubroot which was so commonplace in major production centers of Chinese cabbage.

As a result, some varieties proved to be resistant to clubroot, including three varieties such as CR607 in 1998, two varieties such as CR 902 in 1999, and six varieties such as CR power in 2000. These varieties would be promising to grow Chinese cabbage with organic cultivation in the area infested with club root diseases.

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Effect of biofertilizers and organic manures on quality and fruit yield of tomato (*Solanum lycopersicum Mill.*)

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Key words: Tomato, Organic manure, Vermicompost, Biofertilizers.

Abstract

A field experiment was conducted in the summer season of 2008 at experimental farm of Department of Vegetable Science, Dr. YS Parmar University of Horticulture and Forestry, Nauni- Solan, Himachal Pradesh (Indian Himalayas) to evaluate the effect of biofertilizers and organic manures on various quality characters and yield of tomato fruit as compared to recommended dose of NPK and control. No significant effect was observed regarding number of locules per fruit. However, shelf life and pericarp thickness were significantly influenced by Azotobacter application. Amongst the organic amendments application of Vermicompost recorded the highest fruit yield. highest fruit yield followed by Azotobacter. It was also observed that highest fruit yield was obtained through NPK applications, however it was at par with Vermicompost treated plots.

Introduction

Tomato being an exhaustive crop requires large quantities of organic and inorganic fertilizers. Application of chemical fertilizers alone supplies one or two nutrients to the crop in question but their continuous supply for years is causing environmental pollution, which has become an international concern. Use of organic growing media offers a valuable alternative over commercial fertilizers due to their good water holding capacity, proper aeration and nutrient absorption. Biofertilizers help in improving biological activities of desired microorganisms in the soil and help to improve plant growth and yield. Therefore, their use in soils of low fertility and for those areas and systems that use low amount of fertilizers is more relevant. Biofertilizers are also useful in sustainable agriculture and organic farming. Present study was conducted in order to find out the effectiveness of biofertilizers and organic manures on various quality characters and fruit yield of tomato.

Materials and methods

Experiment was laid out in summer season of 2008. It comprised of 10 treatments viz., FYM (T_1), vermicompost (T_2), poultry manure (T_3), green manuring with cowpea (T_4), *Azotobacter* (T_5), *Azospirillum* (T_6), PSB (T_7), *Mycorrhiza* (T_8), NPK (T_9), and control (T_{10}). *Azospirillum*, *Azotobacter* and Phosphate solubilizing bacteria each @ 5 kg/ha and *Mycorrhiza* @ 12.5 kg/ha were evenly applied to the respective plots as soil

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[2] As Above

[3] As Above

application. Organic manures were applied directly to the soil based upon the nitrogen content of FYM which was applied @ 25 t/ha before transplanting. Vermicompost was applied @ 10 t/ha while, Poultry manure was applied @ 12 t/ha. Half of Nitrogen and whole of phosphatic and potassic fertilizers were applied at the time of transplanting and remaining half of nitrogen was applied after 25 days of transplanting. These were applied through CAN (25% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O) @ 100, 75, 55 kg/ha respectively. Experiment was laid out in a Randomised Block Design with four replications of each treatment having a plot size of 2.7 x 2.1m^2. Observations were recorded on number of locules per fruit, pericarp thickness, shelf life, total soluble solids content, number of fruits per plant, fruit yield per plant, per plot and per hectare.

Results and Discussion

Number of locules per fruit is an important fruit character which may be linked to number of seeds per fruit. Usually, lower number of locules per fruit is preferred, however in the present studies there was no significant effect observed of various treatments on number of locules per fruits. Maximum number of locules per fruit was recorded by applying FYM while, minimum (2.34) number was recorded by Green manuring with cowpea. Thicker pericarp is preferred in view of long distance transportation as the fruits having thicker pericarp are considered to have longer shelf life. Maximum pericarp thickness of 6.72 mm was recorded in T_5 (*Azotobacter*) and minimum value (5.91 mm) was obtained in T_9 (NPK). Similar results were observed by Kumar and Sharma (2006) and Shukla *et al*. (2006) who also observed more pericarp thickness by the use of organic manures and biofertilizers. Shelf life plays an important role in keeping quality of the fruits. Fruits having longer shelf life can be transported to distant markets whereas fruits with poor shelf life are vulnerable to long distance transport. Application of *Azotobacter* (T_5) proved out to be superior among all the treatments with a shelf life of 10.4 days, lowest value (8 days) was recorded in T_{10} (Control). Difference in the shelf life of fruits may be attributed to high firmness and thicker pericarp of the fruits obtained with biofertilizer application. Chaurasia *et al*. (2001) also observed longer shelf life of tomato fruits with *Azotobacter* inoculation. Highest value for TSS was obtained through FYM application as compared to minimum obtained with no fertilizer application i.e. control. Accelerated mobility of phytosynthates from source to sink, enhanced metabolism of carbohydrates as influenced by growth hormones might have resulted in higher total soluble solids content. Youssef *et al.* (2001) and Prabakaran and Pitachi (2002) have also reported increased total soluble solids content with application of different sources of organic manures. Yadav *et al*. (2004) also observed an increase in total soluble solids content with FYM application. Maximum number of fruits per plant (21.02) was obtained in T_9 (NPK) and lowest number of fruits per plant (14.5) was recorded in T_{10} (control). Enhanced accumulation of carbohydrates in the presence of high nitrogen increases growth, number of fruits per plant and ultimately yield. The findings are in line with those of Reddy *et al.* (2002) and Bharkad *et al*. (2005) who reported maximum number of fruits per plant with recommended dose of NPK. Similarly, maximum fruit yield per plant (1078.27 g), per plot (22.64 kg) and per hectare (399.33q) was obtained through NPK application. Increased yield as compared to other treatments through NPK application may be attributed to optimum fertility conditions. Optimum supply of nutrients have led to prolific plant growth and better root development leading to extensive vegetative growth, more number of fruits per cluster and increased fruit weight thereby resulting in higher fruit yield. These finding are in conformity with those of Rastogi *et al*. (1978), Srinivas and Prabhakar (1982), and Yadav *et al*. (2004).

Conclusion

In the present investigation, it can be concluded that the application of biofertilizers and vermicompost will give good quality fruits and high yield of tomato in the Indian Himalayas.

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Evaluation of Populations of squash (*Cucurbita moshata L.*), under biodynamic management and participatory genetic breeding, in Botucatu-SP, Brazil.

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Key words: Agrobiodiversity, Cucurbitaceae, mass selection, biodynamic agriculture

Abstract

The squash (Cucurbita moshata), plant of American origin, it is cultivated in many states in Brazil, mainly by familiar farmers. There is a great biodiversity of genetic material. This plant is used for human and animal feeding. The aim of this work is to evaluate the income and the quality of fruits of one kind of squash, with the participatory approach and through the mass selection of four populations in three generations, in a biodynamic familiar farm in the Botucatu city in São Paulo state-Brazil. There were two experiments comparing the original seed and three cycles of selection, one in September (2009) and another in November (2009). For such, this assay was conducted through an experimental design of randomized blocks, with seven repetitions. We evaluated the following items: Average number of fruits per plant; average weight of the fruits; total length of the neck and the bulge, and diameter of the neck and the bulge. The results of the three cycles of selection indicate an increase in the frequency of plants with longer and fine fruits. It is observed a lesser frequency of plants with undesirable format of fruits.

Introduction

The squash (*Cucurbita moshata*), plant of American origin, is part of the tradition of old civilizations that colonized America and it is cultivated in many states in Brazil, mainly by familiar farmers. There are a great biodiversity of genetic material. This plant is used for human and animal feeding. According to FAOSTAT 2009 the distribuition of squash and pumpkin in the world is: China- 353.000 ha, Cameroon - 110.000, Cuba – 66.000, Russia – 54.000, Egypt – 40.000, total amount in the world – 1.556.000 há.

According to IBGE 2006, there are nine thousand organic gardeners in Brazil. While in Europe the legislation for organic and Demeter products prohibits the use of conventional agriculture seeds, here in Brazil, when we talk about vegetable seeds there are few options at the market. It is very important to research, develop and produce new seeds adapted to the organic cultivation.

The aim of the present work is to evaluate the income and the quality of fruits of one kind of squash, with the participatory approach and through the mass selection of four populations in three generations, in a biodynamic familiar farm in the Botucatu city, in São Paulo state, Brazil.

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Materials and methods

According to Paterniani 1978, simple massal selection consists in the choice of the best plants for harvest occasion and use of their seeds in the fields for the next generation. The parental control is made only through the feminine progenitor, once the male gametes come from every population. The stratified massal selection is a system used to prevent soil heterogeneity from interfering in the results. The advantages of this method are the assessment of a large number of plants, low cost and speed. Its efficiency depends on the existence of genetic variability and low environmental variation. This method is more efficient for qualitative characteristics selection

The aim of participatory breeding is to reach a collective process which enhances the farmers knowledge about management and product quality, allied to the knowledge of breeder selection techniques (Boef *et al* 2007).

The experiment was lead by the local farmer Edmilson Veríssimo at Botucatu city/SP. He is a biodynamic horticulturist whose fields are certified as Demeter. The area lies at south latitude 22o44'00", longitude 48o34'00" west of Greenwich, altitude of around 900 meters above the sea level. The climate is classified as Mesotérmico Cwa, which means, subtropical humid with dry winter period at the international system of Köppen (Setzer 1946). The ground is classified as latossolo red-yellow, sandy texture, distrofic. The farmer`s area is surrounded by diverse tree rows, in a riparian forest area and with extensive pasture in the neighborhood, with more than 1 km of geographic isolation from other vegetable crop areas.

For the initial culture there were used seeds of four distinct populations from the research material of PhD Antonio I. Cardoso (FCA-UNESP University).

The soil was prepared with the disk harrow, to incorporate the wreckage of the previous crop and after rail. The irrigation system used was by spraying. The sowing was direct, made manually after manuring with biodynamic compost on the pit. There were 2 plants per hole. It was 200 hole spaced 3 X 1.5 m (400 plants) in alternated rows with Japanese or hokkaido squash spaced 3 x 3 m. The improved squash was sowed 10 days before to work as pollinator for the Japanese squash. Manual weedings, with no pesticide phytosanitary control. Biodynamic preparations 500 and 501 was applied.

During the plants growth several selections were made: Nonstandard plants and that ones showing diseases and pests incidence were discarded. At the end 40-50 plants were marked, with 1 fruit per selected plant. The selection criteria were defined according to the farmer's knowledge of acceptance of this product in biodynamic fairs. The main selection criteria were: fruit shape, length and diameter of neck and bulge, fruits longer and thinner, fruits weight - around 1 Kg. After harvested, the fruit was left at rest for 21 days in shed ventilated.

There was three cycles of sowing**:** 2008- March - 1º cycle ; 2008- September - 2º cycle ;2009 - February - 3º cycle. After the evaluations in each cycle, seeds were washed in current water and placed to dry in the shade in dishes of clay. Later they were benefited to remove empty ones and stored (the seeds of each selected fruit were separated for the next cycle). For each cycle, 30 seeds of each selected fruit will be mixed uniformly for later sowing.

After the three cycles of sowing, there were two experiments comparing the original seed and three cycles of selection, one in September (2009) and another in November (2009). For such, this assay was conducted through randomized blocks experimental design, with four treatments, seven repetitions and ten plants for repetitions. We evaluated the following items: Average number of fruits per plant; average weight of the fruits; total length of the neck and the bulge, and diameter of the neck and the bulge. We used the SAS statistical program.

Results

The results of the three selection cycles indicate an increase in the frequency of plants with longer and fine fruits. It is observed a lesser frequency of plants with undesirable format of fruits. The results of weight of the fruits is not significant. It is necessary a higher number of cycles of selection to achieve the expected results.

Tab. 1: Evaluation of populations of squash (Cucurbita moshata L.) after three selection cycles between 2008 and 2009 in Botucatu-SP, Brazil. First comparative assay - September 2009.

selection cycles	% of commercial fruits	bulge-average diameter-cm	Total average lenght /average diameter	Neck-length/diameter
Original seeds	71,62 c	11,40 a	3,05 b	2,34 b
First selection cycle	76,10 bc	10,67 ab	3,18 ab	2,44 ab
Second selection cycle	89,62 ab	10,67 ab	3,52 a	2,89 a
Third selection cycle	97,14 a	10,42 b	3,41 ab	2,74 ab

significant for P<0.05 (Duncan test)

Tab.2: Evaluation of populations of squash (Cucurbita moshata L.) after three selection cycles between 2008 and 2009 in Botucatu-SP, Brazil. Second comparative assay - November 2009.

selection cycles	% of commercial fruits	bulge average length cm	neck average length cm	Total average lenght /average diameter –cm
Original seeds	65,56 b	7,86 b	14,26 b	2,731 b
First selection cycle	92,86 a	8,93 a	16,73 a	3,202 a
Second selection cycle	89,80 a	8,74 ab	15,73 ab	3,229 a
Third selection cycle	92,85 a	8,49 ab	16,02 ab	3,283 a

- significant for P<0.05 (Duncan test)

Significant gains have being noticed since the first selection cycle, specially in the increase of comercial fruits number. There were no significant differences in any of the aspects from second to third selection cycle.

Discussion and conclusions

According to Robinson & Decker-Walters 2004, the main objectives of squash breeding programs are: income of orange color caroten and diseases and virus resistence. According to Bezerra Neto *et al* 2006, heritability for average fruit weight and external longitudinal length were higher than 80%, with a variation index higher than one. Thus, application of simple breeding methods, such as mass selection, show a real improvement.

The experience of participatory improving brings a rich knowledge for both involved - researcher and farmer

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The effects of organic and biological fertilizers on yield and essential oil of *basil (Ocimum basilicum* L.) under an organic production system

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Key words: Cow manure, azotobacter, vermicompost, ecological input

Abstract

To evaluate the effects of organic and biological fertilizers on yield and essential oil of basil (Ocimum basilicum L.) an experiment was conducted at Research Farm of Ferdowsi University of Mashhad, Iran, in year 2009. A split plot arrangement based on Complete Randomized Block Design with three replications was used.Ten different fertilizer (1-cow manure, 2-sheep manure 3-chicken manure, 4-compost, 5-vermicompost, 6-nitroxin (trade mark) as a biological fertilizer containing of Azotobacter sp. *and Azospirillum* sp.*, 7-Phosphate Solubilizing Bacteria (PSB) containing of Pseudomonas* sp. *and Bacillus* sp.*, 8-mixture nitroxin and PSB, 9-Chemical NPK and 10-control) were assigned to the main plots and three cut of basil considered as the subplots. The highest above-ground biomass and leaf yield resulted in vermicompost, cow and chicken manure, respectively. The highest yield of essential oil, were obtained from plants treated with cow and sheep manure, vermicompost and chemical fertilizer, respectively. The highest above-ground biomass, leaf yield and essential oil yield, obtained in third cut but essential oil percentage in the first cut was more than other cuts.*

Introduction

The use of the various ecologically inputs can substantially impact on yield and quality of products (Kapkiai *et al*. 1999). In many agricultural systems, especially in sustainable agriculture, bio-organic fertilizers would be used to improve some soil characteristics such as fertility, increase soil organic matter, plant growth, and soil properties (Azeez *et al*. 2010). Many of bacterial species which called plant growth promoting rhizobacteria affect on crop yield through the biological fixation of nitrogen, increasing availability of mineral elements such as phosphorus and potassium, inhibition of soil borned pathogens and produce plant growth hormones (Sifola & Barbieri 2006).

Among the species of the ocimum genus, *Ocimum basilicum* L. (basil) have more economic importance and can be used both fresh and dried as spice. Basil has been used traditionally as an important medicinal herb (Sifola & Barbieri 2006).

Due to emphasis of sustainable agriculture, especially on quality of the plants products and importance of medicinal plants, and also the lack of studies on the

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fertilizer needs of basil, this study aimed to assess the effects of the various organic and biological fertilizers on some qualitative and quantitative characteristics of basil was conducted.

Materials and methods

The experiment was conducted at the Research Farm of Ferdowsi University of Mashhad, Iran, in year 2009. The treatments were arranged as split plots over time based on Complete Randomized Block Design with three replications. Ten different fertilizers were assigned to the main plots and three cut of basil considered as the subplots. Fertilizers were 1- cow manure (30 ton.ha-1), 2- sheep manure (20 t.ha-1), 3- chicken manure (10 t.ha-1), 4- municipal waste compost (10 t.ha-1), 5- vermicompost (7 ton.ha-1), 6-nitroxin (trade mark) as a biological fertilizer (containing Azotobacter sp. and Azospirillum sp. bacteria), 7- phosphate solubilizing bacteria (PSB) (containing Pseudomonas sp. and Bacillus sp.), 8- Mixture of Nitroxin and PSB, 9- chemical NPK fertilizer (110,60.60 kg.ha-1) and 10- control (no fertilizer). Based on soil data required amounts of organic and NPK fertilizers were applied to the regarded plots. Basil seeds were sown every 6 cm on rows which apart 50 cm of each other, in May 2009. Irrigation was done immediately after planting and then once every seven days separately for each plot. During the growing season, at the same developmental stage (5-10% flowering), three cut was harvested. Plants in each plot were harvested and after drying, leaf and total above ground biomass were measured. Air dried leaves in the three time of harvesting (50 g) were subjected to hydro distillation for 3 h using a clevenger apparatus, and percentage and yield of essential oil were determined. Data were subjected to analysis of variance (ANOVA) using the SAS Ver.9. MS-Excel ver.14 and Slide-Write Ver.2 were used for drawing the figures. Means Comparisons were performed using Duncan's multiple range test at 5% level of probability.

Results

Total above ground biomass and leaf yield

Plants treated with vermicompost had the most above ground biomass and cow manure ranked second. The lowest above ground biomass was observed in control and NPK fertilizer, respectively. Dry leaf yield was highest on plots with vermicompost and had no significant difference with chicken and cow manure plots (fig.1.). Leaf yield and above ground biomass significantly increased from first to third cut, as each cut had significant difference with previous cut (Table 1), it could be related to slow and gradual release of elements from organic fertilizers.

Percentage and yield of essential oil

The chemical and controls treatments that have the lowest total above ground biomass and leaf yield produce the largest percentage of essential oil and have significant difference with other treatments, except chicken and cow manure. The lowest percentage of essential oil was observed in plants treated with nitroxin, PSB and mixture of nitroxin and PSB (Fig. 2 & 3). Amongst the cuts, the highest percentage of essential oil was obtained in the first cut as it has significant difference with other two cuts (Table 1). Since the yield of essential oil is resultant of leaf yield and percentage of essential oil, and both of them were high in cow manure treatment, it could be postulated this treatment had also the highest essential oil yield and chicken manure, vermicompost and NPK fertilizer, ranked after the cow manure, regarding this trait. However, control treatment caused the highest percentage of essential oil, though it was not considerable because of low leaf yield in this treatment. (Fig. 2 & 3). Among the cuts, the third cut had maximum essential oil yield (Table 1).

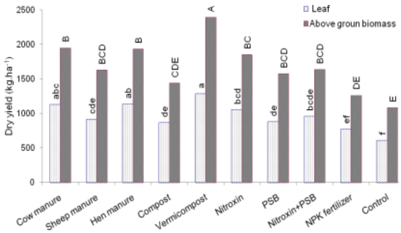

Fig. 1. Variation in leaf and above-grand biomass affected by different

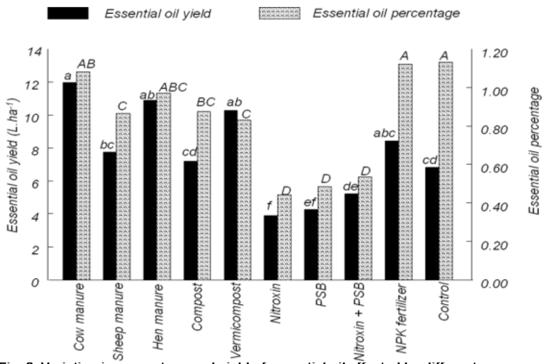

Fig. 2. Variation in percentage and yield of essential oil affected by different fertilizers.

Discussion

There are reports that proposed application of organic and biological fertilizers could be resulted in increasing in soil water holding capacity, strengthening the plant hormone-like activities and providing the required elements, increasing in nutrient availability and absorption by plants and at a glance may improve the chemical, physical and biological properties planting bed, finally it could be reflected in improved yield (Mahfouz & Sharaf-Eldin 2007, Khalid et al. 2006). Vermicompost is beneficial for crop yield because it improves the physical structure of the soil, enhance the biological properties of the soil (aggravate micro-organisms activities, secretion of growth hormones such as auxins and gibberellic acid, and exudation of enzymes, such as phosphatase, cellulase, etc.) (ValdezPerez et al. 2011). In another experiment, the combination of the organic fertilizers with inorganic nitrogen fertilizer, significantly enhanced growth characteristics of basil (Sifola & Barbieri 2006).

NPK fertilizer had no significant effect on plant performance, maybe this could be partially related to more susceptibility of chemical fertilizer to sublimation, leaching and denitrification processes and unlike organic fertilizers, chemical fertilizers does not any positive impact on soil bulk density (Kolata et al, 1992). Mahfouz and Sharaf-Eldin (2007) reported that application of different strains of biofertilizers amended with a half dose of N, P, and K increased fennel fruit yield compared to 50% and 100% NPK treatments.

Table 1- Means comparison of some measured characters in basil among different cuts.

	Dry leaf yield (kg.ha-1)	Above-ground biomass (kg.ha-1)	Essential oil (%)	Essential oil yield (L.ha-1)
First cut	706.8c	1168.8c	0.939a	6.52b
Second cut	906.5b	1497.3b	0.793b	7.18b
Third cut	1264.3a	2344.8a	0.771b	9.78a

* In each column, means followed by the same letter(s) are not significantly different at the 5% probability level .

The highest percentage of essential oil in the first cut and control treatment, which has had the lowest leaf yield, could be related to increased levels of the secondary metabolites which might have increased under stress conditions (such as low amounts of nutrient elements and water), because organic fertilizer increase soil water holding capacity, and increase plant nutrient elements availability, therefore help the plants to avoid from stresses.

Conclusions

The results showed that using of organic fertilizers has superiority compared to chemical fertilizers and this could be considerable for the sustainable production of medicinal plants. It seems that treatments of vermicompost and animal manure, particularly cow and chicken manure, were more effective due to increasing biomass and essential oil yield of basil compared with the standard treatments.

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Dynamics of soil microbial community in organic, green and conventional vegetable production systems

Zhao, J.-J.[1], Li,J., Du X.-G.

Key words: Organic; Green; Conventional; Soil microorganisms; number

Abstract

This study is a long-term trial of greenhouse vegetables production under three different treatments: organic, green and conventional, began in March 2002 in Quzhou Experimental Station of China Agricultural University. Soils were sampled in 0-20cm and 20-40cm layer four times in January, April, July and October 2009. To reveal the number and dynamic changes of soil microorganisms under different managements, conventional plate culture and colony counting method were used to determine the number of soil microorganisms. The results showed that: (1) The systerm of organic management significantly increased the number of soil bacterium. The number of bacterium in the organic system was more than that in conventional system, and the number of bacterium reached a significant level in April and October in 0-20cm soil layer. The number of bacterium in the organic systerm was more than that in green systerm and conventional systerm, and the number of bacterium reached a significant level in April, July and October in 20-40cm soil layer. (2) The systerm of organic management significantly increased the number of soil actinomycetes. Among three systerms, the number of actinomycetes was the most in the organic systerm and the least in the conventional systerm in the 0-20cm and 20-40cm soil layer. In the 0-20cm soil layer, the number of actinomycetes reached a significant level between the organic systerm and conventionall systerm in April, July and October. In the 20-40cm soil layer, the number of actinomycetes reached a significant level between the organic systerm and conventional systerm in October. (3) Organic management significantly reduced the number of soil fungi. Among three systerms, the number of fungi was the least in the organic systerm and the most in the conventional systerm in the 0-20cm soil layer and the number of fungi reached a significant level between the organic systerm and conventional systerm in October. Compared with the 0-20cm, the trend was opposite in the 20-40cm soil layer.

Introduction

Vegetables are indispensable in our daily life. However, over-reliance on chemicals (i.e. synthetic fertilizers and pesticides) have brought negative impacts on the environment, food safety and human health (Ma W. Q., *et al.* 1999). Regarded as an environmentally friendly agriculture without inputs of chemical fertilizers, pesticides and growth regulators (Du X. G., *et al.* 2006), the total area of the world organic agriculture cultivation was 30.5 million hectares in 2007 (Kledal, *et al.* 2007). In *China, the certified organic food industry started in the 1990s,* and its rapid growth since then indicates the use of a huge amounts of organic fertilizers in organic agriculture. Soil

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microbial communities may be strongly influenced by agricultural practices which change the soil environment (E.J Lundquist, *et al.* 1999). Øvrea°s and Torsvik reported that the microbial community in an organic soil was more diverse and more evenly distributed than that in a sandy soil (Øvrea°s and Torsvik,1998). Enrichment of the microbial community following manure treatment has also been shown by enhanced microbial biomass C contents (Hopkins, D. W.,1996; Parham, J. A.,2002), soil enzyme activities (Parham, J. A. *et al.*,2002), N flush (Ritz, K., R. E. *et al.*,1997), and gram-negative bacterial populations (Peacock, A. D. *et al.*,2001).

The aim of this study is to compare dynamics of soil bacteria, antinomycetes and fungi in different production systems (i.e. organic agriculture, certified green-food production and conventional agriculture).

Materials and methods

a)Site location

This study site is located at Quzhou Experimental Station of China Agricultural University (36º52´N,115º01´E). Where the average elevation is 39.6 meters, the annual rainfall is 791.7mm. and the annual average temperature is 13.4℃. The long-term experiment has been carried out in three Chinese traditional solar greenhouses with different vegetable production systems (i.e. organic, certified green-food, and conventional). since 2002 In organic system, animal manure was used exclusively, whereas also synthetic fertilizers were used in the conventional and green systems. The nutrient content before experiment was shown as follows, 0-20cm soil layer: Total N 1.24 g·kg-1, Total P 1.61g·kg-1, Available K 278.14 g·kg-1, Organic matter16.94 g·kg-1; 20-40cm soil layer: Total N 0.73 g·kg-1, Total P 0.97g·kg-1, Available K 131.92 g·kg-1, Organic matter16.94 g·kg-1. The cropping patterns in the Solar Greenhouse was shown as follows. At least one tomato crop was grown every year with cucumber, celery or fennel as break crops . The average input of nutrients, pesticides and irrigations in three production systems was shown in Table 1. The irrigation times and amount were same in three systems.

Table 1 Average input of nutrients, pesticides and irrigations in three production systems

Treatments	N kg·hm-2·a-1	P_2O_5 kg·hm-2·a-1	K_2O kg·hm-2·a-1	Pesticides application times	Pesticides application kg·hm-2·a-1
CON	861	327	281	20	29
GRE	783	300	860	10	9
ORG	889	387	1282	0	0

b)Sampling

Soils were sampled randomly in triplicate in 0-20cm and 20-40cm layer four times in January, April, July and October 2009. 72 soil samples were collected, sieved and stored in the -80℃ freezer. Conventional plate culture and colony counting method were used to investigate the number of soil microorganisms (Yao H.Y.,2006; Bao S.D.,2008; Shen P,2005).

c)Statistical analysis

Data were analyzed by Excel 2003 and SPSS v.17.0 software.

Results

1. Dynamic of soil bacterium in different production systems (organic, green and conventional)

The number of soil bacterium in different production systems was showed Fig 1. In April, July and October, the number of bacteria in the organic system was more than that in conventional system, and the number of bacteria reached a significant level in April and October in 0-20cm soil layer. The number of bacterium in the organic system was more than that in green and conventional systems, and the number of bacterium reached a significant level in April, July and October in 20-40cm soil layer.

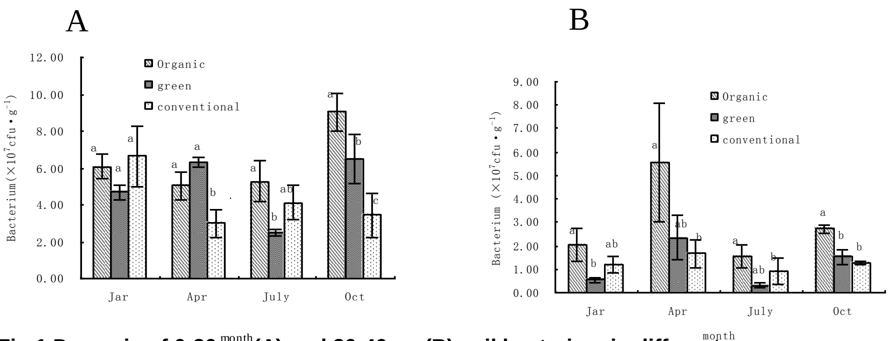

Fig 1 Dynamic of 0-20cm (A) and 20-40cm (B) soil bacterium in different systems. Error bars are ±SE. Different letters indicate significant differences between different years (Duncan, P < 0.05).

2. Dynamic of soil actinomycetes in different systems (organic, green and conventional)

The number of soil actinomycetes in different production systems was showed in Fig 2 . It can be seen that the number of soil actinomycetes was the most in organic system and the least in the conventional system in April, July and October in 0-20cm and 20-40cm soil layer. In the 0-20cm soil layer, the number of actinomycetes reached a significant level between the organic management and conventional control in April, July and October. In the 20-40cm soil layer, the number of actinomycetes reached a significant level between the organic management and conventional control in October.

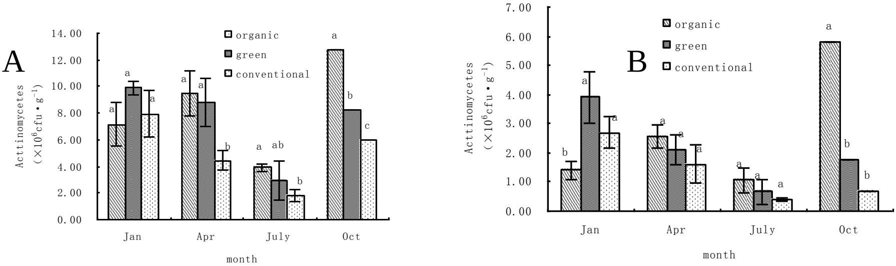

Fig 2 Dynamic of 0-20cm (A) and 20-40cm (B) soil antinomycetes under different treatment. Error bars are ±SE. Different letters indicate significant differences between different years (Duncan, P < 0.05).

3. Dynamic of soil fungi in different systems (organic,green and conventional)

The number of soil fungi in different production systems was showed in Fig 3. It can be seen that the number of fungi was the least in the organic system and the most in the conventional system in the 0-20cm soil layer, the number of fungi reached a significant level between the organic management and conventional control in October. Compared with the 0-20cm soil layer, the trend was opposite in the 20-40cm soil layer, the number of fungi reached a significant level between the organic management and conventional control in January, April and October.

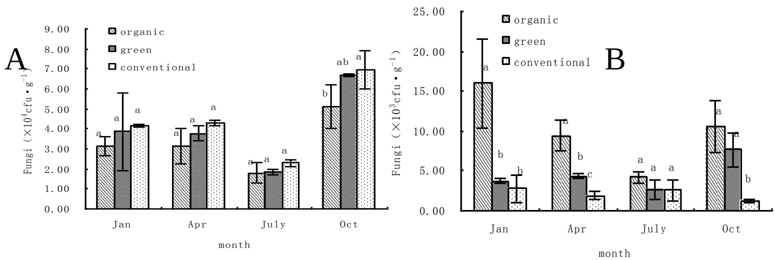

Fig 3 Dynamic of 0-20cm (A) and 20-40cm (B) soil fungi under different treatment. Error bars are ±SE. Different letters indicate significant differences between different years (Duncan, P < 0.05).

Discussion and Conclusions

Studies have demonstrated that shifts in microbial community structure were following adaptation of soil management practices (Buckley *et al.* 2003; Peacock *et al.*,2001). For long-term soil management practices, the observed impact was greater than for short-term land use (Buckley *et al.*, 2003). While the significant shifts of the microbial community following soil management practices remains to be recognized, it was evident that organic amendment, in general, enriched the soil microbial community and promoted diversity and a more even distribution of bacterial species within the community. These results were in agreement with those obtained by evaluating the culturable microbial populations. In summary, the soil microbial community was considerably impacted by management practices. The different microbial community in different production systems reflected different soil management practices. Organic management increased soil bacterial population and actinomycetes population and reduced soil fungi populations in the 0-20cm soil layer. Organic fertilizers have increased microbial diversity and enhanced nutrient cycles in soils in organic agriculture..

Acknowledgments

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Effect of organic medium amended with fish-fermented liquid manure and *Bacillus subtilis* SL9-9 on the growth of cucumber seedlings

Kim, Yu.[1], Kim, Yo., Cho, Y., Lee, S. & Ko, Y[2]

Key words: Organic Medium, Bacillus subtilis SL9-9, Cucumber

Abstract

This research was conducted to evaluate the effect of organic growth medium amended with different ratios of fish-fermented liquid manure(FFLM) and Bacillus subtilis SL9-9 on the growth of cucumber seedlings. Bacillus subtilis SL9-9 was isolated as a cellulose-producing strain in JeJu Island and had plant growth-promoting effect. To achieve our goal, sixteen media were formulated by adjusting blending ratio of FFLM and cell density of the Bacillus. Then, the growth characteristics were investigated 30 days after sowing. The treatment of L2-M4 in amending ratio of 2% FFLM and $1*10^7$ density of Bacillus subtilis SL9-9 produced the highest fresh and dry weight. The growth of cucumber inoculated with Bacillus subtilis was better than those without inoculation. When our developed organic bedsoils were compared with commercial organic and commercial plant growth bedsoils, especially the root weight of cucumber was greater in our developed organic bedsoils, which leading to the production of high quality plug seedlings. FFLM and Bacillus subtilis SL9-9 can be used as bedsoil amendments of plant growth media for seedlings in organic farming.

Introduction

Bedsoils are the main factors to grow high quality seedlings in plug systems. The healthy seedlings are essential in organic system to reduce the chemical materials. As the recent trend in agriculture is to support organic farming, the development of horticultural bedsoils for organic seedling is much sought after. At the core of the organic philosophy lies a ban on the use of synthetic fertilizers, pesticides and herbicides. Therefore, the purpose of this experiment was to develop the horticultural bedsoils for organic seedling by adding mackerel-fermented liquid manure as a source of nutriment and plant growth-promoting bacteria in order to produce higher quality seedlings.

Materials and methods

Mixing ratios of bedsoils

The blending rates of the developed bedsoils were peatmoss 40%, cocopeat 40%, perlite 10% and vermiculite 10% in solid amendments in % vol. The amended ratios

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of fish-fermented liquid manure(FFLM) were 0%, 1%, 2%, 3%, respectively in % vol and the amended density of *Bacillus subtilis* SL9-9 were control(distilled water), $1*10^5$, $1*10^6$, and $1*10^7$, respectively. The blending rate of Bacillus was 2%(v/v). FFLM was manufactured by fermenting the by-product of mackerel for more than six month. The process of FFLM was that the by-product of mackerel, bones and internal organs, black sugars and *Bacillus subtilis* SL9-9 as fermenters were mixed in the ratio of 1 : 0.3 : 0.05 in % weight at first and then fermented. After fermenting for six month, there was no a considerable change in the amount of mineral contents of FFLM.

Seedlings of cucumber

For this experiment, the variety of cucumber “Jeongseon-Samcheok” (Dongbu Hitek Co., Korea) was used. A seed germination test was conducted in several media for 6, 7 and 10 days after sowing. To demonstrate the developed bedsoil, seedlings of cucumber were carried out with three types of bedsoils in three places, respectively. Seedling characteristics were examined 30 days after sowing. For seedling characteristics, the fresh and dry weights of leaf, stem and root were measured. The experimental plots were arranged by the randomized block design in three replications. Data collected were analyzed using SAS and compared with DMRT.

Results

Table 1. Effects of organic media amended with different ratios of fish-fermented liquid manure and *Bacillus subtilis* SL9-9 on the germination of cucumber seedlings

Treatments	Amended ratio of FFLM x) (%,v/v)	Amended density of Microorganism (cfu mL-1)z)	Germination Percentage(%)		
			6daysw)	7days	10days
L0-M1	0	Cony)	99.5	99.5	99.5
L0-M2		1*105	98.1	98.1	98.6
L0-M3		1*106	99.1	99.5	99.5
L0-M4		1*107	98.1	98.1	99.1
L1-M1	1	Con	97.7	98.6	99.1
L1-M2		1*105	99.5	99.5	99.5
L1-M3		1*106	97.7	97.7	99.5
L1-M4		1*107	96.8	97.2	97.7
L2-M1	2	Con	97.7	97.7	98.1
L2-M2		1*105	97.2	98.1	99.5
L2-M3		1*106	97.7	98.1	98.6
L2-M4		1*107	100.0	100.0	100.0
L3-M1	3	Con	65.7	91.2	98.1
L3-M2		1*105	59.0	83.3	97.9
L3-M3		1*106	93.1	96.8	98.6
L3-M4		1*107	76.9	91.7	98.1

Z) Amended ratio of Microorganism : 2%(v/v)

Y) Con : Distilled water

x) FFLM : Fish Fermented Liquid manure

w) days after sowing

Table 2. Effects of organic media amended with different ratios of fish-fermented liquid manure and *Bacillus subtilis* SL9-9 on the growth of cucumber seedlings

Treatments)	Fresh weight(g/plant)			Dry weight(g/plant)		
	Shoot	Root	Total	Shoot	Root	Total
L0-M1	0.96fy)	0.62e	1.59f	0.16g	0.030h	0.19g
L0-M2	1.00f	0.61e	1.61f	0.17fg	0.031h	0.20g
L0-M3	1.17f	0.65de	1.82f	0.19fg	0.035gh	0.23fg
L0-M4	1.20f	0.69de	1.89f	0.20fg	0.037gh	0.23fg
L1-M1	1.76e	0.81dc	2.57e	0.24ef	0.050ef	0.29ef
L1-M2	2.94dc	0.92cd	3.86cd	0.34c	0.050ef	0.39c
L1-M3	2.53d	1.00bc	3.53d	0.31cd	0.056de	0.37cd
L1-M4	3.19c	1.22ab	4.41bc	0.36bc	0.066bcd	0.43bc
L2-M1	1.76e	0.82dc	2.57e	0.27de	0.045gf	0.31de
L2-M2	3.26c	1.25ab	4.50b	0.34bc	0.062bcd	0.40c
L2-M3	3.24c	1.24ab	4.49b	0.31cd	0.060cde	0.37cd
L2-M4	4.20a	1.46a	5.66a	0.43a	0.077a	0.51a
L3-M1	1.92e	0.83dc	2.75e	0.23efg	0.044gf	0.27ef
L3-M2	3.74c	1.44a	5.18a	0.36bc	0.072ab	0.43bc
L3-M3	2.94cd	1.19ab	4.13bc	0.32cd	0.063bcd	0.38c
L3-M4	3.97ab	1.35a	5.32a	0.41ab	0.070abc	0.48ab

Z) See the table 1, y) Duncan's Multiple Range Test(<0.05)

Table 3. Comparison of developed organic bedsoil with commercial organic and commercial bedsoils on the growth of cucumber seedlings

Test Placesz)	Treat-mentsy)	Fresh weight(g/plant)				Dry weight(g/plant)				T/R
		Leaf	Stem	Root	Total	Leaf	Stem	Root	Total	
A	DOB	1.88cx)	3.53c	2.51b	7.91b	0.22bc	0.16b	0.10ab	0.48b	3.9
	COB	1.69d	3.39c	1.56c	6.65d	0.19c	0.16b	0.06c	0.41b	6.3
	CB(a)	2.04b	3.77b	1.67c	7.48c	0.23b	0.18b	0.07bc	0.48b	5.7
	CB(b)	2.21a	4.24a	3.08a	9.52a	0.28a	0.21a	0.11a	0.60a	4.5
B	DOB	2.06c	4.68c	2.77a	9.51c	0.36c	0.21c	0.12a	0.68c	4.8
	COB	2.16bc	4.93c	2.24c	9.32c	0.35c	0.23bc	0.09b	0.67c	6.5
	CB(a)	2.35a	5.76a	2.86a	10.97a	0.44a	0.31a	0.12a	0.86a	6.3
	CB(b)	2.21b	5.26b	2.51b	9.98b	0.39b	0.25b	0.10ab	0.75b	6.2
C	DOB	1.76b	4.73a	2.08a	8.57a	0.19d	0.16c	0.09a	0.43b	4.0
	COB	1.72b	4.01c	1.62b	7.35c	0.22c	0.19b	0.06b	0.46b	6.5
	CB(a)	1.95a	4.51b	2.21a	8.68a	0.28a	0.22a	0.09a	0.58a	5.6
	CB(b)	1.73b	4.47b	2.04a	8.25b	0.25b	0.21ab	0.09a	0.54a	5.3

z) A : Gujwa, B : Samyang, C : Hallim, y) DOB : Developed organic bedsoil, COB : Commercial organic bedsoil, CB(a, b) : Commercial bedsoils, x) Duncan's Multiple Range Test(<0.05)

In the media supplemented with 3% FFLM, the germination of cucumber was lower than other FFLM treatments (Table 1). But below 2% supplements of FFLM and inoculation density of microorganism tested(0~1*10^7 cfu mL^{-1}) had no effect on germination. To investigate optimum blending ratios of FFLM and microorganism for cucumber plug seedlings, fresh and dry weight(shoot, root) were determined at 30 days after sowing. The growth in the treatment L2-M4 was about 2.5~3 times higher compared to L0-M1 (0% of FFLM and control), L0-M4 (0% of FFLM and $1*10^7$ of *Bacillus* cells). Also the growth of cucumber inoculated with *Bacillus* cells were higher than those without inoculation by 1.7~2.2 times (Table 2). To compare the developed organic bedsoil with other types of bedsoils, fresh and dry weight(leaf, stem, root) and T/R ratio(dry shoot weight/dry root weight ratio) were determined at 30 days after sowing. The overall results showed that the quality of plug seedlings was the best in the developed bedsoils judging from T/R ratio(Table 3).

Discussion

For the development of horticultural bedsoils for organic seedlings, substituted for chemical ingredients, good quality seedlings must be produced. In this study, we investigated combination ratios of FFLM for nutrition supply (especially N) and *Bacillus* cells for plant growth promotion. In test of media formulated by blending FFLM and *Bacillus* cells, treatment L2-M4 (2% of FFLM and $1*10^7$ of *Bacillus* cells) gave significantly higher growth than other treatments. Those results showed that FFLM can be used in replacement of chemical fertilizer for nutrition supply and FFLM treatment with *Bacillus* has a synergistic effect on seedling growth. Comparison of our developed organic bedsoil with other commercial bedsoils revealed that the root weight of cucumber was the greatest in our developed organic bed soil, which led to the production of high quality plug seedlings. Among all places tested, T/R ratio was significantly lower in the treatment of our developed organic bed soil than others(Table 3).

Conclusions

Fish-fermented liquid manure(FFLM) and *Bacillus subtilis* SL9-9 can be used as bedsoil amendments of plant growth media for seedlings in organic farming.

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Growth of chinese cabbage and nitrogen availability of fertilizer in Organic Farming with poultry manure compost and nature ore fertilizer in rainshelter cultivation

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Key words: Chinese cabbage, Nitrogen availability, Organic farming, Rainshelter

Abstract

This study was carried out to evaluate nitrogen availability of applied fertilizer and to investigate yield and growth of Chinese cabbage in organic farming system in rainshelter.

Nitrogen availability of applied fertilizer by Chinese cabbage was lower in fertile soil (clay loam) than in infertile soil (sand loam) and the lower that was, the more fertilizer applied. By application of poultry manure compost 20Mg ha^{-1} and nature ore fertilizers equal to amount of fertilizer recommended in conventional farming, the yield of Chinese cabbage in infertile soil (sand loam) with 1% organic matter came up to 90% of the yield in fertile soil (clay loam) with 6% organic matter.

Therefore application of nature ore fertilizers such as guano, phosphate rock, and potassium magnesium rock will be used to correct nutrient unbalance of soil in rainshelter organic farming.

Introduction

The organic farming is considered to be an alternative to conventional farming, to enhance agricultural sustainability in Korea. But a decreased yield in organic farming of highland Chinese cabbage is the source of trouble. Crop growth is limited by soil fertility. Conventionally, organic fertilizer that exceeded for crop requirements was supplied to increase fertility of cultivation soil in organic (Poudel *et al*. 2002, Evanylo *et al*. 2008). Especially continuous application of animal manure compost brought out unbalance of nutrient of soil, which reduced yields in protected cultivation (Lee *et al*. 2006, Ge *et al*. 2010).

This study aimed to compare the yield and the growth of Chinese cabbage between conventional farming with artificial fertilizers and organic farming with various fertilizers, and to evaluate the utilization possibility of nature ore fertilizers in correcting unbalance of nutrients in organic cultivated soil.

Materials and methods

Chinese cabbage was cultivated by conventional and organic farming in rainshelter with clay loam soil as rich soil and sand loam soil as poor soil from Jun. 21 to Aug. 26, 2010 in Dagwallyeong highland (altitude 800m), Korea.

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Nitrogen availability of applied fertilizer and growth of Chinese cabbage were investigated in the soil as affected by application of artificial fertilizer, poultry manure compost, and nature ore fertilizer. Descriptions of fertilizer application practices and chemical properties of soil used in the experiments appeared in table 1 and table 2, repectively.

Nitrogen availability of applied fertilizer was calculated by rate of nitrogen uptake excluding nitrogen uptaken in the control (no amendments) against to the amount of nitrogen supplied in the soil. Effect of fertilizer application on growth of Chinese cabbage was investigated by measuring head weight. The experimental design was a randomized complete block, replicated three times.

Tab. 1. Description of fertilizer application practices in the experiments

Application of fertilizer	Nutrients(kg ha^{-1})			Description
	N	P_2O_5	K_2O	
Control	-	-	-	No amendments
Chemical fertilizer(CF)	320	78	198	Amount of artificial fertilizer recommended in Chinese cabbage protected cultivation
Chemical fertillizer + Poultry manure compost(CPM)	686	316	440	Amount of artificial fertilizer recommended in Chinese cabbage protected cultivation and poultry manure compost 20 Mg ha^{-1}
Poulty manure compost + Guano + Potasium magnesium sulfate rock(MGS)	320	78	198	Poultry manure compost:4.8 Mg ha^{-1} Guano 2.1 Mg ha^{-1} Potasium magnesium sulfate rock 0.25 Mg ha^{-1}
Poultry manure compost(PMC-I)	120	78	80	Poultry manure compost 6.6 Mg ha^{-1}
Poultry manure compost(PMC-II)	320	210	210	Poultry manure compost 17.5 Mg ha^{-1}
Guano + Phosphate rock + Potasium magnesium sulfate rock(GPS)	320	78	198	Guano 2.9 Mg ha^{-1} Phosphate rock 0.25 Mg ha^{-1} Potasium magnesium sulfate rock 0.37 Mg ha^{-1}
Pourtry manure compost + Guano + Phosphate rock + Potasium magnesium sulfate rock(MGPS)	686	316	440	Poultry manure compost 20 Mg ha^{-1} Guano 2.9 Mg ha^{-1} Phosphate rock 0.25 Mg ha^{-1} Potasium magnesium sulfate rock 0.37 Mg ha^{-1}

Tab. 2. Chemical properties of soil used in the experiment

Soil	pH	EC (dS m^{-1})	O.M. (g kg^{-1})	T-N (g kg^{-1})	Av. P_2O_5 (mg kg^{-1})	Ex. Cations($cmol^+$ kg^{-1})		
						K	Ca	Mg
Clay loam	5.68	1.07	58.9	3.1	685	1.11	5.7	1.4
Sand loam	6.10	0.35	11.3	1.0	153	0.13	9.6	1.8

Results and discussion

Factor affecting fertilizer response of Chinese cabbage was the level of soil fertility. In control (no amendments), the growth of Chinese cabbage was very poor in infertile soil (sand loam), but that not in fertile soil (clay loam).

There were big differences in the yields as affected by fertilizer applications in poor soil (sand loam). Nitrogen fertilizer use efficiency of Chinese cabbage was higher in the infertile soil than in the fertile soil. And nitrogen availability of applied fertilizer by Chinese cabbage was lower in fertile soil (clay loam) and in the soil supplied more fertilizer. By application of poultry manure compost 20Mg ha^{-1} and nature ore fertilizers equal to amount of fertilizer recommended in conventional farming, the yield of Chinese cabbage in infertile soil with 1% organic matter came up to 90% of the yield in fertile soil with 6% organic matter. Poultry manure compost was thought to be certainly effective on the growth of Chinese cabbage compared to nature ore fertilizer. The content rate of three major nutrients in almost compost manufactured based on the animal manure are in a regular range, and that are not agree to the uptake rate of nutrients by crop. Continuous application of animal manure compost resulted in increase of specific nutrient in soil (Lee *et al*. 2006). Therefore it was showed that organic farmers might have a difficulty to manage nutrient balance favorably in the soil by using only animal manure compost. In this case, application of nature ore fertilizers that have a major nutrient was thought to be available to manage nutrient balance. Therefore utilization of nature ore fertilizers such as guano, phosphate rock, and langbeinite was thought to improve soil quality by preventing the accumulation of special salt, and to play a role in maintaining of agricultural sustainability in Chinese cabbage organic farming system that applied mainly poultry manure compost.

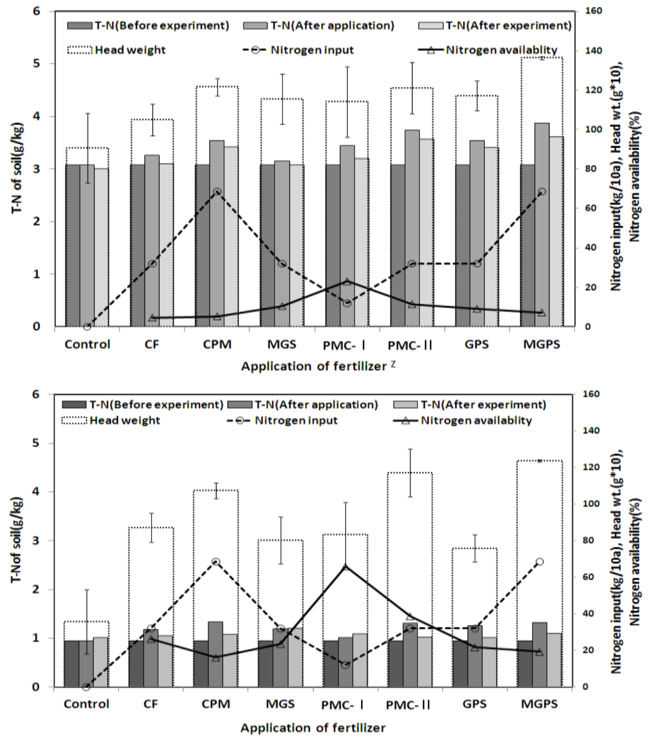

Figure 1: The changes of nitrogen content of soil, nitrogen availability of applied fertilizer, head weight of Chinese cabbage affected by application of chemical fertilizer, poultry manure compost, guano, and nature ore fertilizer in

rainshelter cultivation. Vertical bars represent SE of the means (n = 3). (upper: clay loam soil, lower: sand loam soil),^{Z}: See table 1.

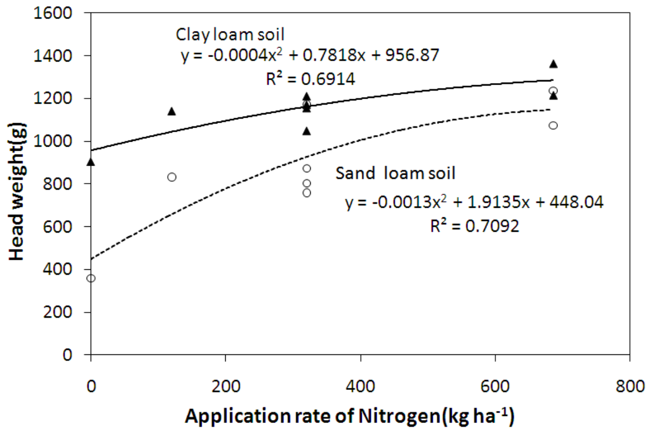

Figure 2: Relationship between application rate of nitrogen and head weight of Chinese cabbage cultivated in rainshelter from Jun. 21 to Aug. 26, 2010.

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Cattle manure rate for bulb onion grown with reduced chemical fertilizer

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Key words: sustainable agriculture, *Allium cepa* L., soil organic matter

Abstract

A field experiment was conducted to evaluate yield performance, to assess soil fertility with composted cattle manure under the reduced rate of chemical fertilizer for sustainable onion production in 2006-07 growing season. The quantity of chemical fertilizer was reduced to a third based on the recommended amounts of N, P and K, which was regulated amounts for certification of product grown without agricultural chemicals in Korea. Treatments consisted of 5 levels of cattle manure (0, 20, 40, 60, 80 t ha^{-1}). There was a significant increasing effect on bulb yield by applying cattle manure compared to 0 t ha^{-1}. The highest marketable yield was 62.7 ton•ha^{-1} at 4 t ha^{-1} rate, which was not significantly higher than at 2 t ha^{-1} rate. There was an increasing linear effect of manure rates on organic matter, available P and exchangeable cation contents at the vegetative growth stage and harvest. We concluded that overdose of cattle manure was not effective to onion yield, although it accumulated soil fertility in the short term application.

Introduction

The experiment on onion fertility has been one of the various subjects for onion productivity worldwide. Especially, onions have a shallow branched root system with most roots in the top 30 cm of soil (Portas, 1973). Such a root system pattern leads to the characteristic low density of roots in onion, the main cause of onion fertilizer requirements being so much higher than what is actually used by the crop (Brewster, 2008).

For sustainable crop production, pesticides and herbicides are not allowed and application rates of mineral fertilizers are restricted legally in Korea. The quantity of mineral fertilizer should be reduced to below a third based on the recommended rates of N, P and K, which was regulated rates for certification of product grown without pesticides. Pesticide-free product is not full organic, but it is considered a pre-step system to transfer to organic in Korea.

When onion (*Allium cepa* L.) plants were grown in plots of sandy loam soil, compost applied over a 2-year period at cumulative totals of 37 t ha^{-1} increased yield (Bevacqua and Mellano, 1993). There was a significant linear effect on total onion yield with increasing poultry litter applications from 0 to 25 t ha^{-1} (Boyhan et al., 2010). On the contrary, onion yield response to animal manure or compost rates was not

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positive in some reports (Gambo et al., 2008). Vidigal et al. (2010) reported that the application of 43 t ha^{-1} of swine compost was enough to obtain onion bulbs with great quality and yield.

While generally, farmers supporting sustainable agriculture have been trying to increase onion yield depending on increased compost application, the effect of compost may be not significant in the short term. The objective of this study was to evaluate the effect of composted cattle manure on bulb yield of intermediate-day onions and soil fertility under reduced chemical fertilization rate in the short-term practices. Furthermore, it could be adaptable for organic bulb onion which is grown without any chemicals.

Materials and methods

The present experiment was conducted at the Onion Research Institute's experimental farm, Changnyeong district, Korea (35°55′N latitude and 128°47′E longitude) in the 2006–07 seasons. Top soil texture was silt loam with an organic matter (OM) content of 17.8 g•kg^{-1}, pH 7.4, and residual NO_3-N, available P and exchangeable K were 5.3 mg•kg^{-1}, 104 mg•kg^{-1}, 0.50 $cmol_c$•kg prior to planting onion. Onions cv. *Changnyeongsindaego* (an open pollinated cultivar for fall transplanting) were sown on 8 Sept. 2006, and transplanted into beds mulched with a sheet of transparent polyethylene on 8 Nov. 2006 with a spacing of 15 cm in-row and 20 cm between rows with 7 rows. The bed size was 12×1.4m, accommodating 560 plants per plot. Harvesting was conducted after 80% of the tops had fallen down on 8 June 2006. Treatments consisted of cattle manure applied at rates of 0, 20, 40, 60, 80 t ha^{-1}. The composted cattle manure was obtained from local compost producer. The cattle manure contained 14.3 g N, 2.5 g P, 27.5 g K, and 380.7 g per kg on dry weight basis. Chemical fertilizers were applied at 80 kg N, 11 kg P, and 43 kg K per hectare to each treatment according to the Rural Development Administration (RDA) in Korea (RDA, 2006).

Irrigation, hand weeding, and other cultural practices were completed according to Korea RDA recommendations (Suh et al., 2000). No pesticides or herbicides were sprayed for disease or weed control, in compliance with the NAQS guide (2010) for being certified as pesticide-free product.

Results

Manure application rate at 20 t ha^{-1} is as good as any higher rate for onion bulb yield, although the maximum yield was 62.7 t ha^{-1} at 40 t ha^{-1} compost rate (Tab. 1). The stand reduction was negatively affected by increasing cattle manure. The cattle manure rate of 20 t ha^{-1} resulted in a significant decrease in stand reduction compared to 80 t ha^{-1}. This attribute was presumably due to an increased salt concentration of higher cattle manure, which might cause a worse establishment of onion seedlings at transplanting.

Tab. 1: Comparison of different manure rate effects on yield, stand reduction, bulb dry matter and tissue nutrient levels in short-day onions.

Manure rates	Yield, t ha-1		Stand reduction, %	Bulb dry matter, %
	Marketable	Unmarketable		
0 t ha-1	53.6	0.27	3.8	9.5
20 t ha-1	59.0	0.29	2.5	9.0
40 t ha-1	62.7	0.22	1.9	9.3
60 t ha-1	57.4	0.25	3.8	9.3
80 t ha-1	58.0	0.29	6.0	9.0
LSDz	4.7	NS	2.7	NS

zFisher's protected least significant difference (*P≤ 0.05*)

The organic matter, available P and exchangeable cation contents were significantly affected by increasing cattle manure rates, while nitrate nitrogen contents were not significantly different among treatments at harvest (Tab. 2). Apparently, manure rates had a linear effect on most soil nutrient contents at the vegetative as well as at harvest.

Tab. 2: Influence of different manure rates on soil pH, organic matter and major nutrients.

Manure rates		Vegetative stage, 147 DAT z						Harvest, 210 DAT					
		OM	NO_3-N	Av.P	Ex. Cation, $cmol_c$ kg-1			OM	NO_3-N	Av.P	Ex. Cation, $cmol_c$ kg-1		
		mg g-1	mg kg-1	mg kg-1	K	Ca	Mg	mg g-1	mg kg-1	mg kg-1	K	Ca	Mg
0 t ha-1		16.6	55.0	100.1	0.55	5.4	1.2	14.7	26.3	90.2	0.40	4.5	1.4
20 t ha-1		19.2	35.5	103.5	0.59	5.9	1.1	19.7	29.6	133.9	0.73	6.0	1.4
40 t ha-1		27.9	53.9	169.3	0.81	6.9	1.1	18.8	27.8	122.1	0.59	6.0	1.5
60 t ha-1		25.9	55.2	131.6	1.15	6.6	1.2	20.5	27.3	160.4	0.73	8.8	1.7
80 t ha-1		31.1	49.8	186.0	0.95	6.8	1.5	22.8	29.4	156.0	0.77	6.4	1.7
LSDy		5.0	17.8	68.1	0.30	NS	0.3	4.1	NS	46.7	0.30	2.1	0.3
Rx	Pw	0.000		0.016	0.002			0.002		0.006	0.034	0.027	0.006
	R2	0.74 (Lv)		0.37 (L)	0.54 (L)			0.55 (L)		0.46 (L)	0.30 (L)	0.32 (L)	0.45 (L)

zDays after transplanting; yFisher's protected least significant difference (*P≤ 0.05*); xRegression analysis; wProbability; vLinear

Discussion

Although animal manure were effective to improve soil organic matter content and soil fertility, especially in the long-term application (Haynes & Naidu, 1998; Prasad, 2009), the effectiveness of animal manure on bulb onions was not evaluated significantly by many literatures. The response of onion crops to manure depends on nitrogen availability for crop growth, and nitrogen availability from manure varies greatly, depending on the type of animal, type and amount of bedding, and age and storage of manure (Bary et al., 2001). Meanwhile, long-term manure application based on nitrogen can result in accumulation of other nutrients like P and K in soil and eventually reach excessive levels (Bary et al., 2001).

Nitrate nitrogen is an available nitrogen source which can be absorbed by crops in upland soil. The estimated percent of total nitrogen which is potentially mineralized after compost application depends on compost C/N ratio (Prasad and Foster, 2009). According to the assumption, C:N ratio of 15.0 which is equivalent to that of cattle manure in our study could produce 10% or less mineralized nitrogen from organic nitrogen in the first year. The very low mineralization of nitrogen was characterized in our result which was low soil nitrate nitrogen content at the vegetative stage. It might be due to higher N consumption by microorganism during decomposition of manure in soil than released N from manure at the vegetative growth stage.

Conclusions

Cattle manure compost improved yield of short-day onion and soil fertility under reduced rate of chemical fertilizer in the short-term period. However, over-application of compost more than 40 t ha^{-1} did not increase onion bulb yield, but accumulated soil nutrients. Further long-term experiments should be carried out to clarify residual and beneficial effects from compost on crop and soil quality for pesticide-free and organic onion production as well.

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Effect of rice bran and wood charcoal on soil properties and yield of continuous cropping of red pepper

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Key words: physical property, rice bran, soil microbial communities, wood charcoal

Abstract

To improve the soil properties of physical and microbial community, rice bran and wood charcoal were applied in the continuously cultivated plastic film house soil. Soil physical properties were improved by application of rice bran and charcoal compared to chemical fertilizer application (control) by 8~14% in bulk density and 5~9% in soil porosity. Changes in the biological ratio indexes of fatty acids in the soils were detected depending on the inputted materials. Especially in application of rice bran including mixture with charcoal, much more fungi and less bacteria were detected and the ratio of fungi to bacteria was increased, suggesting the more organic carbon metabolically active in these treatments. The high ratio of aerobe to anaerobe and cycloprophyl to precursor suggested the better aerobic conditions were in the soil inputted wood charcoal. From these results, it is important and possible to select some materials for the organic pepper cultivation, which may improve the poor condition soil.

Introduction

According to a definition of organic agriculture proposed by Codex alimentarius commission, organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity (CODEX 1999). General characteristics of vegetable replanting problems appeared to be decrease on red pepper yields due to injuries of continuous cultivation of single crop in plastic film house soil (Jeong *et al*. 2005). Salinity problems are caused from accumulation of soluble salts in the soil. These excess salts reduce plant growth and vigour by altering water uptake and causing ion-specific toxicities or imbalance (Kim & Chung 2005). Therefore it is very practical to cultivate green manure crop or to input some environment friendly matters for reducing the injuries of continuous cultivation same crops. Red hot pepper is one of the most important vegetable crops for seasoning food in Korea. Therefore, this study was carried out to improve the soil properties of physical and microbial community by application of eco-friendly or organic materials like rice bran and wood charcoal in the continuously cultivated plastic film house soil.

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Materials and methods

This study was carried out to investigate the effect of application of rice bran and wood charcoal on assessing the physical and microbial properties in continuously red pepper cultivated plastic film house soil. A randomized block design was used with three replications and individual plots were approximately 20 m^2 (2 X 10m) for this research. At first, each plot was applied with compost 10 ton per ha except the control. After that the plots were treated with rice bran 10 ton per ha, woody charcoal powder 2 ton per ha and rice bran (10 ton) + woody charcoal (2 ton). In control, only chemical fertilizer were treated with N:P:K = 190:112:149 kg per ha. On April 10, 'Superbigarim' variety seedlings were transplanted in 100 cm rows. The red peppers were harvested three times and the fruit characteristics were investigated. Soils were sampled to a depth of 10 cm with a soil probe (diameter: 5 cm) at three points in each plot after the red pepper seedlings were transplanted. The sampled soils were dried at shady place and passed through a 2-mm mesh sieve and stored within closed plastic bags at -80℃ in the dark until analysis. Microbe populations were analyzed by phospholipid fatty acid (PLFA) method (Feng 2003). In brief, lipids were extracted from soils by a one-phase chloroform, methanol and water extractant, and then fractionated into neutral lipids, glycolipids and phospholipids on a silicic acid column. The phospholipids were then subjected to alkaline methanolysis and analysis on a gas chromatograph with a flame ionization detector. Statistical analysis of data was carried out using SAS and to determine the significance among the means of treatments, LSD was computed at the 5 % probability level.

Results

Soil physical properties were investigated after inputting rice bran and wood charcoal (Table 1). Bulk density and porosity of soil were 1.03 g m^{-3} and 61.1 % in control and 0.89~0.95 g m^{-3} and 66.3~64.6 % in other treatments. Among the three phases of soil, solid phase was reduced and gaseous phase was increased in rice bran and charcoal inputted soil compared to control soil**.**

Tab. 1: Changes of soil physical properties and three phases as affected by application of rice bran, woody charcoal and conventional chemical fertilizer (control) in continuous cultivated soil of red pepper in plastic film house

Treatments	Bulk density (g cm-3)	Soil porosity (%)	Three phases of soil (%)		
			Solid	Liquid	Gaseous
Rice bran	0.89±0.05	66.3±1.8	33.7±1.8	24.8±0.4	41.5±1.9
Woody charcoal	0.94±0.01	64.6±0.4	35.4±0.4	24.9±3.0	39.7±3.4
Rice bran + charcoal	0.95±005	64.1±1.9	35.9±1.9	24.4±1.6	39.7±0.4
Control	1.03±0.03	61.1±1.2	38.9±1.2	23.3±1.0	37.8±0.6

* Values are means±SD

In the soil microbe populations analyzed by PLFA, it was differed among the four material applications except fungi group (Figure 1). Even though there was not significantly different, fungi group was increased in the soil inputted with rice bran and mixture of rice bran and charcoal. On the other hand, bacteria and actinomycetes groups were increased in the soil inputted with wood charcoal and chemical fertilizer. VAM-fungi group was increased just only in woody charcoal application. In changes of the biological ratio indexes of fatty acids in the soils, although there was no significantly difference among treatments, some tendencies were detected. Ratio of gram-negative to gram-positive bacterial PLFA was increased in rice bran and mixture of rice bran and charcoal. Ratio of aerobes to anaerobes was high in woody charcoal and mixture of rice bran and charcoal. It suggested that more aerobic soil conditions were made by inputting woody charcoal into the soil. The ratio of saturated to unsaturated fatty acids and cycloprophyl to precursor showed the same tendency that those ratios were higher in control than other treatments. The ratio of fungi to bacteria was also high in the application of rice bran and mixture of rice bran and charcoal.

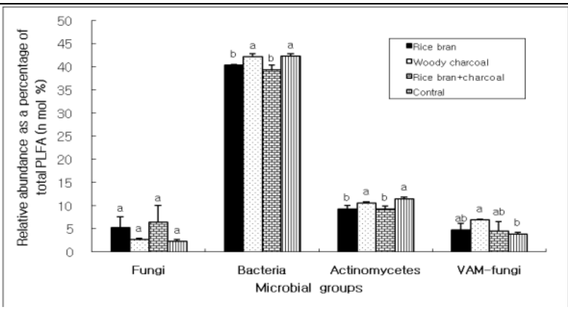

Figure 1: The class of fatty acids on the soils amended with four different treatments. The vertical bars indicate the standard deviation of the means.

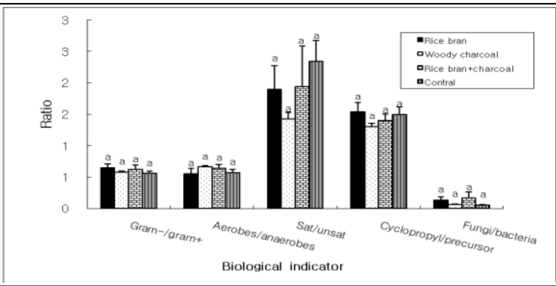

Figure 2: Changes in the biological ratio indexes of fatty acids in the soils amended with four different treatments. The vertical bars indicate the standard deviation of the means.

Due to the improvement of soil physical properties and the microbial communities, the pepper plant growth and yield were somewhat influenced. Fresh weight and fruit number of red pepper were higher in application of mixture of rice bran and charcoal as 993 g and 59.1 per plant (Table 2). But those of control were 914 g and 50.1 per plant. Finally the yields of dried red pepper were 5.72 in application of mixture of rice bran and charcoal and 5.16 ton per ha in control.

Tab. 2: Yield (t ha^{-1}) and fruit characteristic of red pepper as affected by application of rice bran, woody charcoal and conventional chemical fertilizer (control) in continuous cultivated soil of red pepper in plastic film house

Treatments	Fresh W. (g plant-1)	Fruit number (no. plant-1)	Fresh W. (g fruit-1)	Dry W. (g fruit-1)	Yield (t ha-1)
Rice bran	923±34	56.5±6.9	20.4±3.4	4.3±0.3	5.38±0.5
Woody charcoal	888±30	53.7±3.5	21.2±1.9	4.4±0.1	5.09±0.2
Rice bran + charcoal	993±74	59.1±4.9	21.7±0.9	4.5±0.1	5.72±0.2
Control	914±85	50.1±4.8	22.1±0.5	4.5±0.2	5.16±0.4

* Values are means±SD

Discussion

Researchers have reported that the soil physical and chemical properties of the continuous red pepper cropping field were dramatically improved with incorporation of rice bran, wheat bran and wood charcoal. In present study, we investigated that not only the effects of soil properties but also changes of microbial communities in soils amended with organic amendments. The bulk density and porosity of soil were improved by application of rice bran and charcoal as reported by Kim *et al.* (2006). Kim *et al.* (2006) reported that the improving of hydraulic conductivity and water stable aggregation by organic materials influenced the soil physical properties. Biochemical methods, such as the PLFA approach, are increasing in popularity as a means to characterize microbial communities (Wander et al. 1995). Changed biological ratio index of fatty acids in the soils were detected depending on the inputted materials. Especially in application of rice bran including mixture with charcoal, the ratio of fungi to bacteria increased, suggesting the more organic carbon metabolically decomposed under these treatments. The high ratio gram-negative to gram-positive also suggests more nutrition for microbes in rice bran inputted soil. The high ratio of aerobe to anaerobe and cycloprophyl to precursor suggested the better aerobic conditions in wood charcoal inputted soils.

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Characteristics of the Pig Roundworms, *Ascaris suum,* and Occurrence of Parasite Eggs on Cabbage in Gyeonggi-do

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Key words: Parasite, *Ascaris suum*

Abstract

This study was conducted to prevent the contamination of parasite egg on vegetables for supporting the safe production of leafy vegetables. After the chinese cabbages and soil samples were collected at 5 cities in Gyeonggido in 2007 and 2008, the existence of parasite eggs was surveyed. All collected samples had no parasite egg, so the chinese cabbages produced in the Gyeonggi area were assumed to be parasite egg-free. To examine the characteristics of parasite eggs, the pig roundworms, Ascaris suum, were collected from the intestine of infected pig and the parasite eggs were collected from the uterus of A. suum. The eggs of A. suum developed to embryonated eggs, which can infect humans, at 20-30°C, but not at 15°C and 35°C, when cultured at different temperatures. The eggs developed to embryonated eggs after drying for 0-24h when cultured after different drying times. The effect of soakage in different salt solutions and over different times showed that the eggs developed to embryonated eggs after soakage at 0-25% salt solution for 0-24h. For eliminating the parasite eggs attached to leafy vegetables, it was efficient to soak using a salt solution for 5 minutes and washing 5 times with water.

Introduction

KFDA (Korea Food and Drug Administration) reported in October 2005 that parasite eggs were detected in 3.2% of 502 surveyed kimchi manufacturers and that parasite eggs were detected in 4.8% of 165 tested domestically distributed Chinese cabbage (KFDA, 2005). Parasite eggs can be contaminated by use of manure in the cultivation of crops, and from the feces of cats or dogs. Parasite eggs can be spread through the soil by such organisms as roundworm (*Ascaris lumbricoides*), pig roundworm (A. suum), dog roundworm (*Toxocara canis*), whipworm (*Trichocephalus trichiurus*), etc. Roundworm eggs discharged to the outside from the intestine of humans begin to develop embryonated eggs in about 2 weeks at the proper humidity and temperature (22-30°C). If these eggs are eaten by humans, the embryonated eggs hatch in the stomach or upper small intestine and molt to II stage larvae (Moon, 2003). This study was conducted to prevent the contamination of parasite eggs on vegetables for supporting safeproduction of leafy vegetables.

Methods and materials

Regional occurrence of parasite eggs: Chinese cabbage and soil samples were collected at Chinese cabbage fields in Hwaseong, Pyeongtaek, Yongin, Gimpo, Paju in 2007 and 2008. Investigation of Chinese cabbage was performed according to precipitation methods following KFDA guidelines (KFDA, 2005), and the investigation of soil was performed according to suspension methods (Cho etc. 2002).

Development of pig roundworm according to the environmental conditions

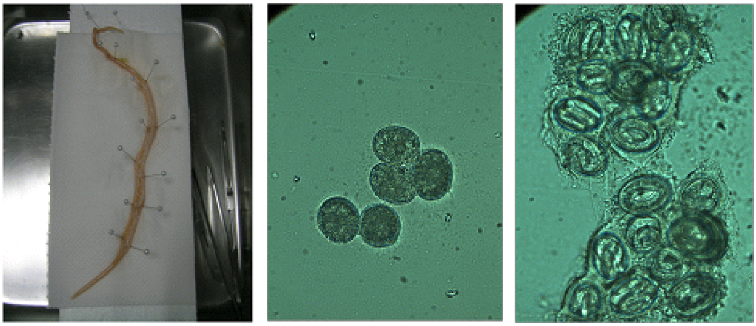
Pig roundworms were collected from infected pigs and the eggs were drawn out from the uterus of the worms. For the rate of embryonated eggs according to temperature, the eggs were cultured at a constant temperature chamber of 15, 20, 25, 30 and 35°C and investigated every week for 8 weeks. For the rate of embryonated eggs according to dryness, the eggs were dryed for 0, 3, 6, 12 and 24 hours at 30°C and cultured at 25°C and investigated every week for 8 weeks. For the rate of embryonated eggs according to salt density, the eggs were soaked in 0, 5, 10, 15, 20, and 25% salt solution for 3, 6, 12, and 24 hours cultured at constant temperature chamber of 15, 20, 25, 30 and 35°C and investigated every week for 8 weeks.

The removal of pig roundworms eggs from Chinese cabbage

A diluted solution of pig roundworms eggs was sprayed to leaves of Chinese cabbage and dryed 1 hour at room temperature. The leaves of Chinese cabbage were washed after each treatment and investigated according to precipitation methods of KFDA guidelines. As treatment, S. water was washing using standing water of 3L for 15 seconds, R. water was washing using running tap water for 1 minute and salt solution was soakage using a 10% salt solution for 5 minutes.

Tab. 1: The occurrence rate of parasite eggs on cabbage in the Gyeonggi area.

Samples	Occurrence of parasite eggs	Pyeongt aek		Yongin		Hwaseo ng		Gimpo		Paju	
		'07	'08	'07	'08	'07	'08	'07	'08	'07	'08
Vegetable	No. of samples	10	10	10	10	15	11	10	10	10	10
	Occurrence rate (%)	0	0	0	0	0	0	0	0	0	0
Soil	No. of samples	10	10	10	10	15	11	15	10	15	10
	Occurrence rate (%)	0	0	0	0	0	0	0	0	0	0



(A) (B) (C)

Figure 1: Pig roundworms, *Ascaris suum*. Female adult (A), Fertilized eggs (B), and Embryonated eggs (C)

Tab. 2: The occurrence rate of embryonated eggs for fertilized eggs of pig roundworms, *Ascaris suum*, cultured at different temperatures

Culture temperature (°C)	Ⅰ		Ⅱ		Ⅲ		Average occurrence rate (%)
	No. of samples	Occurrence rate (%)	No. of samples	Occurrence rate (%)	No. of samples	Occurrence rate (%)	
15	99	0	96	0	56	0	0
20	74	24.3	108	17.6	64	3.1	15.0
25	99	15.2	162	10.5	46	17.4	14.3
30	115	27.0	66	3.0	98	6.1	12.0
35	112	0	218	0	188	0	0.0

Tab. 3: The occurrence rate of embryonated eggs for fertilized eggs of pig roundworms, *Ascaris suum*, cultured after different drying times

Drying times (Hour)	Ⅰ		Ⅱ		Ⅲ		Average occurrence rate (%)
	No. of samples	Occurrence rate (%)	No.	Rate (%)	No.	Rate (%)	
0	78	11.5	76	6.6	98	7.1	8.4
3	304	4.3	187	2.1	183	1.1	2.5
6	174	6.9	115	20	177	6.2	11
12	165	2.4	170	2.9	252	0.8	2.1
24	142	2.8	197	1	264	6.8	3.6

Tab. 4: The occurrence rate of embryonated eggs for fertilized eggs of pig roundworms, *Ascaris suum*, cultured after soakage using a salt solution

Density	0%		5%		10%		15%		20%		25%	
Soakage time	No. of samples	Occurrence rate (%)	No.	Rate (%)	No.	Rate (%)	No.	Rate (%)	No.	Rate (%)	No.	Rate (%)
3h	252	8.4	159	10.7	619	7.6	313	2.9	454	9.1	86	2.1
6h			236	6.2	378	2.7	319	4.2	470	2.3	82	4.1
12h			160	2.5	287	5.3	501	3.5	356	2.4	141	5.8
24h			311	4.3	477	4.7	282	1.9	338	1.5	122	1.3

Tab. 5: The elimination rate of parasite eggs attached to leafy vegetables by several washing methods

Washing methods	No. of detected parasite eggs			Mean♭	Elimination rate (%)
	Ⅰ	Ⅱ	Ⅲ		
S. water♩ 3 times	38	63	41	47.3[a]	84.7
R. water♪	17	26	35	26.0[b]	91.6
S. water 5 times	13	3	9	8.3[c]	97.3
Salt solution♬+R. water	0	1	4	1.7[c]	99.5
Salt solution+S. water 5 times	0	0	0	0.0[c]	100
Control	307	240	384	310.3	-

♩ S. water: Washing using standing water for 15 seconds,♪ R. water: Washing using running tap water for 1 minute , ♬ Salt solution: Soakage using 10% salt solution for 5 minutes
♭ DMRT (5%)

Results and Conclusions

Regional occurrence of parasite eggs

At all samples including Chinese cabbage and soil from the surveyed five localities, the parasite eggs were not detected. At a survey strawberry field in 1971, roundworm eggs were detected on 3% of the strawberries, 100% in soils were human manure was used, and 16% in soil using chemical fertilizers (Yun etc, 1971). At a survey vegetable field in 1975, roundworm eggs were detected on 49% of the vegetables and 45% in soils (Jeong etc, 1975). These reports showed different results from this study. At that time, human parasite infection rates were as high as 55% (Moon, 2003) but nowadays the infection rates are very low at 0.05% (KFDA, 2005). Also, human manure is no longer used, so it is considered that there are no parasite eggs in soil and on cabbage.

Development of pig roundworm according to the environmental conditions

The pig roundworm eggs developed to embryonated eggs with 12.0-15.0% at 20, 25, 30°C, but did not develop at the 15°C and 35°C temperatures. The eggs developed to embryonated eggs after dryness for 24h in the proper temperature and humidity. The eggs developed to embryonated eggs after soakage in 25% salt solution for 24h. In conclusion, it is difficult to block the parasite eggs attached to Chinese cabbage to develop to embryonated eggs when processing and manufacturing kimchi.

The removal of pig roundworms eggs from Chinese cabbage

The pig roundworm eggs attached to Chinese cabbage were removed by 97.3-99.5% at 5 times washing in standing water and washing in tap water after soakage in a salt solution, and by 100% at 5 times washing in standing water after soakage in the salt solution. Similar to this study, Yun, et al. (1971) reported that the pig roundworm eggs attached to strawberries were removed by 99% at 4 times washing in tap water and by 100% at 5 times washing in tap water.

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Organic tomatoes

Mulching Method Evaluations in Organic Tomato Production

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Key words: straw, weed control, paper mulch, yield

Abstract

The goal of the examination is to choose appropriate mulching methods in transplanted tomato production that can serve weed management and the quality production simultaneously. Untreated control, herbicide control, control by hoeing, straw mulch, straw mulch combined with Phylazonit, black plastic mulch, paper mulch, grass clippings mulch, legume clippings mulch, compost and weed clippings mulch were tested. The six-year long field experiment had four replicates in each experimental year. Plastic mulch and paper mulch were significantly more effective than straw mulch treatments in the average of years on total weed control because of the solid surface cover. Paper and plastic mulch treatments provide the highest tomato yield, as well.. Pest free, marketable yield ratio was measured separately where straw mulches were the best treatments. The experiment proved that appropriate mulching can reduce weed problems in general and against some typical weed species also. Mulching has also a great effect on yield quality, which must be kept in mind when the appropriate strategy is chosen for production.

Introduction

Non-chemical weed management strategies have high importance in any organic production method (Radics, Pusztai 1994). Although physical methods are widely used in organic farming, mulching has only limited role (Radics *et al.* 2002) in Hungary.

The goal of the experiments was to choose proper mulching methods in transplanted tomato production system that can serve weed management and quality tomato production also. Eight different soil cover methods were compared with one another and with untreated, traditionally controlled hoed and herbicide treated controls. Similar tests were done by Díaz-Pérez (2009) in broccoli, but only black plastic foil was investigated in that case.

The effect of tested mulches were studied on total weed cover percentage in general, on total weed cover of different life form groups and on separate cover percentage of all existing weed species to determine the mulching methods which can suppress weed infection if the farm that has problems with only some typical weed species.

Results have never been published in its totality where two different statistical methods and on its basis the complex evaluation of rank numbers was implemented.

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Materials and methods

The six-year long field experiment was at Soroksár, Hungary, on a certified experimental area of Department of Ecological and Sustainable Production Systems of Corvinus University of Budapest from 2000 to 2005. 11 treatment combinations were compared with four replicates in each experimental year. Each of the 44 plots was 2 m x 5 m = 10 m^2 per plot and 440 m^2 for the whole experiment. Plots were divided by weed-free roads of 0,5 m width.

Soil tillage was made by ploughing and harrowing to prepare fine seed bed. No plant protection treatments were used during the experiment against pests or diseases. During the six years of the trial only limited irrigation was used to keep balanced moisture in each year in the soil's upper level. The tested tomato (*Lycopersicon esculentum*) hybrid was Dual Early (1997). Seedlings were planted into 60 cm plant-to-plant distance with 70 cm row space. Time of transplanting was the end of May in every year: 29 May 2000, 29 May 2001, 25 May 2002, 28 May 2003, 27 May 2004, 26 May 2005.

Treatments of the experiment were: untreated control (1), herbicide control (2), hoed control (3), straw mulch (4), straw mulch completed with Phylazonit (5), black plastic mulch (6), paper mulch (7), grass clippings mulch (8), legume clippings mulch (9), compost (10) and weed clippings mulch (11). Phylazonit is a bacteria fertiliser which has a significant effect on soil microbiological life (LÉVAI *et al.* 2008) and can improve decomposting straw and other plant residue.. Samples were taken identically in every year by assessing weed cover percentage. After weed survey and data recording, statistical data analysis was made.

Measurements were done as it follows:

- survey of weed cover and tomato percentage in June, July and August in every year on every plot. Different weed species were estimated on a randomly selected 1 m^2 survey area in every replication of every treatment.
- weight measurement of healthy and infected/harmed tomato yield on every plot were made according to the intensity of ripening; measuring fresh yield of tomato was done right after the harvest on the field directly. Healthy marketable and infected fruits were collected and weighted separately.

Weediness was analysed from the following aspects: total weed cover in general, cover percentage of different life forms groups and main weed species, as well. Data were analysed in total average of six years and in each experimental year in every treatment. Tomato cover percentage was analysed with the same method as total weed cover. Effect of different mulching methods on tomato yield and effectiveness in weed control were evaluated also by rank numbers together. Results of data analysis of the main examined factors were ranked by their effectiveness and characterized with rank numbers. Cumulative rank number was set up in accordance with the total tomato weight (a) total tomato weight (b) and ratio (c) of healthy/marketable tomato yield and weed suppress effectiveness (d) factors. The highest rank number means the best effect.

Weed cover percentage is an estimated, ordinal variable thus traditional analysis of variance by Levene test and Games-Howell or Tukey-Kramer test does not give a proper result. Ordinal variables as weed or tomato cover percentage are better to be compared by their relative rate (VARGHA, 2000). These analyses were made by

Brunner-Munzel and Bonferroni test. The two analysing methods were used to evaluate cover percentage of weeds and tomato to decide which statistical way fits better to the cover percentage based surveys.

Results

There were no difference among yearly average and monthly data of weed and tomato cover percentage by treatments as the earlier studies showed it (Radics *et al.* 2006.). The total average of six years could describe the tendency of weed suppressing effect and tomato yield without significant difference with yearly results, so here the total average is detailed only.

The effectiveness of herbicide control (2), legume clippings mulch (9), compost (10) and weed clippings mulch (11) according to total weed cover percentage was only limited. There was no significant difference between these treatments. The compost (10) and weed clippings mulch (11) was not more successful than untreated control (1) either. Comparing the two types of straw mulch (4,5), no significant difference was observed. It gave significantly better effect than the worst treatments thanks to its good tractability and structural stability. Regular control of mulch layer is not to be failed neither in the case of straw mulch because as a consequence of packing, the mulch layer easily becomes too thin through which weeds can grow in the second part of the growing season. The two treatments with the most effective weed suppressing ability were plastic (6) and paper mulch (7) in the average of the six years. Significant difference between these two treatments was not observable, but they had better weed controlling effect than all the other treatments.

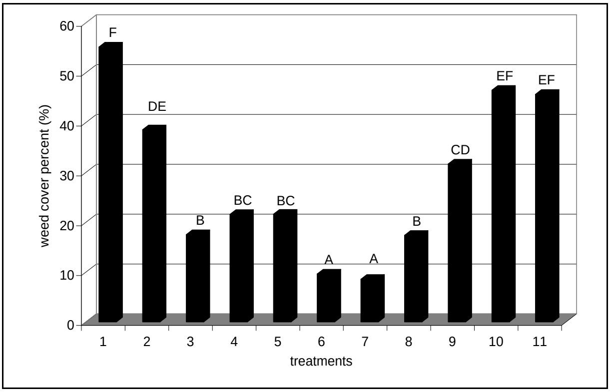

Figure 1: Total weed cover percentage (%) in average of the six years by

Late summer annual broadleaf weeds were dominant on the experimental area so their cover percentage can be characterized just the same way as total weed cover. *Portulaca oleracea* gave stable cover in almost every year of the examination, average total cover of this species was one of the highest. It was found that weed clippings mulch (11) was the less effective treatment against *P. oleracea*. Straw mulches (4 and 5), plastic mulch (6), paper mulch (7) and grass clippings mulch (8) were effective with no significant difference within this group. Other important weeds were also analysed in details.

The highest yield was observed in paper mulch (7) and plastic mulch (6) treatments. More accurate picture could be seen on healthy yield ratio when the healthy and total yield is compared. In this case the best ratio was found in straw mulches. Positive effect of straw mulch on plant health is confirmed by other scientific examinations also. Straw mulch should be kept in mind as an effective method against leaf-pests and insects in organic farming. Hoeing was not favourable, as it may cause harm on tomato plants directly and by soil littering.

One of the most effective treatments of the experiment was plastic mulch (6) in the complex rank order. Except for the ratio of healthy yield, it was on the first two places in the rank of treatments. Straw mulch with Phylazonit (5) did not differ from straw mulch (4). The bacterial fertilizer did not improve tomato yield in a statistically verifiable amount compared to untreated straw mulch. Straw mulch, as it is found in literature, was an effective treatment. According to the ratio of healthy yield, paper mulch (7) was only the fourth in this order, but there was no significant difference among the first four treatments.

Conclusions

The experiment could prove that mulching can provide effective defense against weed problems in general and against certain weed species, too. Mulch type has also a great effect on tomato yield quality which must be kept in mind when the appropriate strategy is chosen for production. Competitiveness of straw mulch to plastic mulch regarding weed management effect and yield of tomato together is justified. Positive effect on plant health of natural mulches, especially straw much is proved. Effectiveness of straw mulch, straw mulch with Phylazonit, plastic mulch, paper mulch, grass clippings mulch in weed management of tomato with respect to local circumstances is verified.

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Influence of fertilizer formulations and methods of application in organic greenhouse tomato

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Key words: Organic farming, Protected agriculture, Organic fertilizers

Abstract

Investigations were conducted from 2006-2010 in order to develop a package of cultivation practices for producing organic greenhouse vegetables under Kuwait's environmental conditions. One of the objectives of these investigations was to evaluate different organic fertilizer formulations with a view to select fertilizers for organic greenhouse vegetable production. Commercial organic fertilizer formulations viz. Earth juice, fish hydrosylate (Neptunes Harvest), seaweed and desert bat guano (Squantos secret) were evaluated in different proportions, either as soil drench or foliar applications in tomato. Results revealed that soil application of Earth juice products and fish hydrosylate produced equally good or even better vegetative growth and fruit yields as compared to conventional fertilizers. Soil application of organic fertilizers was found to be significantly effective than the foliar application.

Introduction

In recent years, vegetable production under the protected environment has become an important agricultural activity in Kuwait (Bhat *et al.* 2010). Because of the excessive use of imported production inputs, synthetic fertilizers, and pesticides in growing fresh vegetables, the local producers are faced with high production cost, rapid deterioration of soil health and productive capacity, increased risk of crop failures, and declining crop productivity. The organic farming system, which has been shown to restore, promote, and sustain soil health and its productive capacity, is considered crucial to the future of protected environment food production in Kuwait; however, as yet, this has not been tried in the country. Therefore, since 2006, efforts had been underway to develop practices for organic greenhouse vegetable producton under Kuwait's environmental conditions. One of the objectives of this investigation was to select suitable organic nutrient formulations and application methods for producing greenhouse vegetables. In this regard, a series of experiments were conducted between 2006 and 2010 to evaluate commercially available organic fertilizer formulations on growth and yield of greenhouse vegetables. Results of studies on tomato, particularly, are discussed in this paper.

Materials and methods

Raising of seedlings

Certified organic seeds of two cultivars (Cindel F_1 and Sakura F_1) of tomato (*Lycopersicon esculentum* Mill.) were sown individually in 5-cm polyethylene

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containers filled with a mixture of sphagnum peat moss; coco peat and perlite (2 : 0.5 : 1 by volume). Seedlings were fertilized weekly with organic fertilizers, Algafarm soluble K powder (Valagro, Italy) and Fontana (Memon B. V., Arnhem, Netherlands) in the nursery.

Production system

Twenty-five-litre flexible polyethylene containers filled with a locally formulated organic substrate containing vermicompost; sphagnum peat moss; coco peat and perlite @ 1: 1: 1: 1 ratio was used to grow the crop. DOrS (Stanes, India) containing 1.0% N, 0.75% P, 1.0% K, 16% organic carbon was mixed uniformly in the growing substrate @ 15 kg/ m^3 prior to the planting of seedlings. One hardened seedling was planted in wet substrate in each container. Standard cultural practices were adopted to secure optimum crop performance (Bhat *et al.* 2010). The fertilizer treatments are given in Table 1.

Tab.1: Fertilizer formulations and application methods

Treat.	Fertilizer Formulation	Nutrient Composition (N-P-K)	Quantity of Stock solution*	Method of Appl.	Freq. of Appl.
T_1	Earth Juice products (Grow, Bloom, Catalyst and Meta K)	2-1-1, 0-3-1, 0.03-0.01-0.1 and 0-0-10	50 ml/ l	Soil drench	Weekly
T_2	Fish hydrosylate (Neptune Harvest) and Soluble seaweed powder	2–4-1 and 1-0-10	50 ml/ l	Soil drench	Weekly
T_3	Desert bat guano and Soluble seaweed powder	8-4-1 and 1-0-10	10 g bat guano and 5 g seaweed/ l	Soil drench	Bat guano weekly and Seaweed monthly
T_4	Earth juice products (Grow, Bloom, Catalyst and Meta K)	2-1-1, 0-3-1, 0.03-0.01-0.1 and 0-0-10	50 ml/l	Foliar spray	Weekly
T_5	Fish hydrosylate (Neptune Harvest) and soluble seaweed powder	2–4-1 and 1-0-10	50 ml/l	Foliar spray	Weekly
T_6	Earth Juice products (Grow, Bloom, Catalyst and Meta K)	2-1-1, 0-3-1, 0.03-0.01-0.1 and 0-0-10	100 ml/ l	Soil drench	Weekly
T_7	Fish hydrosylate (Neptune Harvest) and Soluble seaweed powder	2–4-1 and 1-0-10	100 ml/ l	Soil drench	Weekly
T_8	Desert bat guano and Soluble seaweed powder	8-4-1 and 1-0-10	20g bat guano and 10 g seaweed/ l	Soil drench	Weekly

Experimental design and data analysis

Fertilizer treatments were replicated three times in a randomized complete block design. Periodic data on plant height, number of leaves, and chlorophyll index were recorded on fifteen randomly selected plants in each treatment. Moderate attacks of whiteflies and leaf curl virus was noticed but they were controlled by spraying 5 ml/l of Nimbecidine at weekly intervals. One spray of BioCure (*Trichoderma viride* 1.15% WP) was also applied as a prophylactic measure against fungal infestation.

Nimbecidine spraying was alternated with Garlic barrier and BioCatch (selective stain of naturally occurring entomopathogenic fungusof *Verticillium lecanii*) sprayings to avoid the building up of resistance to the pesticide by pest the populations. The data were analyzed by ANOVA using the "R" procedure (Crowley 2005) and significant treatment means were identified using Duncan's Multiple Range Test (Little and Hill 1978). The data on the 140 d after planting (DAP) stage are presented in this paper.

Tab. 2: Average height, number of leaves, and per plant yield of tomato plants (*Lycopersicon esculentum* cv. Cindel F_1) at 140 DAP in different fertilizer treatments

Treatments	Height (cm)	Number of leaves	Per plant fruit yield (kg)
T1	205.3b	18.0c	2.80
T2	205.1b	17.3c	2.76
T3	195.3ab	16.4ab	2.56
T4	188.7a	15.7a	2.57
T5	184.9a	16.5ab	2.42
Control	171.1a	15.1a	2.59
Significance	***	*	NS

* significant for P<0.05

*** significant for P<0.001

Tab. 3: Average height, number of leaves,leaf chlorophyll and per plant yield of cherry tomato plants (*Lycopersicon esculentum* cv. Sakura F_1) produced in different fertilizer treatments

Treatments	Height (cm)	Number of leaves	Leaf chlorophyll	Per plant fruit yield (kg)
T_7	289.3c	18.6	18.8b	2.77b
T_8	258.5b	15.7	18.2b	1.85ab
T_9	273.4bc	18.6	13.9a	1.95ab
Control	219.1a	15.2	28.2c	2.23a
Significance	***	NS	***	*

* significant for P<0.05

*** significant for P<0.001, NS not significant

Values followed by the same alphabets within the column are not significantly different.

Results

Tomato (*Lycopersicon esculentum* cv. Cindel F_1)

Tomato plants that received weekly soil applications of Earth juice products (T_1) and fish hydrosylates and seaweed (T_2) fertilizers were taller and contained greater number than those that received foliar applications of these formulations (Table 2). The control plants were the shortest of all plants with least number of leaves. Though the plants which received soil application (T1 and T2) produced higher yield per plant than other treatments, there was no significant difference among treatments with respect to per plant fruit yield.

Cherry Tomato (*Lycopersicon esculentum* cv. Sakura F_1)

Plants that received soil-drench applications of Earth juice products (T6) were taller and contained greater numbers of leaves followed by application of desert bat guano (T8) and fish hydrosylate (T7) than the control plants. However, they had lower leaf chlorophyll levels than those of the plants used as control (Table 3). Highest yield was obtained for treatment T6 with earth juice products than all other treatments (Table 3). Therefore treatment with Earth juice products (T6) was found superior in all the parameters in the cherry tomato (*Lycopersicon esculentum* cv.Sakura F1) cultivation.

Discussion

The results of this investigation demonstrated that the organic nutrient formulations produced similar, if not even better vegetative growth and yields compared to inorganic fertilizers. However, yields obtained in these studies were far below the commercial levels. The main reason for low yields was the interruption in the normal growth of plants due to severe infestations of thrips and whiteflies in the early stages of seedling growth and their continuing impact on subsequent growth, fruit set, and yield. The natural pesticides used to control these pests took longer time to reduce insect populations to more manageable levels. Hence, more efforts are needed to control insects to allow for uninterrupted vegetative growth and flowering.

Conclusions

Soil-drenching applications of Earth Juice products and Fish hydrosylate produced better vegetative growth and yields than the other formulations in tomatoes.

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Effect of bio-fertilization of *Trichoderma* species on early growth of some tomato cultivars

Olabiyi, T.I.[1], Ruocco, M[2] & Lanzuise, S.[3]

Key words: *Trichoderma*, tomato, seedling emergence, growth.

Abstract

The effects of P1 isolates of Trichoderma atroviride and T22 ATCC isolate of T. harzianum were assessed twice on Corbarino, LA 0716, LA 1777, N82, SM36 and TA206 tomato varieties in the greenhouse. There were 6 tomato varieties with 3 treatments and 5 replicates fitted into randomized complete block design. Seeds of different tomato cultivars were coated with spore suspension of each species of Trichoderma and sown into compost amended autoclaved soil. The result of the experiment shows that P1 isolate of T. atroviride and T22 isolates of T. harzianum improved seedling emergence and the growth rate of the tomato cultivars. The tomato cultivars treated with Trichoderma have higher growth than the untreated tomato (control). However, T. atroviride enhanced the growth of tomato more than T. harzianum. Further investigations are required to assess the effect on yield of tomato in the field.

Introduction

Bio-fertilizer is a natural organic fertilizer that provides all the nutrient required by the plant under favourable environmental conditions and also helps to increase the quality of the soil with natural micro-organisms. Fungi of the genus *Trichoderma* is a natural micro-organism that has track records of promoting growth and root development of a wide range of plants (Harman *et al*., 2004) and an important organic bio-fertilizer.

The effect of *Trichoderma harzianum* (T22 isolate) had been reported on maize whereby maize plants treated with *T. harzianum* had much deeper rooting and higher growth compared with untreated plants (Harman & Bjorkman, 1998). *Trichoderma* induces the growth of plant. However, the mechanism that *Trichoderma* uses to increase root, shoot growth and yield depends on its ability of some physiological processes of plant. *Trichoderma* have the ability to make more nutrients available for plant uptake and also degrade toxic compounds (Harman *et al*., 2004). They are also able to produce a diffusible metabolite that has plant hormone characteristics (Windham *et al*., 1986).

Literature is very scanty on the effects of *Trichoderma* species on the growth of tomato. The present study therefore focuses on the effects of bio-fertilization of *T. atroviride* (P1 isolate) and *T. harzianum* (T22 ATCC isolate) on the early growth of some cultivars of tomato.

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Materials and Methods

Tomato cultivars (genotypes) used during the course of this research was Corbarino, LA0716, LA1777, N82, SM36 and TA209.

Sterilization of tomato seeds – Dispense 10mls of 10% bleach into 10 tomato seeds in an ependorf tube and allow it to rest for 1 hour. Rinse the seeds with deionised water 3 times consecutively in order to remove the bleach. There were three (3) treatments: (a). Different cultivars of tomato inoculated with *T. atroviride* P1 isolate (b). Different cultivars of tomato inoculated with *T. harzianum* T 22 ATCC isolate (c) Different cultivars of tomato that were not inoculated with *Trichoderma* (control).

Direct seeding was done for all except LA0716 and LA1777 which were planted directly inside the Petri dishes previously lined with water soaked filter paper. At germination, all were carefully transferred appropriately into the soil. Autoclaved (sterilised) soil, with a composition of 1 part organic matter and 3 part soil, was used for each of the experiment in the greenhouse with control temperature of $25\pm1^{o}C$ and 80% humidity. Each tomato seed genotype in the treatment 'a' was inoculated with $1x10^{-5}$ spores of *T. atroviride* P1 isolate, those in treatment 'b' were inoculated with $1x10^{-5}$ spores of *T. harzianum* T 22 ATCC isolate, while treatment 'c' (control) was neither inoculated with *T. atroviride* P1 isolate nor *T. harzianum* T 22 ATCC isolate. Each treatment was replicated 5 times with 2 seedlings per stand.

Data were collected on the plant height and number of leaf per plant at week 3, 5 and 7 after planting. Data collected during the two trials were pooled together and the average was as presented in Table 1.

Results

The bio-fertilization effects of *Trichoderma* species were studied on some cultivars of tomato. The result presented on Table 1 shows that *T. atroviride* (P1 isolate) and *T. harzianum* (T22 isolate) improved the shoot growth (plant height and number of leaf per plant) of the different tomato cultivars. However, Corbarino, LA0716, LA1777 and N82 cultivars responded more to the *Trichoderma* species than other tomato cultivars (SM36 and TA209). The tomato cultivars treated with *Trichoderma* have higher growth than the untreated tomato (control). However, *T. atroviride* enhanced the growth of tomato more than *T. harzianum*

Table 1: Bio-fertilization effect of Trichoderma species on the growth of tomato

Treatments		Mean number of leaf/ plant at week 3	5	7	Mean height (cm) of tomato at week 3	5	7
	Corbarino	5.8a	6.9a	10.8a	10.6a	19.1a	37.9a
	LA0716	4.6b	6.7a	10.7a	3.4d	7.1c	12.1e
	LA1777	4.1b	6.2b	10.4a	4.6c	6.6c	13.2d
Control	N82	4.0b	6.3a	9.2b	9.4b	15.5b	29.4b
	SM36	4.7b	7.0a	9.2b	1.4e	5.3d	9.6f
	TA206	4.0b	5.8b	9.3b	4.7c	15.4b	22.6c
	Corbarino	5.9a	7.2a	10.5a	11.5a	20.1a	45.1a
P1 isolate	LA0716	4.6b	7.3a	11.1a	3.6d	7.4c	12.2e
of	LA1777	4.0b	6.1b	10.9a	4.4c	7.8c	14.8d
Trichoderma	N82	4.0b	6.0b	9.4b	9.2b	15.6b	32.1b
atroviride	SM36	5.0b	7.0a	9.4b	1.5e	6.0d	9.9f
	TA206	4.0b	6.6b	9.6b	4.6c	19.0b	25.0c
	Corbarino	6.0a	7.2a	12.0a	10.3a	20.0a	38.2a
T22 isolate	LA0716	4.8b	7.2a	11.1a	2.8d	8.0c	14.0e
of	LA1777	4.6b	6.5b	11.0a	5.8c	7.0c	16.5d
Trichoderma	N82	4.0b	6.0b	9.4b	10.0b	16.8b	32.1b
harzianum	SM36	4.0b	7.0a	9.5b	1.4e	5.0d	8.0f
	TA206	4.0b	5.7b	9.6b	5.0c	15.0b	21.0c

Means with the letter along the same column are not significantly different.

Discussion

Many researchers have reported that *Trichoderma* species improved the growth of plants (Muktar, 2008, Harman, 2006, Muthukumar *et al*. 2005). The result corroborates earlier findings of Muktar (2008) reported *T. harzianum, T. viride and T. koningii* that enhanced seedling emergence (germination percentage) of okra. Premsekhr & Rajashree (2009) reported significantly taller tomato plants and higher yield of tomato when treated with *Azosprillium* + 75%N + 100%PK. Application of *Trichoderma* species have been reported to cause increased growth of plants (Harman & Bjorkman, 1998). Moreover, Woo *et al*. (2006) and Vinale *et al*. (2009) reported that *Trichoderma* increases plant growth and development.

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Soil salinization of organically-grown greenhouse tomato

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Key words: growth, mineralization, salt, soil fertility, yield

Abstract

Nowadays, tomato growers are looking to improve greenhouse growing systems to be more sustainable. Irrigation management and the stimulation of soil biological activity are important aspects to consider in organic farming in order to optimize fertilisation management and consequently productivity. To reproduce different soil properties, the experimental set-up conducted at Université Laval (Québec City, Canada), consisted of 36 experimental units (1.5 m^3 containers). The organic soils used were: 1) loam, 2) sandy loam, 3) sandy soil, 4) muck soil, 5) reconstituted organic soil with 40% air porosity and 6) peat soil amended with sawdust. Ten grafted tomato plants (Lycopersicon esculentum) were cultivated in each growing container from March to December 2010. The crop was fertilized using certified organic compost, crab meal and seaweed extract. The concentration of SO_4^{-2}, NO_3^- and Cl^- ions in the soil solution increased in all six soils throughout the production period. The highest NO_3^- concentration increase was observed in the mix of peat, sawdust and compost. This increase was associated with a decrease in biomass accumulation towards the end of the production period.

Introduction

Organic greenhouse production systems have for a long time been recognized as being environmentally friendly. Because of regulation implemented in Europe and recently in Canada, fertilisation of greenhouse crop relies mostly on solid sources such as manure, compost and meals. Although rich in essential nutrients such as nitrate, they also contain high amounts of salts such as sulphate, sodium and chloride. These salts tend to accumulate in the soil of greenhouses where organic productions take place. This is especially true in growing systems where recirculation of the drained solution is used to reach the 0 nutrient emission. However, this salt accumulation can have a detrimental effect on plant growth and fruit quality due to an ionic and osmotic effects (Dorais *et al.* 2001). On the other hand, soil texture and structure affect the activity of soil microorganisms, the mineralization rate of organic matter and the accumulation of salts (Dorais 2007). The overall objectives of this study were to 1) evaluate for an organic greenhouse tomato crop the nitrate availability and the salt accumulation of six organic soils when effluents are recycled to the crop, and 2) the effect of salt accumulation on plant growth.

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Materials and methods

Greenhouse trials were conducted in a 150 m^2 compartment at Laval University (Québec City, Canada, Lat. 46.7 N, Long. 71.4 W) between March and December 2010. The experimental design consisted of 36 containers (each 1.5 m^3). Six organic soils with different physical and chemical properties were tested. These soils were: 1) loam, 2) sandy loam, 3) sandy soil, 4) muck soil, 5) reconstituted organic soil with 40% air porosity and 6) peat soil amended with sawdust. Ten tomato (*Lycopersicon esculentum* cv Trust grafted on Beaufort) plants were cultivated in each of the containers. Solid fertilisation consisted of 1 L per container of shrimp meal (8.5-6-1.2; Distrival inc., QC, Canada) every two weeks and 1 L of a mix of kelp meal (0.5-0.2-17; Distrival inc., QC, Canada) (1/4) and Marin biosol compost (2-1-1; Fafard inc., QC, Canada) (3/4) every other week. Effluent from each container was collected and pooled independently for each soil. Effluents were than monitored prior to being remixed and diluted with water in the irrigation tanks. Every week, a soil solution sample was collected from suction lysimeters installed at a depth of 15 cm. The nitrate, sulphate and chloride content in the soil solution was evaluated using a ion chromatography analyser ICS-1100 (Dionex Canada Ltd, Oakville, ON). Fruit yield were evaluated once a week throughout the production period. The number of fruit and the weight was measured every time. Plant biomass was evaluated three times during the crop (May, July and October 2010). Each time, plant mass (fresh and dry weight of fruits, stem and leaves), total leaf surface area and plant length were measured. The experimental design was a split-plot with 3 replicates. Data were analyzed using the SAS Mixed Models procedure (SAS Institute, Cary, NC). When significant ($P \leq 0.05$), means were compared by the Tukey's multiple range test.

Results

No significant difference between the six different soils was observed during the biomass evaluation in May 2010 (Figure 1). At the second biomass evaluation in July, however, plants grown in the sandy soil showed the lowest dry weight accumulation per leaf surface area, percentage of dry matter in leaves and stems (Figure 1a, b and e, respectively). Similar results were observed for the percentage of dry matter in the stem for the October evaluation (Figure 1e). No significant difference between the six different soils was observed in the percentage of dry matter in the fruits, the dry weight accumulation per stem length as well as for dry weight accumulation per leaf surface area during the evaluation in October (Figure 1). Biomass accumulation showed a tendancy to decline over time (Figure 1a, d and e).

Table 1: Increase in anion concentration in the soil solution sampled using suction lysimeters during the production period.

	Anion accumulation increase (x-fold)[1]			
	Cl^-	SO_4^{-2}	PO_4^-	NO_3^-
Sandy soil	3.8±3.6	6.2±3.5	0.4±0.22	17.8±14.1
Peat, sawdust, compost	2.6±1.8	5.0±3.1	0.4±0.27	36.8±33.3
Peat, compost	3.5±0.8	5.5±1.7	0.2±0.04	14.2±6.7
Sandy loam	3.4±0.5	6.4±3.1	0.5±0.01	12.7±3.9
Loam	3.2±0.8	7.0±1.4	0.7±0.19	7.2±1.4
Muck soil	2.4±1.5	9.6±4.7	0.8±0.04	5.2±3.6

[1] The accumulation increase was calculated using the following formula: average ion concentration in the soil solution during the 4 last weeks of the production period/ the average ion concentration in the soil solution during the 4 first weeks of the production period.

The concentration of Cl^- ions in the soil solution increased between 2.4-fold (muck soil) and 3.8-fold (sandy soil) (Table 1). The increase in SO_4^- ion ranged between 5.0-fold in the mix of peat, sawdust and compost, and 9.6-fold in the muck soil (Table 1). Nitrate concentration increase was very different between the six types of soil. A higher increase was observed in the sandy soil (17.8-fold), the mix of peat, sawdust and compost (36.8-fold), the sandy loam (12.7-fold) and the mix of peat and compost (14.2-fold) (Table 1). The increase was however lower in the two other soils (5.2- and 7.2-fold). Compared to the first four weeks of crop, the concentration of PO_4^- lowered over time, especially in the two soils containing peat (Table 1).

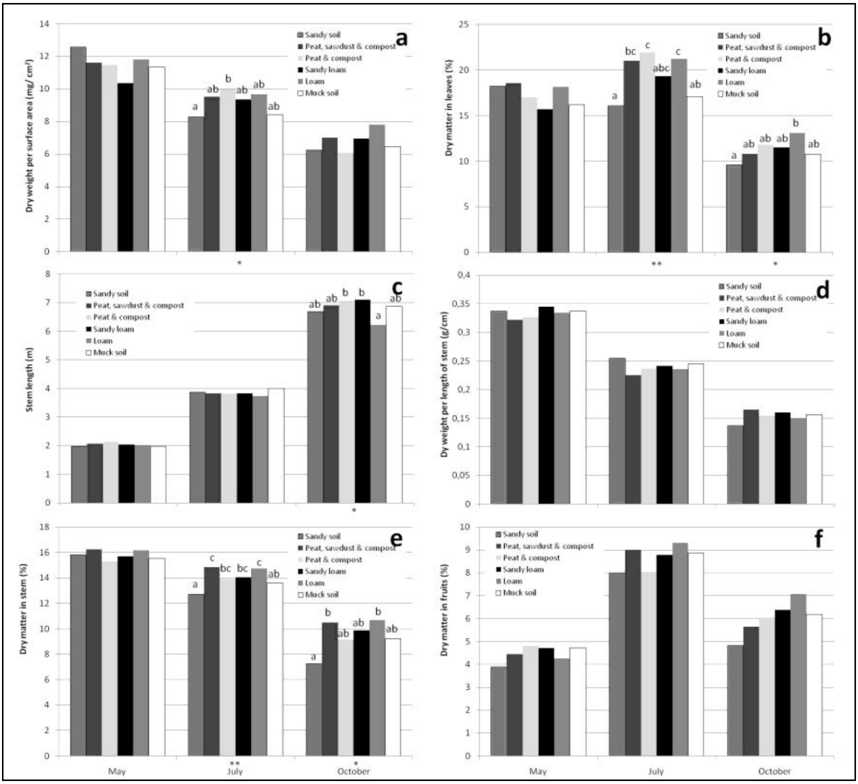

Figure 1: Tomato plant biomass at three sampling dates during the production period. Dry weight accumulation per leaf surface area (a), percentage dry weight in leaf (b), stem length (c), dry weight accumulation per length of stem (d), percentage dry weight in stem (e) and in fruits (f) were evaluated.* significant for P<0.05 ** significant for P<0.001

Discussion

Solid fertilisation, such as shrimp meal, kelp meal and manures often contain high amount of Na, P, SO_4 and Cl. However, as they usually contain relatively low concentration of important nutrients such as NO_3 and K, organic greenhouse production tend to be overfertilized which causes an accumulation of unwanted salts in the soil and the soil solution. De Visser *et al.* (2006) also showed that denitrification losses can be considerable in organic productions, sometimes reaching 25% of the total N balance output. This causes an even higher input in fertilisers to maintain acceptable levels of N to sustain production. Even though concentrations that can be detrimental to tomato plants were not observed during the season length of this experiment, the salt accumulation was constant and could become problematic over time. This is especially true in the case of organic greenhouse production where the same soil is used over a long period of time and numerous cropping periods with similar intensive fruit crops (tomato, sweet pepper, cucumber, eggplant). In recirculation systems (conventional or organic), nutrient accumulation in recycled water, especially bivalent ions, can negatively affect the crop or fruit quality by an ion competition (SO_4^{2-} vs NO_3^-; K^+ vs Ca^{2+} and Mg^{2+}) and an osmotic effect, which result in a reduction of water and nutrient absorption by roots because of a decrease in the osmotic potential of the nutrient solution combined with an increase in the resistance of the xylem transport system inside the plant or the fruit (Dorais *et al.* 2001). Although P accumulation in organic greenhouse horticulture crops has been previously observed, it was not observed in the case of this experiment (Voogt, 1999). The increase in SO_4^{2-} and Cl^- in the soil solution might have caused, at least partially, the decrease in biomass accumulation observed in this experiment. However, no visual damages were observed on tomatoes, even at the end of the cropping season.

Conclusions

A solid fertilisation based on N needs of a tomato crop results in an accumulation of Cl^- and SO_4^{2-} in the soil. However, contrary to what was expected, no P accumulation in the soil solution was observed. The recirculation of the irrigation water probably increased the accumulation of those ions. If recirculation is used under production conditions, a treating system to lower the concentration of Cl^- and SO_4^{2-} should be developed and used even though it can reduce nitrate content of the treated effluent.

Acknowledgments

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Effect of compost suspension on tomato seedling emergence

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Key words: Compost, tomato, seedling emergence.

Abstract

The effect of Terra ecosystem, Wyvern waste, Green waste, Farm yard manure and Garden waste suspension in pure forms were assessed on tomato seedlings. The research was conducted at the Environmental Research Laboratory, Coventry University, UK under a control temperature range of 20 + 2oC for 10 days. The experiment was repeated three times and the average data were recorded. The percentage organic matter, moisture content and pH of the compost were also determined. The result shows that compost suspension retard tomato seed germination. Highest retardation was observed in Farm Yard Manure, closely followed by Terra ecosystem. The pH of the compost varies from 6.5 to 9.1. The pH of the compost affects the percentage germination of the tomato seed. Highest percentage seed germination was recorded with pH 7, these decreases with slightly lower or higher above pH 7. Highest percentage organic matter content of the different composts ranged from 29.94 to 73.76% with Farm Yard manure having the least (29.94%) and Garden waste having the highest (73.76%). Farm yard manure had the highest moisture content (81.04%) while Green waste had the least (16.17%). Farmers are therefore advised that they should not sow the seed directly on compost in order to avoid germination failure.

Introduction

Compost is organic matter (plant and animal residues) which had been rotted down by the action of bacteria and other micro- and macro-organisms, over a period of time.

Many types of organic matter, such as leaf, stem and root, wood ash, fruit and vegetable materials and animal manure can be used to make compost. The end product (compost) is very different from the original materials. It is dark brown, crumbly and has a pleasant smell, alternatively referred to as humus. Compost, when added to the soil, has the advantages of improving the soil and crop quality; it improves the structure of the soil by allowing more air into the soil, improves drainage and reduce erosion; it helps to stop the soil from drying out in time of drought by holding more water; and also add more nutrients to the soil. By improving soil structure, compost makes it easier for plants to take up the nutrients already in the soil. All these can help in the production of better yields and reduce pest and disease problems in the soil and on the crop. The crop will be stronger and healthier and therefore resist pest and disease attack (Pimentel *et al.* 2005, Olabiyi *et al.* 2007).

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The objective of this study is therefore to investigate the effect of different compost suspension on seedling emergence. The result of this study would help the farmers to know whether or not they could apply compost at or before or after seeding operation during crop production.

Materials and Methods

Effect of compost on tomato seed germination: Air-dried Terra ecosystem, Wyvern waste, Green waste, Farm yard manure and Garden waste were ground using Glen Creston Rotary hammer mill, to pass a 1mm mesh. The samples were then packed separately in re-sealable polythene bags. Ten (10) ml each of the compost was transferred to plastic poly-bottles to which were added 25ml of de-ionized water. The bottles were capped and then shaken for 15 minutes on a reciprocating shaker (200 -250 hub/min) and the resulting suspension was filtered through Whatman filter paper number 1. Two (2) ml each of the solution (compost) was put into Petri dishes which had been lined singly with Whatman number 1 filter paper. Twenty tomato seeds (Source: Heritage Seed Library, Ryton Garden Organic, Coventry, UK) were placed on each Petri dish and covered. Petri dishes with de-ionised water (2ml) only served as the control. Each compost treatment was replicated four times. All the Petri dishes were arranged in the incubator (20 ± 2^oC) for 10 days. Counts were made on the number of seeds that germinated within the experimental period. This was calculated on the percentage basis.

$$\% \text{ Germination} = \frac{\text{Number of germinated seed}}{\text{Total number of seed}} \times 100$$

The experiment was repeated three times and average data on the percentage seed germination were recorded.

Determination of pH: Terra ecosystem, Wyvern waste, Green waste, Farm yard manure and Garden waste were ground (2mm) using laboratory attrition mill. Ten (10) ml each of the air-dried compost was transferred to plastic poly-bottles to which were added 25ml of de-ionised water. The bottles were capped and then shaken for 15 minutes on a reciprocating shaker (200 – 250 hub/min) and the resulting suspension was filtered through Whatman number 1filter paper. The pH of the filtrate was determined using a previously calibrated pH meter (Corning pH meter 220). The samples were measured in triplicate and an average measurement was recorded.

Determination of percentage moisture content: Approximately 100g of each compost (Terra ecosystem, Wyvern waste, Green waste, Farm yard manure and Garden waste) was accurately weighed (FW) into the porcelain crucible and transferred to an oven at a regulated temperature of 80^0C for 48 hours (2 days). Each of the compost has three replicates. It was then re-weighed and the differences in the weight were determined. The average weight loss (DW) was determined and percentage moisture content was determined using the following formula:

$$\% \text{ MC} = \frac{(FW-DW)}{FW} \times 100$$

Determination of percentage organic matter: Approximately 100g of each compost (Terra ecosystem, Wyvern waste, Green waste, Farm yard manure and Garden waste) was accurately weighed (X) into the porcelain crucible and transferred to a furnace (Muffle furnace) at a regulated temperature of 500^{0}C for 24 hours. Each of the compost has three replicates. It was then re-weighed and the differences in the weight were determined. The average weight loss (Y) was determined and percentage organic matter was determined using the following formula:

$$\% \ OM = \frac{(X - Y) \times 100}{X}$$

Result and Discussion

Table1 elicits the effect of compost on tomato seedling emergence. Control (distil water only) permitted highest number (98.4%) of tomato germination, this is closely followed by garden waste (88.3%), green waste (88.3%) and Wyvern waste (81.7%). The least tomato seed germination was observed in the farm yard manure (43.4%) closely followed by Terra ecosystem (56.6%).

Table 1: pH, % organic matter, % moisture content and effect of compost on tomato seedling emergence

Compost	% germination	pH	% organic matter	% moisture content
Terra ecosystem	56.6	6.5	58.15	57.77
Wyvern waste	81.7.	7.5	57.64	58.55
Green waste	88.3	7.5	55.66	16.17
Farm yard manure	43.4	9.1	29.94	81.04
Garden waste	88.4	6.9	73.76	56.57
Control	98.4	7.0	0.0	100.0

The pH of the compost varied from 6.5 to 9.1. Terra ecosystem was slightly acidic (pH 6.5), while Wyvern waste (pH 7.5), green waste (pH 7.2) and farm yard manure (pH 9.1) were slightly alkaline. De-ionised water (control) was neutral (pH 7.0). The % organic matter in the compost varied from 29.94% to 73.76%. Green waste had the highest (73.76%) percentage organic matter, followed by Terra ecosystem (58.15%), Wyvern waste (57.64%), green waste (55.66%) and farm yard manure (29.94%) respectively. The % moisture content in the compost varied from 81.04% (farm yard manure) to 16.17% (green waste). Other % moisture contents of the compost were Wyvern waste (58.55%), Terra ecosystem (57.77%) and garden waste (56.57%). The % moisture content of the control (de-ionised water) was 100% but had no organic matter. The pH of the compost affects the percentage germination of the tomato seed. Highest percentage seed germination was recorded with pH 7, these decreases with slightly lower or higher above pH 7. The inhibition level of tomato seed germination is affected with pH values. The result corroborate earlier findings of Gliessman (1998) and Pimentel *et al*.(2005) who reported that direct planting of viable seeds in the compost caused poor seed germination.

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Effect of allelopathy and microclimatic modification of intercropping with marigold and rosemary on tomato early blight disease development

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Key words: Monoculture, weight, allelopathy, tomato

Abstract

In order to investigate the effects of marigold and rosmary allelopathy on tomato early blight disease development, an experiment was conducted as split plot based on complete randomized block design with 3 replications at the agricultural research station, Ferdowsi University of Mashhad, Iran, during 2007 and 2008. Treatments included 2 varieties of tomato (Jina and Mobile) in main plots and 4 planting patterns (tomato monoculture, intercropping of tomato-iranian marigold, intercropping of tomato-foreign marigold and intercropping of tomato-rosmary) in sub plots. Tomato varieties and different planting pattern had significant effects on number and weight of healthy and unhealthy tomatoes per plants. The highest number and weight of healthy and unhealthy tomatoes is observed in monoculture of Jina variety. Fresh weight of healthy and unhealthy fruits was affected significantly by planting pattern. The highest number and weight of healthy and unhealthy fruits was observed in tomato monoculture and other planting pattern did not differ significantly for these traits.

Introduction

Agroecosystems are ecological systems that their functions were organized for agricultural products and based on external inputs (Koocheki *et al.* 2004 a., Nassiri-Mahllati *et al.* 2001). Researchers believe that agroecosystems are unstable compare to natural ecosystems because they relay on external inputs and incorrect use of internal relation in ecosystem (Koocheki *et al.* 2004 a., Koocheki *et al.* 2004 b.). Altieri (1999) reported in agroecosystems, biodiversity performs ecological services beyond the production of food, including recycling of nutrients, regulation of microclimate and local hydrological processes, suppression of undesirable organisms and detoxification of noxious chemicals. Decreasing biodiversity in agroecosystem is threatening for agroecosystem survival and world food security (Koocheki *et al.* 2004 b.). A mothod for increasing biodiversity in agroecosystems is using intercropping. Go´mez-Rodrı´guez *et al.* (2003) indicated that intercropping with marigold induced a significant reduction in tomato early blight caused by A. solani, by means of three different mechanisms: allelopathic effect of marigold, altering the microclimatic conditions around the canopy, to provide a physical barrier against conidia spreading. Bukovinszky *et al.* (2004) reported that pupa and larva population of *Plutella xylostella* in cabbage and barley intercropping was lesser than monoculture. The aim of this

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considering that crop reaction is different in various climates and planting pattern, this study is investigating the allelopathic effect marigold and rosemary on tomato early blight disease development.

Materials and methods

In order to investigate the effects of marigold and rosmary allelopathy on tomato early blight disease development, an experiment was conducted as split plot based on complete randomized block design with 3 replications at the agricultural research station, Ferdowsi University of Mashhad, Iran, during 2007 and 2008. Treatments included 2 varieties of tomato (Jina and Mobile) in main plots and 4 planting patterns (tomato monoculture, intercropping of tomato-iranian marigold, intercropping of tomato-foreign marigold and intercropping of tomato-rosmary) in sub plots. Main plots were 8m*4 m and subplots were 2m*4 m. measured parameters included number and weight of healthy and unhealthy (infected to early blight disease)tomatoes per plants.

A) Figures

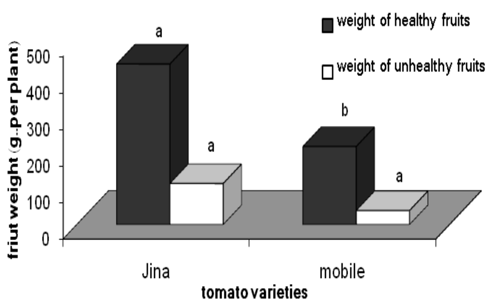

Figure 1 : Effect of tomato variety on fresh weight of healthy and unhealthy fruits

B) Tables

Tab.1: Effects of Tomato varieties and different planting pattern on number and weight of healthy and unhealthy tomatoes

Tomato varietes	Planting pattern	Total number of fruits (g. per plant)	Total weight of fruits (g. per plant)	number of healthy fruits (g. per plant)	Weight of healthy fruits (g. per plant)	number of unhealthy fruits (g. per plant)	Weight of unhealthy fruits (g. per plant)
Jina	Jina-iranian marigold	7.050^{b}	365.946^{bc}	5.972^{bc}	326.779^{bc}	1.078^{b}	39.167^{b}
	Jina-foreign marigold	8.660^{b}	563.332^{b}	7.000^{b}	504.166^{ab}	1.660^{b}	59.166^{b}
	Jina-rosmary	6.933^{b}	353.083^{bc}	5.975^{bc}	322.000^{bc}	0.958^{b}	31.083^{b}
	Jina-Jina	22.939^{a}	924.674^{a}	12.056^{a}	604.672^{a}	10.883^{a}	320.002^{a}
Mobile	Mobile- iranian marigold	5.995^{b}	402.857^{bc}	4.839^{bc}	340.598^{bc}	1.156^{b}	62.259^{b}
	Mobile -foreign marigold	2.867^{b}	198.000^{c}	2.400^{c}	138.500^{c}	0.467^{b}	29.500^{b}
	Mobile - rosmary	4.265^{b}	254.387^{bc}	3.035^{c}	210.928^{c}	1.230^{b}	43.458^{b}
	Mobile- Mobile	3.748^{b}	183.491^{c}	2.948^{c}	165.158^{c}	0.800^{b}	18.333^{b}

The means in each column was comoared with LSD test (P<0.05)

Tab.2: The effect of planting pattern on number and weight of healthy and unhealthy fruits

Planting pattern	Total number of fruits (g. per plant)	Total weight of fruits (g. per plant)	number of healthy fruits (g. per plant)	Weight of healthy fruits (g. per plant)	number of unhealthy fruits (g. per plant)	Weight of unhealthy fruits (g. per plant)
tomato-iranian marigold	6.523^{b}	384.401^{b}	5.406^{ab}	333.689^{b}	1.117^{b}	384.401^{b}
tomato -foreign marigold	5.763^{b}	365.666^{b}	4.700^{b}	321.333^{b}	1.063^{b}	365.666^{b}
tomato -rosmary	5.999^{b}	303.735^{b}	4.505^{b}	266.464^{b}	1.094^{b}	303.735^{b}
tomato monoculture	13.344^{a}	554.083^{a}	7.502$_{a}$	384.915^{a}	5.842^{a}	554.083^{a}

The means in each column was comoared with LSD test (P<0.05)

Results

Tomato varieties and different planting pattern had significant effects on number and weight of healthy and unhealthy tomatoes per plants. The highest number and weight of healthy and unhealthy tomatoes is observed in monoculture of Jina variety and other treatments except for intercropping of Jina tomato-foreign marigold had not difference significantly (table 1).
As it is observed in figure 1, the highest weight of healthy was obtained in Jina variety of tomato, but 2 varieties of tomato had not significant difference for weight of

unhealthy tomatoes. It seems that Jina variety has higher potential yield and resistance to early blight disease rather than Mobile variety.
Fresh weight of healthy and unhealthy fruits was affected significantly by planting pattern. The highest number and weight of healthy and unhealthy fruits was observed in tomato monoculture and other planting pattern did not differ significantly for these traits (table2).

Discussion

Go´mez-Rodrı´guez *et al.* (2003) indicated that intercropping with marigold induced a significant reduction in tomato early blight caused by A. solani, by means of three different mechanisms: allelopathic effect of marigold, altering the microclimatic conditions around the canopy, to provide a physical barrier against conidia spreading. Bukovinszky *et al*. (2004) reported that pupa and larva population of *Plutella xylostella* in cabbage and barley intercropping was lesser than monoculture.
Skovgård and Päts (1997) stududied effect of intercropping maize with cowpea on the damage caused by three species of lepidopteran stemborers (*Chilo partellus*, *Chilo orichalcociliellus*, and *Sesamia calamistis*). They observed higher yield and lower numbers of stem borers in intercropping system.

Conclusions

Tomato monoculture had more plant number to compare intercropping because it had highest yield. Also, the highest unhealthy fruit yield was obtained in monoculture. Because there were more tomato number in square meter in monoculture without phisical and chemical barrier. Further experiments needed to be conducted for utilization of allelopathic effects of marigold and rosmary to increasing tomato yield.

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Organic fruits

Effects of organic apple production systems on foliar macronutrient concentrations

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Key words: ground cover management system, nutrient, organic apple

Abstract

An organic apple (Malus × domestica Borkh.) orchard was established to study the interaction effects of ground cover management systems (GMS) and nutrient sources (NS) on soil and tree nutrient status and tree growth. Trees received one of four GMS: 1) green compost (GC), 2) wood chips (WC), 3) shredded paper (SP), and 4) mow-and-blow (MB). Across all GMS, one of three NS was applied: A) a commercial organic fertilizer (CF), B) poultry litter (PL), and C) control (NF). Overall, GMS had greater effects on the variables than did NS. GC mulch supplied greater nutrients, followed by WC, SP, and MB mulches. SP trees had lower foliar [N] in the first two years than the GC and WC trees. GC- and WC-treated trees had larger trunk cross sectional area than the SP and MB trees.

Introduction

For maintaining the optimum nutrition for fruit trees, organic managers must be aware not only of the level of nutrients sufficient to prevent abnormal tree growth and leaf symptoms but also of those necessary to avoid reduced fruit quality and pest incidences with GMS (Shear, Faust, 1980). Few studies of organic orchard nutrition have generally been conducted in the arid Pacific Northwest, the West, or the colder Northeast region with little or no research in the warm and humid Southern region in the U.S. This study was established to evaluate soil and foliar nutrient concentrations, and tree growth when grown under four GMS with three NS in the Southern U.S.

Materials and methods

GMS mulches with NS annually applied to 'Enterprise' apple trees on M.26 rootstocks at the University of Arkansas, Main Agricultural Experiment and Extension Center, Fayetteville (36°N, 94°W), AR, USA in April from 2006 (year 1) to 2008 (year 3). Trees were planted at 2 m spacing within rows and 4 m between rows for an approximate density of 1,250 trees per hectare. GMS were as follows: 1) urban green compost from leaves, grass, and small brush (GC), 2) raw wood chips (WC), 3) shredded paper mulch (SP), and 4) mow-and-blow green mulch (MB) where the between row fescue was mowed after seed head formation each spring and monthly through the season and simultaneously blown under the tree canopies with a side-discharge mower. GMS were split-plot for NS treatments applied. The NS treatments were: A)

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formulated, certified organic pelletized fertilizers (10N-2P-8K, Nature Safe®) (CF), B) composted poultry litter (PL), and C) control (NF) where nutrition would be derived from the GMS. On the GC, WC, SP mulches, an approximately 10-cm thick layer of mulch was initially applied in April of year 1 and annually reapplied for maintaining the mulch depth by adding the GMS in years 2 and 3. Annual nutrient applications (PL, CF) were made at rates equivalent to approximately 50 g actual N per tree per year in April based on local protocols (Garcia, 2010).

The experimental design was a randomized complete block with six replications of each treatment. The data analysis was performed using the PROC GLM procedure of SAS statistical analysis software (SAS version 8.2, Cary, NC, USA), and mean comparison was calculated by least significant difference (LSD, $\alpha = 0.05$).

Results and Discussion

GMS and NS provided a wide range of nutrient contents and C:N ratios to the systems (Table 1), and mostly, GC and WC mulches supplied greater nutrient contents per tree of each year. GC mulch supplied two times greater N (998 g) than the WC mulch (429 g). SP and MB mulches supplied less than 50 g N per year recommended for young apple tree growth (Garcia, 2010).

Tab. 1: Estimated amount of macronutrients applied of ground cover management system (GMS) and nutrient source (NS) in average of 3 years in an organic apple orchard, Fayetteville, AR.

GMS+NS	Supplied nutrient content (g/tree/year)				C:N ratio
	C	N	P	K	
Green compost+Commercial fertilizer (GC)	15,240	1,018	166	468	15
Green compost+Poultry litter	16,121	1,015	205	492	16
Green compost+No fertilizer	14,861	961	149	438	15
Wood chips+Commercial fertilizer	18,382	449	50	182	41
Wood chips+Poultry litter	19,262	446	89	206	43
Wood chips+No fertilizer	18,003	392	33	152	46
Shredded paper+Commercial fertilizer	8,051	96	18	37	84
Shredded paper+Poultry litter	8,932	93	57	61	96
Shredded paper+No fertilizer	7,672	39	1	7	197
Mow-and-blow+Commercial fertilizer	808	80	20	42	10
Mow-and-blow+Poultry litter	1,689	78	59	66	22
Mow-and-blow+No fertilizer	429	23	3	12	19

All GMS-treated foliar [N] was in a low range of 1.7 to 2.2% in August of years 1 and 2 (Table 2) based on the recommendation (2.4 to 2.6% of N for young non bearing apple trees) of a conventional apple orchard (Stiles, Reid, 1991) and below the ideal nutrient range obtained by a conventional apple orchard in Arkansas (Naraguma, 1994). Lower foliar [N] was found in the SP-treated trees in years 1 and 2. GC trees that usually maintained high foliar [N] showed less [P] among the GMS in years 2 and 3, while SP trees with low foliar [N] in years 2 and 3 had high foliar [P]. This was similar to the previous result that trees with low foliar [N] were usually more foliar [P] (Faust, 1989). However, an adequate level of foliar [P] (0.11 to 0.33%) (Stiles, Reid, 1991) was observed for GC trees during the years. WC, SP, and MB-treated trees had more than adequate [P] level in years 2 and 3. Foliar [K] was not consistently affected by the treatments in August of each year and ranged optimum levels of 1.3 to 2.1% for tree growth (Stiles, Reid, 1991) (Table 2). In April of year 2, the freezing damaging was observed for all the trees, and the symptoms seemed to be more severe in the SP-treated trees. This would have caused the SP trees to grow or regrow late in a season, which could have increased the [K] in the August of year 2. Treatment effect, however, was diminished for foliar [K] in year 3, probably due to the larger tree size as years advanced.

Tab. 2: Foliar [N], [P], and [K] of 'Enterprise'/M.26 apple trees in an organic orchard as affected by ground cover management system (GMS) and nutrient source (NS) from years 1 (2006) to 3 (2008)

GMS+NS	[N] (%)			[P] (%)			[K] (%)		
	Yr 1	Yr 2	Yr 3	Yr 1	Yr 2	Yr 3	Yr 1	Yr 2	Yr 3
GCCF	2.1	2.0	2.2	0.16f	0.21	0.14	1.8ab	1.7cd	1.4
GCPL	2.0	2.1	2.3	0.24cde	0.19	0.14	1.9a	1.7d	1.3
GCNF	2.0	2.1	2.2	0.37ab	0.39	0.16	1.9a	1.7cd	1.4
WCCF	2.2	2.0	2.2	0.20ef	0.33	0.31	1.8ab	1.7d	1.7
WCPL	2.1	2.0	2.2	0.32bc	0.35	0.27	1.8ab	1.7d	1.6
WCNF	2.1	2.1	2.0	0.42a	0.53	0.42	1.9ab	1.9bc	1.6
SPCF	2.0	1.7	2.0	0.29bcd	0.42	0.50	1.7bcd	1.8cd	1.7
SPPL	1.9	1.7	1.9	0.33ab	0.53	0.50	1.7abc	2.0ab	1.7
SPNF	1.8	1.7	2.2	0.31bc	0.65	0.44	1.5e	2.1a	1.6
MBCF	1.9	2.0	2.2	0.21def	0.42	0.38	1.6de	1.6d	1.4
MBPL	2.0	2.0	2.1	0.29bcde	0.47	0.32	1.8ab	1.7d	1.4
MBNF	1.7	2.0	2.2	0.33ab	0.43	0.39	1.6cde	1.7d	1.5
P value	ns	ns	ns	<0.05	ns	ns	<0.001	<0.05	ns

Different letters above bars indicate significant difference as determined by LSD, 5% level. GCCF = Green compost + Commercial fertilizer; GCPL = Green compost + Poultry litter; GCNF = Green compost + No fertilizer. WCCF = Wood chips + Commercial fertilizer; WCPL = Wood chips + Poultry litter; WCNF = Wood chips + No fertilizer. SPCF = Shredded paper + Commercial fertilizer; SPPL = Shredded paper + Poultry litter; SPNF = Shredded paper + No fertilizer. MBCF = Mow-and-blow + Commercial fertilizer; MBPL = Mow-and-blow + Poultry litter; MBNF = Mow-and-blow + No fertilizer

GC- and WC-treated trees, receiving greater nutrients than those of SP and MB trees (Table 1), increased trunk cross sectional area (Fig. 1). SP+NF treatment plots had the highest ratio of C:N, lower foliar [N] in years 1 and 2, and had the smallest trunk cross sectional area.

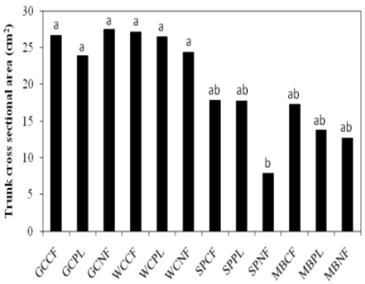

Fig. 1. Trunk cross sectional area of 'Enterprise'/M.26 apple trees in an organic orchard as affected by ground cover managemtn systems and nutrient source in year 3 (2008)

Different letters above bars indicate significant difference as determined by LSD, 5% level. GCCF = Green compost + Commercial fertilizer; GCPL = Green compost + Poultry litter; GCNF = Green compost + No fertilizer. WCCF = Wood chips + Commercial fertilizer; WCPL = Wood chips + Poultry litter; WCNF = Wood chips + No fertilizer. SPCF = Shredded paper + Commercial fertilizer; SPPL = Shredded paper + Poultry litter; SPNF = Shredded paper + No fertilizer. MBCF = Mow-and-blow + Commercial fertilizer; MBPL = Mow-and-blow + Poultry litter; MBNF = Mow-and-blow + No fertilizer.

Conclusions

WC treatment would be the best GMS from the aspect of N use and tree growth. Data developed in this study could be used to develop standards and recommendations for organic orchard nutrition. The project also provided a demonstration for growers as the growth effects of GMS during all three years of an organic orchard were visually profound.

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Water stress on acerola (*Malpighia emarginata*) for production stimulation in low season on organic agriculture managements

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Key words: production stimulation, irrigation managements, organic agriculture practices, productivity in low season.

Abstract

Acerola (Malpighia emarginata D.C.) acquired world-wide importance after discovery the high vitamin C level in its fruits. Effects of water stress in low season were investigated in acerola trees with five, 10 and 15 days on water stress effect. It was evaluated the buds break dormancy performance, bloom induction in order to increase the yield during the low season that correspond dry season, no use chemicals only water managements. The experiment was conducted at Nutrilite Brazil Farm in Ubajara - CE, with randomized blocks designed with four replications. The treatments were the control treatment and different water stress levels, such as: five days, 10 days and 15 days. Each plot was composed of 12 plants with BV 07 acerola variety, after the each level of stress it has been completed, the irrigations were resumed than maintained next soil field capacity that is 12%. The treatment that had the best yield was 10 days, followed for five days and 15 days, even so the treatment with 15 days of water stress showed results of 34.4% higher when compared to control treatment. Thereby it has been concluded that the water stress management in low season increased the acerola yield.

Introduction

In Brazil, the acerola production historic has showed a drop considerably in dry season, with the best harvests concentred in the rainy months from January to April.

So with the need to increase and to control the crop production, the search for techniques that induce flowering has been stimulated, not only improve the production but also no use chemicals for these practices.

Water stress is a method known and adopted in crops such as mango and citrus, in order to achieve improvements on productivity in the orchards.

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It has been observed that vegetative and reproductive growth in trees are differentially sensitive to water stress. Additionally, reproductive growth is differentially sensitive to water stress at different times of the season (BERMAN & DEJONG, 1996).

ALBUQUERQUE & Mouco, 2000 showed as water stress is important for mango floral induction, which as well as the plants can flourish quickly in response to irrigation or rainfall after a period among 6 - 12 weeks without water supply.

BALLY ET AL, 2000, studied the water stress in Kensington Pride mango varieties with 15 years of age, the following conditions: a) irrigation during the year, b) without irrigation since maturation to first flow vegetative phase with 90% anatomically floral buds, and c) without irrigation since maturation of the next phase flow to 70% of inflorescence emerged. They concluded that, without irrigation, an increase of 20.5% in terminal panicles and 17% in production in two of the three years evaluated. Other studies also noted the importance of water stress on mango culture, obtaining increased annual production. Mostert & Hoffman, 1996; LU & Chacko, 1999.

The objective of this study was investigate the effects on acerola production during low season.

Materials and methods

Localization

The work was carried out in the place Nutrilite Brazil Farm in the town of Ubajara - CE, Brazil (3°51'12"S and 41°5’10’’W, elev. 700 m), annual average precipitation is 600 mm and temperature average is 26ºC. The Nutrilite site consisted of a deep sandy soil.

Plant material

Acerola variety was BV 07, which the plants were 10 years old, were propagated from graft, the rootstocks were from acerola variety Sertaneja.

Treatments

The experiment was set up as a split-plot with four blocks and four treatments consisted of the control and different levels of water stress, such as: 1 - control, 2 - five days, 3 - 10 days and 4 - 15 days of water stress. Each plot was composed of 12 plants. After each level of stress completed, irrigation was restarted, keeping the soil next field capacity, with water amount of 108 L / plant by sprinklers.

The study began on October 19, when was suspended the irrigation to plants so started water stress.

This research trial was managed according to organic standards, without use chemical. For overall plants were applied 30 kg of compost with 1.5% of Nitrogen.

Data analysis

All mean, standard error determinations and ANOVA were done using Sisvar statistical software (Universidade Federal de Lavras, Brasil), which were compared thru Tukey test with 5% of probability.

Design was the factorial one at four blocks randomized versus four treatments which the main aim was comparison acerola yield.

Results

All treatments that were applied water stress showed production highest than control (Table 1). Water stress, which can substitute chemicals application for flowering stimulation, showed an production increased by 34 – 58%.

Table 1 - Tukey's test for variance factor of water stress time, (TE) and the average yield in kg / plant in each treatment, Ubajara, CE, 2008.

Treatment	Yield (kg/plant)*
Control	90,16a
5 days	153,91b
10 days	155,33b
15 days	137,36b

*Similar letters do not differ from the values, in conformity with Tukey test at 5%

Discussion

The increases in water stress treatments were due to acerola flower induction that occurs in response to water stress, and flowering intensity is related to the duration of the water stress period. When trees have been exposed to sufficient water stress, leaf margins on terminal leave curl upward toward the midrib, and about 10 mm of irrigation in then required to initiate flowering season in detrimental to flowering and encourages vegetative growth.

Bally et al. (2000), who observed that water stress increased the fruit set in your investigation with the hose 'Kensington Pride'. Mostert and Hoffman (1996), who verified the importance of water stress during the development of flowering buds of the mango, reflected in an increase of 9% in annual production.

This practice showed the ability to increase the yield of acerola, through the floral induction without the use of chemicals, using only the water management.

Water stress that promoted breaking dormancy, showed important results not only to satisfy the economic gains but also to enable the selection and production practices suitable for organic acerola grower.

Conclusions

Water stress is an important organic management, in order to acerola flowering stimulation during low season, so achieve improvements on productivity year round.

Acknowledgments

We gratefully acknowledge the support of Nutrilite Farm for use of its orchards and financial recourses.

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High tunnel production of organic raspberries

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Key words: calcium, fruit quality, growth, *Rubus*, soil fertility

Abstract

High tunnel production under Northern growing conditions can enhance the sustainability of organic berry fruit farming by the extension of the cropping season and the improvement of fruit quality. However, only marginal areas are organically-grown even though the market doesn't fulfil the demand for organic raspberry. The goal of this study was to compare two organic fertilization management methods (liquid and liquid+solid) with a conventional culture grown under high tunnels and to determine the effect of $CaCl_2$ *spray foliar application on berry quality. A complete randomized experimental design with 8 replicates was established at Les Fraises de l'Île d'Orléans, QC, Canada and the combined 6 treatments were compared during 2010. Although no important differences were observed in the soil nutrient solution, soils of organic farming had higher content of N (28%), P (23%), K (46%), Mg (93%), Ca (17%), Fe (10%), Mn (17%) and compared to conventional soil, resulting in their higher leaf concentration. At the end of the cropping season, higher (*$P<0.05$*) plant biomass (39-54%), yield (21%) and fruit size were observed under the organic production systems compared to the conventional system (*$P<0.01$*). Fruits quality were not affected (*$P<0.05$*) by* $CaCl_2$ *treatment.*

Introduction

Numerous studies have shown that consumption of fruits reduces the risk of developing some chronical diseases due to their health-promoting compounds (Dorais & Ehret 2008). Consequently, from 1969-2001 fruit consumption increased by 23% in the USA, 5% in Japan, 475% in South Korea, and 835% in China (Granatstein *et al.* 2010). High tunnel production can enhance the sustainability of organic berry fruit farming. By using high tunnels, production can be advanced in spring and extended in autumns as risks of late or early freezing is reduced. Moroever, "rain free" harvest conditions, reducing potential fungal infections (Rom *et al*. 2010). For an organic established raspberry crop grown under high tunnels in Arkansas (USA), autumn primocane yield of three cultivars was 65% higher than the field crop as well as the berry size, which was 2-23% higher than conventional growing plants (Rom *et al*. 2010). Under unheated greenhouse growing conditions in Turkey, organic raspberry had higher yield when liquid farm manure was provided (Ordu *et al.* 2009). A total of 42 kg/ha per year of N was required for raspberry as the average total N removed from a summer-bearing red raspberry field was 14 kg/ha in harvested fruit;

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13 kg/ha in floricane prunings, and 15 kg/ha in senescing primocane leaves (Strick 2008). The goal of this study was to compare two organic fertilization management methods with a conventional culture grown under high tunnels and determine the effect of $CaCl_2$ spray foliar and fruit application on berry quality.

Materials and methods

High tunnels of 75 m long x 9.1 m wide x 5.2 m high (TunnelPro, Les Industries Harnois, St-Thomas de Joliette, QC, Canada) were constructed in summer 2008 over experimental plots located at Les Fraises de l'Île d'Orléans, Quebec, Canada (Lat. 46.86 N, Long. 71.03 W). Raspberry plants (*Rubus idaeus* L. cv Autumn Britten) established in 2008 in a sandy loam at a plant density of 10 000 plants ha^{-1}. In 2010, two organic fertilization treatments (1- liquid organic fertilization 2- liquid + solid organic fertilizations) were compared with a conventional fertilization (Koester 2003), and the effect of bi-monthly $CaCl_2$ foliar application (360 ppm, 150 mL $plant^{-1}$, *Dowflake*™ 83-87% $CaCl_2$) studied for a total of 6 combined treatments. The experimental design was a complete randomized blocks with 8 replicates for a total of 48 experimental units (e.u.). Plots were soil isolated by coroplast panels to reduce any horizontal nutrient leaching from one plot to another. In May, the first 5 cm deep of organic plots were enriched with 100 L of organic compost per 1 m^3 of soil (Tourbières Berger Ltée, 1.5-0.2-0.2). For all treatments, nutrients were provided at a N-P-K ratio of 3-1-4 kg ha^{-1} per week for the first 8 weeks of growth and then at a ratio of 2-1-4 kg ha^{-1} per week for the remaining growing season, corresponding to a total of 55-20-100 kg ha^{-1}, which fulfil recommendation for a conventional raspberry crop (Koester 2003). The organic liquid fertilization (EC ~0.8mS cm^{-1}, pH 5.8) was based on a fermented grain extract (*Converted Organics*™ *GP 321*, 2.8-1.5-1.0) and liquid K (*allganic*™, 0-0-52+18 S), while poultry pellet manure (*Acti-Sol*® 5-3-8) was used as solid organic amendment. For the mix of liquid and solid organic treatment, liquid fertilization was weekly alternated with the solid amendment. Conventional fertilization used synthetic fertilizers. Drip irrigation systems (20 L m^{-1}) were installed at both sides of the row. Two irrigation per week were provided at 20 L per linear meter to maintain a soil moisture of ~60 cm. Soils (6 cores of 15-20 cm per e.u.) and leaf (15 leaves per e.u.) samples were montly collected for mineral analyses (Melich III for P, K, Ca, Mg, Fe, Cu, Mn, Zn; H_2SO_4-H_2SeO_3-H_2O_2 digestion for N). Every week, a soil solution sample was collected from suction lysimeters installed at a depth of 15 cm. The NO_3, SO_4, P and Cl content in the soil solution was evaluated using a ion chromatography analyser ICS-1100. Fruits were harvested every two days and classified according to their size and exernal quality. Plants were cut at 5 cm from the ground and their fresh and dry biomass evaluated at the end of the harvesting season (mid-October). The averaged air temperature for the whole growing season was 20.7±5.56°C SD. Proc Mix and a *priori* contrast tests were performed with SAS v. 9.1 at ($P<0.05$).

Results and Discussion

The fertilization regime had little effect on the anion concentration of the soil solution except for Cl (Figure 1). For all treatments, the NO_3 content of the soil solution sharply decreased until August 25, and then remained at a low level, which corresponds to the lower N fertilization during the second part of the growing season and the end of the intensive growth period. No buildup of SO_4 was observed during the growing season. For all sampling periods, soils from OF had higher ($P<0.001$) concentration of N (28%), P (23%), K (46%), Mg (93%), Ca (17%), Fe (10%), Mn (17%) and Zn

(108%) compared to conventional soil (Table 1). Significant differences ($P<0.05$) were observed between the two organic treatments (liquid vs liquid+solid) for K, Fe, and Mn (Table 1). Time sampling had a significant effect although interactions were observed for some ions ($P<0.05$). The richer organic soil mineral content resulted in August to higher leaf N (25%), Mg (22%) and K (18%) concentrations of organic-grown plants ($P<0.05$). At the end of the season, we also observed higher ($P<0.05$) dry biomass for organically-grown plants (Liquid 1211±43 and L+S 1094±61 g/linear m) compared to conventional grown plants (787±34 g/linear m).

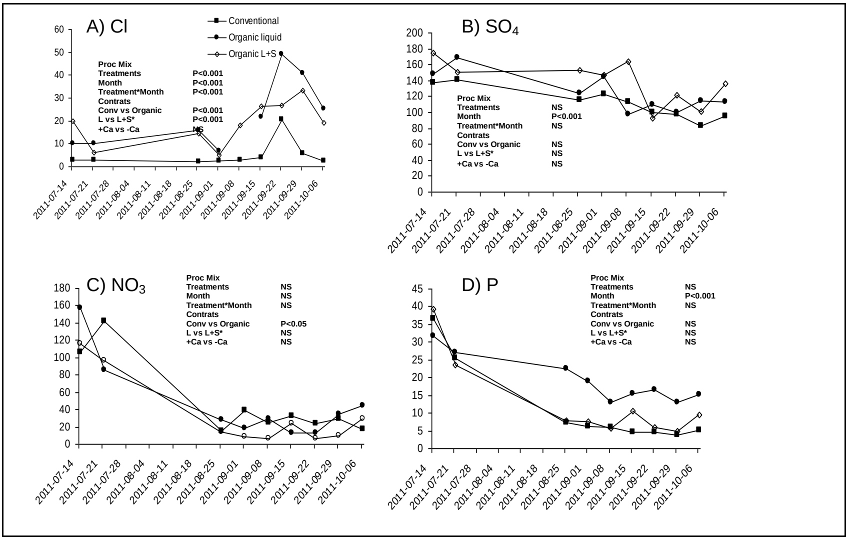

Figure 1: Evolution of the anion concentration (ppm) of the soil solution during the growing season 2010 (n=96).

Consequently, the total fruit marketable yield of organic crops was 21% higher ($P<0.01$) than the conventional crop (Figure 2) with a larger fruit size (3.57 g $fruit^{-1}$ vs 3.43 g $fruit^{-1}$) ($P<0.01$). No significant difference was observed for the percentage of marketable fruit, which ranged from 63 to 66%. $CaCl_2$ foliar application had no significant effect ($P<0.05$) on fruit quality and the percentage of marketable fruits.

Conclusions

Soils of organic farming had higher content of macro- and micronutrients resulting in higher plant biomass, yield and fruit size of organic-grown plants compared to conventional plants. No effect of $CaCl_2$ treatment on fruit quality was observed. High tunnels extended the cropping season by ~40 days under Northern growing conditions and are a promising way to produce high yield of quality fruits.

Acknowledgments

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Figure 2: The influence of three fertilization regimes on the total yield of raspberry grown under high tunnels expressed by g of fruit per linear meter (n=145).

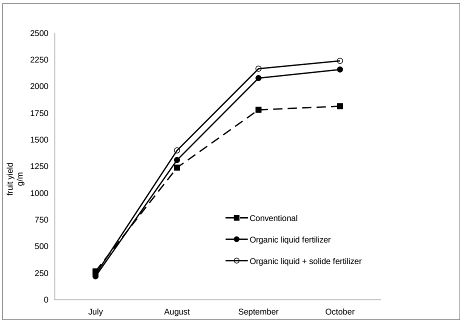
Proc Mix

Treatments	**P<0.01**
Month	**P<0.001**
Treatment*Month	**NS**

Contrasts

Conv vs Organic	**P<0.001**
L vs L+S*	**NS**
+Ca vs -Ca	**NS**

***Liquid and solid organic fertilizers**



Tab. 1: Soil mineral content (Melich III) during the growing season 2010 (n=145).

Fertilization treatments	P (mg Kg^{-1})	K (mg Kg^{-1})	Ca (mg Kg^{-1})	Mg (mg Kg^{-1})	Fe (mg Kg^{-1})	Cu (mg Kg^{-1})	Mn (mg Kg^{-1})	Zn (mg Kg^{-1})	N tot (%)
Organic liquid fertilization									
July	168±3.01	305±13.69	1607±53.66	209±12.37	355±4.80	3.83±0.19	23±0.65	3.48±0.18	0,24±0.01
September	171±9.68	319±18.88	1472±61.22	180±7.76	308±8.38	4,14±0,19	17±0.60	2,86±0,15	0,21±0.01
October	183±12.54	339±16.26	1367±72.74	163±8.61	279±4.48	3.86±0.28	16±0.64	2.64±0.15	0,21±0.01
Organic liquid + solid fertilization									
July	158±3.26	275±9.48	1629±38.16	183±7.81	333±5.23	4.32±0.27	21±0.68	3,28±0.16	0,24±0.01
September	155±4.43	285±12.94	1514±61.33	167±8.86	308±5.58	4.66±0.24	16±0.46	2.96±0.14	0,22±0.01
October	162±7.33	306±14.19	1547±83.21	155±9.53	292±6.42	4,38±0.30	15±0.47	2,56±0.15	0,21±0.01
Conventional fertilization									
July	165±23.54	182±4.97	1311±37.24	81±2.03	309±4.15	4.19±0.21	18±0.38	1.49±0.06	0,17±0.00
September	113±2.29	216±11.91	1270±61.87	96±5.96	284±9.42	4.90±0.28	14±0.57	1.52±0.08	0,18±0.00
October	126±5.60	230±11.12	1336±53.37	97±4.11	261±4.94	4.62±0.26	14±0.61	1,27±0.08	0,17±0.003
P values									
Treatment	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	NS	P<0.001	P<0.001	P<0.001
month	P<0.05	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001
Treatment*month	NS	NS	P<0.01	P<0.001	P<0.05	NS	NS	P<0.01	P<0.05
Contrasts									
Conventional vs Organic	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	NS	P<0.001	P<0.001	P<0.001
Liquid vs Liquid+Solid*	NS	P<0.01	NS	NS	P<0.05	NS	P<0.01	NS	NS

* Organic liquid and solid fertilizers

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Response of fruity vegetables between some organic matters compositions and inorganic fertilizer

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Keywords: cow manure, *Tithonia diversifolia*, inorganic fertilizer, tomato, and cucumber

Abstract

The aims of study were: 1) to compare the difference of tomato (Lycopersicum esculentum Mill) and cucumber (Cucumis sativus L.) yield between using some organic matters compositions and inorganic fertilizer at same level of N, 2) to get the best treatment based on the economic value and nutrient residue. The same treatment was carried out from March to July 2009 for tomato and for cucumber from June to October 2009 at the Field Exerimental Station of Foreign Labour Agricultural Training and Development Institute Singosari Malang. The treatments were arranged in randomized complete block design with three replications for tomato and four replications for cucumber. The treatments both crops were A= 0.139 t/ha Urea + 0.40 t/ha Phonska, B= 11.35 t/ha cow manure, C= 9 t/ha cow manure + 1.50 t/ha Tithonia diversifolia, D= 6 t/ha cow manure + 3 t/ha T. diversifolia, E= 3 t/ha cow manure + 4.50 t/ha T. diversifolia, F= 6 t/ha T. diversifolia. The results showed that at the same level of N both for tomato and cucumber yield and R/C between differences some cow manure and T. diversifolia compositions at one side and inorganic fertilizer at the other side were not significantly difference. In all treatments, soil P content after harvesting higher compared before planting both of tomato and cucumber.

Introduction

In Kenya wild sun flower (*Tithonia diversifolia*) was characterized for quality parameters for organic soil amendment (Palm and Rowland, 1997). Jama *et al.* (2000) assuming mean concentrations of green biomass of Tithonia is 3.5 %N, 0.37 %P, and 4.1 % K equivalent to 2 to 4 dry matter/ha will likely supply sufficient N (70 to 140 kg N/ha), and K (80 to 165 K/ha) to crops. Lignin concentration of Tithonia is 6.48 % and poliphenols 1.59 %, at three weeks about 80 % of N and P had been released from Tithonia leaves (Gachengo *et al.*, 1999). Corn yield with Tithonia was higher than mineral NPK fertilizer (Jama *et al.*, 2000). Corn yield between 60 kg N/ha in combination between cow manure + Tithonia or combination 30 kgN/ha of Tithonia + 30 kgN/ha inorganic fertilizer was higher than 60 kg N/ha inorganic fertilizer (Mugwe *et al.*, 2007). Tithonia biomass as a nutrients source is more profitable with high-value

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crops such as vegetables than with relatively low-valued corn (Jama *et al.*, 2000). In recent time, at the vegetables centre area in Indonesia, the small farmer use cow manure 20 ton/ha + inorganic ferlilizer, but because of cow manure price tend to increase some small farmers use Tithonia biomass. The question is how to get best combination to increase the fruity vegetables by considering economic and environment conservation? The aims of study were: 1) to compare the differences of tomato (*Lycopersicum esculentum* Mill) and cucumber (*Cucumis sativus* L) yield between using some organic matters compositions and inorganic fertilizer at same level of N, 2) to get the best treatment based on the economic value and nutrients.

Materials and methods

The same treatment was carried out from March to July 2009 for tomato and for cucumber from June to October 2009 at the Field Experimental Station of Foreign Labour Agricultural Training and Development Institute, Singosari Malang. The experimental site was located on an Alfisol soil, an altitude of 491 m above sea level. Soil pH 6.81, C 1.86 %, 0.174 % N (low), C/N 10.69, 10.40 ppm P_2O_5 and 0.50 me/100mg K. The treatments were arranged in Randomized Complete Block Design (RCBD) with three replications for tomato and four replications for cucumber. Both the treatments were A= 0.139 t/ha Urea + 0.40 t/ha Phonska, B= 11.35 t/ha cow manure, C= 9 t/ha cow manure + 1.50 t/ha *T. diversifolia*, D= 6 t/ha cow manure + 3 t/ha *T. diversifolia*, E= 3 t/ha cow manure + 4.50 t/ha *T. diversifolia*, F= 6 t/ha *T. diversifolia*. NPK cow manure concentrations were 1.08 %, 0.20 %, 0.10 %, Tithonia were 3.51%, 0.37 %, 4.10 % respectively, and water content was 80.50 %. N dosage for all treatments were 122 kgN/ha. Dosage considered by soil N, recommended practise N dosage for each vegetables, organic matter N concentration, expected N level (Agustina *et al.*,2004). Each of cow manure and Tithonia fresh leaves cut 3 cm incorporate to soil two weeks before planting. NPK dosage from recommended practice for tomato was 83.72 kg N: 21.25 kg P_2O_5: 60 kg K_2O and for cucumber is 103.50 kgN/ha: 29.25 kg P_2O_5: 60 kgK_2O. *Thrips tabaci* Lind and *Spodoptera litura* L. on tomato were sprayed by *Annona muricata* and garlic extract, respectively. Tithonia leaves extract was sprayed on cucumber to control pest. Observations included fruit set, fruit weight per plant and per ha, NPK before planting and after harvesting, and R/C. Data were analyzed by using RCBD. Differences between treatments were determined by using LSD 5 %.

Results and Discussions

Fruit set, fruit weight and R/C ratio: organic versus inorganic fertilizer

Based on observation at the same N dosage, fruit set (Tab. 1), fruit weight (kg/plant) and fruit weight (ton/ha) and R/C of tomato and cucumber (Tab. 2) between cow manure and Tithonia in single and combination were not significantly difference with inorganic fertilizer. Especially for the effect of Tithonia was the same as Kayuki *et al*. (2001), where in *Phaseolus vulgaris* L. the effect of Tithonia is effective as chemical synthetic fertilizer at the same N dosage. But in this case, the effect of cow manure was also effective as Tithonia. The fact was difference with in corn that was reported by Mugwe *et al.* (2007). At the same N dosage, corn yield was higher at combination between cow manure and Tithonia than only inorganic fertilizer. R/C ratio between organic and inorganic treatment were not significantly difference.

Soil NPK before planting and after harvesting: organic versus inorganic fertilizer.

Tab. 3 showed that concentration of C, N, and C/N before and after harvesting at the same N dosage both tomato and cucumber were the same as at low level. It means, adding 122 kgN/ha is enough for tomato and cucumber crop to produce high productivity on an Alfisol soil at low level N and high organic matter. Especially soil organic matter, eventhough at the same level it tend to increase after harvesting. Controversially, P concentration tends to increase from low to medium for all treatments. Increasing of P was higher in treatment D, E, and F than A, B, and C. It means Tithonia can be used as source of P for annual vegetables such as tomato and cucumber.At the same N dosage for tomato and cucumber, K concentration before and after harvesting are same at medium level. In Exception, on tomato it increased from medium to high at treatment D and F, and on cucumber it increased at treatment A and C. It means cucumber needs more K than tomato.

Conclusions

By using organic matter (cow manure, Tithonia) or inorganic fertilizer at the same N dosage (122 kgN/ha) didn`tt effect on tomato and cucumber growth and yield, the best treatment was organic because have many advantages such as nutrient residue especially P and economic value.

Tab. 1: Tomato and cucumber fruit set at different treatments

Treatment	Fruit Set (%)	
	Tomato 66 DAP	Cucumber 42 DAP
Organic versus Inorganic		
Organic	72.07	65.44
Inorganic	67.75	61.67
LSD (5%)	ns	Ns
A	67.75	61.67
B	73.94	78.33
C	66.05	86.67
D	74.59	55.56
E	69.25	53.33
F	76.55	53.33
LSD (5%)	ns	Ns

A= 0.139 ton/ha Urea + 0.40 ton/ha Phonska, B= 11.35 ton/ha *cow manure*, C= 9 ton/ha *cow manure* + 1.50 ton/ha *T. diversifolia,* D= 6 ton/ha *cow manure* + 3 t/ha*T. diversifolia*, E= 3 t/ha *cow manure* + 4.50 t/ha *T. diversifolia*, F= 6 t/ha *T. diversifolia,* ns=non significant

Tab. 2: Tomato and cucumber fruit weight per plant, per ha and R/C at different treatment

Treatment	Fruit weight (kg/plant)		Fruit weight (ton/ha)		R/C	
	Tomato	Cucumber	Tomato	Cucumber	Tomato	Cucumber
Organic versus Inorganic						
Organic	1.456	1.962	38.884	61.476	1.608	1.276
Inorganic	1.66	1.81	53.34	56.71	2.57	1.28
LSD (5%)	ns	ns	ns	ns	ns	ns
A	1.66	1.81	53.34	56.71	2.57	1.28
B	1.49	1.67	39.74	52.33	1.47	1.04
C	1.28	2.19	34.40	68.62	1.34	1.36
D	1.41	2.20	37.60	68.93	1.54	1.42
E	1.55	1.95	41.34	61.10	1.79	1.31
F	1.55	1.80	41.34	56.40	1.90	1.25
LSD (5%)	ns	ns	ns	ns	ns	ns

A= 0.139 ton/ha Urea + 0.40 ton/ha Phonska, B= 11.35 ton/ha *cow manure*, C= 9 ton/ha *cow manure* + 1.50 ton/ha *T. diversifolia,* D= 6 ton/ha *cow manure* + 3 t/ha*T. diversifolia*, E= 3 t/ha *cow manure* + 4.50 t/ha *T. diversifolia*, F= 6 t/ha *T. diversifolia,* ns=non signifcant

Tab. 3: The pH, C, N, C/N, soil organic matter, P and K before planting and after harvesting tomato and cucumber at different treatments

Treatment	pH		C (%)	N(%)	C/N	Organic matter (%)	P_2O_5 (ppm)	K (me/100mg)
	H_2O	KCl						
Before planting	6.81m	6.00 m	1.86 l	0.174 l	10.69 l	3.09 h	10.40 l	0.50 m
After harvesting tomato								
Organic versus Inorganic								
Organic	6.37m	5.43 m	1.85 l	0.17 l	10.98 l	3.19 h	11.72 m	0.57 m
Inorganic	6.59m	5.70 m	1.98 l	0.18 l	10.84 l	3.41 h	11.82 m	0.50 m
A	6.59m	5.70 m	1.98 l	0.18 l	10.84 l	3.41 h	11.82 m	0.50 m
B	6.44m	5.50 l	1.96 l	0.17 l	11.26 m	3.38 h	11.80 m	0.54 m
C	6.42m	5.48 l	1.87 l	0.17 l	12.37 m	3.22 h	11.79 m	0.52 m
D	6.30m	5.40 l	1.80 l	0.17 l	10.47l	3.10 h	11.60 m	0.63 h
E	6.37m	5.39 l	1.79 l	0.17 l	10.53 l	3.08 h	11.72 m	0.59 m
F	6.32m	5.41 l	1.84 l	0.17 l	10.28 l	3.17 h	11.71 m	0.60 h
After harvesting cucumber								
Organic versus Inorganic								
Organic	6.48m	5.51 l	1.93 l	0.17 l	10.65 l	3.30 h	11.74 m	0.55 m
Inorganic	6.37m	5.39 l	1.85 l	0.16 l	10.95 l	3.16 h	11.00 s	0.60 h
A	6.37m	5.39 l	1.85 l	0.16 l	10.95 l	3.16 h	11.00 m	0.60 h
B	6.36m	5.38 l	1.87 l	0.17 l	10.75 l	3.19 h	11.10 m	0.49 m
C	6.50m	5.48 l	1.89 l	0.17 l	11.12 m	3.23 h	11.20 s	0.63 h
D	6.48m	5.49 l	1.96 l	0.18 l	10.65 l	3.35 h	12.01 m	0.56 m
E	6.49m	5.50 m	1.95 l	0.18 l	10.48 l	3.33 h	12.20 m	0.57 m
F	6.58 m	5.70 m	1.99 l	0.19 l	10.47 l	3.40 h	12.21 m	0.50 m

A= 0.139 ton/ha Urea + 0.40 ton/ha Phonska, B= 11.35 ton/ha *cow manure*, C= 9 ton/ha *cow manure* + 1.50 ton/ha *T. diversifolia,* D= 6 ton/ha *cow manure* + 3 t/ha*T. diversifolia*, E= 3 t/ha *cow manure* + 4.50 t/ha *T. diversifolia*, F= 6 t/ha *T. diversifolia,* l=low, m=medium, h=high

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Comparative study of response of passion fruit to two organic fertilizers

Abiola, I.[1], & Aiyelaagbe, I. [2]

Key words: growth, manure yellow passion fruit

Abstract

Between February and April 2010 the response of yellow passion fruit (Passiflora edulis.var flavicarpa) to the rate of poultry manure and 'Sunshine organic fertilizer ' was investigated In a pot experiment conducted in Ibadan, Nigeria. The rates of application were 2.5, 5, 10 and 15g fertilizer kg soil^{-1}*. The rates and type of fertilizers were combined factorially and assigned following a completely randomized design replicated four times. Vine length was not significantly influenced by fertilizer rate. Application rates of 10g fertilizer kg soil*$^{-1}$ *significantly increased leaf area and number of tendrils compared with lower application rates, thus 10g fertilizer kg soil*$^{-1}$ *is considered optimum. Higher rates did not significantly enhance vegetative growth. Poultry manure and Sunshine organic fertilizer did not significantly differ in their effects. They can be used as substitutes at 10g fertilizer kg soil*$^{-1}$*.*

Introduction

Following a ban on the importation of fruit juice concentrate by the government there has been a demand for locally produced fruits such as passion fruit (*Passiflora edulis var. Flavicarpa*) by the domestic fruit juice industry in Nigeria. Organically produced fruits fetch a premium. Passion fruit has hitherto been grown in south western Nigeria as a garden plant. Promotion of commercial organic passion fruit could help diversity cropping systems in Nigeria and increase farm income. To promote commercial production, there is the need to develop a technology package including fertilizer recommendations. Organic fertilizers have a beneficial effect on passion fruit (Ceu *et al*. 2008, Piere *et al*. 2009). Earlier attempts to determine optimum organic fertilizer requirements for passion fruit in south-western Nigeria were futile (Aiyelaagbe and Abiola, 2008) probably due to the low grade of fertilizer used. Thus, this study set out to determine it using a newly released commercial brand of organic fertilizer 'Sunshine Organic Fertilizer' compared with poultry manure.

Materials and methods

A potted experiment was conducted at the Federal College of Forestry Ibadan Nigeria *(7^0 26'N, 3^0 25'E)* between February and April 2010. Two types of organic fertilizer-cured poultry manure (PM) or 'Sunshine Organic Fertilizer' (SOF) produced by the Ondo State Integrated Waste & Recycling Project, Akure, Nigeria were applied to 10kg of sandy loam soil in polyethylene bags at 2.5, 5.0, 10.0 and 15.0g organic

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fertilizer kg soil. (These rates corresponded to 5, 10, 20 and 30t ha^{-1}). PM contained N 3.41%, P 3.12%, K 1.34%, Ca 5.33% and Mg 0.33%. SOF contained N 2.55%, P 3.92%, K 2.21%, Ca 8.45% and Mg 0.36%. The soil used contained total N 0.05%, av P 5.0ppm, K, Ca and Mg 0.12 Cmol kg^{-1}, 7.65 Cmol kg^{-1} and 0.01 Cmol kg^{-1}, respectively. The rates and fertilizer type were combined in a 2 x 5 factorial and assigned following a completely randomised design with four replicates. One month later, four-month old seedlings of yellow passion fruit were transplanted one each into the potted soils on a 1m x 1m grid. The vines were trained unto 3m tall bamboo stakes. Growth response was monitored at two-week intervals by vine length, leaf area, number of branches and number of tendrils. Data is presented for 12 weeks after transplanting (WAT) which corresponds to the stage at which the vines transit from the vegetative to the reproductive phase. Vine length measurements were taken using the main vine. Leaf area was determined non-destructively using the regression model Y=11X - 49.2 (r^2 = 0.94) developed by Makinde, Aiyelaagbe and Fagbayide (unpublished data). In this equation, Y = leaf area cm^2 $plant^{-1}$ and X = lamina length (cm $plant^{-1}$).

Results

Main effects of rate and type of organic fertilizer

The vegetative parameters differed in their sensitivity to organic fertilizers. Vine length was not significantly influenced by rate of organic fertilizer. Nonetheless, leaf area, number of branches and number tendrils were significantly influenced by rate of organic fertilizers. Application of10.0 organic fertilizer kg $soil^{-1}$ significantly increased leaf area and number of tendrils better than lower application rates. Its effect on leaf area did not differ significantly from that of 15.0g organic fertilizer kg $soil^{-1}$), but 10.0 organic fertilizer kg $soil^{-1}$ produced significantly more tendrils than 15.0 organic fertilizer kg $soil^{-1}$(Table1). Compared with control, application of 2,5g organic fertilizer kg $soil^{-1}$ significantly increased number of branches. Higher rates of application did not significantly increase number of branches (Table1)

Table1: Growth response of passion fruit to rates of organic fertilizer

Rate (g kg $soil^{-1}$)	Vine length (cm)	Leaf area (cm^2 plant-^{1})	Branches (No plant-^{1})	Tendrils (no plant-^{1})
0	194	1987	1.78	20.0
2.5	202	2874	3.51	21.0
5.0	203	2258	3.32	18.2
10	217	3243	4.0	28.8
15	234	3419	4.12	24.5
Standard	24.5	297	0.46	2.87

Error				

The type of organic fertilizer applied did not significantly influence vegetative growth of passion fruit (Table 2).

Table 2: Growth response of passion fruit to type of organic fertilizer

Type	Vine length (cm)	Leaf area (cm^2 plant-^{1})	Branches (No plant-^{1})	Tendrils (no plant-^{1})
Poultry manure	203	2666	3.49	21.8
Sunshine Organic fertilizer	217	2847	3.20	23.2
Standard error	15.5	186	0.29	1.81

Interactive effects

Similarly, there was no interaction between the rate and type of organic fertilizer applied (data not shown).

Discussion

The absence of significant differences between the effects of the types of organic fertilizers used in our study differs from the conclusions of Calavante *et al*. (2008).The absence of differences we observed could be because PM and SOF are similar in nutrient content and nutrient release patterns. Thus they delivered nutrients in the same amounts and at the same rate. The absence of interaction between rate and type of organic fertilizer support this. Thus, PM and SOF could be used as substitutes. Leaf area is a major index of photosynthetic capacity of plants which has a strong influence on plant growth. The appearance of tendrils is an indicator of onset of flowering in passion fruit. Both parameters are good indicators for assessing the growth of passion fruit. Thus, the significant effect of 10g organic fertilizer kg soil^{-1} on these parameters suggests that this is the optimum rate for the vegetative phase of yellow passion fruit. This rate corresponds to 20t organic fertilizer ha^{-1} which would supply 510-682 kg N, 624-784 kg P and 268 – 442 kg K ha^{-1} depending on which of the organic fertilizers is used. Higher application rates would cause luxurious uptake of nutrients by plants without significant effects to plant vigour or fruit yield. Furthermore it may result in leaching of mobile nutrients into the ground water.

Conclusions

Poultry manure and Sunshine Organic Fertilizer have similar effects on the growth of passion fruit. The 10g kg soil^{-1} or 20t ha^{-1} of either fertilizer is optimum for the vegetative growth of yellow passion fruit in south western Nigeria.

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Current practices and economic performances of organic kiwifruit production in comparison with conventional one in Korea

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Key words: organic, kiwifruit, practices, performance

Abstract

Organic production practices varied among producers. Generally, organic producers were relying on imported input materials such as organic compost and liquid fertilizer even more than conventional producers. Very few organic farmers had composting facilities or sites for the own supply of compost in need. The productivity of organic kiwifruit orchard (92%) was not as low as that of conventional while the net income (243%) was more than double that of conventional. This was mainly attributed to high farm gate price of organic fruits, low paid labour use and electricity. As a consequence, organic kiwifruit production seems to become a feasible option in Korea. However, high dependence on imported farming material, fuel and labour for too frequent liquid fertilizer spray should be addressed to achieve long term sustainability of organic kiwifruit production.

Introduction

By now, kiwifruit is regarded as an easy crop for organic conversion in Korea due to less occurrence of pest and diseases and strong vigour (Koh *et al.* 2008). However, organic kiwifruit production is only 2.1% in Korea according to the survey of Fruit Research Institute of Jeonnam province (unpublished, 2010). Some reasons for this presumably prevail at every corner including the worries on low yield, difficulties in pest and disease control and soil nutrient management thereby low farm income (Leake 2000, Lee *et al.* 2005, Niemsdorff and Kristiansen 2006). Meanwhile, a long-term case study from New Zealand shows that there are even more nutrients input than removal in organic kiwifruit production system (Carey *et al.* 2009). Soil organic matter has increased in organic kiwifruit orchard soil and significant nutritional deficiencies were not found in organic kiwifruit leaves (Hasey *et al.* 1995). Recent statistics showing high demand on organic foods and governmental plan to raise organic industry are attracting more farmers into organic production. However, almost no organic kiwifruit information is available in Korean condition. So, this survey research was performed to know current production-level problems and economic achievement so as to set up better cultural practices and improve economic performances.

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Materials and methods

5 pairs of commercial organic and conventional kiwifruit orchards were selected for comparison (3 in Jeonnam, 1 in Gyeongnam and 1 in Jeju province). Each orchards received 2 visits for observation and questions on farm and 1 phone interview to complete the questionary (90 items in total). Each pair had very similar cultural conditions such as orchard soil properties (sandy loam or loam), wind breaking net facilities (less 2mm^2) and same variety (cultivar name, 'Hayward (*Actinidia deliciosa*)') at similar ages fully producing (24 to 32 year-old vines). All the general cultural practices were the same between organic and conventional such as pruning (winter and summer), shoots training on pergola system, artificial hand pollination, spring cooler irrigation during drought period only, harvest at over 7°Bx soluble solid content by hand refractometer, storage at 0 to 1℃ and packaging by small scale weight grader and hands) between each pair of orchards. 5 organic orchards have been managed organically at least 5 years up to over 20 years. These orchards were also blocked and separated by wind breaking nets, wide trenches (1.5m wide and deep each) and agricultural road (3 to 4m wide) around orchards at least. Common practices were summarized by several categories (Tab. 1). For the comparison of production and economic performances, each of organic and conventional orchards' data was averaged. The individual orchard yield was achieved from recent 3 years' average (2008 to 2010).

Results and Discussion

A. Cultural practices. The major differences between organic and conventional kiwifruit cultivation are briefly summed in Tab. 1. **Soil surface management.** In organic system, growers used to introduce rye to improve physical underground soil condition by its root system and suppress weeds by its strong weed competitiveness. But they did not sow rye in recent years because physical soil condition was improved and weeds do not become problematic after introducing rye for several years. **Use of fertilizer and its source**. In winter, organic compost is applied as basic fertilizer before or after pruning but organic growers were largely purchasing most organic fertilizer from organic fertilizer companies not from own sources. In growing seasons, some organic growers started to spray liquid plant extracts or mineral mixture from early spring to just before harvest. The purposes of this spray are various, pest and disease control, supply of nutrients by folia spray, fruit firmness enhancement, for example. In some case, more than 18 times sprays were given throughout the year which required much labour and time, not to mention cost. **Fruit size enhancement**. Conventional growers have been using 'CPPU [*N*-(2-Chloro-4-pyridyl)-*N*-phenylurea]' or some unidentified materials for better fruit size about 2 weeks after pollination. However, some organic growers were using liquid form amino acid formula or plant and fruits extracts by own recipe on farm. The use of these unknown materials still needs further evaluation. **Pest and disease control**. Both organic and conventional system introduce light bulbs at night to trap insects and install simple bottles with attractants such as fermenting fruits and juice in it. To control scales (i.e., *Pseudaulacaspis pentagona*), black sheet bondages are used to wrap trunk around and major branches as well where scales favour to lay eggs, then, bondages are removed and brush scales out on the trunk surface at certain time.

B. Comparative production cost. The expenses of production cost in organic system were lower than conventional (Tab. 2). Regardless of unpaid or paid labour cost, as seen in low paid labour of organic system (44.9%), organic growers are more dependent upon their own labour than conventional. One reason of this low paid labour cost was attributed to the more frequent exchange of labour with neighbours, which was not included as paid labour. Organic growers were actively sharing their labour with neighbours in turns. Organic system was also less dependent on fuel and electricity. However, organic kiwifruit growers seemed to heavily rely on external input materials compared to conventional growers. Most of inputs imported out of their farms were organic fertilizers, which were much more expensive than conventional compost.

C. Productivity and economic performances. Organic kiwifruit productivity was slightly lower than conventional (Tab. 3). However, the farm net income was almost 2.5 times the conventional. This was due to the double selling price of organic kiwifruit. Another reason for this could be different marketing route. Organic growers had direct selling marketing route in most cases by phone, internet and mail from dedicated customers.

Tab. 1: Major cultural practices investigated between organic and conventional kiwifruit production system

Practices	Organic	Conventional
Soil surface management	Native herbs, cut and mulch 3-4times	Rye (*Secale cereale*) introduced as cover crop, herbicide spray
Fertilization	Organic compost in winter, liquid extracts foliar spray from spring to autumn 10-18 times	conventional compost in winter, NPK or NK in spring to autumn 2-3 times
Compost source	Imported or rarely own sources	Imported
Fruit size enhancement	Natural plant extracts or amino acids 1-3 times or none	Synthetic growth promoter 2 times
Pests and disease control	Installment of insect traps, black sheet bondage, natural extracts from various herb sources under trellis	Insecticides or insect traps, fungicides 3-5 times

Tab. 2: Comparison of production cost between organic and conventional orchard system (Korea won/ha)

Farming system	Labour		Input materials	Fuel and electricity	Total cost (unpaid labor)
	Unpaid	Paid			
Org.	8,102,149	1,030,208	6,190,070	517,383	15,839,810
Con.	10,752,492	2,292,000	4,368,950	710,628	18,124,070
Org/Con	75.4	44.9	141.7	72.8	87.4

*Org; organic, Con; conventional, won; Korean currency. Unpaid labor means family labour.

Tab. 3: Productivity and economic performances between organic and conventional kiwifruit production system.

Production system	Yields (ton/ha)	Farm gate price (won/kg)	Gross income (won/ha)	Net income (won/ha)
Org.	17.2	5,500	94,600,000	78,760,190
Con.	18.7	2,700	50,490,000	32,365,930
Org/con (%)	92.0	203.7	187.4	243.3

*Org; organic, Con; conventional, won; Korean currency. Net income without unpaid labor cost.

Conclusions

Organic kiwifruit production system is not so different from conventional but rely on imported farming materials which need to be addressed. The productivity was slightly lower than conventional but it showed better profitability which resulted from higher selling price and direct sales. Consequently, organic kiwifruit system is considered a good option for kiwifruit growers in Korea.

Acknowledgments

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Effect of organic manures and biofertilizers on organic production of mango

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Key words : Soil characters, Organic manure, Bio-fertilizers, Fruit quality, Mango

Abstract

An investigation was carried out during 2006-2009 at the University Research Station to study the effect of organic manures and biofertilizers on organic production of mango. Results revealed that different treatments of organic manures and bio fertilizers significantly improved the soil character, fruit quality and microbial population of rhizosphere soil. Among different treatments, T5 consisting of Azotobacter + Azospirillum VAM + potassium mobilizer + vermicompost proved very effective in this regard while untreated control recorded minimum of these qualities.

Introduction

Biofertilizers are one of the major components of organic fruit production which are defined as the preparation containing innumerable living cells of beneficial microorganisms which are capable of supplying plant nutrient to soil plant system by their biological activities (Clarson, 1998). The beneficial effects of biofertilizers are now well established in fruit crops. Organic food products have a growing domestic as well as global market and fetch premium price over conventional products. Currently the market of organic food is enormous. Mango is one of the most excellent delicious fruits of tropical and sub-tropical region of the world. The crop has tremendous export potentiality. At the export front, the demand of organic mango is tremendous. So there is a great need for standardize the eco-friendly technologies for the production of organic mango using organic inputs and biofertilizers as per codex standard for getting high economic return and produce safe, residue free fruit. Keeping this, the present investigation was carried out.

Materials and methods

The study was conducted during 2006-2009 at the University Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, West Bengal (22.410N latitude and 88.300E longitude with an average altitude of 9.75 m above the mean sea level) on 11 years old tree of mango cv. Himsagar spaced at 10 m × 10 m. The orchard Soil was clay loam having pH 6.20, 0.52% organic carbon, available nitrogen 271.00 kg ha-1, phosphorus 28.00 kg ha-1 and potassium 200.00 kg ha-1. The various treatments are as T1 (Azotobacter + VAM + potassium mobilizer), T2 (Azospirillum + VAM + Potasium mobilizer), T3 (Azotobacter + Azospirillum +VAM + Potassium mobilizer), T4 (Azotobacter + VAM + Vermicompost + potassium mobilizer), T5 (Azotobacter + Azospirillum + VAM + vermicompost +

potassium mobilizer), T6 (Azospirillum + VAM + Vermicompost + potassium mobilizer), T7 (Azospirillum + vermicompost + potassium mobilizer), T8 (Azospirillum +

vermicompost + potassium mobilizer), T9 (Vermicompost + VAM + Potassium mobilizer, T10 (Control). The biofertilizers @ 200 g/plant/year and vermicompost (N-1.60%, P-2.20% and K-0.67%) @ 5 kg/plant/year along with fixed dose of 3 kg FYM (N-1.22%, P-1.08% and K-1.47%) were applied as per treatment in the month of July around the trunk of the tree. The experiment was laid down in Randomized block design with ten treatments with three replications. The mature fruits were harvested and physico-chemical analysis were done following standard methods. Soil properties like N (Black, 1965), P (Jackson, 1973), K (Piper, 1956) and pH (1:5, water) were also analyzed. Soil microbial population was counted using the methods an described by collin and Lyne (1985). During the period of investigation plant protection was done through organic means.

Results

Soil properties

Different combination of nutrients significantly increased the soil pH, organic carbon and available N, P and K as shown in Table 1. Among different treatments T5 (Azotobacter + Azospirillum +VAM + Vermicompost + potassium mobilizer), showed maximum organic carbon (0.98%), available N (285.11 kg ha-1), P (29.99 kg ha-1) and K (219.20 kg ha-1) followed by T6 (Azospirillum + VAM + Vermicompost + potassium mobilizer) with higher pH (6.92) nearer to neutral while control recorded minimum of organic carbon, available N, P and K with lower pH. T5 also recorded maximum soil bacterial population.

Fruit quality and yield

Table 2 indicated that different treatments of nutrients significantly increased the physico-chemical characters of fruit. T5 recorded maximum fruit weight, fruit length/diameter, yield, total soluble solids, total sugar, beta-carotene content and shelf life followed by T6. Control recorded minimum of these qualities with maximum acidity.

Discussion

There was improvement in soil characters due to application of organic manure and biofertilizer. The increase in organic carbon of soil which is might be due to the addition of organic matter through organic manure and recycling of organic materials in the form of crop residue which brings the soil pH nearer to neutral and increase the nutrient availability.

Increase in Physico-chemical parameters of fruits might be due to better moisture retention capacity and supply of nutrients due to favourable soil conditions brought out by organic manures and biofertilizers. Similar observation was noted by Biswas (2009) in litchi.

Conclusions

From the present study, it is concluded that organic manures and biofertilizers are effective in improving the soil characters, fruit qualities and leaf mineral content of mango. Among different combinations of nutrient, Azotobacter + Azospirillum +VAM + potassium mobilizer + Vermicompost proved very effective. Therefore, this combination can be applied for organic fruit production of mango.

Tab. 1 : Soil pH, organic carbon, available N, P and K as influenced by different nutrient treatments

Treatments	pH	O.C. (%)	Available N (Kg ha-1)	Available P (Kg ha-1)	Available K (Kg ha-1)	Microbial population (bacteria) (cfug-1 soil)
T_1 – *Azotobacter* + VAM + potassium mobilizer	6.77	0.71	279.20	29.11	212.72	6.9 x 106
T_2 – *Azospirillum* + VAM + potassium mobilizer	6.74	0.79	281.11	29.10	213.11	7.0 x 106
T_3 – *Azotobacter* + Azospirillum + VAM + potassium mobilizer	6.78	0.79	281.40	28.77	211.72	7.4 x 106
T_4 – *Azotobacter* + VAM + vermicompost + potassium mobilizer	6.82	0.83	280.20	29.34	200.72	7.5 x 106
T_5 – *Azotobacter* + *Azospirillum* + VAM + vermicompost + potassium mobilizer	6.92	0.98	285.11	29.99	219.20	8.5 x 106
T_6 – *Azospirillum* + VAM + Vermicompost + potassium mobilizer	6.81	0.98	281.11	29.71	214.72	7.5 x 106
T_7 – *Azospirillum* +vermicompost + potassium mobilizer	6.87	0.71	275.11	28.99	210.11	7.3 x 106
T_8 –*Azospirillum* + vermicompost + potassium mobilizer	6.74	0.72	274.11	28.70	212.11	7.4 x 106
T_9 – Vermicompost + Vam + potassium mobilizer	6.71	0.73	279.00	28.11	209.11	5.1 x 106
T_{10} – Control	6.20	0.52	271.00	28.00	200.00	2.7 x 105
CD (P=0.05)	0.01	0.11	0.37	0.34	0.71	-

Tab. 2 : Effect of organic manure and bio-fertilizers on physico-chemical qualities and shelf life of mango cv. Himsagar

Treatments	Fruit wt (g)	Fruit length/ diameter (cm)	Yield (kg/plant)	TSS (0Brix)	Total sugar (%)	Acidity (%)	□-carotene (µg/100 g)	Shelf life in days (at ambient room temperature)
T_1 – *Azotobacter* + VAM + K- mobilizer	204.50	9.10/8.71	36.94	18.0	13.11	0.29	6231.72	7.0
T_2 – *Azospirillum* + VAM + K- mobilizer	202.92	9.11/8.12	36.51	17.8	13.00	0.31	6314.82	7.0
T_3 – *Azotobacter* + Azospirillum + VAM + K- mob.	212.80	9.00/8.11	37.82	16.8	12.92	0.28	6411.00	5.0
T_4 – *Azotobacter* + VAM + vermicompost + K- mob.	217.70	9.00/8.17	38.77	16.8	12.90	0.30	6672.17	6.0
T_5 – *Azotobacter* + *Azospirillum* + VAM + vermicompost + K mob.	231.30	9.13/8.87	41.77	18.9	14.95	0.21	6860.50	8.0
T_6 – *Azospirillum* + VAM + Vermicompost + K- mob.	219.11	9.00/8.72	38.67	17.2	12.97	0.25	6370.11	6.0
T_7 – *Azospirillum* +vermicompost + K- mob.	222.30	8.92/8.00	39.11	17.4	12.93	0.26	6711.32	6.0
T_8 –*Azospirillum* + vermicompost + K- mob.	211.11	8.97/8.1	37.10	16.8	12.10	0.27	6312.41	5.0
T_9 – Vermicompost + Vam + K- mob.	210.10	9.00/8.2	33.17	16.9	12.11	0.27	6011.92	5.0
T_{10} – Control	200.00	8.11/8.06	32.00	16.0	12.00	0.35	5121.00	4.0
CD (P=0.05)	0.31	0.31/0.17	0.02	0.09	0.02	0.02	0.79	0.02

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The system of citrus diseases and pest control by using environment-friendly agrochemicals

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Key words: Citrus diseases and pests, copper, environment-friendly agrochemicals**,** paraffin oil, sulfur lime

Abstract

This study was carried out to develop the control manual against citrus diseases and pests by using of environment-friendly agrochemicals without organic synthetic agrochemicals. For this, control effect against citrus pests and diseases was surveyed in open field cultivated with satsuma mandarin in Namwon and Kosan area in Jeju Island where disease incidence has been relatively more and less, respectively according to different control programs by using environment-friendly agrochemicals composed of copper, lime sulfur, paraffin oil and etc selected in preliminary studies. The citrus diseases and pests were some controlled without using of organic synthetic agrochemicals though the scab was very difficult and the melanose was some difficult to control in some area where rainfall is more, relatively. Based on these results, we made the control manual by 7 times sprays against citrus diseases and pests by pesticide-free method without using of organic synthetic agrochemicals.

Introduction

It has been recently increased that the interest in safety of agricultural product. Therefore, it have been needed the manual to control the citrus diseases and pests by using environment-friendly agrochemicals without organic synthetic agrochemicals. We thought that the manual is developed enoughly because the copper fungicides, paraffin oil and lime sulfur have been improved to accelerate the control effect and diminish the spray injury and other materials including herbal extracts have been developed. In this study, we were carried out to develop the control manual against citrus diseases and pests by using of environment-friendly agrochemicals without organic synthetic agrochemicals.

Materials and methods

Copper (bordeaux), lime sulfur(made by Bayer CropScience, Korea), paraffin oil and etc were used as the materials to control the citrus diseases and pests for pesticide-free agricultural products. They were selected in preliminary test among several

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environment-friendly agrochemicals. The bordeaux was used by bordeaux CM150 ("CM150-505" made by Choogang Plaza Co., Korea) and the paraffin oil was used by machine oil registered for miticides. One % of the Bordeaux(w/v) and lime sulfur(v/v) diluted with water were finally applied.

Control of citrus pests and diseases by using environment-friendly agrochemicals

Control effect by using environment-friendly agrochemicals against citrus pests and diseases was surveyed in open field cultivated with satsuma mandarin in Namwon and Kosan area in Jeju Island where disease incidence has been relatively more and less, respectively. The spray were done 5, 6, 7 times in treatment with environment-friendly agrochemicals, Org-A, B and C, respectively. In case of Namwon area which disease incidence has been relatively more, the spray was done one more time. Most of control was done with bordeaux and lime sulfur. The bordeaux was applied 3 to 5 times in April, May, late of June, early of July and August, especially the boreaux used in May was mixed with 1% of paraffin oil to control the mite and scab caused by *Elsinoe fawcettii*. The lime sulfur was applied 2 times in early or middle of June and middle or late of July. The block was composed of over 10 trees 25 years old and the treatment has 3 replicate (1 block per replicate). The treatment of control was done by conventional spray schedule.

Results and discussion

Control of citrus pests and diseases by using environment-friendly agrochemicals by different control schedules

Melanose caused by *Diaporthe citri* was severer in Namwon than Kosan area in open fields cultivated with satsuma mandarin. Though the % of diseased fruit by melanose was relatively higher in treatment with environment-friendly agrochemicals than that with organic synthetic pesticides, it was not big problem as environmentally-friendly agricultural product, especially in Kosan area where the disease was less (Table 1). It was difficult that the scab caused by *Elsinoe fawcettii* was controlled without using of organic synthetic agrochemicals. However we think the scab can be some controlled if it is adequately controlled in early of incidence. In conclusion, citrus diseases and pests could be some controlled without using of organic synthetic agrochemicals though scab, melanose and scale etc were some difficult to control in some case.

Citrus diseases and pests control manual by using environment-friendly agrochemicals

Based on these results, we made the control manual against citrus diseases and pests by using of only environment-friendly agrochemicals without using of organic synthetic agrochemicals. It was followed as Table 2 composed of 7 times spray. Though the control manual was prepared, cultural control should be carried out including thinning, elimination of diseased tissue and etc before spray for control. The copper should be used by low concentration as possible, especially after late of July. And it must be careful of spray injury of copper and lime sulfur.

Table 1. The control effect against citrus diseases and pests by using environment-friendly agrochemicals according to control programs in 2006, 2007 and 2008 season

Season	Field	Treatment	% of injured fruit					
			Mel.1	Scab	Canker	Gray M.	F.I.I.1	Scale
2006	Namwon	Control	4.1	0.1	0.6	-2	3.1	-
		Organic-A	58.7	1.3	0.1	-	4.3	-
		Organic-B	64.3	0.7	0.0	-	3.6	-
		Organic-C	62.2	1.1	0.2	-	2.4	-
	Kosan	Control	1.8	6.6	3.0	-	2.7	-
		Organic-A	33.6	52.5	0.0	-	0.1	-
		Organic-B	35.4	59.6	0.0	-	0.7	-
		Organic-C	20.0	31.0	0.0	-	1.5	-
2007	Namwon	Control	12.1	0.2	0.0	0.0	0.5	0.0 3
		Organic-A	72.4	0.7	0.0	0.0	1.3	0.1
		Organic-B	82.1	4.0	3.5	0.0	1.3	0.1
		Organic-C	81.3	0.4	0.0	0.0	0.4	0.0
		Non-treat.	100.0	11.3	0.0	0.0	1.5	0.5
	Kosan	Control	12.9	2.3	0.7	0	1.7	0.3
		Organic-A	33.2	14.5	0	0.45	3.0	0
		Organic-B	59.5	22.8	0.1	0	2.2	0.2
		Organic-C	17.1	3.0	0.7	0	2.3	1.9
2008	Namwon	Control	0.6	3.5	0	0.3	3.2	-
		Organic-A	49.4	18.1	0	1.4	4.3	-
		Organic-B	13.1	23.9	0	0.0	4.8	-
		Organic-C	26.9	18.3	0	0.8	5.6	-
		Non-treat.	91.7	59.9	0	2.8	4.0	-
	Kosan	Control	0.7	1.2	0	1.0	3.6	-
		Organic-A	2.1	13.0	0.0	0.9	2.6	-
		Organic-B	2.2	24.3	0.0	0.9	5.5	-
		Organic-C	1.3	7.7	0.3	0.8	2.4	-

1 Mel. : melanose; Gray M. : gray mold; F.I.I: Flower injurying insect

2 Not assayed

3 Percent of injured branch

Table 2. Control manual against citrus diseases and pests by pesticide-free method without using of organic synthetic agrochemicals

Control time	Materials	Target	Note
L. April	Copper	Scab	Bordeaux(2-4) + paraffin oil[1]
E. May	Copper or herbal extract	Scab	The orchards which scab was occurred in last season Bordeaux(2-4) + paraffin oil[1], herbal extracts
M. May	Copper	Scab, gray mold	Bordeaux(2-4) + paraffin oil[1]
E. June	Lime sulfur	Scab, melanose, scale, thrips	Lime sulfur (x100)
L. June	Copper + machine oil	Melanose, scale	Bordeaux(2-4) + machine oil (x100)
M. July	Lime sulfur	Melanose, scale	Lime sulfur (x100)
M. August	Copper or herbal extract	Melanose (scale)	Bordeaux(1-2 or 2-6) or herbal extract

1. Material to reduce the copper spray injury

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Soil fertility and fruit damage survey of organic apple orchards in Korea

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Key words: Apple, Organic culture, Cultivar, Soil, Inorganic Component, Disease, Pest

Abstract

Soil fertility and fruit damage by two fruit moths (Carposina sasakii and Grepholita molesta) in organic apple orchards in 2009-2010 were investigated to know if there were any significant soil nutrient limitation and how many damage to the fruit moths. In the non-chemical apple tree the fruit damage to the apple cultivars were investigated to select the proper cultivars for organic apple growing. Soil analysis indicated that many of the organic orchards have nutrient deficiencies. The organic matters in the most of organic apple orchards sampled were lower than that of conventional apple orchards, where soil pH and inorganic components(such as P, K, Ca, Mg) were higher. Fruit damage by two fruit moths in organic apple orchards were very different from 90% to 0.1%. The fruit damage of the organic orchards treated the mating disruption with eco-friendly materials were low from 0.1% to 3%. The fruit damage of bagging fruit orchard was also low even though no mating disruption. So it was important to do mating disruption or bagging fruit with eco-friendly materials for reducing the fruit damage by two fruit moths in organic apple orchards. In the non-chemical apple trees, fruit damage of 'Gala' and 'Fuji' by disease and pest 13.3% and 50.0%, while others 100%.

Introduction

Numbers of certified organic apple orchards in Korea have been increasing now. In 2010 number of organic apple growers are 103(Original organic growers: 50, Chemicals free growers: 53). As 'Fuji', 'Tsugaru' and 'Hongro' cultivars were mainly grown in the organic orchards, they were suffered from many difficulties such as diseases and pests. It is necessary to select the suitable cultivars in the organic apple orchards. It is also important to make the better soil condition by analysing the present soil situations, managing the weeds effectively and fertilizing the organic matters. Lime sulfur and bordeaux mixture to diseases were suggested as the proper eco-friendly materials to control the main diseases effectively. But, the fruit damage of fruit moths was really severe problem without suitable measures in the organic apple orchards. Several investigations about cultivar, soil and fruit moths were carried out to suggest the appropriate management conditions in the organic apple orchards.

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Materials and methods

Soil analysis

Analyse the soil pH, the organic matters and the inorganic components in 15 organic apple orchards in 2009.

Test Diseases and Pests

Survey on the use conditions of eco-friendly agricultural materials, the captured fruit moth density on the sex pheromone trap of *Carposina sasakii* and *Grepholita molesta* and the damage of fruit moths(*Carposina sasakii* and *Grepholita molesta)* in the 12 organic apple orchards in 2010.

Non-chemical Test

Investigate the fruit damage by diseases and pests on 19 apple cultivars in the non-chemical cultured apple trees in 2010. These apple trees of 7 years old were managed conventionally until 2009.

Results

It showed that soil pH and inorganic components(such as P, K, Ca, Mg) of organic apple orchards were higher compared to that of conventional apple orchards, while organic matters of organic apple orchards were lower(Tab. 1).

Fruit damage by two fruit moths in organic apple orchards were very different from 90% to 0.1%. The fruit damage by oriental fruit moth, *Grapholita molesta* in the organic orchards treated the mating disruption with eco-friendly materials such as emulsified plant oil and plant extracts was 0.2~2% while the fruit damage without mating disruption was 3.5~90%. The fruit damage by peach fruit moth, *Carphosina sasakii* in the organic orchards treated the mating disruption with eco-friendly materials was 0~2% while the fruit damage without mating disruption was 0~18%. Fruit damage by two fruit moths in organic apple orchards were very low when the mating disruption was treated in the organic apple orchards. The fruit damage of bagging fruit orchard was also low even though no mating disruption. So it was important to do mating disruption or bagging fruit with eco-friendly materials for reducing the fruit damage by two fruit moths in organic apple orchards(Table. 2).

In the non-chemical apple trees during the season, the rates of damaged fruits from diseases and pests were the least in 'Gala' by 13.3% and middle in 'Fuji' by 50.0%. while the fruit damage of ‘Tsugaru’, ‘Pink Lady’ and ‘Hongro’ apple cultivars were 100%. Gala' and 'Fuji' cultivars to disease and pests in non chemicals were stronger than Tsugaru’, ‘Pink Lady’ and ‘Hongro’ cultivars(Table. 3).

Table 1. Soil, chemical properties in 15 organic apple orchards in 2009

Division	pH (1:5)	OM (g/kg)	P_2O_5 (mg/kg)	K (cmol/kg)	Ca (cmol/kg)	MG (cmol/kg)
Average	7.30	17.9	593.5	1.13	11.3	2.79
Standard deviation	0.41	1.24	229.0	0.63	3.85	1.25
Maximum	8.28	56.9	1,034.7	2.42	16.2	5.98
Minimum	6.65	7.0	257.6	0.39	6.8	1.59
Conventional apple orchard*	6.55	19.5	545	0.96	6.19	1.61

*Park, J, M et. al., (2006). Kor. J. Hort. Sci. Technol 24(3):347-353, Soil chemical proportion and nutrition composition of leaf of Fuji/M26 tree in organic apple orchard

Tab. 2. Survey on the use conditions of eco-friendly agricultural materials, the captured fruit moth density on the sex pheromone trap and the fruit damage rate in the organic or non-chemical control apple orchards in 2010

District Farmer	Eco-friendly materials(No. of spray)			Oriental fruit moth		Peach fruit moth	
	Mating disruption	Emulsified plant oil	Other substances	Density (♂/trap)	Damage (%)	Density (♂/trap)	Damage (%)
ES C○○	○	5	Neem oil 5	77	0.2	2	0
CJ S○○	○	5	Plant extracts 1	130	0.3	0	0
CJ H○○	○	4-5	Biopesticides 10	141	3.0	0	0
MJ K○○	○	4	Plant extracts 5	1(595)	1.0 ~ 1.5	0	0
MJ L○○	○	5-6	Plant extracts 5	0(260)	1.0	0(8)	0
JS K○○	×	×	Neem oil 4, Derris 2	(346)	40	(155)	10
JS P○○	×	3	Plant extracts 4	(1,151)	90	(386)	18
JS Y○○	×	4	Pyrethrum 1	(412)	2 ~ 5	(44)	0
ES K○○	×	8	Neem oil 9, Plant extracts 2	(430)	18	(133)	2.0
CS S○○	○	8	Apple vinegar 4	53	0.1	0	0
CS J○○	×	3	Bagging, Plant extracts 4	(625)	1 ~ 2	(25)	0
CG J○○	○	6	Elimination of damaged fruit	15(327)	0.2	0(102)	0

* Parenthesis represent numbers of captured male moths on the sexpheromone trap in the non mating disruption apple orchards

Tab. 3. Fruit damage(%) by diseases and pests in non chemical apple tree during season in 2010

Cultivars	Fruit damage (%)
Gala	13.3
Fuji	50.0
Tsugaru	100
Pink Lady	100
Hongro	100

Discussion

The suitable cultivars to organic growing among the conventional cultivars in Korea were 'Gala' firstly and 'Fuji' secondarily.

Soil pH and inorganic components were higher and organic matters were lower in the organic orchards in comparison with the optimum levels.

Mating disruption with sex pheromone forecasting trap and complementary treatments with eco-friendly materials is a prerequisite for managing fruit moths in the organic apple orchards. Bagging fruits is also good means to reduce fruit damage against the fruit moths at an early stage of organic apple growing.

Conclusions

Soil analysis indicated that many of the organic orchards have nutrient deficiencies. It was important to do mating disruption or bagging fruit with eco-friendly materials for reducing the fruit damage to two fruit moths(oriental fruit moth and peach fruit moth) in organic apple orchards. It showed ‘Gala’, and ‘Fuji’ apple were suitable cultivars in organic apple orchards.

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Comparison of the quality of conventionally and organically grown oranges in Spain

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Key words: Navelina oranges, ascorbic acid, mineral content & harvest date

Abstract

We compared the quality profile of conventional (CON) and organic (ORG) oranges grown in Spain in the 2008 season. In total 640 oranges of two harvest dates (early and optimal) and two origins (CON and ORG) were analysed for a range of important quality parameters. Data were evaluated by ANOVA followed by Tukey's test. Compared with organically grown oranges, those grown conventionally were significantly higher in weight (224 vs. 204 g) and in relative skin proportion, and were slightly higher in height and diameter. Soluble dry matter and citric acid content of the juice were not affected by the growing system, while the maturity index was significantly lower in ORG compared with CON oranges. The L-ascorbic acid content was significantly higher in ORG than in CON fruits (65.2 vs. 58.4 mg per 100 g juice).The potassium and magnesium (significant) content of orange juice tended to be higher in ORG, while the phosphorus (significant) and calcium content were higher in CON. Optimal timing of harvesting significantly improved the quality profile of both CON and ORG oranges. Although statistically significant for some variables, the absolute differences between CON and ORG were comparatively low for most variables, suggesting that genotype and location were the dominant factors for quality formation.

Introduction

High product and process quality are key criteria for the successful marketing of organic products such as oranges. While orange breeders and producers are mainly interested in crop properties such as yield, fruit uniformity and disease resistance, consumers appreciate good flavour, high nutritional value and attractive appearance (Huyskens-Keil & Schreiner 2003). Nutritional value is determined mainly by the ascorbic acid and the mineral content, while taste is related to the sugar / acid ratio. Higher dry matter contents due to lower nutrient input, in particular nitrogen, are often a distinct feature of organic compared with conventional products, which may result in a concentration of beneficial compounds such as ascorbic acid. With respect to pesticide contaminants, organic oranges are much safer. In a recent survey in Germany, about 93% of the conventional citrus fruit samples (n=99) had pesticide contamination above 0.01 mg per kg, while only 3% (n = 37) of the organic citrus fruits were that highly contaminated (MLRBW 2009). Likewise process quality, which reflects the environmental impacts of a production system, often is higher for organic compared with conventional products. The objective of our experiment was to

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compare the quality of organically and conventionally grown oranges and to assess the impact of harvest date on fruit quality based on a set of classical parameters.

Materials and methods

Oranges cv. 'Navelina' were harvested on 11th of November and 8th of December 2008 from both a certified organic (ORG) and a conventional (CON) private orchard (700 m distance) in the La Safor Valley, Gandia, close to Valencia, Spain (38° 54' N, 0° 11' W) with comparable pedoclimatic conditions. The mild climate (average annual temperature = 17 C, no frost) and the nutrient-rich silty loam (pH = 7,5 - 8, ca. 30% $CaCO_3$) have favoured the growth of oranges for centuries. Orange trees from both plantations were grown on the same rootstock (Carrizo citrange) and were about 15 years old. CON trees received approximately 400 kg ha^{-1} mineral N, while ORG oranges only received 30 kg ha^{-1} (Vegethumus). In total, 640 oranges (320 ORG and 320 CON) were analysed one by one following a systematic sampling procedure over 4 blocks (4 fruits per tree x 4 trees = 1 block).

In the laboratory, the fresh weight of individual fruits was taken using an automatic balance. Likewise, individual fruit diameter and height were recorded. Colour indices of the peel were determined using a colorimeter MINOLTA CR-300 according to Jimenez-Cuesta *et al*. (1981). Fruit samples were halved and juiced one by one with an electric fruit press.

Juice and peel were weighed to calculate the relative juice, peel und pulp proportion. Weight loss (%) of fruits was determined after storage according to the formula: $wL= [(w1 – w2)/ w1]\times100$; where wL is the percentage weight loss, w1 is the weight of the fruit before storage and w2 is the weight of the fruit after storage. Soluble dry matter content of the juice was determined by a hand-held refractometer and expressed in °Brix. Titrable acidity (TA, as % of anhydrous citric acid) was determined by a standard method (Pailly *et al*. 2004). The sugar / acid ratio determines the maturity index of oranges. Ascorbic acid concentration in orange juice was determined by potentiometric titration with chloramine-T using a 702 SM Titrino (Metrohm). Before P, K, Ca, and Mg were measured, the juice samples were centrifuged at 2000 rpm. Minerals were determined by standard methods.

Data were evaluated by ANOVA followed by Tukey's Test ($\alpha = 0.05$) using a statistical model with repeated measurements (Piepho *et al*. 2004). The key idea of this method is to increase the precision by additionally considering the variation between individual oranges within one plot.

Results

Compared with organically grown oranges, those grown conventionally were significantly higher in weight (224 vs. 204 g) and in relative skin proportion, and were slightly higher in height and diameter.

Compared with organically grown oranges, conventionally grown oranges were significantly heavier (224 vs. 204 g) and were greater in height and diameter. Likewise, compared with oranges harvested earlier, those harvested later were significantly higher in weight and height. The relative skin proportion was significantly lower in ORG (24.3%) compared with CON (26.7%), while the juice and pulp proportions under both growing systems were not significantly different. The share of the paring (26.4%) was significantly higher in later compared with earlier harvested oranges (Tab. 1). The soluble dry matter and the citric acid content of the juice were slightly higher in ORG versus CON oranges, while the maturity index was significantly lower in ORG than in CON oranges. The content of soluble dry matter was significantly higher in oranges harvested later than in those harvested earlier, while the opposite was true for citric acid.

The L-ascorbic acid content was significantly higher in ORG compared with CON fruits (65.2 vs. 58.4 mg per 100 g juice). Later harvesting of the oranges resulted in significantly higher L-ascorbic acid content compared with early harvesting.

Tab. 1: Effects of growing system and harvest date on quality parameters of Spanish oranges from the 2008 season, ingredients refer to orange juice, CON = conventional, ORG = organic, NOV = November, DEC = December, different letters indicate significant differences, Tukey-Test (α = 0.05).

	Growing system		Harvest date		
Parameter	CON	ORG	NOV	DEC	Mean
Weight (g)	224.3a	203.7b	207.6b	220.8a	214.0
Height (cm)	78.5	76.7	76.6b	78.6a	77.6
Diameter (cm)	77.4	74.6	75.3	76.8	76.0
Paring (%)	26.7a	24.3b	24.7b	26.4a	25.5
Juice (%)	43.4	43.5	44.7a	42.3b	43.5
Pulp (%)*	29.9	32.4	30.6	31.4	31.2
Soluble d.m. (%)	9.3	10.6	9.7b	10.2a	10.0
Citric acid (%)	2[.0]?	2.4	2.3a	2.1b	2.2
L-ascorbic acid	58.4b	65.2a	60.7b	62.7a	61.8
Maturity index	5.1a	4.8b	4.8b	5.2a	5.0
Phosphorus (mg l^{-1})	89a	73b	72b	90a	81.0
Potassium (mg l^{-1})*	1200	1663	1410	1453	1431
Magnesium (mg l^{-1})	85b	103a	94	95	94.0
Calcium (mg l^{-1})*	83.5	69.5	79	74	76.5
Weight loss (%)	3.8	4.1	4.4	3.4	3.9

*: significant interaction between growing system and harvest date

The potassium and magnesium (significant) content of orange juice tended to be higher in ORG, while the phosphorus (significant) and calcium contents were higher in CON. Harvest date did not affect the mineral content of oranges except for the P-content, which was significantly higher in later compared with earlier harvested fruits. Interestingly, skin colour, an important quality trait for consumers, was not affected by the growing system (data not shown). Likewise, weight losses after storage were not affected by either the growing system or the harvesting date (Tab. 1).

Discussion

Our results suggest that under the same site conditions, using the same variety, the ingredient profiles of conventional and organic oranges differ only slightly for most variables. However, some typical effects of intensive mineral nitrogen fertilisation were noted in conventional compared with organic oranges. For example, the higher fruit weight of CON versus ORG oranges indicates a higher nitrogen supply, generally resulting in higher yields (Sarooshi *et al*. 1991). Likewise, the higher content of soluble dry matter as well as ascorbic and citric acid in organic compared with conventional oranges may be due to a dilution effect, since mineral nitrogen fertilisation tends to increase the relative water content of plant tissues. The increase of the sugar / acid ratio of later harvested oranges followed the typical pattern of maturing fruits. However, there is no evident explanation for the significantly lower maturity index of the organic compared with conventional oranges. Due to a higher ratio between fruit surface and weight, smaller fruits are expected to cause higher mass losses during storage (Pailly *et al*. 2004). In our experiments, weight loss after two months of storage was not affected by the growing system, although ORG oranges were significantly smaller than the CON fruits. The observed differences in the mineral composition of CON and ORG orange juice are probably a result of the different fertilisation strategies in both systems.

Conclusions

Our assessments have shown that the ingredient profile of oranges, an important element of product quality, was only slightly affected by the growing system. Our findings are in accordance with Roussos (2011), who observed comparable contents of antioxidants and other quality parameters in oranges cv. ‘Salustiana’ from integrated and organic production in Greece. Product quality is the complex result of a range of factors, including variety, fertilisation and in particular weather conditions during growth. However, product quality also includes the absence of harmful compounds, and it has been shown repeatedly that organic oranges contain significantly lower pesticide residues.

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Effects of grafted rootstocks on the growth and fruit quality of Campbell Early

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Key words: Grape, Campbell Early, Rootstock, Scion, Grafted cultivation

Abstract

The Campbell Early cultivar was grafted on five rootstock varieties (5BB, SO4, 188-08, 5C, 3309) to investigate the effects of grafted rootstocks on growth, and berry quality of cultivars in protected cultivation from rain. Stem diameter and shoot length of scion were the largest at 5BB and smallest at 3309. Berry shattering at 5BB was lowest with 39.0%. Magnesium contents were lowest at SO4 and 188-08 respectively with 2.6g/kg and 2.9g/kg. Yield was smallest from 3309 and cluster weight, berry weight, berry number did not show any significant difference by rootstock. Soluble solids and anthocyanin contents were highest at 3309 respectively with 16.7°Bx and 2.16(OD:530nm).

Introduction

The Campbell Early cultivar is the most common grapevine making up 73% of total grape vineyard cultivars. It is increasingly being raised by inserting a graft into a stock (=grafting cultivation). However, how the stock affects the scion cultivar being grafted has not been overlooked. Also, there are several problems caused by grape farmers indiscriminately carrying out grafting without considering the characteristics of the rootstock and vineyard, and by densely planting grafted nursery plants, such as the delayed maturation period and physiological disorder including berry shattering. As a result, an increasing number of grape farmers have been asking for special measures to solve these problems. This test was implemented to investigate how the stock affects the growth and fruit characteristics of our major cultivar, the Campbell Early.

Materials and methods

Before the test began, we confirmed that the tested cultivar was the Campbell Early, and there are five kinds of rootstock: 5BB, SO4, 188-08, 5C, and 3309. We took a test of randomized block design three times in repetition, appointing rooted cutting as a control. After planting the rootstock in April and having it cut, leaving 60cm in length in the early of June, scion was grafted by greenwood grafting. We closely observed the diameter of scion, shoot length, berry shattering to figure out the effects of the rootstock on the growth of scion cultivar. We also analyzed the composition of T-N, P2O5, K2O, CaO, MgO to figure out the effects of the rootstock on how many minerals can be absorbed into the leaves of the grafted scion cultivar. We analyzed T-N based on Kjeldahl method, P2O5 on Vanadate method, K,Ca,Mg by ICP(Integra XM2, Australia) equipment. In order to find out the fruit characteristics, we collected 20 fruits taken from each the repetition of treatment in harvest season. With the fruits, we examined the soluble solids by refractometer, took the fruit coloring on the

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coloring degree. As for the amount of Antocyanins, we gathered some fruit skin from the designated area of fruit and gauged the degree of absorbance under the condition of 530nm after abstracting for 24 hours by 1% hydrochloric acid Methanol.

Results

Tab. 1 shows that the diameter of scion is the largest as 49.0mm for the 5BB stock, which is larger than the control by 9.3mm. On the other hand, the diameter of scion of is the smallest as 35.1mm for the 3309 stock, which is smaller than the control by 4.6mm (Tab. 1). From these findings we can conclude that 5BB stocks make the tree vigor of the Campbell Early very strong and 3309 stocks make it very weak. Berry shattering rate is much lower by 39.0% in case of 5BB stocks than other stocks, and it is lower by 7.5% compared to the control. Based on this information, we can convince grape orchard farmers who have poor berry setting that it is very effective to use 5BB stocks.

Tab. 1: Effects of stocks on the growth of grafted cultivars of Campbell Early

Stocks	Diameter of scion (mm)	Shoot length (cm)	Berry shattering rate (%)
5BB	49.0a	116a	39.0
SO4	38.4bc	115a	47.0
188-08	41.5b	114a	48.0
5C	35.8c	112a	48.0
3309	35.1c	98b	44.0
Control	39.7bc	111a	46.5

DMRT ($\alpha=0.05$)

After investigating how much the stocks affect the mineral elements which exist inside of the leaf stalk of the grafted cultivar of Campbell Early, we could not find any large difference between the grafted cultivar and the control in terms of the amount of Nitrogen, Phosphoric Acid, Potassium, Calcium (Tab. 2.). Magnesium content is much lower at 2.6g/kg and 2.9g/kg respectively in stock SO4 and stock 188-08 than the control and it cannot reach the minimum content, 3.4g/kg of magnesium which is the most proper amount contained inside the leaf stalk.

Tab. 2: Effects of stocks on the mineral elements inside the leaf stalk of the grafted cultivar

Stocks	T-N (g/kg)	P_2O_5 (g/kg)	K_2O (g/kg)	CaO(g/kg)	MgO(g/kg)
5BB	5.7	9.7	41.5	19.8	3.5ab
SO4	5.1	4.8	40.6	15.5	2.6b
188-08	4.7	6.2	37.9	17.5	2.9ab
5C	5.4	8.9	36.7	20.1	4.0a
3309	5.3	6.3	35.5	13.6	4.0a
Control	4.8	9.7	44.6	15.6	3.6ab

DMRT ($\alpha=0.05$)

Tab. 3 shows the effects of stocks on the quantity of grafted cultivar, cluster weight, berry weight, and berry number. Yield per one tree was the lowest at 14.0kg in stock 3309 and there was no difference from the control in other stocks. Cluster weight, berry weight, and berry number are not much different between stocks and the control.

Tab. 3: Effects of stocks on the quantity of the grafted cultivar & fruit characteristic

Stocks	Yield (kg/1 tree)	Cluster weight (g)	Berry weight (g)	Number of berry (ea)
5BB	19.6a	310a	5.2	59.7
SO4	18.5a	318a	5.5	57.4
188-08	17.6ab	305a	5.7	53.5
5C	17.8ab	309a	5.2	59.1
3309	14.0b	285a	5.3	51.9
Control	19.1a	313a	5.5	56.6

DMRT (α=0.05)

In Tab. 4, soluble solids are the highest in stock 3309 and acid contents are the same in all stocks. The coloring range and antocyanin content are high in both stock 3309 and the control.

Tab. 4: Effects of stocks on the fruit characteristic of the grafted cultivar

Stocks	Soluble solids (°Bx)	Acid contents (%)	Fruit coloring (1-9)	Antocyanin (OD:530nm)
5BB	15.1bc	0.47	8.6	1.79
SO4	15.1bc	0.47	8.5	1.63
188-08	15.0bc	0.43	8.6	1.66
5C	14.7c	0.45	8.3	1.62
3309	16.7a	0.42	9.0	2.16
Control	16.0ab	0.45	9.0	2.07

DMRT (α=0.05)

Discussion

This test shows that stock 5BB strengthens the tree vigor of the grafted cultivar, the Campbell Early, while stock 3309 makes it very weak. According to Parejo(1995), it has been found that 3306, 3309, 420A, 5C, 8B, Gloir made scion cultivar dwarfted and 5BB, SO4 made scion cultivar vigorous. This result is the same as our test result which was taken on 3309 and 5BB. Therefore, we suggest that it is better to use stock 5BB in protected cultivation. In fact, many grape farmers have suffered from the problems which were caused by low growth rate due to a sharp decline of the tree vigor after they spent 3-4 years growing the rooted cutting in protected cultivation. When it comes to orchards where grape farmers are afraid of shoot over growth, it is much better to use stock 3309. Magnesium content is extremely low in stock SO4 and 188-08. Just like Shaffer(2004)'s claim that SO4 rootstock is very weak in absorbing

Magnesium, this study also shows the same result because the amount of magnesium from the rootstock is so low. While Brancadoro(1994) and Papric(1998) asserts that SO4 rootstock has a high amount of potassium, this test shows no difference in potassium amount. We presume that there are two reasons for these differences in nutrient absorption among the stocks. The first reason is the different suction layer toward special vegetation according to the specific aspect of stocks. The second reason is the difference between pH and nutrient components since the root distribution of the stocks is much wider and deeper than the rooted cutting. Ozisik(1990) says that SO4 rootstock has the good tree vigor, the highest yields, and the highest quality of fruits after taking an experiment of 8 kinds of rootstock such as SO4, 5BB, etc,,, on the Semillon grapes. James (2002) and his research on 16 stocks such as 5C, 5BB, 3309 and 6 cultivar concluded that tree vigor and fruit characteristic are greatly affected by soil texture, planting distance, cultivation characteristic, soil depth, water soil, and water condition. With the help of this research, we can understand how growing conditions can influence the grafted cultivar. Therefore, we believe that various tests which diversify the condition of soil texture, soil depth, water soil, and water condition should be undertaken in the foreseeable future and the selection of stocks should be accurately done to reject stocks which are not suitable for the respective environment.

Conclusions

In conclusion, stock 5BB strengthens the tree vigor of the grafted cultivar, the Campbell Early, while stock 3309 makes it very weak. Stock 5BB has lower rate of berry shattering than other stocks. Magnesium content is extremely low in stock SO4 and 188-08. Soluble solids and coloring degree were high in stock 3309 but the quantity was very low. Therefore, we strongly urge grape farmers to choose stocks considering the effects of stocks on the growth and fruit characteristic of the grafted cultivar and other necessary conditions such as soil texture, soil depth, and water condition.

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Current status of organic cultivation in oriental pear orchards of Korea

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Key words: Insecticides, Management, Scab, Sulphur

Abstract

Lime sulphur and oils were preferred as insecticides and scab, mealybugs, woollybugs and barkminers were main pests to manage in organic pear orchards. Compared to conventional pears, organic pears were smaller sized and more pest damaged. For the biodiversity of amphibians, snakes, pheasants, and rodents, there was no difference between organic and conventional orchards, but Rufous turtle doves flied more in the organic area than conventional one.

Introduction

The interests in producing organic pear fruits is growing among growers as well as among consumers. However, organic cultivation system for oriental pear is not developed, although the organic proportion of total cultivated area increased gradually; there are 39 organic pear orchard managers and the area is reached to roughly 0.1% of the total pear orchard area in Korea. Most of insecticides such as organophosphates and carbamates were used to control major pests in pear orchards but these are highly toxic to birds because these are directly related to bird's mortality. In order to systemize and support the organic pear culture, basic scientific data relating effective pest control are required. In this study, we intended to get information on pest control based on the questionaire for orchard managers and to investigate biodiversity between organic and conventional orchards.

Materials and methods

Questionaire was made up to get informations on cultural practices about pest control in the oriental pear orchards of organic system. Twenty two answers were collected by the mail and telephone response. Fruit characteristics of oriental pear were analyzed on weight, length, width, acidity and sugar content by AOAC method. For the biodiversity with amphibians and snakes, we counted the number of individuals encountering in the orchard areas of 350㎡. For the nesting vertebrates such as pheasants and rodents, we added up the numbers of habitat vestages such as feather s and dens. For the bird's census in the orchards, all sightseeings of bird's individuals over about 1ha per survey unit was recorded at each observation point

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from 6 a.m to 7 a.m(Brower *et al*, 1989). For the biodiversity survey on these amphibians, snakes, and birds, two trials were carried out on August 19 and on October 1 in 2010.

Results

Orchard managers of organic pear preferred lime sulphur and oils as insecticides and they had a problems to control pest mainly for scab, mealy bugs, woolly bugs and bark miners(Tab. 1). The problematic disease to the farmers was pear scab(*Venturia nashicola*) and pear rust(*Gymnosporangium asiaticum*) which is similar to those of conventional system. Whereas, insect pests were mealybugs(*Planococcus kraunhiae, Pseudococcus comstocki, Cricicoccus matsumotoi*), woollybugs(*Prociphilus kuwanai*), barkminers(*Spulerina* sp.), curculios(*Neocoenorrhinus* sp.), and stink bugs(*Plautia stali*, *Dolycoris baccarum*). Organic farmers usually applied 7 to 10 and 5 to 8 times a year for the disease and insect pest control, respectively(Tab. 2). The pear fruits of conventional system were heavier and bigger than those of organic, but there was no significance in texture hardness of fruit flesh and the content of soluble sugar(Tab. 3). For the biodiversity of amphibians, snakes, pheasants, and rodents, there was no difference between organic and conventional orchards, but Rufous turtle doves flied more in the organic area than conventional one(Tab. 4, Tab. 5).

Tab. 1: Status of Organic farm based on the questionaire of 22 orchard managers for organic pear

Questions	Answers(No. of farm)
Preferential fungicides	lime sulphur(15), Bordeaux mixture(3), others(4)
Preferential Insecticides	machine oil(3), plant oil(4), mating disrupter(2), plant extract(2), others(11)
Main diseases	scab(15), rust(7)
Main insects	mealybugs(3), woollybugs(3), barkminers(3), curculios(2), stink bugs(2), others(9)

Tab. 2: Frequency of organic insecticide's application based on the questionaire of 10 orchard managers for organic pear

Range of Frequency	< 4	5~6	7~8	9~10	>11
Applying for disease control	-	-	3	5	2
Applying for insect control	3	3	3	1	-

Tab. 3: Fruit characteristics of oriental pear(cv. 'Niitaka') from 11 organic and conventional orchards, respectively

Types of Cultural Practices	Weight (g)	Length (mm)	Width (mm)	Hardness (kg/Ø5mm)	Soluble Sugar (°Bx)	Acidity (%)
Organic	543.4±97.8	80.1±7.9	94.9±7.6	1.5±0.7	14.7±6.7	1.02±0.3
Conventional	608.3±37.3	88.3±4.0	107.9±3.9	1.1±0.1	12.1±0.7	1.01±0.1
t-test(*P*=0.05)	*	*	*	n.s	n.s	n.s

Tab. 4: Biodiversity between orgarnic and conventional orchards

	Amphibians*	Snakes	Habitat Vestiges	
			Pheasant	Rodents
Organic	2.0±1.0	1.3±1.2	0.7±0.6	8.7±6.0
Conventional	0.0±0.0	0.0±0.0	0.0±0.0	8.0±6.0
t-test(*P*=0.05)	ns	ns	ns	ns

* Counted the number of individuals encountering in the orchard areas of 350㎡. The counting numbers for two trials in August 19 and in October 1 are added up.

Tab. 5: Number of birds flying in orchard's areas

Types of Cultural Practices	Black-billed Magpies*	Azure-winged Magpies	Grey-eared Bulbul	Rufous turtle Dove	Total
Organic	6.7±2.3	5.3±1.5	5.3±1.5	7.7±1.5	25.0±7.4
Conventional	6.0±0.0	3.7±1.2	3.7±1.2	4.7±1.2	17.3±4.0
t-test(*P*=0.05)	ns	ns	ns	*	ns

* Counted bird's individuals flying in the orchard areas of 1ha. The counting numbers for two trials in August 19 and in October 1 are added up.

Discussion

Compared to the various insecticides only two fungicides, lime sulphur and Bordeaux mixture were used in organic system. This suggests that other effective agents should be developed to control main diseases. The main diseases in organic pear production were the same as those in conventional due to the predominant cultivar 'Niitaka' which is susceptible to pear scab and pear rust and cultivated over 81% of total production area of oriental pear(Ishii *et al*, 1992; Shin *et al*, 2008; Wu *et al*, 2006). Insect pests nuisant both to organic farms and to conventional ones were mealybugs and stink bugs. Woollybugs, barkminers, and curculios were major pests to some of organic farms, but just minor pests to the conventional. The major pests of conventional system were oriental fruit moths(*Grapholita molesta*), pear suckers(*Psylla pyricola*) and mealybugs(*Pseudococcus comstocki, Cricicoccus matsumotoi*). From the frequency of applying pesticides, it appeared to be difficult to control diseases more than insect pests. It seemed that sod culture in organic system give lots of habitats to the natural enemies. The reason why fruits of conventional cultivation were heavier than those of organic seems to be the leaves' drop caused by pear scab and the less tree vigor which is resulted in shorter and fewer shoots (MacHardy, 2007). Considering birds and amphibians are among the most conspicuous fauna, and they may be highly at risk from the use of agricultural pesticides(Hardy *et al*, 1987), this report needs more consideration about research methods including long-term monitoring of habitat usage in orchards by vertebrate animals. The reason why rufous turtle doves flied more in the organic area seemed that there were more weed seeds from long periods of sod culture and doves gathered to have them.

Conclusions

Lime sulphur and oils were preferred as insecticides and scab, mealybugs, woollybugs and barkminers were main pest to manage in organic pear orchards. Compared to conventional pears, organic pears were smaller sized and more pest damaged; these could be unattractive to casual customers. For the specific analysis for the biodiversity of amphibians, snakes, birds and rodents, annual fructuation data should be collected with the advanced methods to monitor each species.

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Effects of tree vigor and fruit quality on organic fertilizer split application in organic culture of Sweet Persimmon

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Key words: Organic culture, Fertilizer, Split application, Tree vigor, Fruit quality

Abstract

The purpose of this study is to identify the effects of tree vigor and fruit quality on organic fertilizer split application in organic culture of sweet persimmon. Soil chemical properties by organic compound split application shows that pH 6.99-7.46 in experimental groups is higher than that of the control group. Also, organic contents are higher in experimental groups than in the control group. The number and length of succulent shoot become less and shorter with more organic fertilizer split application. The number of bearing mother branch is highest in the 3 times group with 127.3ea and there is no meaningful difference among the other groups. The number of fruit setting is more in the 3 times split application group with 162 than the 1 time group with 147. Total yield per 10a is highest in the 3 times group with 2,400kg. In terms of sugar content, firmness and leaf color, the more split application, the better the fruit quality is.

Introduction

To control tree vigor in sweet persimmon, root control and controlling application amount of nitrogen fertilizer are used. When nitrogen fertilizer is insufficient, the growth of the tree and yield are lower. Also, the growth and quality of fruit are bad (Park et al, 2010). However, when nitrogen fertilizer is oversupplied, over vegetative growth can result in lowering fruit quality by creating too many succulent shoots which lead to lowering flower bud, decreasing fruit setting and sugar content, and increasing diseases and physiological stress (Raese, et al., 1997).
In organic cultivation, organic fertilizer is applied instead of chemical fertilizer. Usually, organic fertilizer is applied all at once in winter. In this case, contents of nitrogen fertilizer are oversupplied at once, leading to unnecessary growth and inferior result on sugar content and fruit color due to the oversupply of nutrition.
In culturing sweet persimmon, 50% of the total amount is applied at once and the other 50% is divided into 2 times and applied in summer and winter with 25% respectively (RDA, 2003).
By splitting organic fertilizer application into 3 applications, it is possible to avoid the oversupply of nutrition and provide the proper amount of organic fertilizer. The purpose of this study is to identify the effects of tree vigor and fruit quality on organic fertilizer split application in organic culture of sweet persimmon.

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Materials and methods

In this study, 10-year old *Diospyros kaki* cv. Fuyu sweet persimmon spices were used. Culture type was 5×3m (67weeks/10a) of intensive culture and organic culture management was used during the cultivation period.
Mixed expeller cake fertilizer was applied after converting it based on nitrogen 15kg. In mixed expeller cake fertilizer, T-N, P_2O_5, K_2O is contained in 2.73, 4.38, 1.95%, respectively, calculated by 72.4% of nitrogen mineralization rate of expeller cake.
4 groups were prepared: control group, 1 time group, 2 times group, and 3 times group. A completely randomized design was used. Top soil (0-15cm) after drying under the shade and sifting the soil with 2mm sieve was used to analyze soil characteristics in October 2010. The characteristics of soil and leaf were analyzed by soil chemical analysis method set by National Academy of Agricultural Science. Harvesting in 9 weeks, fruit weight, quantity, and fruit quality were analyzed once in 3 weeks based on research standards of National Academy of Agricultural Science in Rural Development Administration (RDA, 2003).

Results

Soil chemical properties by organic compound split application indicated that pH was higher than the appropriate range of 5.6-6.5 (RDA, 1990). Organic contents and phosphoric acid in the soil were higher in experimental groups. It is believed that high organic content (82.5%) and phosphoric acid (4.38%) in mixed expeller cake fertilizer can lead to that result. Among inorganic components in leaf, the nitrogen amount is higher in lesser split application groups. Temporary oversupply of nutrition may be the reason. Phosphoric acid and kali seem the same trend.

Tab. 1: Comparison of soil chemical properties by organic compound split application

Split application	pH (1:5)	O.M. (g/㎏)	Av.P_2O_5 (㎎/㎏)	Ex. Cation (cmol+/㎏)			C.E.C (cmol+/㎏)	EC
				K	Ca	Mg		
1 time	7.01	24.33	839	3.13	8.80	2.73	22.07	0.33
2 times	6.99	26.33	826	3.08	8.90	2.84	22.44	0.42
3 times	7.46	22.00	730	2.19	8.07	2.37	20.04	0.36
Control	6.92	21.67	641	2.54	8.20	2.72	20.87	0.39

Tab. 2: Comparison of mineral element properties by organic compound split application

Split Application	T-N (%)	P_2O_5 (%)	K_2O (%)	CaO (%)	MgO (%)	B (mg/ℓ)
1 time	2.51	0.23	2.28	1.05	0.52	32.1
2 times	2.41	0.23	2.54	1.26	0.65	36.6
3 times	2.34	0.25	2.62	1.23	0.65	39.3
Control	2.27	0.18	1.98	1.06	0.58	24.8

The number of succulent shoots was higher in the 1 time split application group with 46 compared to the 3 times application group with 36.6 (Tab. 4). The length of succulent shoot and leaf color show the same trend. This is due to the fact that oversupply of nitrogen concentration affects vegetative growth since succulent shoot is produced from May to June. The thinning amount in summer was less in more split application groups. Generally, leaf color was higher with higher nitrogen content in a tree. This study shows that leaf color is higher in experimental groups than the control group. Leaf color among experimental groups is highest in the 1 time split application group, followed by 2 times and 3 times application group. Light intensity under canopy is higher in more split application groups.

Tab. 3: Characteristics of succulent shoot and light intensity under canopy by organic compound split application

Split application	Succulent shoot characteristics		Thinning amount (kg/plant)	Leaf color (Spad)	Light intensity (Lux)
	Number (ea/plant)	Length (cm)			
1 time	46.0a[z]	113.5a	14.21a	61.6a	6,100c
2 times	40.1ab	94.8b	14.22a	61.4a	6,400c
3 times	36.6ab	84.6c	11.7ab	58.8b	7,300b
Control	30.7b	80.4c	10.70b	57.6b	7,900a

[z]Mean separation within columns by Duncan's multiple range test at P=0.05.

Fruit setting of the 1 time group was 147, which was lower compared to the 3 times split application group. It is related to the number of bearing mother branches. Due to oversupply of nitrogen, the bearing mother branch forms turions so that most of it is removed in winter while cutting and thinning branches. Fruit weight shows no significant difference among experimental groups but was lower in the control group. There is a report that nitrogen fertilizer content in the fruit fattening stage has significant impact on fruit fattening and if nitrogen is not sufficient in that period, fruits could not get enough fattening (Park, 2002). This study confirmed that result.

Yield per 10a was highest in the 3 times group with 2,400kg. Sugar content was higher in the 3 times group with 17^{o}Bx compared to the 1 time group with 16.2^{o}Bx. There is a report that supplying nitrogen fertilizer in the late stage of growth makes lower sugar content (Park, 2002) and this study confirmed that result. Oversupplying nitrogen fertilizer has led to accumulation in soil, leading to stimulating unnecessary growth of new branches and lowering fruit quality and color, and increasing disease (Peterson & Stevens, 1994). The result of this study gave similar results as the other existing reports, that higher nitrogen makes soluble solid and anthocyanin contents lower and bad coloring. In terms of firmness and coloring, the result shows that the more split application, the higher firmness and coloring. This difference was statistically significant.

Tab. 4: Number of bearing mother branch, fruit setting, weight and yield by organic compound split application

Split application	Bearing mother branch (ea/plant)	Fruit drop (ea/plant)	Fruit setting (ea/plant)	Fruit weight (g)	Yield (kg/10a)
1 time	113.9b[z]	9.3a	147.4b	222.8a	2,200b
2 times	123.6a	9.0a	170.2a	212.8ab	2,369a
3 times	127.3a	6.2b	162.6a	220.3a	2,400a
Control	123.8a	4.2b	152.0b	203.0b	2,067c

[z]Mean separation within columns by Duncan's multiple range test at P=0.05.

Tab. 5: Comparison of soluble solid, firmness and coloring yield by organic compound split application

Split application	Soluble solid (°Bx)	Firmness (kg/Ø5mm)	Coloring (Hunter)		
			L	a	b
1 time	16.2b[z]	2.57a	59.45a	14.65b	56.17a
2 times	16.0b	2.76a	60.40a	18.93a	58.15a
3 times	17.0a	2.74a	59.24a	20.35a	60.26a
Control	17.3a	2.81a	56.25a	21.84a	57.94a

Conclusions

We investigated organic fertilizer split application to improve fruit quality and tree vigor on organic culturing of sweet persimmon. The result showed that the 3 times split application group had less succulent shoots and thinning amount and more bearing mother branches. Tree vigor was more stabilized and the quality of fruit and yield were increased compare with the 1 time group.

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Pest and disease management

Evaluation of locally available media for the growth and development of nitrogen fixing micro-organisms

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Key words: Organic farming, nitrogen fixers, panchagavya, jeevamrutha, digested biogas slurry

Abstract

Biofertilizers play a major role in maintenance of soil fertility in organic farming and which are not readily available in rural areas. In order to multiply these viz; Rhizobium spp., Azospirillium , Azatobacter etc., a study was conducted using locally available organic material such as digested bio-gas slurry, compost, press mud, jeevamrutha and panchagavya with the objectives, to evaluate locally available nutrient sources for mass production of beneficial micro organisms and for comparative evaluation of growth rate among the nitrogen fixing micro organisms. Many nitrogen fixers performed better growth in compost extract, digested biogas slurry, press mid, jeevamrutha and control than panchagavya. Whereas, when these media were used in combinations, growth of microorganisms varied. Supplementation of 1 per cent glucose showed higher growth with combinations of different media. It indicates that nitrogen fixers can be multiplied using locally available substances at very low cost.

Introduction

Soil fertility status is maintained in organic farming through organic manures, crop residues, green manure crops and use of biofertilizers. Biofertilizers such as Rhizobium, Azospirillum and Phosphobacteria provide nitrogen and phosphorous nutrients to crop plants through nitrogen fixation and phosphorous solubilization processes. At present, Biofertilizers are supplied to farmers as carrier based inoculants. Formulations based on agricultural waste products, *viz.,* bran of grains, oil cakes, farmyard manure etc., are found to support excellent growth carrier and storage media (Patibanda *etal.* 2003). Several researchers have comprehensively worked on various agricultural wastes and byproducts for mass multiplication of *Trichoderma* (Jeyarajan and Angappan 1998). Therefore, to multiply these bio-inoculants by the farmers using locally available organic materials by themselves in their farm with minimal knowledge and technical guidance.A laboratory study was conducted with the following objectives; to evaluate locally available nutrients sources for mass production of beneficial micro organisms and comparative evaluation of growth rate among nitrogen fixing micro organisms.

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Material and Methods

Experiment was conducted at Organic Farming Research Centre,(OFRC) ZARS, Navile, Shivamogga. The nutrient materials tested were: digested bio-gas slurry, compost, press mud, jeevamrutha and panchagavya. Six nitrogen fixing microorganisms used as nitrogen fixers were tested for their growth and development on locally available media substances. Nitrogen fixers tested include, *Rhizobium leguminoserum, Rhizobium Phaseali, Rhizobium* Sp (Dhiancha), *Rhizobium Japonicum* , *Azotobacter Chrococcum, Azospirillum* sp. As a control treatment the bacterial cultures were inoculated on nutrient agar medium. The experiment was conducted with and without 1 per cent glucose to know whether carbon supplementation is required for better growth.

Test organisms were isolated locally from the organic plots of OFRC. Test materials used as growth media were, digested bio-gas slurry, compost, press mud, Jeevamrutha and panchagavya and they were mixed in 1:1 proportion with sterilized distilled water and soaked overnight and the extract was filtered. The extrantant was sterilized along with 20 g agar as solidifying agent. Then, 15-20 ml of sterilized media was transferred to each petri plate and nitrogen fixers were inoculated under aseptic condition. The inoculated plates were incubated under room temperature and observations were recorded after 48 hours for bacteria.

Growth observations were recorded after three days and it compared with the growth in control plates and they were scored as + average, ++ better, +++ good, and – Nil. The experiment was conducted with following treatment combinations:

T_1	Compost extract	T_9	DBS + panchagavya (1:1)
T_2	Digested biogas slurry (DBS)	T_{10}	DBS + Jeevamrutha (1:1)
T_3	Panchagavya	T_{11}	Compost extract + Jeevamrutha (1:1)
T_4	Jeevamrutha	T_{12}	Press mud + Panchagavya (1:1)
T_5	Press mud	T_{13}	Press mud + Jeevamrutha (1:1)
T_6	Control	T_{14}	DBS + compost extract (1:1)
T_7	Compost extract +DBS + Panchagavya + Jeevamrutha + Press mud (in equal proportion)	T_{15}	DBS + press mud (1:1)
T_8	Compost extract + panchagavya (1:1)		

Results and Discussion

Results of the experiment are presented and discussed below. The visual observations recorded on growth of different nitrogen fixers on locally available natural media alone and their combinations, with and without glucose supplementations are presented in table 1 to 4.

It could be clearly seen that, among the different basal media used viz., compost extract, digested biogas slurry, panchagavya, jeevamrutha and press mud extracts, without supplementation of glucose jeevamrutha supported maximum number of test organisms followed by digested biogas slurry (DBS) and compost. Bacterial growth was supported by almost all the different media used (Table 1) in the experiment.

Tab.1: Growth of nitrogen fixing micro organisms on locally available nutrient media alone without glucose supplementation

Organisms	T_1	T_2	T_3	T_4	T_5	T_6
Rhizobium leguminoserum	++	++	+	++	++	++
Rhizobium Phaseali	++	++	+	++	++	++
Rhizobium Sp (Diancha)	++	++	+	++	++	++
Rhizobium Japonicum	++	++	+	++	++	++
Azotobacter Chrococcum	++	++	+	++	+	++
Azospirillum sp.	++	++	-	++	+	++

Among the different media combinations tested, it was observed that Digested Biogas Slurry + panchagavya did support the growth of all nitrogen fixers followed by, Digested Biogas Slurry + Jeevamrutha and press mud + panchagavya (Table 2). In general it was observed that in all the media combinations, where panchagavya was used as a component had supported better bacterial growth.

The different media compositions were evaluated using 1 per cent glucose as initial carbon supplement for growth and establishment of organisms and results are presented in Table 3 and 4. It was observed that, individual nutrient media components with 1 per cent glucose supplement, press mud extract and digested biogas slurry did support normal growth of all test organisms (Table 3). However, maximum growth was observed in control treatment and minimum in panchagavya treatment.

Tab. 2 : Growth of nitrogen fixing micro organisms on locally available nutrient media alone without glucose supplementation

Organisms	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}	T_{14}	T_{15}
Rhizobium leguminoserum	++	+	+	++	++	+	++	++	++	+
Rhizobium Phaseali	++	+	++	++	++	+	++	+	+	+
Rhizobium Sp (Diancha)	++	+	++	++	++	+	+	+	+	+
Rhizobium Japonicum	++	+	++	++	++	+	+	+	+	++
Azotobacter Chrococcum	++	+	+	++	+	+	+	++	+	+
Azospirillum sp.	++	+	++	++	+	+	+	+	+	+

Tab. 3 : Growth of nitrogen fixing microorganisms on locally available nutrient media alone with glucose supplementation

Organisms	T_1	T_2	T_3	T_4	T_5	T_6
Rhizobium leguminosarum	+	++	-	+	++	+++
Rhizobium Phaseali	+	++	+	+	++	+++
Rhizobium Sp (Diancha)	++	++	+	+	++	+++
Rhizobium Japonicum	+	++	+	+	++	+++
Azotobacter Chrococcum	+++	++	-	++	++	+++
Azospirillum sp.	+	++	-	+	++	+++

Among the different nine media combinations with 1 per cent glucose it was observed that combinations did support the growth of all six nitrogen fixing organisms (Table 4), except compost + panchagavya combination with 1 per cent glucose supplementation. Where, growth of nitrogen fixing micro-organisms was slightly reduced as compared to other media combinations. Minimum growth was recorded in compost extract + panchagavya followed by compost extract + Jeevamrutha media combination.

Tab. 4 : Growth of nitrogen fixing micro organisms on locally available nutrient media alone with glucose supplementation

Organisms	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}	T_{14}	T_{15}
Rhizobium leguminoserum	+++	++	+	++	++	+	++	+	++	++
Rhizobium Phaseali	+++	++	+	++	++	+	++	++	++	++
Rhizobium Sp (Diancha)	+++	++	+	+	++	+	++	++	++	++
Rhizobium Japonicum	+++	++	+	++	++	++	++	++	++	++
Azotobacter Chrococcum	+++	++	+	++	++	++	++	++	++	++
Azospirillum sp.	+++	++	+	+	++	++	++	+	++	++

Discussions

The results indicate that local media alone without 1 per cent glucose supported better growth of nitrogen fixers except with panchagavya. Supplementation of 1 per cent glucose resulted in maximum growth in control followed by digested biogas slurry and press mud while, it was hindered in panchagavya and jeevamrutha. Less growth observed with panchagavya might be due presence of other micro organisms, very high acidic nature of panchagavya. When it was supplemented with 1 per cent glucose, lower growth of N-fixers observed which may also be due to wider C: N ratio of the media. These results are in conformity with results of Natarajan (2002) Somasundaram et al. (2003) and who have reported higher acidity and more content of beneficial micro organisms in panchagavya.

While, growth of nitrogen fixers was affected due to combinations of different media compositions, and it was better with compost extract and digested biogas slurry used either with panchagavya or jeevamrutha. Growth of all the nitrogen fixers were better with supplementation of 1 per cent glucose except in compost extract + panchagavya followed by compost extract + jeevamrutha. The varied growth with these may be due to wider C: N ratio of the media which might have affected the growth of many beneficial micro-organisms. Also, it may be due to the antagonistic effect of microbes and other metabolites present in these formulations. Natarajan (2002) and Devakumar et al. (2008) have reported the presence of beneficial microorganisms and other useful metabolites in panchagavya and jeevamrutha. Further, it needs to be studied in detail to know other reasons for such growth pattern. However, farmers can multiply N-fixers and beneficial micro organisms on their own at low cost with guidance from the resource persons.

Conclusions

Locally available substances such as compost, digested biogas slurry, Press mud and jeevamrutha can be used for multiplication of nitrogen fixing micro organisms.

Whenever either panchagavya or jeevamrutha are used with compost extract and digested biogas slurry, growth was more and sustained for longer period.

Combination of digested biogas slurry with compost extract or press mud resulted in less growth of nitrogen fixers.

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Organic seed treatment possibilities

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Key words: seed, plant pathogens, tomato, pepper, environmental friendly

Abstract

In organic farming systems the focus is on prevention with regards to plant protection. To follow the rules of Good Agricultural Practice one is able to avoid serious yield losses; if it is not possible the use of allowed materials are permitted. Healthy and high quality propagation material plays a significant role from economic aspect, which places the propagation material production industry into the focus of improvement and research. In organic farming, propagation materials have to originate from organic production from 1. January 2004, which, in parallel, trigerred the need of their protection (1452/2003). Organic farmers have less material to protect their plants so it is necessary to find effective potential alternatives. Bacterial and fungal diseases of tomato and pepper can cause serious losses in yield. Different materials were tested against some plant pathogen bacterial (Clavibacter michiganensis subsp. michiganensis, Pseudomonas syringae pv. tomato, Xanthomonas campestris pv. vesicatoria and fungal (Phytophtora infestans, Rhizoctonia solani, Sclerotinia sclerotium) strains in order to find potential materials in the field of organic seed treatment. In vitro trials have shown that vinegar, cider vinegar, red wine vinegar, white wine vinegar, cinnamon and thyme oil have inhibiting effect against the causative agent of bacteria and fungi.

Introduction

Organic farming is a closed system in harmony with nature, therefore the demand for organic seeds has been escalated and its necessity was declared by European Seed Association as well. In traditional agriculture, numerous methods are known and used for seed treatment during the production process. However, organic seed treatment is so recent, that only insufficient number of methods for the examination of seeds and materials for treatment are available which can be applied in practice successfully. For filling this market and technological gap, appropriately tested and efficient materials are necessary, if we are to implement organic agriculture seriously and increasingly.

During the research the main aim was to find environmentally friendly, cheap and easily applicable materials for organic seed treatment with selecting appropriate materials for organic seed treatment according to scientific literature (*Borgen 2004*) and former examinations with in vitro microbiological examinations of perspective materials against previously chosen pathogenic microorganisms and defining the

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lowest, yet effective concentration of the materials which have been proven to be microbiologically effective to inhibit the reproduction of microorganisms safely.

The experiment is realized with the aim of TÁMOP-4.2.1/B-09/1/KMR-2010-0005 project with the title of "Fenntartható fejlődés – élhető régió – élhető települési táj".

Materials and methods

The materials for examination have been chosen on the grounds of scientific literature (*Borgen 2003*): materials applied in food conservation and of natural origin. Microbiological tests were implemented at Corvinus University of Budapest, Faculty of Food Science, Natural Collection of Agricultural an Industrial Microorganisms (NCAIM).

The following microorganisms were examined:

Clavibacter michiganensis subsp. michiganensis NCAIM B001778, NCAIM B001779
Pseudomonas syringae pv. tomato NCAIM B001277, NCAIM B001682, NCAIM B001538
Xanthomonas campestris pv. vesicatoria NCAIM B001771, NCAIM B001226
Sclerotinia sclerotium F00738
Rhizoctonia solani 268
Phytophtora infestans K39

Natrium-hydroxide, Kasumin 2L, Streptomycin-sulfate and destillated water were applied as controlls. We examined several materials but here only effective or more important ones will be introduced; different essential oils: cinnamon essential oil (*Aetheroleum cinnamomi*), thyme essential oil (*Aetheroleum thymi*), vinegar, red wine vinegar, white wine vinegar, cider vinegar, baking soda (Natrium-hydrogencarbonicum), propolis etc.

Microbiological efficiency was tested by cup plate method, disk diffusion test (*Gavin 1957*), and poison agar assay (*Klement et al 1990*).

Handling and primary processing of data during the experiments was executed with Microsoft Excel 2003 programme. Statistical analysis of data was done by SPSS for Windows 14.0 statistical software and Ropstat programme package.

Results

In vitro bacteriological assays results are the followings: essential oils examined in 100% concentration had inhibition effect against all examined strains. Among oils cinnamon was the most effective as it had significantly bigger inhibition zone than 1,5% NaOH control. In lower concentration (25% and 50%) cinnamon oil has inhibition effect on the reproduction of all examined strains. Thyme oil was less effective but it had inhibition effect from 25% concentration.

In all examined materials 10% vinegar caused the highest inhibition.

Vinegar, cider vinegar, red vine vinegar and white vine vinegar have inhibiton effect from 0,5% concentration on examined Pseudomonas strains (B.01277, B.01682), on Xanthomonas strains (B.01807, B.01771, B.01226) and on Clavibacter strains (B.01778, B.01779).The effect of vinegar was the same in all strains. The examined highest concentration (10%) was the most effective; lower dose induce lower inhibition. Correlation was observed between concentrations and inhibition zones as all type of vinegars showed correlation.

During experiments the objective was to choose materials with the widest spectrum of activity, thus in further tests only bacteriologically efficient materials were examined. The results of tested materials on fungi are presented in Table 2.

Tab. 2: Results of tests on fungi

Strains	Rhizoctonia solani R268			Sclerotinia sclerotium F 00738			Phytophtora infestans K39
Methods	a	b	c	a	b	c	a
Tested agents, concentrations							
control	100%	100%	100%	100%	100%	100%	100%
NaOH 1,5%	81%		52%	100%		0%	0%
material with kasugamycin	100%		100%	95%		83%	
vinegar 10%	0%	0%		0%			0%
vinegar 5%	56%	0%	48%	44%	0%	0%	100%
vinegar 4%			63%			32%	
vinegar 2,5%	80%		76%	100%		31%	100%
vinegar 0,5%	82%		86%	100%			
red wine vinegar 6%	84%		48%	100%	0%	0%	100%
white wine vinegar 6%	88%		45%	50%	0%	0%	
cider vinegar 6%	85%		56%	73%	0%	0%	
cinnamon oil 100%	100%			0%			9%
thyme oil 100%	75%			51%			100%
propolis 100%	95%			100%			

Key to symbols: a: poison agar assay, b: further test on cid effect , c: direct contact method, P=0,05

Discussion

The objective of my experiments was to find materials suitable for organic seed treatment. Vinegars in 0,5% concentration inhibit reproduction and by increasing concentration this effect can be multiplied. Inhibiting effect of vinegar in 10% concentration exceeds that of 50 ppm Streptomycin-sulfate. Hydrogen ion on pH 3-6 has bacteriostatic, while on pH <3 has bactericid effect, which was proven in case of tested bacteria strains. Alkalis, however, have much lower effect on propagation of bacteria. Alkaline medium does not present such an extent of inhibition on the propagation of bacteria as those of acids. Baking soda did not have any effect, while 1,5% NaOH solution, with pH 13, only showed little effect on the growth of strains.
The effect of 0,5% vinegars had the same effect as 1,5% NaOH, while in higher than 2,5% concentration it has proved to be more efficient. Cinnamon and thyme essential oils have to be applied in at least 25% concentration to perform inhibition on the propagation of bacteria. 25% concentration compared to 50% showed efficiency and did not present significant difference, however from ecological point of view lower concentration is reasonable. These oils inhibited the growth of all three bacteria from 25% concentration. In case of tested fungi strains it is considered to be a good result if the material decelerates their growth, thus providing vantage for the germination of seeds. The Chosen materials generally decelerate the growth of fungi (static effect), however not many of them could have cid effect. In the case of *R. solani* and *S. sclerotium* the majority of tested agents in higher concentrations (> 6%) had cid effect, while in case of *P. infestans* only 1,5% NaOH, vinegar in 10% concentration and

undiluted cinnamon essential oil inhibited growth. These materials also inhibited the growth of other fungi strains. In case of mildews, natural acids under pH 3 did not have any inhibition effect. On the basis of my experiments antimicrobial effect of vinegar, cider vinegar, white and red wine vinegar can be established.

Conclusions

The above mentioned compounds in higher concentration have cid effect on bacteria, while stronger acids have the same effect on fungi as well. Microbiological efficiency of vinegars is directly proportional to their concentration. Tested vinegars are efficient in lower dose; therefore their application is to be implemented in such, for they decelerate the speed of the growth of microbes, which might be a key factor of prevention and plant protection in organic farming. With their better performance, plants are able to reach a level in their development for the unfavourable period, so that pathogenic microbes cannot infect them in healthier and better condition. Vinegars, red and white wine vinegars, cider vinegars in 0,5% concentration have presented complex spectrum of activity, for they have been efficient against both the tested bacteria and mildews. As for expenses, NaOH 1,5% is the cheapest, followed by vinegar 0,5%, cider vinegar 0,5%, red wine vinegar 0,5% white vine vinegar 0,5%, and the agent with kasugamycin content. Tested agents can be utilized in organic plant protection, where other means of application have to be considered as well. In such use, concentration does not have limiting role, for the surface of plants is less sensitive than seeds, thus treatments cannot be so harmful. Developing agents with appropriate effect at fields beyond seed treatment can be researched further on. Results have to be applied and their use in practice can be tested widely in the future.
The significance of further research lies in the fact, that the tools of plant protection are to be broadened not just in organic but also in conventional farming, and as long as it is possible to provide more environmentally friendly and cheaper agents, than presently available ones, all members of the consumer chain might benefit both from the aspect of environmental protection and economy.

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Efficacy of biopesticides against jassid (*Amrasca biguttula biguttula* Ishida.)

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Key words: bio-pesticides, microbial pesticides, plant extracts, vegetable IPM, organic farming

Abastract

Ladysfinger (Abelmoschus esculentus L.) (Moench) is an annual vegetable crop grown in tropical and sub-tropical areas of the globe. Studies were made to evaluate efficacy of extracts from plants such as Polygonum hydropiper L. and Pongamia pinnata L., microbial insecticides like spinosad 45 SC (Saccharopolyspora spinosa Mertz & Yao) and Beauveria bassiana Vuillemin against jassid infesting ladysfinger under field conditions during the post-kharif season. Methanol was used as solvent for extract. Imidacloprid 17.8% SL was used as check. Sprays were made four times at 12-days intervals. Total jassid numbers per leaf were counted at 3, 7 and 11 days after treatment (DAT). Imidacloprid was found the most effective treatment for controlling jassids, followed by the microbial insecticide spinosad. It was observed that extracts of Polygonum plant and Pongamia leaves at a concentration of 5% and the microbial insecticide spinosad gave satisfactory Jassid control, recording more than 50% mortality. The extract of Polygonum at 5% concentration was found very effective against jassids, achieving more than 60% mortality at 3 and 7 DAT. Plant extracts and microbial insecticides are biopesticides having less or no hazardous effects on human health and environment. Thus they can be incorporated in IPM programmes and organic farming in vegetable cultivation.

Introduction

Ladysfinger (*Abelmoschus esculentus* L.) (moench) is an important annual vegetable crop in the family Malvaceae grown in tropical and sub-tropical areas of the globe. This crop is cultivated at a commercial scale in the sub-himalayan region of north east India where insect pest damage limits production (Ghosh *et al*. 1999). The crop is susceptible to various insect pests of which jassid (*Amrasca biguttula biguttula* Ishida.) is most predominant. Jassid caused up to 63.41 % yield loss on okra (Sharma & Sharma 2001). Its infestation begins at very early stages of crop growth (Faleiro & Rai1985) and continues up to harvest. The use of synthetic insecticides during the fruit bearing stage is problematic because toxic residues in the fruits could pose a health hazard.

Kaur 2002 reported that seed treatment with imidacloprid and foliar spray resulted in the lowest mean population of cotton jassid. Additionally, the oil of *Pongamia* repelled brown plant hopper (*Nilaparvata lugens* Stall.) in rice and significantly reduced its ingestion and assimilation of food. *Polygonum* is a well known weed in the terai agro-

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climatic region of West Bengal, India locally known as “Biskanthali” (Sarkar and Mukharjee 2005). Badshah *et al*. 2005 reported from Pakistan that crude leaf and flower extracts of *Polygonum hydropiper* were responsible for mortality rates 10 days after feeding of 28% and 52% for *Heterotermes indicola* and 28% and 74.7% for *Coptotermes heimi* respectively. Acharya *et al*. 2002 reported that abamectin was safer to use in the presence of coccinellid predators. The objective of this study was to determine the efficacy of the microbial pesticide *Beauveria bassiana,* the microbial toxin *Saccharopolyspora spinosa*, and plant extracts of *Polygonum hydropiper* and *Pongamia pinnata* against jassid.

Material and Methods

This two year (2006-2007) study was conducted at the instructional farm of Uttar Banga Krishi Viswavidyalaya (State Agricultural University) at Pundibari, Coochbehar, West Bengal, India. The experimental area is situated in the sub-himalayan region of north-east India.

The ladysfinger variety ‘Nirmal-101’ was grown during the post-kharif (early September) season in both years under recommended fertilizer levels (120:60:60 kg NPK/ha) and cultural practices in 4 m x 5m plots at a spacing of 75 cm x 35 cm. The treatments were replicated three times in a Randomized Block Design.

Two microbial insecticides, *Saccharopolyspora spinosa* (Spinosad 45 SC) @ 1.0 ml/ 3 L and *Beauveria bassiana* (Bals.) Vuillemin (Biorin 10^7 conidia /ml) @ 1.0 ml/L, and two botanical extracts, *Pongamia pinnata* leaf extract @ 1.0% and 5.0% and *Polygonum hydropiper* plant extract @ 1.0% and 5.0 %, were evaluated and compared with the ability of imidacloprid (Confidor 17.8 SL) @ 1ml/5 L) to control jassid. This insecticide is recommended for use against this jassid pest.

The *Pongamia* leaves and *Polygonum* plants (stem, leaves and floral parts) were extracted in methanol (absolute methanol i.e. 98%) as follows. After washing with water, the plant parts were powdered in a grinder. The powder (50 g) samples of each tested plant were transferred separately to a conical flask (500 ml) and dipped in 250 ml methanol. The material was allowed to stand for 72 hours at room temperature with occasional stirring. After 72 hours the extract was filtered through Whatman 42 filter paper.

Four sprays at 12 day intervals were made, starting with the initiation of infestation. For 1st and 2nd spray 260 liter water and for 3rd and 4th spray 350 liter water were used to cover one hectare field. Jassid population densities were recorded 3, 7, and 11 days after each spraying by counting jassid on each leaf of five apical leaves from five randomly selected plants per replication. The results were expressed as jassid population suppression (%) compared to densities recorded on the control treatment.

The fruits were harvested from each treatment at frequent intervals when they reached marketable size. The yield of marketable produce was converted to tons per hectare.

Tab. 1 : Overall efficacy of plant extracts and microbial insecticides against jassid, and the fruit yield of ladysfinger

treatments	Dose ml./Litre (%)	Pre-Treatment Observation jassid/Leaf	Overall efficacy (% reduction) Days after treatment				Fruit Yield (q/ha)
			3	7	11	Mean	
S. sponisa (Spinosad 45 SC) (T1)	1 ml/3 L	4.99	79.11 (62.90)	75.52 (60.39)	70.42 (57.12)	75.01 (60.13)	40.20
Imidacloprid (Confidor 17.8 S.L.) (T2)	1 ml/5 L	4.81	81.19 (64.45)	85.74 (68.23)	83.09 (66.10)	83.61 (66.26)	41.17
Pongamia (1.0%) (T3)	10.00 (1.0%)	4.93	43.28 (41.13)	47.01 (43.28)	37.08 (37.41)	42.45 (40.60)	32.90
Pongamia (5.0%) (T4)	50.00 (5.0%)	4.95	51.43 (45.82)	56.74 (48.90)	48.14 (43.92)	52.10 (46.21)	36.13
Polygonum (1.0%) (T5)	10.00 (1.0%)	4.89	49.13 (44.50)	51.80 (46.03)	40.70 (39.58)	47.21 (43.37)	31.49
Polygonum (5.0%) (T6)	50.00 (5.0%)	5.08	60.48 (51.07)	61.97 (51.95)	52.48 (46.46)	58.31 (49.82)	36.53
B.Bassiana (Biorin 107 conidia/ml) (T7)	1 ml/ L	4.85	52.97 (46.71)	50.63 (45.36)	41.98 (40.37)	48.52 (44.14)	32.51
Untreated Control (T8)	-	4.82	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	27.08
SE m (±)	-	-	2.13	2.93	2.93	-	1.14
CD at 5%	-	NS	6.34	8.71	8.71	-	3.87

Figure in the parenthesis are angular transformed values, DAT= days after treatment, NS = Not significant

Result and Discussion

The different treatments and their persistence at different days after application varied significantly in their suppression of jassid populations (Tables 1).Among the seven treatments (table 1), imidacloprid provided the best suppression of jassid population (83.61 %), closely followed by microbial toxin Saccharopolyspora spinosa (75.01% suppression). Among the bio- pesticides, Saccharopolyspora spinosa was the most effective followed by the Polygonum plant extract at 5 % concentration (58.31% suppression). From overall observation it was revealed that extracts of Polygonum plant and Pongamia leaf at 5 % concentration gave better result, recording more than 50% jassid suppression. The least effective treatments were the Pongamia leaf extract at 1 % concentration (42.45 % suppression).

Three days after spraying, imidacloprid was the most effective (81.19% suppression) against the jassid, closely followed by Saccharopolyspora spinosa (79.11% suppression). There was no significant difference in efficacy among these two insecticides. Polygonum plant extract at 5 % concentration provide better results against jassid (60.48% suppression). Likewise, the ability of imidacloprid to suppress jassid populations extended to seven and 11 days after spraying.

At seven and eleven days after spraying, among the bio-pesticides, Saccharopolyspora spinosa was found very effective against jassid (75.52% suppression and 70.42% suppression respectively) followed by the Polygonum plant extract at the 5 % concentration (61.97% suppression and 52.48% suppression respectively). Yield was directly related to the efficacy of insecticides. The highest yield was obtained from plots treated with imidacloprid (41.17 q/ha) followed by Saccharopolyspora spinosa (40.20q/ha). There was no significant difference in yield between these two treatments.

Conclusions

The plant extract of Polygonum and leaf extract of Pongamia (5 % concentration) and the microbial toxin Saccharopolyspora spinosa gave satisfactory jassid suppression. The Polygonum plant extract at 5 % concentration was very effective against jassid achieving more than 60% mortality at 3 and 7 days after treatment. Based on their moderate to high efficacy levels, as well as low toxicity to natural enemies and minimum impact on human health, we conclude that microbial insecticides and plant extracts can be incorporated in future IPM programme and organic farming in vegetable cultivation.

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Inhibitory effects of the extract from *Quercus dentata* gallnut against plant virus infection

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Key words : CMV, PMMoV, Daimyo Oak gallnut, Inhibitor,

Abstract

Pepper mild mosaic virus (PMMoV) and cucumber mosaic virus (CMV) are important pathogens in various vegetable crops worldwide. We have found that methanol extracts of Quercus dentate (Daimyo Oak) gallnut strongly inhibit PMMoV and CMV infection. Based on this result, the inhibitor named as "KN0912" formulated from the extract of Q. dentate gallnut was tested for its inhibitory effects on PMMoV or CMV infection to each local lesion host plant (Nicotiana glutinosa; PMMoV, Chenopodium amaranticolor; CMV). Pre-treatment effect of KN0912 against infections of each virus to local host plant was measured to be 75.1±0.5~97.5±1.5% to PMMoV and 70.6±2.2~99.0±1.0% to CMV in 1~10mg/ml conc. and the absorption effect of the antiviral composition of KN0912 to the inside of tobacco leaves tissue, was inhibited by 55.7% to PMMoV and 63.8% to CMV. The persistence of KN0912 treatment was maintained until after the 3 days high inhibitory effect by 98% to PMMoV and by 95.1% to CMV. Inhibitory effects on systemic host plants of KN0912 were measured to be 80~90% to PMMoV and 60~75% to CMV. From the change of morphological characteristics of PMMoV particles under EM, we are tentatively suggested that one mode of action of KN0912 is inactivation due to the destruction of virus particles.

Introduction

Pepper mild mottle virus (PMMoV), a genus *Tobamovirus*, is one of the most important pathogens of pepper. Also, *Cucumber mosaic virus* (CMV), a genus *Cucumovirus*, has a worldwide distribution and a very wide host range. This study was undertaken to develop of environmental-friendly antiviral agent using natural materials of plant resources. Several substances have been reported as plant viral inhibitors, such as milk, polysaccharides (Sano,1999). Many plant resources have been reported to have potent antiviral activity and some of them have already been used to treat animals and people who suffer from viral infection, because they virtually constitute a rich source of bioactive. However, little work has been done to control plant viruses by using these natural products in spite of their excellent pharmacological signification. In this study, we found the ethanol extracts from gallnut of Daimyo oak tree which strongly inhibited the infection of PMMoV and CMV. Here we report several properties of the antiviral activities by KN0912 formulated from the extract of *Q. dentate* gallnut.

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Materials and methods

Prepared samples and extracts. The fresh Gallnut of *Q. dentata* was sampled at Gangnung in Korea and the voucher specimen was deposited and maintained at the Herbarium of SPES, Korea. The dried sample(1kg) was ground using a blender and extracted twice with ethanol(7L) at room temperature and filtered. The filtrate was concentrated *in vacuo* at 40℃ and freeze-dried.

Antiviral activity of KN0912. *Pepper mild mottle virus* (PMMoV) and *Cucumber mosaic virus* (CMV) were used as virus sources. *Nicotiana glutinosa* was used for local lesion assay of PMMoV infection, while *N. tabacum* cv. Samsun was used for systemic infection in the greenhouse. For the virus inoculums, tobacco leaves (0.1g, cv. Samsun) systemically infected with PMMoV, were grounded in 20ml of phosphate buffer (10mM, pH 7.2), filtered and used as PMMoV inoculation. The inoculums of CMV was prepared from *N. tabacum* cv. Samsun NN with similar method mentioned above. *Chenopodium amaranticolor* was used for local lesion assay of CMV infection, while *N. tabacum* cv Samsun NN was used for systemic infection. Antiviral activity in local lesion host was tested by using the half-leaf method. For the antiviral activity in the systemic host, the KN0912 was sprayed onto the entire surface of the systemic hosts, cv. Samsun and cv. Samsun NN. Viruses were inoculated mechanically.

Observation of electron microscopy. 1% KN0912 was mixed with an equal volume of 100ul/ml PMMoV solutions in 10mM phos. buffer. The samples were examined with a TEM electron microscope.

Results

Inhibitory activity of KN0912. The ethanol extract from gallnut of *Q. dentata* was tested against PMMoV by local lesion assay on *N. glutinosa.* Based on these result, the inhibitor named as "KN0912" formulated from the ethanol extract of *Q. dentate* gallnut was tested for its inhibitory effects on PMMoV and CMV infection to each local lesion host plant. First of all, the mixture treatment effect of KN0912 against infections of each virus (PMMoV and CMV) to local infection plant was measured to be 100% to PMMoV and 100% to CMV in 10mg/ml conc. Also, as shown in Table 1, pre-treatment effects of KN0912 against infections of each virus to local host plants were highly estimated to be 75.1±0.5~97.5±1.5% to PMMoV and 70.6±2.2~99.0±1.0% to CMV in 1~10mg/ml conc

Tab. 1: Pre-treatment effect of KN0912 against infections of *Pepper mild mosaic virus* (PMMoV) or *Cucumber mosaic virus* (CMV)

Treatment	Concentration (mg mL-1)	Inhibition (%)**	
		PMMoV	CMV
KN0912*	10	97.5±1.5***	99.0±1.0
	5	93.0±1.2	93.3±0.6
	2	80.2±2.4	84.0±0.5
	1	75.1±0.5	70.6±2.2
Water(control)	-	0.0±0.0	0.0±0.0

* Diluted KN0912 was treated to 2 hr prior to mechanical inoculation of each virus to host plant, ** Inhibition % = (1- No. of local lesions on tretment/No. of lesions on control) x 100, *** Each value represents the mean±standard deviation of three replicates.

These effects were better than ones of the known viral inhibitors such as Lentemin (Oka et al. 2008) 10mg/ml of which reduced local lesions to approximately 90% to compare of the control. In order to assay the absorption of the antiviral composition of KN0912 to the inside of the leaf tissue, the extract(10mg/ml) were applied on the backside of the half leaves of host plants (*N. glutinosa* or *C. amaranticolor*), viruses infection onto the upper surface were inhibited by 55.7% to PMMoV and 63.8% to CMV. (Fig 2). These results indicated that the inhibitory effects of KN0912 were induced not only by barrier effects, but also by some other unclear antiviral effects.

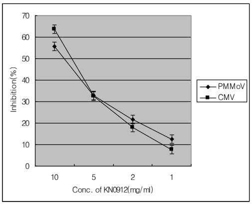

Figure 1: Absorption effect of KN0912 to the inside of the leaf tissue. Dilutions of KN0912 were applied on the backside of half leaf of host and the viruses (PMMoV or CMV) were inoculated on the upside of leaves, respectively. Each point represents the mean of three trials and the vertical bars indicate SE ranges.

Effects of the time of treatment. In order to assay the persistence of KN0912 treatment, the extract (10mg/ml) was applied on the leaves of host plants (*N. glutinosa* or *C. amaranticolor*), The KN0912 showed a higher inhibitory effect as 98% to PMMoV and as 95.1% to CMV until after the 3 days, but the effect of inhibitory was significantly reduced up to 25% at 5 days (Fig 2).

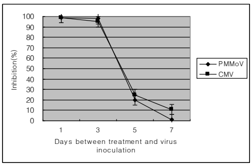

Figure 2 : Duration of inhibitory activity of KN0912 against PMMoV and CMV infection on host plants. Each point represents the mean of three trials and the vertical bars indicate SE ranges.

Antiviral effects in the systemic host. When the KN0912 was sprayed 2 hours before virus inoculation, PMMoV or CMV infections through the leaves of their systemic host were remarkably reduced in greenhouse condition. This result showed that the inhibitory activity of KN0912 was superior to the effects of the known viral inhibitors such as skim-milk or Lentemin (Oka et al. 2008).

Tab. 3: Systemic inhibitory effects of KN0912 against PMMoV or CMV infection on the host plants, respectively

Treatment *	No. plants infected / inoculated **			
	PMMoV		CMV	
	Exp. 1	Exp. 2	Exp. 1	Exp. 2
KN0912	2/20	4/20	12/20	15/20
Skim milk	7/20	12/20	9/20	5/20
Water(control)	20/20	20/20	20/20	20/20

* Experiments were repeated twice with 20 replicate seedlings for each treatment of KN0912 (conc. 4mg/ml) and Skim milk (conc. 100mg/ml). ** Five~six week old tobacco seedlings (cv. Samsun and Samsun NN) were sprayed with treatment indicated (200ml/20pots), and each inoculums was rubbed onto 2 leaves of each plant 2 hrs after treatment. Inhibition was confirmed 4 weeks after inoculation by ELISA

The KN0912 used for this study was apparently harmless to the tobacco seedlings. Judging from the fact that there's no change of leaf colours and there's no symptoms of growth inhibition.

Electron microscopy of PMMoV in the absence or presence of KN0912. The PMMoV particles were almost destroyed or segmented by mixing KN0912, but not affected in the absence of KN0912. Therefore, it is thought that one mode of action of KN0912 is inactivation of the virus due to the destruction of PMMoV particles .

Discussion

This report presents the first evaluation of antiviral activities of *Q. dentata* (Daimyo Oak) gallnut to plant viruses. The gallnut is a plant excretion produced when irritants are released by the larvae of gall insects. It contains high amounts of tannic acids such as gallic acid and ellagic acids. As the gallnut extract is widely used in pharmaceuticals, food and feed additives and dyes, it is safe natural material which can be used in organic agriculture. The gallnut extract used in this report also proved harmless to tobacco seedlings. Our results indicate that it is a potent virus inhibitor that may be used to prevent the spread of plant virus infections in the field. Previously, we reported that the extracts of *P. linteus* and *G. rhois* were sources of potent inhibitors against several plant virus infections (Kwon *et al*., 2010). The mechanisms that these natural materials inhibit PMMoV and CMV infection have not been completely elucidated thus far. But from the change of morphological characteristics of PMMoV, we tentatively conclude that one mode of action of KN0912 is inactivation due to the segmentation of virus particles. Future work will focus on the antiviral components and the mode of action of *Q. dentata* gallnut.

Conclusions

The inhibitor named as KN0912 formulated from the *Q. dentata* (Daimyo Oak) gallnut extract strongly inhibit PMMoV and CMV infection. Our results indicate that KN0912 is a potent virus inhibitor that may prevent the spread of plant virus infections.

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Selection of Resistant or Tolerant Soybean Cultivars Against the Frogeye Leaf Spot, *Cercospora sojina* Hara

Lee, Y. S.[1], Lee, J. H. & Kim, S. K

Key words: Soybean, Frogeye leaf spot, *Cercospora sojina*, Resistant cultivar

Abstract

This study was conducted to survey the Frogeye leaf spot (FLS) occurrence patterns in Korea, and to select the resistant or tolerant cultivar against to FLS in greenhouse or field conditions. The average mobility rate of FLS in 2006 to 2007 was Gang-won (78%) > Gyeong-gi (62%) > Chung-buk (54%) > Gyeong-buk (43%) > Jeon-buk (36%) > Chung-nam (33%), respectively. Twenty one fungal strains were isolated by the pathogenicity test using developing soybean leaves inoculated with Cercospora sojina in 2005 and 2006. Six isolates were selected finally according to area and cultivars. Among 26 cultivars Bogwang, Geomjeong 4, Jangwon, Sinpaldal 2 showed resistance against frogeye leaf spot in result pathogenicity test of six isolates. These selected resistant cultivars can be used as parents in breeding programs to develop the soybean varieties with resistance to FLS caused by C. sojina.

Introduction

The soybean (Glycine max) is one of the most important food plants of the world, and seems to be growing in importance. It is a versatile food plant that, used in its various forms, is capable of supplying most nutrients.

Frogeye leaf spot (FLS), caused by *Cercospora sojina*, is a common foliar disease of soybean around the world. FLS has been found to be most severe in warm, humid climates. This disease occurs mainly on foliage but can also occur on the stem, pods, and seeds. Nowadays in Korea, FLS has become a new problem disease in the main soybean cultivated region. FLS occurs from mid-July to mid-September in the northern part of Gyeonggi Province, and the amount of occurrence increase at mid-August in rapid. However, studies regarding the occurrence, race, control methods of FLS are still insufficient.

Most studies have found yield reductions due to FLS in the range of 10-50% (Laviolette et al., 1970, Mian et al., 1998). Although fungicides are effective in FLS control and can increase yield, the use of resistant cultivars is an inexpensive and environmentally friendly approach to management of the disease.

Therefore, the objective of this study was to survey the FLS occurrence patterns in Korea, and to select the resistant or tolerant cultivar against to FLS in greenhouse or field conditions.

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Materials and methods

Investigation of FLS occurrence patterns. Investigation of FLS occurrence was conducted from 2005 to 2007 in late August. Survey areas were 52 sites (9 provinces, 28 cities and counties) in Korea. The amount of FLS including occurrent part of soybean was surveyed.

Pathogenicity test. Seedling test (2008) and field test (2005-2007) were conducted. Six FLS races that had been selected via identification among 141 strains were used against 27 cultivars. Seedlings, at first, were inoculated at V2 to V8 soybean developmental stage by spraying the surfaces of all leaves with the conidial suspension ($5\text{-}6\times10^4$ spores/ml). Inoculated plants were immediately placed in a humidity chamber for 72 hours at 28℃, and then transferred to a greenhouse bench where they were kept at 25±2℃, RH 70-80%. Twenty one days after inoculation, the number of lesions and the diameter of lesions were surveyed (Fig. 1).

Figure 1: Evaluation of FLS pathogenisity
(R = No lesion and below 2.0mm, S = Over ten lesions and 2.0mm)

Results

Occurrence patterns of FLS. The most affected part of the soybean in the order of frequency in occurrence was leaves (75% >), petioles (20% >), and pods (5%). The average mobility rate of FLS in 2006 to 2007 was Gang-won 78% > Gyeong-gi 62% > Chung-buk 54% > Gyeong-buk 43% > Jeon-buk 36% > Chung-nam 33%, respectively.

FLS resistant cultivar selection. We isolated six *C. sojina* races from the infected plant collected from 52 areas (Tab. 1).

Tab. 1: Six *Cercospora sojina* races were identified in Korea

Isolate No.	Province / Locality	Host variety
Cs-02	Gyeonggi / Pocheon	Daepung
Cs-10	Gyeonggi / Yeoncheon	Daewon
Cs-14	Gyeongbuk / Punggi	Taegwang
Cs-16	Gyeongnam / Daegu	Daewon
Cs-18	Chungbuk / Chungju	Hwanggeum
Cs-20	Chungnam / Cheonan	Taegwang

Among 27 cultivars Bogwang, Geomjeong 4, Jangwon, Sinpaldal 2 showed resistance against frogeye leaf spot in the pathogenicity test of six isolates (Tab. 2).

Tab. 2: Differential responses of 27 soybean cultivars for six *C. sojina* races

No.	Cultivars	Cs-02	Cs-10	Cs-14	Cs-16	Cs-18	Cs-20
1	Ilpumgeomjeong	S	S	S	R	S	S
2	Heukchung	S	S	S	S	S	S
3	Chungja No. 2	S	S	S	S	S	S
4	Chungja No. 3	S	S	S	R	R	S
5	Gumjung No. 4	R	R	R	R	R	R
6	Keunol	S	S	S	S	S	S
7	Gumjungol	S	S	S	S	S	S
8	Hwasung	S	S	R	S	R	S
9	Hwaum	S	S	R	S	S	S
10	Jangwon	R	R	R	R	R	R
11	Taegwang	S	S	S	S	S	S
12	Shingi	S	S	S	S	S	S
13	Chungja	S	S	R	S	S	S
14	Daepoong	S	R	S	R	S	R
15	Daewon	S	S	S	S	S	R
16	Hwanggum	S	R	S	S	S	S
17	Jangsu	S	S	S	S	S	S
18	Manri	S	S	S	S	S	S
19	Jangyeob	S	S	S	S	S	S
20	Chungdu No. 1	S	R	S	S	S	R
21	Shinpaldal No. 2	R	R	R	R	R	R
22	Daemang	S	S	S	R	S	R
23	Bogwang	R	R	R	R	R	R
24	Seonam	S	R	R	S	S	S
25	Poongsanamool	S	S	S	S	S	S
26	Sodam	S	S	S	S	S	S
27	Eunha	S	S	S	S	S	S

R(Resistant) = No lesion and below 2.0mm, S(Susceptible) = Over ten lesions and 2.0mm.

Discussion

This study was conducted to investigate the distribution of FLS races in Korea and to select the standard varieties based on the different responses to isolated 6 FLS races. The mobility rate of FLS in Korea were Gang-won (78%) > Gyeong-gi (62%) > Chung-buk (54%) > Gyeong-buk (43%) > Jeon-buk (36%) > Chung-nam (33%), respectively. We isolated six *C. sojina* races from the infected plants collected from 52 areas based on the morphological characteristics and pathogenicity. Response of 63 soybean varieties to 6 races (*C. sojina*) was different respectively. Bogwang showed resistant response to all FLS races. On the other hand, Taegwang was susceptible to all races. In the tests, ten soybean cultivars showed different responses against the six FLS races that were selected. Breeding for resistance is a long-term disease-management strategy. These selected resistant cultivars can be used as parents in breeding programs to develop soybean varieties with resistance to FLS caused by *C. sojina*. Also, differential varieties that we selected can be used for identifying the pathogenicity of races and resistance gene(s) of FLS in Korea.

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Timorexgold – a novel organic fungicide for the control of plant diseases and black sigatoka in banana

Reuveni, M.[1] & Neifeld, D.[2]

Key words: *Melaleuca alternifolia*, Plant disease control, banana Black Sigatoka, disease management.

Abstract

The natural product Timorex Gold (extract of Melaleuca alternifolia) contains multiple components was found to be effective against broad spectrum of plant pathogenic fungi. In numerous crops including vegetables, herbs, grapevines, bananas and fruit trees. The antifungal activity of Timorex Gold was exhibited by inhibiting: spore germination (conidia and ascospores), mycelial growth, lesion development and expansion and a strong curative activity. Timorex Gold has demonstrated high efficacy against BLS in both organic and conventional production systems. Timorex Gold provided the best and superior disease control among the organic products tested and was as effective as difenoconazole and azoxystrobin in controlling Black sigatoka and significantly different from the non-treated control plants. Semi-commercial trial conducted in Belize, in which a program using Timorex Gold in consecutive applications demonstrated efficacy which was equivalent to the control commercial treatments. Timorex Gold treated plants also had a greater number of healthy leaves per plant than standard treatments. This paper provides substanital evidence that Timorex Gold constitutes an attractive alternative for controlling various diseases and for BLS in banana plantations.

Introduction

The global search for plant protection solutions which are both environmentally safe and are of no risk to human health, is driven by the need to supply food to the ever growing world population and the call for chemical load reduction. The natural extract of Melaleuca alternifolia, contains multiple components, mostly terpenes and their alcohols has been proven to be an effective antiseptic, fungicide and bactericide. It acts by disrupting the permeability of membrane structures of the microorganism, destroying cellular integrity and inhibiting respiration and ion transport processes. Until recently, this extract has not been tested against plant pathogens. We identified the unique and powerful potential of this natural plant extract for plant disease control in agricultural crops and developed a new natural organic fungicide Timorex Gold. In numerous crops including vegetables, herbs, grapevines, bananas and fruit trees we have found this product to be effective against a broad spectrum of plant pathogenic fungi. Among the pathogenic fungi that can be controlled include Oomycetes, Ascomycetes, Basidomycetes and Fungi imperfecti (Alternaria, in various crops).. Timorex Gold is an Emulsifable Concentrate formulation (24 EC), a stable eco-friendly product, safe to the environment and with no residues. The product is not toxic to

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bees and birds.Black Sigatocka, BLS, caused by the fungal pathogen *Mycosphaerella fijiensis* Morelet is a major concern for the banana production. Infection by conidia or ascospores occurs on the youngest leaves of the plant. The first symptm, chlorotic flecks, appears about 15-20 days after infection. Sunsequently, streaks and necrotic spots are produced, often accompanied by extensive leaf death. The youngest leaf with spots on plant is commonly used as measures of disease severity. Six developmental stages of BLS were established to describe disease developmt. The disease spreads rapidly globally and causes vast economic damage. The intensive use of fungicides, of up to 70 sprays/year, due to resistance development, is a major concern for the environment and human health. This paper evaluates the efficacy of Timorex Gold against Black sigatoka in field trials conducted in south and central America.

Materials and methods

Field trials were conducted on young banana plants (seven to nine weeks old) in organic and conventional managements. Plants were arranged in randomized complete block design and underwent four-five replications/treatments. One plant was used per replicate. Backpack sprayer with a mist blower was used for spraying. In Ecuador four consecutive foliar sprays of either Timorex Gold at 0.4 l/ha or systemic fungicides or organic products were applied at 14-day intervals. Organic products included ACT-2 (vitamin K), Blindax and Start 30 which are in common use in Equador. Disease was assessed on a weekly basis by counting the number of lesions on each leaf of each plant at each developmental stage of Black sigatoka. A similar trial was conducted in Guatemala and included 4 replications per treatment. Five consecutive foliar sprays of either Timorex Gold at 0.5 l/ha or systemic fungicides were applied at at weeks 33 (the first application), 37, 39, 42, and week 45 of the 2009 year. The disease developed on leaves was evaluated on weekly basis starting from week 33 using the variable of youngest leaf spotted. Analysis of variance (ANOVA) using the Proc GLM procedure was applied to data. Tukey-Kramer Test was applied to determine whether differences between treatments were significant.

Semi-commercial trial have been conducted in Belize Starting from week 27 of 2008 to week 8 of 2009, in which 32 consecutive foliar sprays of Timorex Gold at 0.4 l/ha were applied to a commercial area of 134 hactars. A control commercial treatment included protectant and systemic fungicides applied in parallel dates.

Results

Results of trials in Ecuador clearly show that Timorex Gold provided the best and superior disease control among the organic products used (Fig. 1) and was as effective as difenoconazole and azoxystrobin in controlling Black sigatoka and significantly different from the non-treated control plants (Fig. 2). Timorex Gold provided an excellent control and inhibited the development of lesions on all tested leaves at each of stages 2–6 (data not shown).

Similar results were obtained in Geuatemala in which Timorex Gold at 0.4 l/ha was as effective as difenoconazole and trifloxystrobin. Timorex Gold and fungicides provided significant disease control in comparison to non-treated control plants, as indicated by an increase in the number of youngest leaves spotted found (Fig. 3).
Semi-commercial trial conducted in Belize, in which a program using Timorex Gold in

consecutive applications, demonstrated efficacy which was equivalent to the control commercial treatments as determined by analysis of the youngest leaf spotted (Fig. 4).

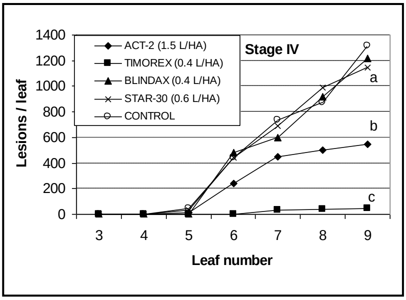

Figure 1: Efficacy of Timorex Gold and and organic Products against BLS

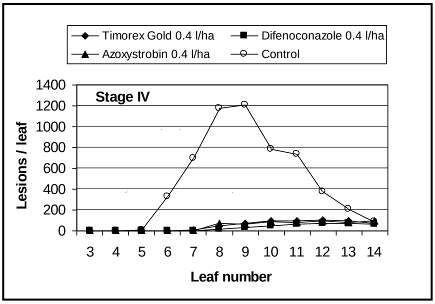

Figure 2: Efficacy of Timorex Gold systemic fungicides against BLS

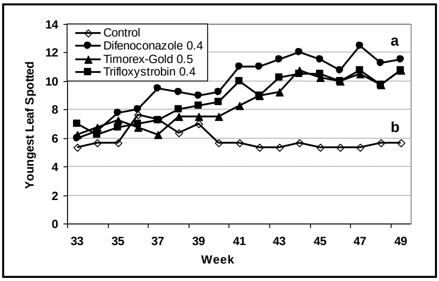

Figure 3: Efficacy of Timorex Gold and systemic in Fungicides against BLS

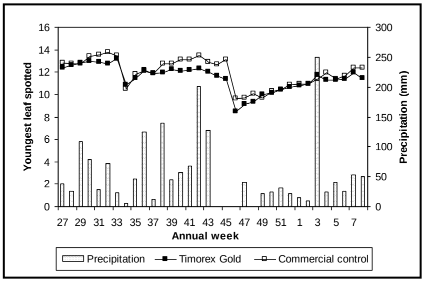

Figure 4: Efficacy of Timorex Gold semi-commercial trial in Belize

Timorex Gold demonstrated an excellent curative activity. Unlike other fungicides, which can either prevent or inhibit Black sigatoka only at stages 1 and 2, Timorex Gold controls Black sigatoka in stages 1, 2, 3, and 4 of BLS development. Trials demonstrated that lesions treated with Timorex Gold at stages 2–4 became dark brown and had no further expansion even 57 days after application (data not shown),

In organic banana plantations Timorex Gold treated plants also had a greater number of healthy leaves per plant than standard treatments (8-9 and 3-5, respectively) and in conventional plantations the plants had one more leaf (data not shown).

Discussion and conclusions

Timorex Gold has demonstrated high efficacy against BLS in both organic and conventional production systems. Timorex Gold inhibited spore germination and mycelial growth of the fungus. It effectively inhibited lesion development and limited the expansion of lesions. The exceptional curative activity of Timorex Gold makes it a unique bio-fungicide and enables growers to use it even when the disease is already visible on the banana leaves. This paper provides substanital evidence that Timorex Gold constitutes an attractive alternative for controlling various diseases and for BLS in banana plantations. The product has shown success due to its effectiveness in both organic and conventional systems.

Timorex Gold is registered in most of the banana producing countries. The Product is widely used commercially to combat BLS in conventional and organic banana and plantain farms. In addition, it is registered in various countries in the world for use in organic managements for the control of various foliar diseases and crops and as an attractive substitute for the reduction of copper and sulphur usage.

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Effect of hot water dipping on disease incidence and marketable quality of organic hybrid muskmelons during storage

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Key words: decay, hot water treatment, melon, fruit firmness, weight loss

Abstract

The melon is an ever more popular, tropical fruit. Due to their healthful properties, the demand for organic fruits and vegetables, increases yearly. The objective of this study was to investigate the changes in quality and disease control of organic hybrid melons (Cucumis melo L.). The melons were treated with hot water at 55º C for 3 or 5 min. and tap water served as the control. The fruit was stored at 13º C and randomly sampled at 3 days interval to determine the quality. Disease incidence of the fruit was significantly reduced after treatment with hot water (compared to that of control). Melons dipped in hot water (at 55º C for 5 min.) had the lowest fresh weight loss. It was also observed that the hot water treatments did not affect total soluble solids, fruit firmness.

Introduction

Consumer demand for safe, fresh fruit and vegetables, which are free of synthetic chemical residues increases world wide. Therefore, the demand for organic produce has increased significantly. Organic fresh produce is not treated with synthetic pesticides and fungicides. This method of farming results in a short shelf life, due to an increased sensitivity to fungal attack (Porat *et al.* 2000). Postharvest decay is the major factor limiting the storage and shelf life of many fresh fruits and vegetables (as a result of the physiological changes). The beneficial effect of hot water treatment to prevent fruit decay and improve shelf life of horticultural commodities has previously been reported (Lurie 1998, Schirra *et al*. 2000). In the present study, we examined the effect of hot water dipping on the quality and postharvest fruit decay of organic melons.

Materials and methods

Fruit preparation:

Cantaloupe melon (*Cucumis melo* L.), supplied by Adam Enterprises, (Thailand) was received at 30º C. The fruits were dipped in hot water (HWT) at 55º C for 3 and 5 min. As a control, the remaining melons were dipped in unheated tap water. Afterward, all the melons were stored at 13° C and 90% RH. Fruit were ramdomly taken to determine quality: weight loss, fruit firmness, TSS and disease incidence at 3 days

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interval. Each treatment was repeated three times. The quality parameters were measured on three melon from each treatment.

Total soluble solids (TSS) content in the juice was determined by squeezing juice from the equatorial slice of flesh directly onto a hand-held refractometer (ATAGO, Model PAL-1).

The fruit firmness tests were performed on a texture analyzer (Model TA-TX2, Texture Technologies Corp., NY) equipped with a 1 kg load cell and 6.2 mm diameter flat-head stainless steel cylindrical probe which penetrated at the middle of the cross-section of each fruit (cut at the equatorial of the piece to a 5 mm depth) at a speed of 2 $mm.s^{-1}$.

Fresh weight: Each fruit was weighed after the heat treatment, during refrigerated storage at 13 °C. Whole-fruit fresh weight loss is expressed as the percentage loss of the initial fruit fresh weight.

Disease incidence: Disease incidence of fruit rot caused by *Fusarium spp*. and *Lasiodiplodia theobromea* was visually evaluated as percentage of infection on fruit surface.

Statistical Analysis: Experiments were performed according to a completely randomized design. Statistical Analysis was performed with SAS (SAS, 1989). Data was analyzed by means of ANOVA, and the means were compared by the least significant difference (LSD) test at a significance level of 0.05.

Results

Weight loss

Weight loss increased throughout the storage period with all treatments. Fresh weight loss was less significantly for those melons receiving the hot water treatment (at 55º C for 5 min.). The relative fresh weight losses were not statistically different among all treatments on day 4. After 8 days storage at 13° C, a significant increase of weight loss was observed both in the control (unheated tap water treated) and the melons treated with hot water at 55º C for 3 min. There was less weight loss of the fruit treated with hot water (55º C for 5 min) the loss of weight remained less than that of the controls after day 12. Weight loss was under 4% after 16 days of storage (Figure 1A).

Firmness

The firmness of the organic melons dramatically decreased throughout the storage period. The hot water treatment did not help retain the melons firmness. Therefore, no statistical difference between the control and hot water treated melons was found (Figure 1B).

Total Soluble Solids (TSS)

There was no statistical difference among all treatments. Surprisingly, the soluble solids values were not significantly changed during storage, ranging from 8.4-10.3 (Figure 2A).

Disease incidence
Fungal attack was observed in the control fruit, (after 12 days of storage). The disease incidence of the hot water treated fruit was also seen after day 12. Fruits that were treated with hot water at 55 C for 3 or 5 min had significantly less incidence of decay compared with that of the control fruits (Figure 2B).

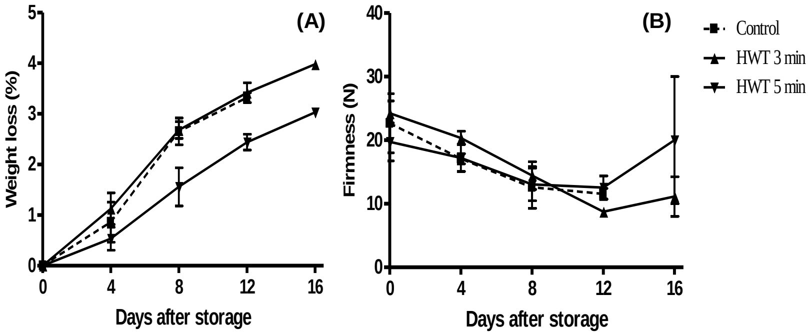

Figure 1. Effect of hot water dips on weight loss (A) and firmness (B) of organic melon stored at 13ºC. Treatments: control = non-treated fruit; HWT = hot water dip (55 ºC, 3 and 5 min). Bars represent standard errors.

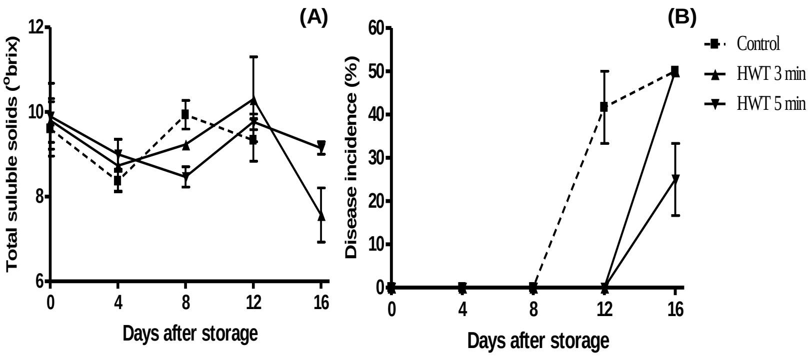

Figure . Effect of hot water dips on total soluble solids (A) and disease incidence (B) of organic melon stored at 13ºC. Treatments: control = non-treated fruit; HWT = hot water dip (55 ºC, 3 and 5 min). Bars represent standard errors.

Discussion

Hot water treatment at 55 º C for 3 and 5 min before stored at 13 ºC could significantly delay fruit decay compared to that of control. Hot water has previously been documented to reduce or inhibit growth of pathogens (Lurie 1998, Hong *et al*. 2007). Besides, hot water brushing treatment at 56 ºC for 20 seconds, significantly reduced the incidence of postharvest decay in organic citrus cultivars (Porat *et al.* 2000). Pre-storage hot water treatment has been reported to reduce water loss in tomatos (Baloch *et al*. 2008). Fruit dipped in hot water at 55 ºC for 5 min had a significantly lower fresh weight loss compared to untreated control fruit. These results are consistent with those of previous studies, of the effects of hot water treatments in strawberry (Vicente *et al.* 2002). Neither immediately after heat treatment nor during storage, was there any difference in the hue angle of mesocarp tissue between the control and hot water treated fruit (Data not shown). However, hot water treatments did not affect total soluble solids, fruit firmness and colour of mesocarp tissue.

Conclusions

In conclusion, hot water at 55 ºC for 5 min significantly reduced postharvest decay in hybrid organic melons, without affecting any of the other melons quality, during storage at 13º C.

Acknowledgement

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Effects of silicon on the activities of defense-related enzymes in cucumber inoculated with *Pseudoperonospora cubensis*

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Keywords: silicon; cucumber; *Pseudoperonospora cubensis*; guaiacol-peroxidase; plant defense.

Abstract

The relationship between silicon (Si) and plant disease has been investigated for many years, and there is an increasing interest in the use of Si for induction of defense mechanisms in response to fungal attacks. A confirmative role of Si in protecting plants against disease, however, has not yet been documented. The effects of silicon application on major defense-related enzymes activities were investigated in cucumber inoculated with downy mildew (Pseudoperonospora cubensis). The results showed that addition of Si to the nutrient solution significantly increased leaf Si content. Si supply to cucumber plants inoculated with P. cubensis significantly stimulated the activities of several defense-related enzymes. In particular, guaiacol peroxidase and polyphenol oxidase showed more intense and rapid activation. The optimum responses of enzyme activities were obtained at 3.6 mM Si. At this level of Si, the downy mildew disease index was reduced by more than 60% compared to control plants not receiving Si. It is concluded that the concentration of Si plays an important role in inhibiting P. cubensis via stimulating the activities of major defense-related enzymes.

Introduction

Synthetic fertilizer can not be used to control plant disease in the organic agriculture. Therefore, silicon is very important to be used to promote plant disease resistance. While silicon (Si) is not considered an “essential” element for plant growth, it has been shown to influence plant growth and plant disease resistance (Elliott and Snyder, 1991). Several studies have shown that Si effectively reduce susceptibility of cereals and several dicotyledons plants to pathogen attack, especially powdery mildew and rice blast (Kim et al., 2002). For example, root application of Si at 1.7 mM reduced disease severity by as much as 80% in wheat powdery mildew control (Guevel et al., 2007). Schuerger and Hammer (2003) revealed that Si inhibited cucumber powdery mildew in water culture in greenhouse. Cucumber downy mildew is a serious disease which infects plants by zoospores (*Pseudoperonospora cubensis*) under humid conditions. Shama et al. (2006) reported that Si played a role in inhibiting cucumber downy mildew. Currently, four aspects have been proposed to explain the possible

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pathways that Si promotes resistance to infection by *P. cubensis*: (1) Accumulation of Si in epidermal cells acts as physical barrier, reinforcing mechanical resistance against pathogenic penetration, thereby inhibiting fungal penetration and hyphae development (Ghanmi et al., 2004). (2) Si increases the activities of natural plant defense compounds such as phenols and phytoalexins (Remus-Borel et al., 2005) and influences the time and extension of plant defense reactions. (3) Si promotes the activities of defense-related enzyme involved in defense reactions of plants to various biotic and abiotic stresses. The activities of these enzymes may accordingly be a bio-indicator for resistance against pathogen in plants. The objective of the present work was to study the relationship between Si concentration and the activities of defense-related enzymes (POD, PPO, SOD) in cucumber plants inoculated with *P. cubensis*.

Materials and Methods

a) Plant Material. Cucumber (variety: Zhongnong 12) seeds（the number of total seeds was 24）were rinsed with distilled water and incubated on moist filter paper in an incubator at 25°C for 2 days. Seeds of uniform size were thereupon sown in a foam box containing aerated half-strength Japan Yama Zaki nutrient solution. After two weeks, six seedlings were transferred to a foam box containing 15 L aerated full-strength Japan Yama Zaki solution with the following composition: (in mM) 3.5 $Ca(NO_3)_2 \cdot 4H_2O$; 6 KNO_3; 0.87 $(NH_4)_2HPO_4$; 1.96 $MgSO_4 \cdot 7H_2O$; 0.071 FeEDTA; 0.046 H_3BO_3; and (in µM) 9.55 $MnSO_4 \cdot 4H_2O$; 0.77 $ZnSO_4 \cdot 7H_2O$; 0.32 $CuSO_4 \cdot 5H_2O$; 0.016 $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$. The pH value of the solution was kept constant at 6.2 and the nutrient solution was renewed every week.

b) Treatments. The experiment was designed with two factors: Si concentrations and *P. cubensis* inoculation. Si was supplied as sodium metasilicate (Na_2SiO_3) one week after the seedlings were transferred to full-strength Japan Yama Zaki solution. Three concentration levels of Si (1.8, 3.6 and 7.2 mM) were obtained by addition of Na_2SiO_3 to the nutrient solution. Control plants did not receive Si. Additional Na introduced by Na_2SiO_3 was balanced by Na_2SO_4 in the control solution. Seven days after addition of Si, the third and fourth leaves of plants in the non-control treatments were inoculated with *P. cubensis* sporangia by use of a hand-held sprayer. The sporangia of *P. cubensis* were isolated from leaves of infected cucumber plants incubated for 24 hours at 20°C before the spores were collected. The spore concentration was adjusted to 1×10^6 mL^{-1}. Each treatment included three replicates.

c) Measurement of Si concentration. Si concentration in cucumber leaves were measured before supplying Si (4th May), then 0 dpi (days post inoculation) (11th May), 1dpi (12th May), 5dpi (16th May) and 9dpi (20th May), respectively. Si concentration was determined following a modified version of the method by Van der Vorm (1987): Cucumber leaves were dried at 67°C for 48 h. HCl and HF (1 mol:2.3 mol, HCl 10 ml, HF 20 ml) were added to 100 ml polyethylene bottles containing 0.2 g dried cucumber leaves. The mixture was shaken at 0.36 *g* for 15 h and left overnight. Then 250 µl suspension was transferred to a clean polyethylene tube, and 750 µl 2.5% H_3BO_3 solution was added. The tube was left to stand for ten minutes, whereupon 1 ml color reagent consisting of a 1:1 mixture of 0.08 M H_2SO_4 and 2% ammonium molybdate $[(NH_4)_6MoO_7 \cdot 7H_2O]$ was added. The mixture was left to stand for another ten minutes before 1 ml 3.3% tartaric acid was added followed by 1 ml 0.4% ascorbic acid ten minutes later. Five minutes later, the absorbance was measured at 811 nm using a spectrophotometer (Model HEλIOSα, Unicam Co., Cambridge, U.K.).

d) Assay of enzyme activities.Enzyme extraction and activity measurement of *Guaiacol-peroxidase*（POD）, *Polyphenol oxidase*（PPO）and *Superoxide dismutase*（SOD）: Enzyme extracts of POD, PPO and SOD were prepared following the method of John et al. (2002) with minor modifications: cucumber leaves were cut into small pieces, and 1 g fresh leaf segments were homogenized in 10 ml 50 mM sodium phosphate buffer (pH 7.8) containing 0.1 g of polyvinylpyrrolidone in an ice bath. The homogenate was centrifuged at 1120 *g* for 10min at 4°C. The resulting supernatant was used for POD, PPO and SOD assays. POD was assayed using 2% H_2O_2 and guaiacol as substrates. The enzyme extract (0.1 ml) was mixed with 2.9 ml of 50 mM sodium phosphate buffer (pH 7.8), 1 ml 2% H_2O_2 and 1 ml 0.05 M guaiacol. The changes in absorbance at 470 nm were measured in a spectrophotometer (Model HEλIOSα, Unicam Co., Cambridge, U.K.). The enzyme activity was expressed as units per gram of protein with one unit representing the amount of enzyme necessary to change the absorbance at 470 nm with 0.01 min^{-1}.

Results

a) Disease index. In inoculated plants, the disease index was significantly lower in the treatments with Si application compared to those without Si application. The greatest reduction in downy mildew index was observed at 3.6 mM Si.

b) Si concentration. No significant differences were observed in the foliar Si content before Si was supplied. Following application of Si at three different levels (1.8, 3.6 and 7.2 mM), the foliar Si content increased with the external Si level. Si content in the leaves of non-inoculated cucumber plants was higher than that in the inoculated parallels at each concentration nine days after inoculating.

c) Enzyme activity responses. No significant difference was observed in the POD activity among all the treatments before inoculation. On the first following inoculation with *P. cubensis*, the foliar POD activity in cucumber plants receiving Si was significantly higher than that in the inoculated treatment without Si application. The POD activity increased over time. Nine days after inoculation, the POD activity in inoculated plants supplied Si was more than 30% higher that in inoculated control not receiving Si. The maximum response of POD activity in inoculated plants was obtained at 3.6 mM. In non-inoculated plants, POD activity did not respond to Si application. The PPO activity in inoculated plants was more than 2-fold higher in treatments without inoculation. Furthermore, Si caused a 50-100% stimulation of the PPO activity in inoculated plants. No significant differences in SOD activity were observed before inoculation. Inoculation with P. cubensis led to a gradual decline in SOD activity. The decline was significantly smaller in plants receiving Si compared to inoculated controls not supplied with Si. The highest response in SOD activity was obtained at the highest Si level, i.e. at 7.2 mM.

Discussion

POD and PPO are reported to have important roles in plant disease resistance (Zhang et al., 2007). POD is widely distributed in the plant kingdom and is one of the principal enzymes involved in the elimination of active oxygen species (Zhang et al., 2007). It has been reported that Si stimulated the accumulation of polymerized phenolics by the increasing activities of POD and PPO (Cherif et al., 1994). SOD is an important protective enzyme which minimizes oxidative damage in plants and plays a central protective role in the superoxide radicals (O_2^-) scavenging process (Al-aghabary et al., 2004). Our data indicated a decrease of SOD activity in infected plants.

Conclusion

The results from this study clearly demonstrate that provision of Si to cucumber plants stimulates a more rapid and extensive defense reactions against attack by *P. cubensis*.

Acknowledgments

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Effect of powder and aqueous extracts of some plant species on reproduction of *Meloidogyne incognita* on tomato and on growth parameters of the crop

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Key words: Root knot nematode, biomanagment, botanical extracts

Abstract

Tomato plants (Lycopersicon esculentum), cultivar Shaft were grown in pots. Effect of aqueous extract of different plant species on the activity of root-knot nematode (Meloidogyne incognita) and the vegetative growth indices of the host plant, was investigated. Treatment of the nematode-inoculated tomatoes with plant extracts of Papaver rhoeas, Euphorbia helioscopia, Descurainia sophia, Gypsophila pilosa and Mentha pulegium, significantly increased shoot dry weights of treated plants over control (non-inoculated tomatoes without plant extract) by about 135, 122, 113, 124 and 127%, respectively. Also gall index in nematode inoculated tomatoes treated with the nematicide, Euphorbia helioscopia, Plantago lanceolata, D. ophia, G. pilosa, Brassica napus and, Cardaria draba respectively showed an increase of about 92, 74, 60, 58, 52, 50 and 50% over control. Compared with control, reproduction factor of the nematode on tomato plants treated with the nematicide, Mentha piperita Brassica napus, Cardaria draba, Euphorbia helioscopia and G. pilosa reduced to 97, 47, 40, 17, 10 and 2%, respectively.

Introduction

Root-knot nematode (*Meloidogyne incognita* Chitwood) is one of the major limiting factors that challenge tomato production. Chemical control of root-knot nematode is not only very expensive and unsustainable but also it adversely affects the agro ecosystem. Keeping these facts in view researchers all over the world have diverted their attention to standardize the environmentally sound methods for bio-management of root-knot nematodes.

With current worldwide drive toward organic agriculture which will subsequently lead to the production of organic foods, it is anticipated that research should continue on botanical products with nematicidal activity which could be used as alternatives to synthetic nematicides. Although majority of the common weeds are harmful to crops through competition for soil nutrients and some are even reservoir hosts of pathogenic organisms, several are quite beneficiary and found useful in both human and herbal medicine (Olabbiyi et al., 2008). The objective of this study was to

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investigate the effect of plant extracts from some common weeds in reducing the damage of root knot nematode (*M. incognita*) on tomato plants.

Materials and methods

Twelve weed species were collected from the research farm of the Experimental Research Center of Shiraz University. The weed species selected were Plantago lanceolata, Gypsophila pilosa, *Brassica napus, Euphorbia helioscopia, Cardaria draba, Papaver rhoeas Mentha piperita, Descurainia sophia, Mentha pulegium, Solanum nigrum, Thymus vulgaris* and *Borago officina*lis. Shoot material of each weed species was air dried and powdered using an electric grinder. The powdered shoot material (10 g) was soaked in 100 ml sterile distilled water and left for 24 h at room temperature. The extract was filtered through two layers of Watman paper and kept at 6 °C prior to use. The root-knot nematode was cultured on tomato plants in a glasshouse. Eggs of *M. incognita* were collected and galled roots with egg masses were washed free of soil and cut into 2-cm pieces. After placing in 0.5% sodium hypochlorite they were triturated for 30 seconds at maximum speed in a two-speed blender. Eggs were separated from debris by pouring the suspension over a series of sieves and collecting them on a 38 mm-pore mesh. Effect of dry powder and extracts of the above pre-screened plant species on reproduction and damage of *M. incognita* on tomato (cultivar Shaft) was further investigated in a randomized complete block design under greenhouse condition. Inoculation with water and Nematicide (Temik) were used as controls. Inoculum comprised approximately 7500 eggs and second stage juveniles (five nematodes per gram of soil) added to soil around the roots of tomato plants at four-leaf stage. An amount of 60 ml water extract of each plant species was added to each pot 24 h post inoculation. Sterile distilled water inoculated plants served as control. Each treatment was replicated four times. Plant and nematode parameters were evaluated 60 days after inoculation. The data were analyzed for detection of any significant treatment effect on growth of tomato plants and nematode parameters using SAS software. The means of treatments were compared with Duncan multiple range test.

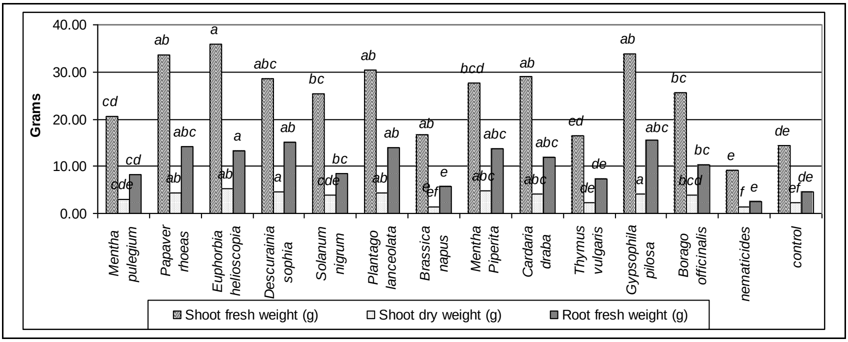

Figure 1: Effect of organic amendment on vegetative growth factors of tomato plant inoculated with sterile water.

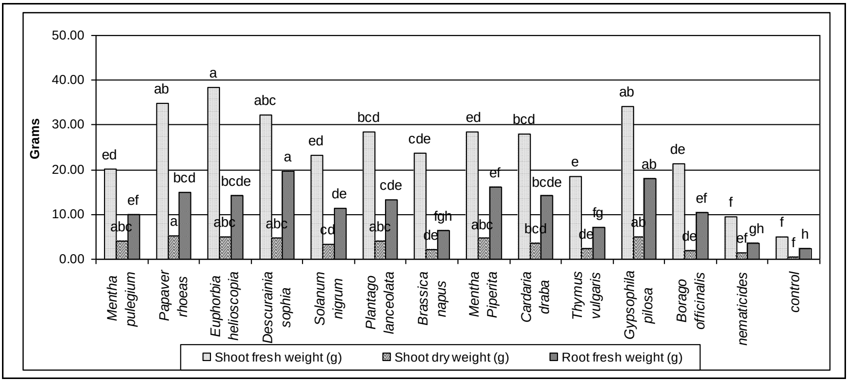

Figure 2: Effect of organic amendment on vegetative growth factors of tomato plant inoculated with *Meloidogyne incognita*.

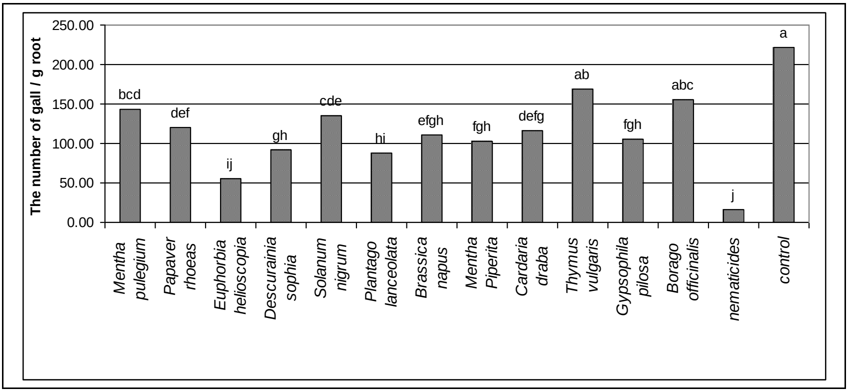

Figure 3: Effect of organic amendment of the soil grown with tomato plants, inoculated with *Meloidogyne incognita* on the number of galls per gram of root on tomato plant.

Results and Discussion

After 60 days of inoculation, effect of treatments was found to be significant on the different growth parameters, galling incidence and stages of nematode development studies. Figures 1 and 2 summarize the effect of organic amendment on the growth of tomato plants as measured by shoot and root biomass weight. Significant differences ($p \leq 0.01$) were observed between the shoot biomass and the number of galls per gram of tomato root treated with organic amendment and the control (Figures 1-3).

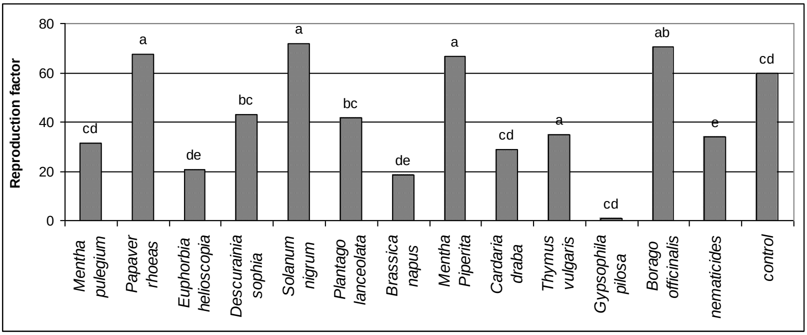

Figure 4: Effect of organic amendment on reproduction factor of *Meloidogyne incognita*. Bars show ± Standard Error of Mean.

The highest weight of shoot and root were observed in *E. helioscopia*, *P. rhoeas* and , *G. pilosa* extracts and lowest in control and nematicide pots (Figure 2). Temik and extracts of *B. napus* were phytotoxic to the treated tomato plants. Treatment of the nematode-inoculated tomatoes with plant extracts of *P. rhoeas, E. helioscopia, D. sophia, G. pilosa* and *M. pulegium*, significantly increased shoot dry weights of treated plants over control (non-inoculated tomatoes without plant extract). The plant extracts tested here reduced *M. incognita* gall formation on tomato. Gall formation was significantly different ($p < 0.01$) in nematicide and *E. helioscopia* extract from compare to control. (Figure 3). Lowest reproduction factor was found in nematicide, *B. napus, E. helioscopia* and control (Figure 4). This research suggests that organic amendment of soil with aqueous extracts of some weeds can simultaneously increase the growth of tomato plants and a significantly reduce the population of root knot nematode. Amendments of soil with aqueous extract of botanical origin may also provide a favorable substrate for the sustenance of soil micro fauna and micro flora. These may in turn substantially reduce the effect of root knot nematodes indirectly through the production of enzymes or toxic metabolites, such as antibiotic of bacterial origin. Moreover the application of organic amendment usually improves soil structure, fertility and consequently the capacity of the soil to hold water and exchange ions that, together with the nutrients released by the organic amendment, can improve the plant growth (Jothi *et al.,* 2004; Chitwood, 2002; D,Addabbo, 1995). Changes in soil enzyme activities may also cause a shift in specific groups of micro organisms after the application of organic amendments.

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Determination of wheat and cereals cultivars resistance to french races of common bunt (*Tilletia caries*)

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Key words: common bunt, *Tilletia caries*, wheat, resistance genes, cereals, organic farming

Abstract

*Common bunt (*Tilletia caries*) is a soft wheat disease controlled in conventional farming by seed treatment fungicides, which are unavailable in organic farming. The objectives of this study are to reference the resistance of soft wheat cultivars and other cereals cropped in France, as well as to determine the virulence genes and racial structure of* T. caries *observed in France. Field trials were carried out for several years on three sites in different regions with cultivars of interest for organic farming. In addition, the 2010 trials included a series of wheat lines carrying individual resistance genes, with the objective of assessing the virulence pattern of the races. Results on all sites and years show significant differences among cereals species and highly significant differences among cultivars. The races on the three sites seem similar, which needs to be confirmed with more data.*

Introduction

Common bunt is a fungal disease caused by *Tilletia caries* (syn. *T. tritici*) or*Tilletia foetida* (syn. *T. laevis*). Spores are present at the surface of the seed or in the soil, the infection occuring during wheat germination. The kernel is replaced with a mass of blackish spores that may give off a distinctive smell of rotten fish. During harvest, the infected seeds burst, releasing the spores on soil and seeds (Mathre, 2000).

In France, bunt used to be the major disease on winter wheat before the years 1950 and chemical seed treatment. It came out again in the years 1980, mostly in organic farming (OF), where seed treatment possibilities are limited. A few seed treatments and techniques, such as sowing date, are available to reduce the risk, but efficacity is not sufficient (Fontaine *et al,* 2007). Combining practises unfavourable to common bunt is the track currently studied in a national research programme. Using cultivar resistance appears as one of the mean to reduce the disease. Yet, because conventional seed treatments are widely efficient on bunt, breeding programmes do not include bunt resistance. Some references on cultivar resistance exist in Europe (Wächter *et al.* 2007), yet they can rarely be transposed to other countries where cultivars, as well as bunt races, are different. The objectives of the present study are to reference the resistance of locally grown cereals cultivars, and to define the

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virulence pattern of local races in various regions. The long-term objective is to include resistance to common bunt in breeding programmes for organic farming.

Materials and methods

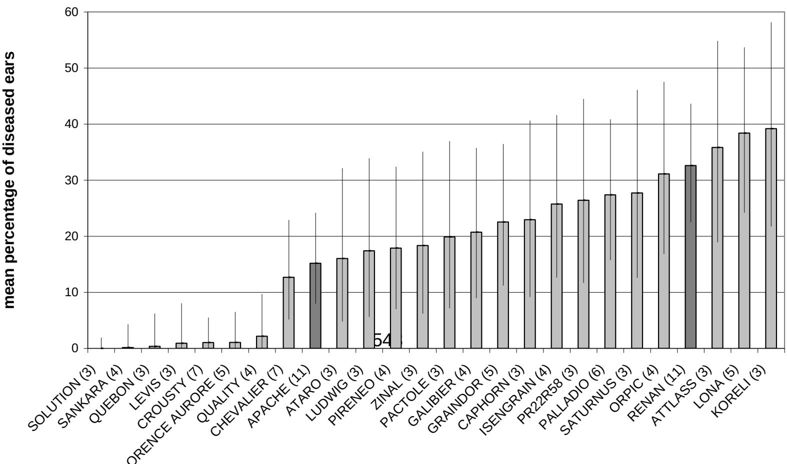
ARVALIS - Institut du Végétal conducts since 2001 a trial to assess the susceptibility of various cultivars of soft wheat (*Triticum aestivum*) and other cereals species to *T. caries*. This trial is located in the Paris region (northern France) and uses a bunt race from the southwest. Two local agriculture administrations joined the experiments, with trials near Valence (south) since 2008 and near Auxerre (center) since 2009, using their own local bunt races. The trials includes soft wheat cultivars commonly grown in OF and/or frequently present in organic variety trials because of traits of potential interest for OF. A few cultivars of durum wheat (*Triticum durum*), barley (*Hordeum vulgare*), triticale (×*Triticosecale*), rye (*Secale secale*), oat (*Avena sativa*) and spelt wheat (*T. aestivum spelta*) were included in some trials. In addition, the three 2010 trials include a series of 17 wheat lines, provided by B.J. Goates (USDA-ARS, Aberdeen, USA), that are monogenic for the individual resistance genes Bt-1 to 15 (except for the control line Bt-0 which has none, and Bt-8,9,10 which has three). These lines are used internationally to determine the races of *T. caries* based on their virulence/avirulence towards them (Dumalasová & Bartoš 2005, Wächter *et al.* 2007).

The Arvalis trial has a three blocks randomized design. Plots consist of two 1.20 m lines, separated by 25 cm. Seeds were artificially inoculated with spores from the previous year trial, to the amount of approximately 20,000 spores per seed (2g of spores per kg of seeds). Ears were harvested manually before maturity and counted. Protocols in South and Center trials were roughly the same. Contamination was higher in the South trials. 2010 Center trial could'nt be harvested because of game damage.

Mean percentages of diseased ears per cultivar underwent arcsinus transformation before being analyzed under the general linear model. Data were then detransformed for using.

Results

Figure 1: Percentage of diseased ears per cultivar (confidence interval for 0.05). Figures in brackets give the number of data for each cultivar (minimum 3). Darker bars correspond to control cultivars.



Some trials had to be discarded for analysis because of insufficient contamination levels or destroyed plots. In all, 11 trials were kept, with very variable contamination rates. Still, the cultivar effect is more significant, for soft wheat, than the trial effect.

Analysis shows significant differences at the 5% threshold between the different species. No diseased ear has been found on oat and barley, while the ratio did not exceed 0.3% for rye and 0.06% for triticale. Durum wheat and spelt appear more susceptible, with respectively 4.9% and 7.7% of diseased ears in the mean. Soft wheat is at 14%. The cultivar effect is significant at the 5% threshold for durum wheat and highly significant ($p < 0.0001$) for soft wheat. In addition to those shown on Figure 1, other cultivars displayed good levels of resistance, but, with only one or two data available, they need to have their resistance confirmed. As for the Bt series, the control line Bt-0 is the only one with high infection levels (Tab. 1). Results in the Paris and Valence sites in 2010 (no results in Auxerre) are extremely similar (R^2=0.98), suggesting that the races have similar virulence patterns, despite very different levels of infection (13.57% of diseased ears for the control in Paris, 90.14 in Valence). The pattern appears closest to the definition of the T-1 race of *T. caries*, which is virulent against Bt-7 only (Goates, 1996), at least for the Paris site.

Tab. 1: Percentage of diseased ears in the Bt monogenic lines, as a percentage of diseased ears for the control line Heines VII Bt-0.

Lines	% diseased ears in Paris	% diseased ears in Valence
Heines VII Bt-0 (control)	100.00	100.00
Sel. 2092 Bt-1	0.00	0.00
Sel. 1102 Bt-2	0.00	0.00
Ridit Bt-3	0.94	0.00
CI 1558 Bt-4	0.00	0.00
Hohenheimer Bt-5	1.25	1.88
Rio Bt-6	3.12	2.58
Sel. 50077 Bt-7	21.30	20.48
PI 173438/Eg Bt-8	0.00	0.00
Bt-8, 9, 10+	0.00	0.00
Eg/PI 178383 Bt-9	0.00	0.00
Eg/PI 178383 Bt-10	0.00	0.00
Eg/PI 166910 Bt-11	0.00	0.00
PI 119333 Bt-12	0.00	0.00
Thule III Bt-13	2.71	1.82
Doubbi Bt-14	0.00	0.00
Carleton Bt-15	3.70	16.64

Discussion

Most varieties of soft wheat are susceptible to common bunt. Renan, the most cultivated one in OF in France (23% of wheat surfaces) is highly contaminated (33%). Other commonly cultivated varieties are also susceptible: Attlass 36%, Pireneo 18%. Yet, some cultivars shows encouraging results, such as Sankara (0,15%) or Quebon (0,3%). Moreover Quebon appeared resistant across several countries in a European ringtest in 2007 (Fontaine *et al*, 2009). Yet, the results presented here are valid only for the bunt races that are used on the three trial sites. Thus, cultivars that were found resistant in this study may be found susceptible if exposed to races form other regions (for instance Sankara was found susceptible in the European ringtest, opposed to

Quebon). To assess resistance/susceptibility for current varieties cultivated in OF, trials must be conducted for several years on different locations (Wolfe *et al.* 2008). The similarity of results from one site to the other hints that these races, that originate from regions distant of a few hundreds of km, are not too different. The first 2010 results with the monogenic Bt series tend to confirm this for the Paris and Valence sites, but further studies are necessary and are currently run.

Conclusions

Common bunt significally affects most soft wheat cultivars, and to a lesser extent durum and spelt wheat. Yet, the differences of resistance between cultivars are important, and cultivars with both a good level of resistance and suitable traits for OF do exist. Thus, cultivar choice appears as a promising method to limit bunt risk in OF. In addition, in case of contaminated fields, cultivation of resistant cereal such as oat, barley, triticale or rye is interessing for limiting return of susceptible cereals in rotation. Besides, bunt races seem little different at a few hundreds of km scale in France. This has to be confirmed for other years and other sites. For the long term, the interest of including bunt resistance in organic breeding programmes is confirmed.

Acknowledgments

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Organic potato producers should use cultivars resistant to late blight

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Key words: fertilisation**;** organic production; potato; *Phytophthora infestans*; yield loss

Abstract

To identify the most important agronomic measures and cultivar traits in Swedish organic potato production, the effects of soil parameters, cultivar, year and geographical location on potato characteristics were investigated using multivariate analyses on data from a series of field trials carried out in Sweden. Soil parameters, including fertility level, had strong effects on potato characteristics. Variables related to duration of haulm growth were other dominant factors in variation. P and K fertilisation increased yield, so the importance of P and K fertilisation is underestimated in organic production. N fertilisation (70-100 kg NO_3^-N) had little effect on yield and a negative impact on emergence. The most important cultivar trait in achieving acceptable yield levels was long-lasting foliage, a characteristic of cultivars resistant to late blight.

Introduction

A severe problem hampering organic potato production is the fungal disease late blight (*Phytophthora infestans)*. This study sought to identify suitable agronomic measures and cultivar traits for use in organic potato production. A series of field trials was carried out in Sweden to compare cultivars with respect to yield, resistance to late blight, earliness and cooking quality. Multivariate analyses were performed on the dataset obtained to evaluate the importance of different traits.

Materials and methods

In total, 21 trials were conducted during a 7-year period at five sites located throughout Sweden. Organic fertiliser was applied in amounts equivalent to 70-100 kg NO_3^--N. Depending on manure composition, P and K were applied at rates of 15-40 and 50-110 kg per hectare, respectively. A randomised complete block design was used, with 4 replicates and 6-8 cultivars per trial. Plant emergence and flowering were assessed in terms of: time to emergence; days to flowering; and number of stems per plant. Plants were not treated against potato late blight. The physiopathological conditions in plots were assessed once a week from the first appearance of late blight in the region. The incidence of late blight and other diseases was determined visually (James 1971).

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After harvest, tuber yield and size distribution into five size fractions were assessed for each plot. Annual raw data from the individual field trials were compiled using the MIXED procedure in SAS software (SAS Institute 1996). Cooking quality was assessed by boiling followed by visual evaluation following national norms with respect to incidence of sogginess, darkening and disintegration.

The multivariate analyses assessed the effect of soil variables, cultivar, year of trial (2001-2007) and geographical coordinates (*x* and *y* in the Swedish national grid) on six potato growth and yield characteristics: days from planting to emergence (emerg), emergence to 2% necrosis (days_2), emergence to 50% necrosis (days_50), emergence to haulm killing (haulm), total yield (yield), yield tuber fraction <40 mm (yield<40); three variables describing cooking quality: sogginess (qual_So), post-cooking darkening (qual_Da), disintegration (qual_Di); and incidence of *Phytophthora infestans* in the tubers (Phyt_tub). Soil characteristics were described by amount of N, P and K fertilisation (Fert_N, Fert_K, Fert_P), ambient levels of soil P and K (Soil_P, Soil_K), soil type described by binary dummy variables coding for sandy soil (Soil_Sa), sandy loam (Soil_Lo), silt soil (Soil_Si), and binary variables on preceding crops comprising spring cereals (CerS), winter cereals (CerW), ley (Ley), sugar beet (Beet), and peas (Pea). Finally, cultivar was represented by 17 cultivars, Appell (App), Asterix (Ast), Cicero (Cice), Ditta, Escort (Esc), Eve Balfour (Eve), Fresco (Fres), Ladu Balfour (Lady), Matilda (Mati), Ovatio (Ovat), Princess (Princ), Raja, Sarpo Mira (Sarpo), Satina (Sati), Superb (Sup), Symfonia (Symf) and Ukama (Ukam). To assess the importance of different sources of variation, the explanatory data were divided into four datasets: a) soil properties including fertilisation, b) cultivar, c) year, and d) geographical location. The relationships between individual soil variables and potato characteristics were assessed by principal component analysis (PCA) and redundancy analysis (RDA) using the software CANOCO v. 4.5 (ter Braak & Smilauer 2002).

Results

Soil parameters including fertility level had strong and significant effects on potato characteristics, explaining 53% of total variation (Figure 1). Variables related to duration of haulm growth were other dominant sources of variation. While P and K fertilisation increased yields, N fertilisation had little effect on yield and a negative effect on time to emergence. The N requirement of potatoes is 2.5-5.9 kg ha^{-1} per ton of tuber yield and was met in these trials. The results indicated that timing of N application is important for yield.

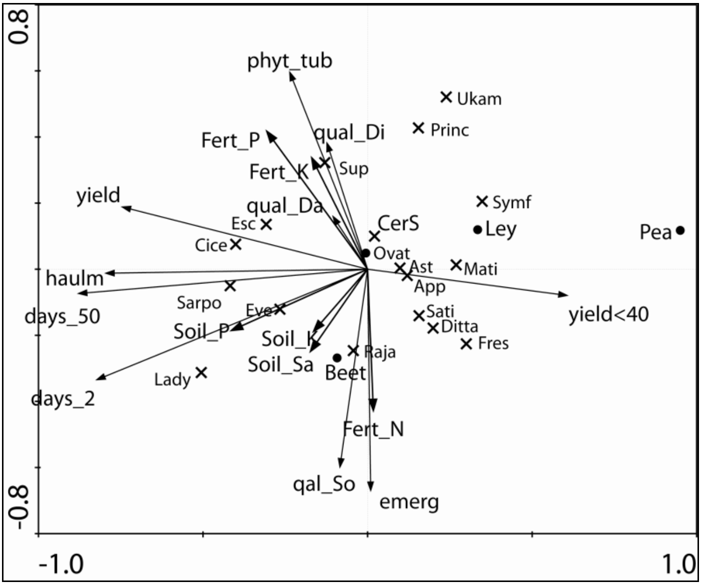

Figure 1: Principal component analysis showing the unconstrained relationships between soil variables (Title case) and potato characteristics (lower case). Potato cultivars (*italics*) were added as passive variable, i.e. after the analyses were performed. Axis 1 explains 31% of the variation and axis 2 another 15%. See text for abbreviations.

Discussion and conclusions

Neither N fertilisation nor soil N was related to yield, contradicting results by Möller *et al*. (2007). However, Finckh *et al*. (2006) found that N use efficiency appears higher in low input systems. N availability is difficult to predict if the N is applied as organic-N, as is the case in organic cultivation systems. In the present trials, the fertiliser was applied in spring before planting. This may have resulted in high soil mineralisation of the N applied, increasing plant-available N to a level where N was no longer the main yield-limiting factor. Lack of K is reported to be a constraint in organic potato production, as few organic fertilisers are rich in K (Finckh *et al*. 2006). The strong correlation between yield and K and P fertilisation indicates that these nutrients were the most restricted and potentially yield-limiting. The RDA analysis showed that a long period before foliage decay was associated with high yield, which indicates that resistance to *Phytophthora infestans* is an important trait. Early tuber initiation is another important trait but the maturity type of the cultivars in this study was very similar and the importance could therefore not be considered. The RDA analysis also indicated a relationship between yield and number of days between planting and emergence. Measures that promote fast emergence, e.g. soil preparation or presprouting, should therefore be beneficial for organic tuber yield. However, presprouting cannot be recommended unconditionally, since it is reported to make potato plants more susceptible to *Phytophthora infestans* and to *Alternaria solani* (Zarzynska & Goliszewski 2007).

The most important cultivar trait in achieving acceptable yield is a long period before onset of foliage decay, a characteristic of cultivars resistant to late blight. We recommend cv. Cicero and cv. Sarpo Mira specifically for use in organic potato production. The importance of P and K fertilisation is generally underestimated in organic potato production in Sweden, so we also recommend that growers consider fertilisation with P and K.

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Effect of *Orius laevigatus* and *Neoseiulus cucumeris* on suppression of thrips density on paprika in greenhouse in summer

Lim, Y. S.[1], Lee, M. J., Shin, Y. S. & Han, Y. Y.

Abstract

*When paprika is cultivated during summer season, thrips starts to occur in the early growing season and reaches its peak in late June. In the treatment using Orius laevigatus and Neoseiulus cucumeris***,** *natural enemies to thrips, thrips density was 87.6/trap and 51.3/trap on June 23. After Orius laevigatus and Neoseiulus cucumeris were treated twice on June 24 and July 23, the number decreased considerably. On August 23, it was 36.9/trap and 40.3/trap and from the mid August to early September thrips density remained low. Effect of Orius laevigatus and Neoseiulus cucumeris on suppression of thrips density was 35.7% and 44.6% on July 22, however, the number went up to 88.8% and 80.5% on September 3.*

Introduction

Paprika (*Capsicum annuum* L.) was first cultivated as a tree for export to Japan in 1995. Its cultivation area size increased to 343ha in 2007. Major harmful insects in summer season from March to December are thrips, spider mite, whitefly, rootfly and others (Kim et al., 2008). *Frankliniella occidentalis* and *Frankliniella intonsa (F. intonsa)* are found in flower first and both cause similar damage (Lee et al., 2006). Larva causes more damage than imago and both insects nibble the surface of fruit. This turns the surface brown and makes the fruit malformed (Moon et al., 2006). Natural enemies to such insects are *Orius laevigatus* and *Neoseiulus cucumeris.* Some Korean paprika farms control insects by using natural enemies, however, most insect control research is focused on winter season cultivation. Currently, cultivation area during summer season is on the rise, therefore, further research on natural enemies against insects is needed. The purpose of this study is to present materials about biological control using *Orius laevigatus* and *Neoseiulus cucumeris.*

Materials and Methods

Field Management

Experiment site was 264㎡ glass house in Gyeongsangbuk-do Agricultural Research & Extension Service and paprika was planted on April 22, 2010. Cultivation, except insect control, was managed using standard cultural practices. Phymetrozine Wettable Powder was sprayed to control aphids.

Release of natural enemies and its effect

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Thrips was treated with single number of quantities of natural enemies and the enemies were produced by Nabis. Co., Ltd. The amount of applied natural enemies and time are described in Tab. 1. The insides of the plants were examined with naked eye every ten days. Yellow sticky trap (15×25㎝) was used for 15 selected spots and the trap was replaced every ten days.

Results

Tab. 1: Application of natural enemies to control thrips on paprika in greenhouse

Pest	Natural enemies	Application time		Quantity (No./㎡)
		First	Second	
Thrips	Orius laevigatus	Jun. 24	Jul. 23	10
	Neoseiulus cucumeris	Jun. 24	Jul. 23	500

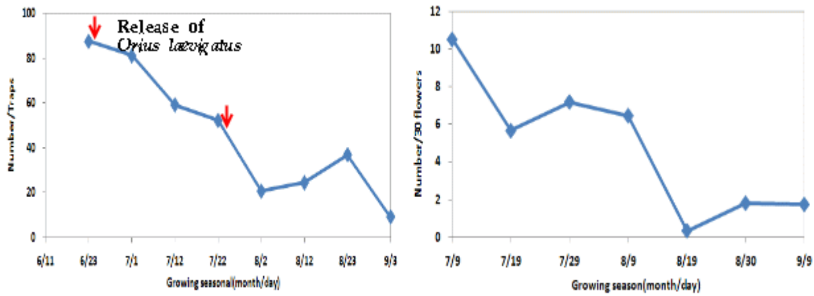

Figure 1: Biological control effect of *Orius laevigatus* against thrips on paprika in greenhouse

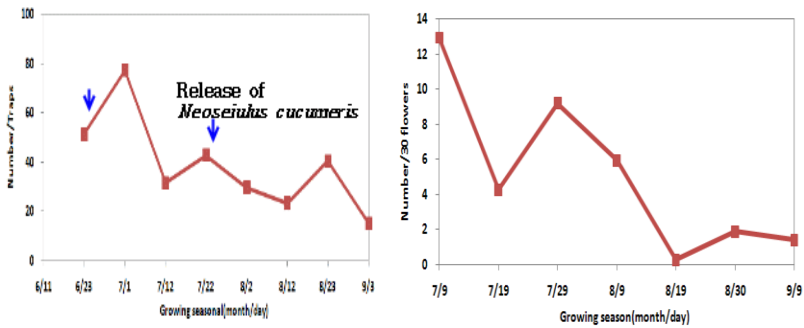

Figure 2: Biological control effect of *Neoseiulus cucumeris* against thrips on paprika in greenhouse

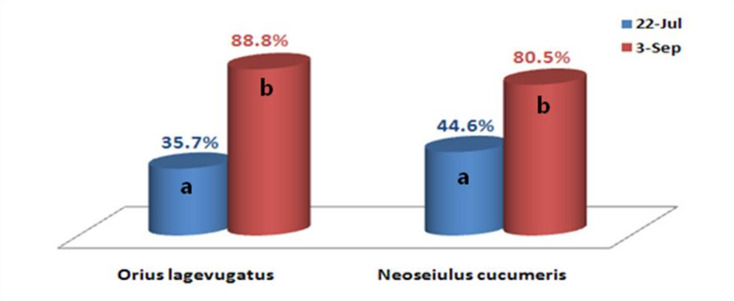

Figure 3: Biological control values of *Orius laevigatus* and *Neoseiulus cucumeris* against thrips on paprika in greenhouse

When paprika was cultivated during summer season, thrips started to appear from the early growing season and reached its peak in the late June. It was on the decline until mid August and kept occurring until the early to mid September. During that period, *Orius laevigatus* and *Neoseiulus cucumeris* were released, the natural enemies to thrips. The result of release is in Fig. 1 and Fig. 2.

In the treatment of *Orius laevigatus* and *Neoseiulus cucumeris*, thrips density was 87.6/trap and 51.3/trap on June 23. After the release of both types of insects, thrips density started to decrease, especially after the second release on July 24. On August 23, the number was 36.9/trap and 40.3/trap and on August 19, both types of insects were rarely found in the flower. Furthermore, low density continued from mid August to early September. The effect of release of natural enemies on suppression of thrips density is shown in Fig. 3. Biological control values of *Orius laevigatus* and *Neoseiulus cucumeris* were 35.7% and 44.6% on July 22 and the numbers grew to 88.8%, and 80.5% on September 3.

Discussion

In the investigation of thrips occurrence, it was found out that thrips density on the red pepper naturally decreases from late July, according to Moon et al. (2006). On the other hand, Choi et al. (2009) identified that the thrips density on paprika during summer season was 7.5/ trap, the highest, in late June. Then, the number kept going down and thrips was rarely found in the early August. Thrips occurred in similar timing in Kimje and Daegu and the density gradually reduced in both areas. It is considered that the timing of natural reduction of thrips and the release of natural enemies contributed to enhancing the density reduction effect.

On the contrary, from late August to mid September, thrips continued to occur in Daegu, unlike Kimje. Natural enemies to thrips are *Orius laevigatus*, *O. Strigicollis*, *Neoseiulus cucumeris* and others (Malais and Ravensberg, 2003). As it was found that *Neoseiulus cucumeris* is effective for winter cultivation (Messelink et al., 2006), it was applied to summer cultivation. As a result, thrips density could be lowered effectively by release of *Orius laevigatus* and *Neoseiulus cucumeris.* If accurate precautions, facilities and environment as well as appropriate natural enemies are applied, biological control effect using natural enemies on summer cultivation can be enhanced.

Conclusions

Major insects of paprika cultivation in summer season are known as thrips, spider mite, whitefly, rootfly and others (Kim et al., 2008). In Korea, most studies on biological control of insect occurring in paprika have carried out on winter cultivation, while few studies on summer cultivation. Therefore, this study presents effect of *Orius laevigatus* and *Neoseiulus cucumeris* on biological control of thrips. Thrips start to occur in the early growing season and reaches peak at late June. Control efficacy of *Orius laevigatus* and *Neoseiulus cucumeris*, natural enemies of thrips, was investigated after release of them at June 24 and July 24. The nunber of thrips decreased considerably from 87 to 36 thrips/trap and from 51 to 40 thrips/ trap after release of natural enemies. The low density of thrips had been maintained until early September by treatment. Control efficacy of *Orius laevigatus* and *Neoseiulus cucumeris* on thrips was 35.7% and 44.6% after first treatment, however the efficacy was increased dramatically to 88.8% and 80.5% with second treatment. So, it is suggested that thrips could be controlled by two time release of *Orius laevigatus* and *Neoseiulus cucumeris* for summer cultivation of paprika.

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Ecology of thrips infesting oriental melon (*Cucumis melo* L.) in vinyl-greenhouse

Yeon, IK.[1], Shin, YS.[2], Do, HW.[1], Lee, JE.[1], Cheung, JD.[1], Choi, DW[1] & Seo, DH.[1]

Key words: Injury symptom, Oriental melon, Thrips.

Abstract

Four types of injury symptom by thrips on oriental melon were observed: pale yellowing and red color exudates of petal, brown spots with silver tint on fruit surface, and leaf spot near shooting apex. Thrips did not move during the night (twenty to six o'clock) and the highest density was observed at fifteen to eighteen o'clock. Flower thrips (Frankliniella intonsa Trybom) was dominant species and blue colored sticky trap was the best to lure three species of thrips. Western flower thrips (Frankliniella Occidentalis Pergande*) and flower thrips preferred male flower to female. Palm thrips (Thrips palmi* Karny*) was only observed at shoot apex. At 3rd survey time (May 15-30), 1,507 thrips were lured by trap and injury fruit ratio was 91.4%. Coefficient between density of thrips captured by yellow color trap and injury ratio of oriental melon fruit by thrips was 0.73374*.*

Introduction

Oriental melon (*Cucumis melo* L. var *makuwa* Makino) is one of the cash crops in Korea, and transplanted during winter season (Dec.-Jan.) and grown for almost 10 months in plastic greenhouse.

In collective cultivation area of oriental melon, Seong-ju county of Korea, density of non-native harmful insects, Thrips, sweet potato whitefly (*Bemisia tabaci* Gonadius), and america serpentine leaf miner (*Liriomyza trifolii* Burgess), is gradually increasing. To properly control these insects infesting fruiting vegetables, cucumber, melon and oriental melon, to understand ecology of theirs is necessary, especially for organic farming.

Flower thrips is known as native to Korea, but western flower thrip was found in Japan in 1990 (Saeki, 1998) and observed at tangerine orchards for the first time at Jeju island of Korea in 1993 (Han *et al*., 1998). Three species of thrips, flower, western flower and palm thrips, are possible to inhabit on oriental melon. Flower thrips was observed on oriental melon field in 2000 (R.D.A.), and western flower and palm thrips were observed in 2001 (R.D.A.) and 2004 (Park *et al*.).

They are also known to have habitat selection, flower and western flower thrips prefer flower, but palm thrips mainly inhabits in leaves. Only, Injury symptom by thrips infesting on oriental melon, brown spots on fruit surface, was reported (R.D.A., 2000, 2001), and research data about thrips infesting oriental melon were restricted.

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In this study, we try to reveal symptoms of injury, incidence of thrips on oriental melon in vinyl-greenhouse, and relation between density of thrips and harvesting of marketable fruit.

Materials and methods

This experiment was conducted in a vinyl greenhouse at Seongju Fruit Vegetable Experiment Station in 2005-2007. Oriental melon (*C. melo* cv. Super-geumssaragi) seedlings grafted onto Shintozoa (*Cucurbit maxima* × *C. moschata*) rootstocks were planted at 45 cm interspacing on the last part of Jan. Collection and count of thrips were done every 2 weeks and 3 hours schedule using yellow, white and blue colored sticky trap. After collection, identification of thrips species was processed under dissecting microscope. Classification of thrips is based on body color of female, number of antennaria, absence of campaniform sensillum, and length and number of stinging hair on prothorax and near compound eyes. After collecting thrips from ten flowers, five leaves, five shoot apexes and a fruit, we made slide specimen after keeping in 70% of ethyl alcohol and classified species under dissecting microscope. Injury symptoms by thrips were frequently observed at fruit, leaves, shooting apex and flowers by naked eyes. To elucidate relation between thrips density and malformed fruit occurring, density was counted based on trap color and part of plant at harvesting time.

Results

We observed that 4 types of Injury symptoms by thrips on oriental melon. The symptoms were pale yellowing and red color exudates of petal, brown spots with sliver tint on fruit surface, and leaf spot near shooting apex. Number of thrips collected by trap color at a day was in Tab. 1. Blue trap was effective to capture thrips. Thrips did not move during the night (20-6 o'clock), it began to move in the morning (6-9 o'clock) and the highest density of thrips was observed at 15-18 o'clock.

Tab. 1: Number of thrips captured by trap colors during a day.

Trap color	Survey time (o'clock)					
	6-9	9-12	12-15	15-18	18-20	20-6
Blue	30	30	48	54	42	0
Yellow	18	30	30	30	24	0
White	8	5	9	18	19	0

Flower thrips was dominant species and blue trap was the best to lure three species of thrips in oriental melon field (Tab. 2). Total density of thrips collected from all plant part was index 100, blue trap was above 607-2,400% than total from plant. Western flower and flower thrips preferred male flower to female flower. Palm thrips was only observed at shoot apex. At leaf, we could hardly observe except western flower thrips.

Tab. 2: Comparison between capturing methods of thrips.

Classification		Density of thrips (No. of individual)					
		Western flower		Flower		Palm	
		Number	%	Number	%	Number	%
Trap	Blue	80	681	296	607	120	2,400
	Yellow	48	409	76	156	40	800
	White	8	68	28	57	26	520
Plant	Female flower	4	34	14	28	0	0
	Male flower	7	55	34	70	0	0
	Shoot apex	1	4	1	2	5	100
	Leaf	1	6	0	0	0	0
	Total	13	100	40	100	5	100

Injured fruit by thrips was begun to observe from April 12-21. At 3th survey time (May 15-30), 1,507 thrips were lured by trap and injury fruit ratio was 91.4%. At 5th, 134 thrips were captured, but injured fruit was not found (Tab. 3).

Tab. 3: Injury ratio of oriental melon fruit and thrips density during harvesting.

Survey time	Density of thrips (No. of individual)			Ratio of injury fruit
	Western flower	Flower	Total	
1st (Apr. 12-21)	182	18	200	7.4
2nd (Apr. 27-May 15)	505	16	521	53.2
3th (May 15-30)	1,485	22	1,507	91.4
4th (May 30-Jun 16)	110	58	168	6.5
5th (Jun 16-Jul. 25))	30	104	134	0
6th (Jul. 22-Aug. 9)	4	36	40	0

We observed correlation between thrips density and fruit injury as: Coefficient between thrips density captured by yellow trap and injury ratio of oriental melon fruit by thrips was 0.73374*.

Discussion

Lewis (1973) and Ananthakrishnam (1982, 1984) reported Injury symptoms by thrips, silver tint and paling of leaves, we observed similar symptoms, but from different parts of plant. Pale yellowing, red color exudates of petal and leaf spot were occurred by high density of thrips. Red color exudates of petal were plant sap leak of injured plant tissue. Similar symptom is observed at oriental melon stem, vascular and phloem tissue damaged, infected by gummy stem blight. To earlier control of thrips, it is necessary to use sticky trap, especially blue trap. In the farm field, reliance on observation by naked eyes is not a proper method. Since, thrips does not move at night and its activity was the highest at afternoon, a further study to set spray time for control should be conducted. At male flower, higher density of western flower and flower thrips was found, because pollen was known as a major food by thrips. Pale yellowing and red color exudates of petal, and brown spots on fruit surface were presumed as symptom by injuring of these species. Since, palm thrips was only found at shoot apex, leaf spot near shooting apex is presumed as symptom by its infesting.

To produce a proper marketable yield of oriental melon, a careful observation to thrips density should be taken, because 168 individuals of thrips begun to injury fruits in our study, and thrips directly injured fruits. Therefore, for economically feasible farming, we suggest that thrips density should be managed below at least 130-200 individuals per trap.

Conclusions

Thrips infesting oriental melon injured several parts of plant, petal, fruit and leaf. Petal injury by thrips is observed for the first time. We revealed that flower thrips was dominant species and thrips moved in the daytime, it can help to select control methods and set spraying schedule. Also, we found that high density of thrips injury fruit, so thrips density should be managed below 130-200 individuals per trap for economically feasible farming.

Acknowledgments

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Microbial ferments effective in insect and disease controls and nutrient supply in nature farming

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Key words: Botanical materials, Calcium deficiency, EM (effective microorganisms), disease and pest control, garlic, Zanthoxylum.

Abstract

Applications of beneficial microorganisms have been adopted in crop productions. In the present study, EM, one of the beneficial microorganisms, was used as inoculant starter to ferment botanical materials, Zanthoxylum bungeanum and garlic, and $CaSO_4$ powder, which were used as pest repellent, fungus inhibitor and foliar calcium fertilizer. When the on-farm ferment of Z. piperitum was sprayed onto leaves of the radish, the aphids were anesthetized and fell down to the soil surface instead being killed. Foliar spray of on-farm garlic ferment decreased the intensity of tomato leaf blight and consequently increased the fruit yields. In conclusion, EM could be used in combination with botanical materials and non-soluble mineral nutrient and these combinations were effective, according to the recipes, in pest control, disease inhibition and mineral nutrient supply in organic crop production.

Introduction

A microbial inoculant, with EM (effective microorganisms) as its brand name, has been adopted in nature farming crop production in Japan (Xu *et al*. 2000; Xu 2007). EM is a mixed culture of beneficial microorganisms with the main species contained as 1) lactic acid bacteria such as *L. plantarum* and *S. lactis*, 2) photosynthetic bacteria such as *R. palustris*, 3) yeasts such as *S. cerevisiae,* and 4) actinomycetes such as *S. albus*. EM applications with both organic and chemical fertilizers promoted plant growth and increased grain yield through increasing photosynthesis and nutrient availability and improving root quantity shown by number and length and the root quality shown by the respiration rate (Xu 2000ab). Although EM shows many positive effects in crop production, it cannot be simply compared with chemical fertilizers and pesticides because it is just a microbial inoculant or starter. Therefore, EM should be used in combination with organic matter and plant materials. In the present research, we used EM as fermentation starter and solvent of plant materials or some kinds of nutrient and produced several kinds of on-farm microbial ferments. These on-farm ferments were used as insect repellent, fungus inhibitor and nutrient solvent in organic crop production. The use of these on-farm ferments is a series of practices in

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response to the increasing demand for alternative and biodegradable botanical pesticides and specific nutrient supply. In the present research, the ferments are produced by microbial fermentation using non-toxic plant materials and easily done by farmers on farm. Here, the ferments do not include and are different from those insect and disease killers that are even derived from plant materials or other natural sources but toxic to non-pest insects, humans, and animals the same as synthesized chemical pesticides. Plant materials, Sichuan pepper and garlic, are not doubted untoxic because they do not harm human. Deficiency of mineral nutrients such as calcium, magnesium and some micronutrients often occurs in crop production because chemical fertilizers are usually applied in unbalance of nutrients. Moreover, some minerals such as calcium are not easily dissolved in water or easily precipitated. In the present study, $CaSO_4$ was added to the EM ferment where Ca was expected dissolving in the organic acid liquid.

Materials and Methods

Experiment 1- On-farm ferment of Sichuan pepper used as an insect repellent: Chinese radish (*Raphanus sativus* L. 'Changhong') was sown in a glasshouse in late September. Spinach *(Spinacia oleracea* L. 'Musashi') was sown in late December in the same house after the radish was harvested. Treatments include organic and chemical fertilization regimes. The organic fertilizer fermented using oil cake, rice bran and fish meal as materials and EM as starter, was applied 200 g m^{-2}. A chemical fertilizer (15-15-15) was applied with N adjusted to 70% of total nitrogen in the organic fertilizer because 30% of N in organic fertilizer cannot not be used in the season. The plots were arranged in a 4X4 Latin Square. Each plot was 4 m X 1.8 m and surrounded by wood panels. After the seedlings established, radish was thinned 20 cm between plants and 25 cm between rows. Spinach was sown 125 seeds per m^2. The on-farm ferment was produced by putting 500 g of the powder of Sichuan pepper (*Zanthoxylum bungeanum* Matim), a popular Chinese spice, into 20 L plastic tank where 1 kg of EM inoculant and 1 kg of molasses and 17.5 kg of water were filled. The tank was placed under 25±3C for fermentation until the pH was down below 3.5. The on-farm ferment was diluted 100 times and sprayed onto leaves every 3 days for 3 times during the experiments of radish and spinach. Spinach was harvested in early February next year. The density of aphids (*Aphis spriecola* Patch) was examined 3 weeks before harvest.

Experiment 2 – On-farm ferment of garlic used as fungus inhibitor: Tomato (*Lycopersicon esculentum* 'Chika') was transplanted in Mid-May in a plastic sheltered house, with a space of 40 cm between plants and 100 cm between rows. The same organic fertilizer as in Experiment 1 was applied at 300 g m^{-2} (high) or 150 g m^{-2} (low). Garlic (*Allium sativum*) ferment was produced in a way similar to that in Experiment 1 with the exception that the added botanical material was 2 kg of fresh garlic slush. The ferment was diluted 50 times and sprayed onto leaves of tomato every one week for three times from June 1. The tomato fruit yield was recorded from July 1 to August 10. Disease index (DI) for leaf blight was estimated as DI = ∑(Number of infected leaves to a certain degree × Degree constant)/(Total leaf number × Highest degree constant). The degree was scored from 0 (no symptom) through 1 (12.5% of the leaf area was infected), 2 (25%), 3 (50%) and 4 (75%) to 5 (completely infected).

Experiment 3 –On-farm ferment of calcium nutrient solution: Tomato cultivar and the management were the same as in Experiment 2. On-farm ferment was produced in a way similar to Experiment 1 with the exception that the botanical material was substituted by 0.5 or 1 kg of $CaSO_4$. The powder of $CaSO_4$ (Down-1000 as its brand name) was obtained from Yoshino Sekkou Co. Ltd. (Tokyo). The Ca on-farm ferment was diluted 100 times and sprayed onto tomato leaves from June 1 for 3 times with interval of one week. The fruit yield was recorded from June 27 to August 19. The index of disease caused by leaf blight was estimated the same way as in Experiment 2.

Result and Discussion

***On-farm ferment of Zanthoxylum piperitum*:** When the on-farm ferment of *Z. piperitum* was sprayed onto leaves of the radish, the aphids were anesthetized and fell down to the soil surface instead being killed. After three times of spray, the density of aphids on the leaves was recorded to 3 groups, severe as 36200-48200 m^{-2}, middle as 15800-27100 m^{-2} and light as 0-5700 m^{-2}. The severely infected and lightly infected leaves were significantly fewer in ferment sprayed plots than in water sprayed plots. Compared with chemical fertilized plots, in organic fertilized plots, severely infected leaves were fewer, but medially infected more and the lightly infected the same (Tables 1). Although the total leaf infestation rate was not different between fertilization regimes and slightly different between spray treatments, the aphid density was much higher in organic fertilized or on-farm ferment sprayed plots than in chemical fertilized or water sprayed plots. The Zanthoxylum ferment spray was also effective in control aphid infestation in spinach leaves (Table 1). *Z. piperitum*, usually eaten as spice in Chinese food, did not poison natural enemies and was expected environment sound when used to plants. The dried fruit of *Z. piperitum* have an aromatic odor with more or less pronounced warm and woodsy overtones. The taste is pungent and biting with a strange, almost anesthetic feeling on the tongue. The pericarp of *Z. piperitum* contains pungent alkamides derived from polyunsaturated carboxylic acids. The common substances are amides of *2E,6Z,8E,10E* dodecatetraenoic acid, *2E,6E,8E,10E* dodecatetraenoic acid, and *2E,4E,8Z,10E,12Z* tetradecapentaenoic acid with isobutyl amine and 2-hydroxy isobutyl amine. Total amide content can be as high as 3%. The results suggested that the *Zanthoxylum* on-farm ferment spray was effective in control of aphids in addition to the organic fertilization.

Table 1. Aphid infestation intensity and infestation rate in Chinese radish.

-----Treatment-----		---Radish---				---Spinach---	
		Infestation rate with different intensity (%)			Leaves Infected	Infest intensity	Infest rate
Fertilizer	Spray	3.62-4.82 cm^{-2}	1.58-2.71 cm^{-2}	0-0.57 cm^{-2}	(%)	(m^{-2})	(%)
Organic	Ferment	17.4	44.5	21.8	83.7	874	79.4
Organic	Water	37.6	45.1	10.6	93.3	2300	97.7
Chemical	Ferment	21.5	26.2	47.3	95.0	1770	80.8
Chemical	water	63.6	24.1	10.5	98.1	2810	100.0
Fertilizer		**	*	NS	NS	*	NS
Ferment		**	NS	**	*	**	**
Fertilizer × Ferment		*	NS	*	*	*	NS

* significant at P<0.05; ** significant at P<0.01; NS no significance and the same for tables below.

***On-farm ferment of garlic as fungus inhibitor*:** Foliar spray of on-farm garlic ferment decreased the intensity of tomato leaf blight and consequently increased fruit yields (Table 2). High rate of fertilization increased leaf blight although it brought high fruit yields. Garlic is most often used as a condiment with superior medicinal value. It contains allicin, a powerful antibiotic and anti-fungal compound (Kamenetsky et al., 2004). It also contains alliin, ajoene, enzymes, vitamin B, minerals, and flavonoids.

Liquid garlic concentrates have been used as botanical pesticides, diluted in water and sprayed onto plants to inhibit fungi and repel insects. Garlic extract is absorbed through stomata and transported throughout the plant but does not alter the taste or smell of any part of the plant. In addition to fungus inhibition, it repels aphids, apple maggots, armyworms, asparagus beetle, cane borers, caterpillars, codling moths, cutworms, earwigs, fall webworms, grasshoppers, and gypsy moth caterpillars (Stjernbergand & Berglund 2000.). As in the present experiment, the key to using garlic effectively is to apply it to plants before there is a disease or pest problem. The results suggested that foliar spray of on-farm garlic ferment was effective in inhibition of fungus disease in the tomato crop.

***On-farm ferment of calcium as foliar nutrient solution*:** Foliar spray of on-farm Ca microbial ferment mitigated blossom-end rot of fruit and leaf blight infection and improved fruit yield and quality in the tomato crop with chemical fertilization. However the effect of the spray did not show the same effect in organic fertilization plots. The reason might be that Ca was not deficient in the organic fertilized tomato crop. In greenhouse tomato production, especially in hydroponic systems, Ca deficiency usually causes lower fruit quality and blossom-en rot of fruit (Ho et al. 1987; Saure 2001). Ca deficiency easily occurs because it does not move easily in plant tissues. Reduced transpiration greenhouse also causes decreases in Ca absorption. As shown by the results of the present study, Ca is easily dissolved in the organic acid liquid and the foliar spray of the on-farm Ca ferment might be expected effective in solving the calcium deficiency problem in tomato production.

Table 2. Effect of on-farm garlic ferment on the tomato crop

----Treatment---		-----Fruit yield (kg/plant)-----			DI
Fert	Spray	Red	Green	Total	(%)
High	Garlic	2.14	0.63	2.77	42
	Water	1.87	0.42	2.29	59
Low	Garlic	1.65	0.37	2.02	33
	Water	1.51	0.22	1.76	39
Fert		**	**	**	*
Garlic		NS	*	*	*
F × G		*	NS	*	NS

Fert, fertilization; DI, disease index.

Table 3. Effect of foliar spray of on-farm calcium microbial ferment on the tomato crop.

Fert	Ca ($g\ kg^{-1}$)	Yield ($kg\ m^{-2}$)	BER (%)	----DI (%)--- Early	Later	Fruit Vc ---($mg\ kg^{-1}$FM)----	Fruit Ca
Che	0	3.4	8.2	19	82	404	104
	25	3.9	2.1	13	74	424	105
	50	4.5	0.7	12	75	462	119
Org	0	6.3	2.3	11	57	623	115
	25	5.5	0.7	13	55	632	118
	50	5.8	0.2	10	52	663	127
Fert		*	**	NS	*	**	**
Ca		*	**	NS	*	**	**
Fert ×Ca		*	NS	*	*	NS	NS

Fert, fertilization; DI, disease index.

Conclusions

When the on-farm ferment of *Z. piperitum* was sprayed onto leaves of the radish, the aphids were anesthetized and fell down to the soil surface instead being killed. Foliar spray of on-farm garlic ferment decreased the intensity of tomato leaf blight and consequently increased the fruit yields. Foliar spray of EM Ca on-farm ferment decreased blossom end rot of fruit and leaf blight and consequently increased fruit yield. Fruit quality shown by concentrations of vitamin C and Ca was also improved by EM Ca on-farm ferment. In conclusion, EM could be used in combination with botanical materials and non-soluble mineral nutrient and these combinations were effective, according to the recipes, in pest control, disease inhibition and mineral nutrient supply in organic crop production.

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Control of spinach downy mildew by forced-ventilation treatment in plastic house

Park, S. H., Lee, J. H., Jeong, K. C., Choi, S. Y. & Park, S. D.

Key words: Spinach, Relative humidity, Forced-ventilation, Downy mildew control

Abstract

A survey was conducted on how forced-ventilation set up in plastic house impacts downy mildew (Peronospora farinose), which is one of the biggest problems of protected cultivation. No big difference was found in temperature of the house according to each treatment, however, relative humidity of those treated with forced-ventilation was 9.2% lower than control. The growth of spinach was good after treated with forced-ventilation and air circulation. Downy mildew started to occur 20 days after seedings in control and the rate of infected leaves were 34.7%, 60 days after seeding. The incidence of downy mildew was, however, 4.0% with forced-ventilation treatment, which shows the effectiveness of the treatment.

Introduction

Spinach is an alkaline vegetable rich in vitamin and iron, which has been widely used for a long time and its demand is on the rise every year. More than 70% of spinach in Korea is sown in the fall, harvested and sold in the coming spring. From fall to spring, productivity and product value of spinach decreases due to downy mildew which breaks out on the leaf. Spinach growers spray agricultural chemicals four or five times during the season for downy mildew control. Downy mildew is known to be deadly because the disease usually breaks out in low temperatures and high humidity and spreads very fast leading to crop failure. Therefore, we closely examined how the forced-ventilation installed in the plastic house reduces damage by downy mildew and enables environmentally friendly growth and the impact on the outbreak of the disease as a part of this study.

Materials and methods

This study was carried out in a spinach growing farm located in Yeonghae-myeon, Yeongdeok-gun, Gyeongsangbuk-do from April to December 2010. The size of the single span plastic house was 180m^2 (width 6m, length 30m) with 1.4m wide ridges. As for the forced-ventilation treatment, fans (φ60cm, 160W) were spaced 6m apart to flow the air out of the house. As for the air circulation treatment, stir-fans (φ60cm, 200W) were spaced 6m apart, 1.5m above the ground to stir the air horizontally (Fig. 1). The house was treated for 12 hours from 8PM to 8AM when the relative humidity reaches the highest level. Spinach was sown on Oct. 18 using a four-season variety. Sprinkler was used for irrigation regularly considering soil moisture, and cultivation and insect and pest control were managed using customary farming practice. Thermo Recorder (TR-72U, Japan) was installed 30cm above the ground to measure temperature and humidity of the house and they were recorded every 20 minutes using data logger. Based on harvest period, 30 spinach plants per treatment were selected to measure the fresh weight of spinach and the occurrence of downy mildew was reflected in the rate of disease leaf after examining the leaf every ten day from leafing time.

Figure 1: Forced-ventilation (top) and air circulation treatment (bottom) in the plastic house

Results and discussion

Fig. 2 shows the change of daily humidity due to forced-ventilation and air circulation treatment in the plastic house from 8PM to 8AM, a time when relative humidity is the highest. The fresh weight of spinach treated with forced ventilation was 17.9g per plant, a 7.5g increased compared to 10.4g of control plants. The result is attributable to lowered night-time humidity inside the house, increased production of plants and active physiological function, which all affected the growth of spinach. The growth of plants treated with air circulation was better than for control plants. Downy mildew started to break out on the control at 20 days after seeding and recorded 34.7% rate of diseased leaf during harvest (60 days after seeding). The rate of those treated with forced-ventilation was 0.7% at 40 days after sowing because the disease broke out later than the control and the rate was 4.0% during harvest, which is a big difference compared to the control. Downy mildew develops rapidly when humidity is high and temperature is low, therefore, it is found that forced ventilation reduced humidity in the plastic house significantly in this experiment making inappropriate condition for spores to germinate on the plant.

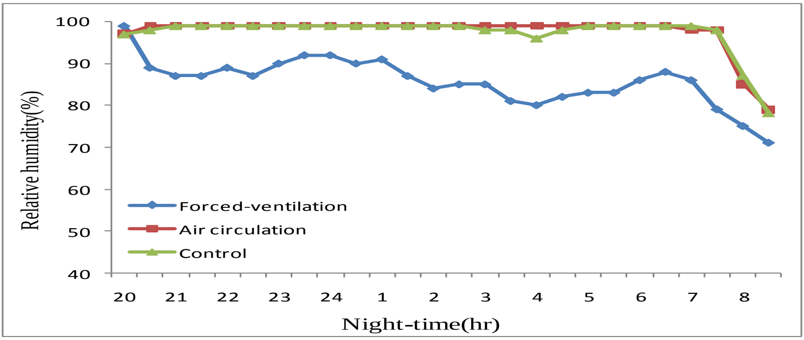
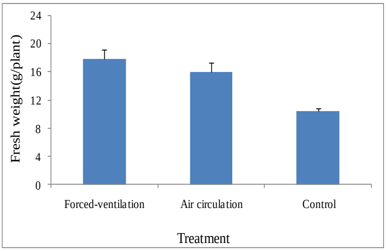


Figure 2: Comparison of typical night-time profiles of relative humidity in the plastic house treated with forced-ventilation, air circulation and control



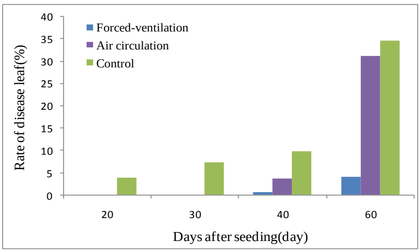


Figure 3: Comparison of fresh weight at harvest of spinach grown in the plastic house treated with forced-ventilation, air circulation and control. Vertical bars show standard errors (n=30)

Figure 4: Downy mildew infection ratio in the plastic house treated with forced-ventilation, air circulation and control

Conclusions

The purpose of this study was to examine way to reduce the occurrence of downy mildew, which is one of the biggest problems in spinach cultivation. Forced-ventilation decreased relative humidity 9.2% in the plastic house compared to the control and the growth of spinach was good. The rate of diseased leaf of control was 34.7% at 60 days after seeding and the rate of those treated with forced-ventilation was 4.0%. The results showed that forced-ventilation reduced the occurrence of downy mildew.

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Sustainable management of insect pests of green cabbage, *Brassica oleraceae* var. *capitata* L. (Brassicaceae), using homemade extracts from garlic and hot pepper

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Key words: Green cabbage, insect pests, natural control, sustainable management.

Abstract

Green cabbage, Brassica oleraceae var. capitata L., is an important leafy vegetable in Ghana. However, attack by insect pests is among the key factors contributing to its *poor yield*. *An experiment was undertaken at the Kwadaso Agricultural Research field in Ghana during the major season of 2010 to explore the use of homemade extracts from garlic, Allium sativum L. and hot pepper, Capsicum frutescens L. in the management of insect pests of cabbage. Emamectin benzoate (ATTACK®) and Lambda cyhalothrin (BOSSMATE®2.5EC) were used as reference insecticides.There were ten treatments made up of three levels of garlic (1, 2, 3) and pepper (1, 2, 3), garlic + pepper, ATTACK®, BOSSMATE® and control (water only).Generally, the efficacy of garlic and pepper was comparable to that of ATTACK® and BOSSMATE®.The highest percentage reduction in Brevicoryne brassicae*(L.) *infestation occured on plots sprayed with pepper 1 and 2. Pepper 2 had the highest reduction in the population of Plutella xylostella L., followed by pepper 3, BOSSMATE® and pepper 1.The application of BOSSMATE® resulted in the highest reduction in the population of spiders and Cheilomenes sp. ATTACK®, pepper 2 and garlic 1 had the highest yields. These preliminary results have demonstrated the potential of low doses of garlic and hot pepper in the management of insect pests of cabbage and thereby conserving their natural enemies.*

Introduction

Recently, the cultivation of green cabbage, *Brassica oleraceae* var. *capitata L.* (Brassicaceae), has become an important source of livelihood for small-scale farmers due to the increasing acceptability and demand of the crop for home consumption and for the food industry in Ghana (Abbey & Manso 2004). However, attacks by insect pests in the field affect the yield and market value of the crop (Zehnder *et al*. 1997).The frequent application of pesticides is the main control strategy by farmers in Ghana (Ntow *et al*., 2006). The current awareness by the public that synthetic pesticides leaves harmful residues in crop produce for human consumption has led to an increased interest in using natural products for pest control. The way forward is to produce highly effective plant protection products that are readily available, safe to the environment, wildlife and consumers. This study investigates the potential of using homemade extracts from garlic and hot pepper in managing the insect pests of cabbage.

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Materials and methods

The study was undertaken during the rainy season, July to September, 2010 at the experimental field of the Crops Research Institute (CRI) at Kwadaso in Kumasi, Ghana. This area is part of the moist semi-deciduous forest ecological zone of Ghana with annual rainfall between 1200-1600 mm. The soil type is sandy loam. Certified healthy cabbage (*B. oleracea* var. *capitata*) (oxyrus) seeds (obtained from a local retail shop, Abnark Agro Services, Kumasi, Ghana) were sown on a raised bed in the field on July 1, 2010. The seedlings were protected from insects with a mosquito net. These were transplanted onto raised beds in the main field after five weeks. The field layout was a Randomized Complete Block Design (RCBD) with three replications. There were ten treatment plots. Each plot (5 m x 2 m) had four rows, with each row having 10 plants. The inter and intra- plant spacing was 0.50 x 0.50 m. The inter plot distance was 3m.

The different treatments were as follows: 1).10g of garlic L^{-1} of water, 2). 20g of garlic L^{-1} of water, 3). 30g of garlic L^{-1} of water, 4).10 g of pepper L^{-1} of water, 5). 20g of pepper L^{-1} of water, 6). 30g of pepper L^{-1} of water, 7). 10g of garlic + 10g of pepper L^{-1} of water, 8). BOSSMATE® 2.5EC (lambda-cyhalothrin) - 2.4ml L^{-1} of water (800ml ha^{-1}), 9). ATTACK® (Emamectin Benzoate) - 1ml L^{-1} of water (300ml ha^{-1}) and 10). Control - only water was sprayed. The treatments were applied with a 15L Knapsack sprayer. The treatments were applied two weeks after transplanting of seedlings and was repeated weekly until the cabbage heads were fully formed. There was split application into the soil of well decomposed poultry manure (NPK levels of 2.20: 1.80: 1.10, respectively), 10 and 20 t ha^{-1} equivalent to 125 and 250g per plant, two weeks and six weeks, respectively after transplanting of seedlings. For each treatment, 10 plants were sampled from the two innermost rows for pests assessment. The number of insect pests on each plant was counted or scored in the case of aphids, using a scale of 0 to 5, signifying no infestation to the highest infestation. Similarly, the number of natural enemies were counted.The data was taken weekly, a day before treatments were applied in the morning between 8-10 am, and repeated 3 days after the application. At harvest, 10 plants per treatment plot were selected at random from the two innermost rows for yield and insect damage assessment. The number of holes in the cabbage heads, multiple heads and head weight was measured. All useful cultural and agronomic practices were employed during the period.

The data was subjected to ANOVA procedure of SAS ($P < 0.05$). Mean separation was done using the SNK test($P < 0.05$). Data in percentages was arcsine square root transformed before analysis. Back transformed values are presented in the table. Percentage reduction of pests and natural enemies populations were calculated according to the equation of Fleming and Retnakaran (1985).

Results

The percentage reduction of the cabbage aphid, *Brevicoryne brassicae* (L.) was highest with paper 1, followed by pepper 2, garlic + pepper and ATTACK® with BOSSMATE® recording one of the lowest (Table 1). The highest reduction in the the whitefly, *Bemisia tabaci* (Genn.) population occured with BOSSMATE®, followed by pepper 2 and garlic + pepper. BOSSMATE® resulted in the highest reduction in the population of cabbage flea beetles, *Phyllotreta* spp., followed by garlic + pepper, garlic 2, 1 and ATTACK®. Pepper 2 had the highest reduction in the population of the diamondback moth (DBM), *Plutella xylostella* L., followed by pepper 3, BOSSMATE® and pepper 1. The application of BOSSMATE® resulted in the highest reduction in the population of spiders, followed by pepper 3, pepper 2, garlic 3 and ATTACK®. Similarly, BOSSMATE®caused the highest reduction in the ladybird,*Cheilomenes* sp. population, followed by ATTACK®, with all other treatments having no effect on the natural enemies population. There were very few or no significant differences in multiple cabbage heads attributable to *Hellula undalis* F. (Table 2). The mean number of borer holes by millipedes, the cotton bollworm, *Helicoverpa armigera* (Hb.) and snails in cabbage heads ranged between 0.07 to 0.57 and these were similar ($P > 0.05$) among the different treatments. The lowest mean head weight occured with BOSSMATE®, but not significantly lower than garlic 2, pepper 1 and garlic + pepper. The yield was highest after treatment with ATTACK®, although not significantly higher than with pepper 2 or garlic 1.

Tab. 1: Percentage reduction in weekly score/number of insect pests/natural enemies recorded per cabbage after spraying during the major season of 2010 at Kwadaso, Kumasi, Ghana.

Treatments	Aphid	Whitefly	Flea beetles	DBM	Spiders	Ladybird
Pepper 1	30.86	21.92	0.00	50.12	10.18	0.00
Pepper 2	26.92	46.82	2.10	80.15	25.30	0.00
Pepper 3	12.07	25.65	3.50	72.50	32.50	0.00
Garlic 1	17.43	20.72	62.26	15.04	3.84	0.00
Garlic 2	16.46	41.30	86.05	3.40	8.11	0.00
Garlic 3	13.70	41.78	82.50	5.06	21.56	0.00
Garlic + pepper	20.47	43.71	88.00	2.16	12.38	0.00
ATTACK®	20.45	14.99	58.18	45.35	17.52	4.36
BOSSMATE®	13.06	62.11	91.35	50.20	50.00	18.00

Tab. 2: Mean (± *SE*) percentage of multiple heads, head weight, and yield of cabbage planted during the major season of 2010, in Kwadaso, Kumasi, Ghana.

Treatments	% of cabbages with multiple heads	Mean head weight per cabbage (Kg)	Mean yield of cabbage heads (t ha^{-1})
Garlic1	13.33 ± 2.20ab	1.12 ± 0.06ab	38.96 ± 2.00abc
Garlic2	20.73 ± 9.40ab	0.74 ± 0.06d	22.98 ± 2.01e
Garlic3	20.73 ± 10.05ab	1.04 ± 0.04abc	33.04 ±1.43cde
Pepper1	29.43 ± 6.09a	0.81 ± 0.10cd	22.93 ± 2.82e
Pepper2	15.27 ± 5.78ab	1.30 ± 0.07a	43.86 ± 2.43ab
Pepper3	19.80 ± 10.27ab	1.15 ± 0.07ab	36.94 ± 2.32bcd
Garlic + pepper	11.93 ± 2.41ab	0.92 ± 0.05bcd	32.25 ± 1.82cde
ATTACK®	3.50 ± 3.50ab	1.21 ± 0.10ab	46.83 ± 3.84a
BOSSMATE®	0.00 ± 0.00b	0.71 ± 0.06d	28.53 ± 2.30de
Control	27.47 ± 14.74ab	1.09 ± 0.11ab	31.61 ± 3.20cde
	*	***	***

* Significant for $P < 0.05$, *** significant for $P < 0.0001$

Means with the same letter(s) are not significantly different ($P < 0.05$, SNK test) within columns.

Discussion

This study has shown that garlic and hot pepper were effective in controlling key cabbage pests like DBM, aphids, cabbage beetles and whiteflies and conserved important natural enemies such as spiders and *cheilomenes* sp. Earlier study by Zehnder *et al*. (1997) also confirm the current observation that garlic and hot pepper could effectively control the pests of cabbage than the synthetic insecticide, KARATE® (lambda cyhalothrin). Thus, homemade garlic and pepper could be a promising alternative to insecticides to manage insect pests of leafy vegetables, especially for small scale growers so as to ensure food and environmental safety.The build up of the aphid population in the BOSSMATE® treated plot could be partly attributed to the subsequent reduction in the population of important natural enemies,i.e. *Cheilomenes* (which feeds predominantly on aphids) and spiders (which are generalist predators). BOSSMATE® is a pyrethroid and a broad spectrum insecticide and could be harmful to spiders. There is also evidence that pyrethroids can increase aphid infestations by killing the beneficial insects and also failing to control the aphids effectively (Insecticide Resistance Action Group, 2010).Thus, in the current study, the BOSSMATE® treated plot recorded low mean cabbage head weight and yield (t ha^{-1}). The study also revealed that lower doses of the natural substances were more efficacious than the higher doses. This is because the lower doses of the garlic and pepper probably had minimal effect on the natural enemies, thus there was dual control of the pests population from these botanicals.

Conclusion

The way forward is to conduct more efficacy trials to standardize the dose for these natural plant products by determining the formulation concentration (i.e. the quantity of active ingredient per liter of spray liquid) and volume application rate (the volume of spray liquid applied per hectare) for pest control agents in organic vegetables.

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Management of Myzus persicae using Beauveria bassiana and Environment–friendly agricultural materials (EFAM) on pepper

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Key words: Beauveria bassiana, Environment-friendly agricultural materials (EFAM),

Myzus persicae,

Abstract

This study was carried out to development the environment-friendly control method of Myzus persicae using Beauveria bassiana and Environment-friendly agricultural materials (EFAM).

Germination rate the dried conidia of B. bassiana was 90 percent at 24~27℃ temperature condition. Mortality of M. persicae was 56.7% at 1X107 cfu/ml conidia concentration. Four EFAM such as Pachungtan, Wangjungwang, Newbiodakill, Muginchon were low toxicity to B. bassiana growth. Among them, Muginchon (derris extract) and Wangjungwang (neem extract) could have synergistic effect to aphid mortality when mixing treat with B. bassiana, which protection value was 99% in 3 days after treat.

Introduction

Entomopathogenic fungi are ecologically classified as fungi that grow either inside of insect bodies or on the surface of their exoskeleton, which eventually causes the death of the host insect. The species of entomopathogenic fungi was Beauveria bassiana, Meira geulakonigii, Nomuraea rileyi, Paecilomyces farinosus and Paecilomyces fumosoroseus. Recently, preserve the ecosystem was the most project in the world. This point of view, Entomopathogenic fungi such as Beauveria bassiana was major factor for control of agricultural pests. B. bassiana such as SFB-205 strain showed 32.7% of insecticidal activity to M. persicae at 4 days after application in the greenhouse(Kim et al., 2008). Many B. bassiana strains was commercialized in the world to control of mites, diamond back moth, beet armyworm (Mutimura et al., 2009). Only application the B. bassiana was not enough to management aphids. For this reason, we selected several commercialized products to improve the control effect of B. bassiana. Aim of this study was select the effective organic pest control materials, and bioassay the improvement effect to control aphids (M. persicae) when mix spray the B. bassiana and organic pest control materials.

Materials and methods

- Mass production the conidia of *B. bassiana* and germination test

In this experiment, entomopathogenic fungi such as B. bassiana collected from suwon university. To gain many conidia, B. bassiana cultured with wet rice media at 26℃

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during 14 days and dried at 35℃ incubator during 2 days. We separate the conidia from dried rice by sieve shaker and storage at 4℃. To germination test, conidia dilution (107) make with sucrose + pepton solution. Input the hole slide grass which 1ml of dilution (107) dropped into plastic scharet (diameter 85mm) and closed cap. This scharet input to incubator controlled at different temperature (15, 18, 21, 24, 27, 30, 33℃), and survey germination rate of conidia using microscope and haematocytometer in each 16, 20, 24, 40 hour after treatment.

- Bioassay

Bioassay the B. bassiana and environment-friendly agricultural materials (EFAM) to Myzus pescicae was tested two methods of leaf disc and field test. M. persicae rear in green house condition on pepper plant. Seven species of EFAM such as Muginchon, Wangjungwang, Hongmaengi, Pachungtan, Bakmeru+, Newbiodakil and Meolguseul extract was selected.

The method of leaf disc was as following: 1) input wet cotton wool at bottom of insect rearing scharet. 2) lay pepper leaf with aphids. 3) manufacture conidia dilution (105, 106, 107, 108, 109). 4) spray 5 times from 30cm distance. 5) dry during 2 hour and close cover. 6) survey mortality (1, 2, 3 day after treat). Mortality field test was as following: 1) planting young pepper in house. 2) inoculation the M. persicae at pepper plant. 3) survey the density of aphids before spray. 4) spray 5 times from 30cm distance each materials. 5) survey aphids density at 1, 2, 3, 5 days after treat.

Results

Germination of *B. bassiana* showed the highest rate at 27℃ after 40 hours(F=6.524, df=14, P= 0.002). The rate was as high as increasing temperature but decreased at 33℃. Mortality of M. persicae by *B. bassiana* was high at $1X10^7$ cfu/ml as 48.4% (F=28.465, df=12, P=<0.001)

Table1. Germination rate of *B. bassiana* in different temperature condition.

Temperature (℃)	Germination rate (%)			
	16 hour	20 hour	24 hour	40 hour
15	0.3±0.6 c	6.4±3.5 b	33.0±5.5 c	85.0±27.6 c
18	31.9±9.5 b	58.9±3.1 a	74.3±11.0 b	88.9±13.0 bc
21	29.7±7.2 b	51.7±27.2 a	60.0±12.0 b	89.0±17.4 bc
24	56.8±27.1 a	58.0±8.2 a	88.8±4.0 a	96.0±15.9 ab
27	56.6±15.5 a	70.1±7.4 a	90.1±18.5 a	98.1±13.6 a
30	60.8±13.8 a	65.0±20.8 a	70.1±13.9 b	92.1±10.2abc
33	32.0±8.0 b	52.0±26.0 a	65.1±11.0 b	86.0±8.5 bc

Values represent means+standard deviation. Same letters at values within a column are not significant different (One-way ANOVA, Post hoc tests by Duncan test 0.05%)

Data transformed arc sine to ANOVA

Table2. Mortality of *Myzus persicae* at different conidia concentration of *Beauveria bassiana* (leaf disc)

Conidia concentration (cfu/ml)	Before density	Mortality (%)		
		1 DAT	2 DAT	3 DAT
1×105	22.0	1.6±2.7 c	8.3±6.7 b	12.8±4.2 b
1×106	25.3	4.1±2.5 bc	6.5±4.1 b	15.5±7.1 b
1×107	27.7	28.7±8.0 a	55.7±11.0 a	64.5±10.9 a
1×108	28.3	17.6±3.0 ab	44.0±14.0 a	50.0±21.1 a
1×109	26.7	13.7±6.6 ab	16.0±0.0 b	8.3±0.0 bc
Control(density)	21.7	21.7 c	22.3 c	29.3 c

Mycelium could grow in low concentration of EFAM(0.1%), but Bakmeru+ could not grow mycelium from 0.5% to 8%(F=128.50, df=14, P=<0.001). Wangjungwang, Pachungtan, and Newbiodakil could grow mycelium till 4%. We recommended these three EFAM to mixing *B. bassiana* to synergist effect of *M. persicae*. In field test, mortality of *M. persicae* was 100% at *B. bassiana* plus Wangjungwang and plus Mujinchon plot after 5 days after application. In table 4, the mortality only Wangjungwang treat and *B. bassiana* (10^7)+Wangjungwang treat did not different to perfect mortality. Therefore, it needs additional study to the lower concentration treat.

Table3. Mycelium growth at different additive concentration of environment-friendly agricultural material (EFAM).

EFAM	Mycelium growth at different additive concentration						
	0.1%	0.2%	0.5%	1%	2%	4%	8%
Muginchon	○	○	○	○	△	×	×
Wangjungwang	○	○	○	○	○	○	△
Hongmaengi	○	○	○	○	△	×	×
Pachungtan	○	○	○	○	○	○	○
Bakmeru+	○	△	×	×	×	×	×
Newbiodakil	○	○	○	○	○	○	△
Meolguseul	○	○	○	○	○	△	×

※Mycelium growth: ○; Good, △; Bed, ×; No growing

Discussion

For biological control of many agricultural insect pests, such as lepidopterous, mites, aphids, planthopper, pathogenicity of *Beauveria bassiana* was tested the bio-control agents in the world (Yun *et al*., 2004; Vu *et al*., 2007). Most of precedent study performed in laboratory condition, and it's control effect was good. But, the control effect was decrease remarkably when trial in field. Maybe it induced bad circumstance condition such as temperature and aerial humidity. In this study, the aphid control effect was perfect in trail field test, when spray *B. bassiana* with environment-friendly agricultural material (EFAM). We expect to development the good agent for bio-control aphid.

Conclusions

Our results show that only *B. bassiana* treat was low control effect to *Myzus persicae* but when mix spray with environment-friendly agricultural material (EFAM), the mortality of *M. persicae* was 99% in 3 days after treat. Therefore, *B. bassiana* could be considered as one of the environment-friendly control agent to control aphids.

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Potential possibility of caucasian persimmon (*Diospyros lotus* L.) utilization in ecological agriculture in Slovakia

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Key words: Caucasian persimmon, *Diospyros lotus* L., economical value, traits variability, ecological agriculture.

Abstract

In this work were evaluated 18 genotypes of Caucassian persimmon (Diospyros lotus L.) grown in Arboretum Mlynany (Slovak Republic), focused on selected economically important traits of fruits and seeds. Genotypes were cultivated from the seeds introduced from China, Korea and Japan. The genotypes were tested for the mean fruit weight in botanical maturity which ranged from 0.8 to 8.1 g, fruit height (9.6 – 22.0 g), fruit diameter (10.2 – 23.3 mm), seed height (6.8 – 13.7 mm) and seed width (3.4 – 9.2 mm), seeds weight in one fruit (0.05 – 1.7 g) and number of seeds in one fruit (1 – 10). Genotypes exhibited a good healthy state. In collection were selected 3 genotypes with potential suitability to be used in practice. In leaves, seeds, calyxes and flesh were analyzed the following concentrations of lysine 3.8 – 3.6 – 1.2 – 1.5 g.kg^{-1}, leucine 5.5 – 3.5 – 2.5 – 2.1 g.kg^{-1}, valine 4.2 – 3.0 – 1.9 – 1.6 and phenylalanine 3.5 – 2.4 – 1.8 – 1.4 g.kg^{-1} respectively. Among mineral substances were detected phosphorus 1200 (flesh) - 2075 (leaves) mg. kg $^{-1}$, potassium 16096 (leaves) – 5799 (roots) mg. kg $^{-1}$, calcium 50570 (leaves) – 2865 (seeds) mg. kg $^{-1}$.

Introduction

Naturers of Caucasian persimmon (*Diospyros lotus* L.) are spread in Japan, China, India and Iran. In cultural form this species is occurring in Korea, Pakistan, Afghanistan, Turkey, Albania, Spain, France and Poland (Kuliyeva 1962). Caucasian persimmon is known as dioecious tree with deciduous leaves. In natural conditions these trees can achieve the height up to 15 m. Degree of tolerance of Caucasian persimmon to high temperatures, dryness and other abiotic and biotic factors in the cultivation environment is higher than in case of *Diospyrus virginiana* L. species (Chencova 2008). *Diospyros lotus* L. fruits are globular with diameter around 8 – 16 mm (Brezhnev & Korovina 1981). Chencova (2008) stated the fruit weight in range 2.8 – 6.2 g. In full maturity the fruits are blue-black or black-brown (Brezhnev & Korovina 1981). Kuliyeva (1962) found in fruits 7 to 9 seeds. Ripe fruits of the Caucasian persimmon are consumable in raw state, anyway could be flavoured depending on taste with lemon juice. They are used to prepare fruit salads, fruit cakes, marmalades, jams, syrops and spirits (Kremer 1995). In China it is used

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traditionally as neuro-protective medicine for healing of apoplexy (Bei et al. 2005). Loizzo et al. (2009) studied these fruits extract for their antioxidant and anti-proliferative properties and isolated eight compounds which were identified as gallic acid, methylgallate, ellagic acid, campherol, quercetin and myricetin. Chencova (2008) found in leaves 2.88 – 5.90 % saccharides and 106.42-111.55 mg% of vitamin C. Azadbakhta *et al.* (2009) experimentally verified and proved the hypoglycemic effect of the water extract from the Caucasian persimmon fruits. Ayaz & Kadioglu (1999) in the fruit lipids 11 fatty acids identified and quantified. Plant populations grown from the seeds are well adapted on the local conditions in the botanical gardens of Slovakia (Grygorieva *et al.* 2009).

Materials and methods

The main task of this work was to evaluate the variability of some traits concerning the fruits and seeds of the Caucasian persimmon (*Diospyros lotus* L.) in a genotypes collection occurring in the Arboretum Mlynany. Population was created from seeds introduced from China, Korea and Japan in 1970. In the Arboretum Mlynany are registered over 70 individual trees. In experimental study carried out in 2010 18 genotypes were tested. For any genotype has been determined the height and diameter of fruits (mm) weight of fruits (g), length, width and thickness of seeds (mm) and seed weight (g). Around with the quantitative characteristics were qualitative traits for any genotype registered as well – the shape and colour of fruits. Chemical analyses have been conducted in accredited laboratory. Protein content was estimated by the Kjeldahl method. In the freeze-dried samples were determined 15 amino acids (Ile, Leu, Lys, Phe, Thr, Trp, Val) by the ionex liquid chromatography.

Results

Testing trials for individual genotypes showed the mean fruit weight in botanical maturity in range of 0.80 – 8.10 g, fruit height 9.62 – 22.07 g, fruit diameter 10.21 – 23.36 mm, seed height 6.89 – 13.79, seed width 3.40 – 9.26, seed weight in one fruit 0.05 – 1.71 g and number of seeds in one fruit 1 – 10 (Table 1). Among tested genotypes were detected significant differences in the shape and color of fruits and seeds as well (Figure 1).

Tab. 1: Variability of selected traits in genotypes collection of Caucasian persimmon (*Diospyros lotus* L.) population occurring in the Mlynany Arboretum

Traits	Min	Max	$\bar{x}$	V%
Fruit weight (g)	0.80	8.10	3.97	37.00
Fruit height (mm)	9.62	22.07	16.14	15.17
Fruit width (mm)	10.21	23.36	17.43	15.69
Fruit stem length (mm)	0.51	6.69	3.15	36.15
Number of seeds in fruit	1	10	4.33	42.55
Weight of seeds in fruit (g)	0.05	1.71	0.60	52.25
Seed length (mm)	6.89	13.79	10.26	12.88
Seed width (mm)	3.40	9.26	5.73	11.37

Genotypes exerted an excellent health state. The high temperatures during the summer time are well tolerated, similarly is acceptable the water deficiency in soil. From the collection were selected three individual genotypes suitable for further use in practice. From the survey of the essential amino acids content the highest values were found generally in the leaves and seeds and lower ones in calyxes and fruit flesh. Mostly prevailed leucine and relatively low concentration were detected by tryptophane (Table 2).

Tab. 2: Essential amino acids content (g.kg^{-1}) in Caucasian persimmon (*Diospyros lotus* L.) plant parts

Amino acids	ILE	LEU	LYS	PHE	THR	TRP	VAL
Fruit flesh	1.80	2.10	1.50	1.40	1.00	< 0.01	1.60
Leaves	3.10	5.50	3.80	3.50	2.50	1.71	4.20
Calyx	1.60	2.50	1.20	1.80	1.40	< 0.01	1.90
Seeds	2.20	3.50	3.60	2.40	2.10	1.30	3.00

Tab. 3: Content of macro-/mikro-elements (mg. kg $^{-1}$) in selected Caucasian persimmon (*Diospyros* lotus L.) plant parts

Component	N	P	K	Ca	Mg	Na	S
Flesh	6954	1200	11482	1895	1004	22.1	520
Seeds	16029	1385	6023	2865	2067	47.8	810
Leaves	16353	2075	16096	50570	8301	27.7	3415
Roots	9230	1550	5799	3852	1499	33.5	350

Analyses of mineral substances dealt with the content (mg. kg $^{-1}$) of phosphorus from 1200 (flesh) - 2075 (leaves) mg. kg $^{-1}$, potassium from 16096 (leaves) to 5799 (roots), calcium from 50570 (leaves) to 2865 (seeds) mg. kg $^{-1}$. All plant parts are quite interesting when taking into account the different concentrations of mineral substances, as documented in Table 3.

(a) (b)

Figure 1: Variability of fruit (a) and seeds (b) shape and color for genotypes in populations of Caucasian persimmon (*Diospyros lotus* L.) occurring in the Mlynany Arboretum

Discussion

Caucasian persimmon growing in Slovakia can achieve tree heigths up to 10 – 14 m. Ayaz & Kadioglu (1999) reported similar values – up to 15 m. Fruits can be in ranges 0.80-8.10g for weight, while Chencova (2008) stated the range of 2.8 – 6.2 g. Comparison of different genotypes in Mlynany resulted in the mean height of fruits of 8 – 16 mm. Brezhnev & Korovina (1981) reported for fruits width (8 – 16 mm), our results from Mlynany were from 10.21 to 23.36 mm. Around with the fruits of persimmon are quite interesting the leaves and seeds, which contain high amounts of C vitamin and moreover, significant doses of essential amino acids and mineral substances. Kuliyeva (1962) detected in fruits from 7 to 9 seeds. From our experiments result the value of 10 seeds. Seeds are valuable source of oil, or can be used to produce seedlings for further propagation of this species. Micro-populations of Caucasian persimmon are well adapted in Slovakia. They exert high degree of tolerance to elevated summer temperatures as well as to cold winter conditions. Moreover, they are quite resistant against diseases and pests (Chencova 2008). Our results when compared with the literature data are proving the fact, that the genotypes cultivated in Slovakia attained economically important parameters, what allows their intensive utilization in practice. During the process of cultivation there is no need for pesticides application, what allows to consider this species as highly suitable for the organic agriculture.

Conclusions

Accumulated knowledge on characteristics of Caucasian persimmon collection grown in Slovakia over 30 years indicates that this species could be utilized in ecological agriculture. Its cultivation can contribute to land-forming and supply valuable resources for agro-food, pharmaceutical and cosmetics industry including several other practical exploitation forms. For the ecological agriculture is highly important its extended tolerance to diseases and pests and the possibility of different plant parts use in practice, what diminishes the waste production.

Acknowledgments

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Determination of the effective spray- interval of *Bacillus thuringiensis* against diamond-back moth (*Plutella xylostella*) on chinese cabbage

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Key words: Bacillus thuringiensis, Plutella xylostella, Chinese cabbage, pest control

Abstract

In organic Chinese cabbage fields, Commercial Bacillus thuringiensis products are used widely against diamond back moth, Plutella xylostella. We conducted the study to determine the effective spray-interval of commercialized B. thuringiensis against diamond back moth on Chinese cabbages. Chinese cabbage leaves were collected 0, 1, 2, 3, 6, 10days after treatment in first trial and 0, 2, 4, 7, 9, 11days after treatment. We compared the insecticidal property of sprayed B. thuringiensis and the density of it on surface of Chinese cabbages using collected leaves. The insecticidal property maintained high until nine days after commercial B. thuringiensis products sprayed.

Introduction

Plutella xylostella, Diamond back moth is major insect pest of cruciferous crops including Chinese cabbage (Talekar & Shelton 1993). Because it has short lifecycle and high fecundity (Kim & Lee 1991), when *P. xyllostella* flies into cabbage field, the density of *P. xyllostella* increases very rapidly.

However, *P. xylostella* is difficult to control effectively. *P. xylostella* can also live on weeds such as shepherd's purse, *Casella nurse-pastoris* (Talekar & Shelton 1993), distributed around Chinese cabbage fields. The population of *P. xylostella* moves into cabbage fields continuously in the early spring season.

To date, Commercial *B. thuringiensis* have been frequently used in organic agriculture (Seo *et al*. 2009). However, commercial Bt products are used practically without information about effective duration of Bt product.

We studied to determine effective spray intervals of *B. thuringiensis* against diamond back moth on Chinese cabbage

Materials and methods

Experimental insects and plants

The susceptible strain of *P. xylostella* was provided by applied entomology division of National Academy of Agricultural Science (NAAS) and reared on leaflets of Chinese cabbage in for five years.

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Chinese cabbage seeds were sown separately in pots filled with horticultural bed soil (Baroker, Seoul Bio co. Ltd, Korea). When two foliage leaves were expended, host plants were individually transplanted to plastic pots (20cm diameter, 15cm height). After 2 weeks transplanted Chinese cabbages were used for experiments.

Treatment

The experiment was conducted in glasshouse in division of organic agriculture, NAAS. It had three treatments. The treatments were two kinds of commercial *B. thuringiensis* products (suspension concentrate and wettable power formulation of *B. thuringiensis* subsp. *aizawai* NT 0423, Dongbu Co., Korea) and distilled water as a control.

Both commercial *B. thuringiensis* products were diluted in distilled water according to the instructions provided by the company.

Bacterial suspensions of *B. thuringiensis* products were sprayed on Chinese cabbages planted on pots. The leaves of Chinese cabbage were collected 0, 1, 2, 3, 6, 10 days after bacterial suspension sprayed in the first trial and collected 0, 2, 4, 7, 9, 11 days after sprayed in the second trial.

The glasshouse where experiment was conducted maintained at 25 ℃

Bioassay

Collected leaves were cut into circular discs (3cm diameter size). A circular leaf disc was put in the petri-dish with filter paper and ten larvae of diamond back moth per a petri-dish were introduced. The mortality was observed after three days. Each treatment had five replications. The mortality was corrected by Abbott's formulation (1925).

$$\text{Corrected percent mortality} = \frac{\%\ \text{Observed mortality} - \%\ \text{Control Mortality}}{100\ -\ \%\ \text{Control Mortality}}$$

Spreading

Collected leaf was cut into ten circular discs (1cm diameter size) with a cork bore. Ten leaf-discs were put in the 20ml tube with distilled water, which shook for thirty minutes. Diluted solutions were spread on TSA and then, they were placed in growth chamber which maintained at 28℃. The number of colony of *B. thuringiensis* was counted 24 hours later.

Results

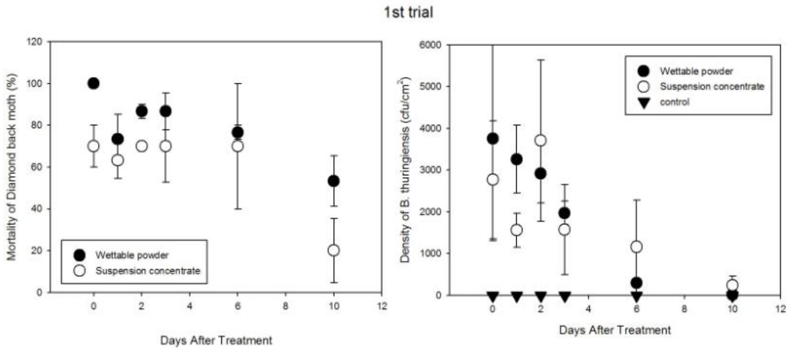

Figure 1: Duration of efficacy of *B. thuringiensis* in first trial (left: mortality of diamond back moth (%), right: density of *B. thuringiensis* (cfu /㎠) on surface of Chinese cabbage after treatment

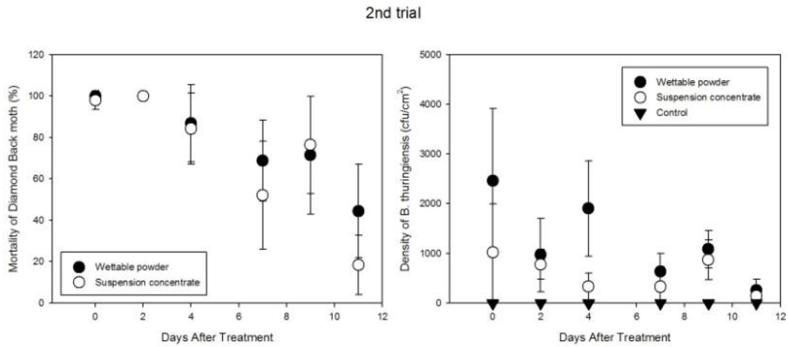

Figure 2: Duration of efficacy of *B. thuringiensis* in second trial (left: mortality of diamond back moth (%), right: density of *B. thuringiensis* (cfu /㎠) on surface of Chinese cabbage after treatment

In both trials of experiment, mortality of *P. xylostella* were 100%, except suspension concentrate treatment in first trial. As time goes by, the efficacies slowly decreased until 9 days after spraying *B. thuringiensis*. However, the day after, the mortality of diamond back moth decreased sharply.

The densities of *B. thuringiensis* on the surface of Chinese cabbage were decreased according to the passage of time.

The comparison between two types of formulation showed that the efficacy of suspension concentrate formulation was decrease rapidly.

Discussion

The result of current study shows that the insecticidal activity of *B. thuringiensis* lasts for nine days. It may be concluded from the result that spray-interval of *B. thuringiensis* should be set as nine days to effectively *P. xylostella*.

However, Behle et al. (1997) suggested that rain causes on reduction in insecticidal activity of *B. thuringiensis* and sunlight degradation of *B. thuringiensis* affects on the insecticidal activity.

For accurate determination of spray-interval of *B. thuringiensis*, the effect of rain and sunlight should be considered.

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Studies on the suppression of transmission of anthracnose with covering method and environment friendly agricultural materials (EFAM) in pepper field

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Key words: Anthracnose, Covering materials, Environment friendly agricultural materials, Pepper.

Abstract

We studies a model for management of pepper anthracnose based covering method and spraying system in field.

1. *Among 82 organic fungicides, 42 materials showed most effective inhibition against mycelia growth of the Colletotrichum acutatum* in vitro*. 23 formulated biocontrol agents were chosen to control the disease from 42 biocontrol agents in greenhouse. In the end, five kinds (2 plant extracts, 2 biopesiticides, 1 Bordeaux mixture) were selected from 23 materials in the field.*
2. *The mulching materials of bed covering in fruit season were thin non-woven fabric sheet and black plastic. The use of a fabric sheet was reduced the spread of anthracnose as compared to the plastic covering.*
3. *The application with the chosen materials was reduced 34% of anthracnose for 7 times sprays to planting 70 days as compared to the untreated control. In yield, nonwoven fabric sheet with formulated biopesticides was increased 17% than black plastic.*
4. *This result indicated that the developed biocontrol strategy could be an effective and economic crop protection system in organic pepper cultivation field.*

Introduction

Several species of plant pathogenic fungi in the genus *Colletotrichum* cause anthracnose in pepper. All growth stages may be affected, including postharvest stages. Symptoms occur primarily on ripening fruit often where fruit is touching the soil or plant debris. On ripe fruit there are small, sunken circular depressions up to 30 mm in diameter. The center of the lesions becomes tan in color while the tissue beneath the lesion is lighter-colored and dotted with many dark-colored fruiting bodies of the fungus that form concentric rings in the lesion. Foliage and stem symptoms appear as small, irregularly shaped gray-brown spots with dark brown edges.

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Materials and methods

This study was carried out in organic pepper cultivation field located at Naju in Jeonnam province, which is located in the South region of Korea. Both experiments were conducted with three replications in a randomized block design.

Covering experiments. Disease development was compared under different mulching materials. The mulching materials of bed covering were thin nonwoven fabric sheet and black plastic.

Fungicides experiments. For testing the control efficacy of non-chemical organic materials against to pepper anthracnose, 82 materials compared between plant growth and spraying system in greenhouse and field. The plot was sprayed with formulated fungicides with 7 –10 days intervals 7 times sprays to planting 70 days as standard farming practices. The EFAM was applied Chitosan+Seaweed extracts (1,000 dilution concentration), *Streptomyces griseofuscus* 200401(500 dilution), *S. rimosus*(100 dilution), Bordeaux mixture(40 dilution), Oriental plant extracts(500 dilution), Garic extracts+chitosan+chitooligosaccharide(1,000 dilution) on control of pepper anthracnose in field.

Data analysis. Disease incidence was counted on the number of infected fruit (water-soaked and sunken lesions, sometimes reaching 4 cm in diameter, develop on mature fruits). The infected fruit was investigated 200 fruit of 20 plants with 3 repetitions. Analysis of variance (ANOVA) was performed, and differences between means of treatments were determined by Duncan's test and t-test using the Statistical Analysis System (SAS Institute, Cary, NC).

Results

Tab. 1: Effect of environment friendly agricultural materials (EFAM) on control of pepper anthracnose in field.

Treatment	DLA(%)x	Control value(%)y
Chitosan+Seaweed extracts	10.0 az	72.2
Streptomyces griseofuscus 200401	11.5 a	68.0
S. rimosus	16.7 b	53.6
Bordeaux mixture	16.6 b	53.9
Oriental plant extracts	16.7 b	53.6
Garic extracts+chitosan+chitooligosaccharide	21.0 c	41.6
Water(control)	35.9 d	-

x DLA means Index of diseased leaf area for total leaves.

y The control value (%) was calculated by the following equation : [(diseased fruit severity of untreated plants − diseased fruit of treated plants)/diseased fruit of untreated plants]×100.

z Mean separation within columns by Duncan's multiple range test at P=0.05.

Tab. 2: Comparison of anthracnose development between different covering materials and spraying system in open field.

Treatment	Diseased incidence of Fruit (%) EFAM application		
	3 times	4 times	7 times
Nonwoven fabric sheet	23.4 az	19.9 a	8.2 a
Black plastic	34.8 b	21.0 a	10.7 b
No covering	35.9 b	32.7 b	42.0 c
F pr	0.038*	0.003**	<.001***
CV	13.4	8.6	2.9

z Mean separation within columns by Duncan's multiple range test at P=0.05.

*, **, *** significant at P≤0.05, 0.01 or 0.001, respectively.

Tab. 3: Average fresh yield of pepper between covering materials and spraying system in open field.

Treatment	Fresh yield(g/plant) EFAM application		
	3 times	4 times	7 times
Nonwoven fabric sheet	373.8***	389.1**	611.5***
Black plastic	288.3	301.7	438.1

, * significant at 1% and 0.1% levels by t-test.

Discussion

In the mulching material and fungicide application experiment in the pepper fields, nonwoven fabric sheet was the effective materials to anthracnose than black plastic (polyethylene) film. The sheet application maintained consistent humidity and lowered the temperature from the rhizosphere of plants in comparison to the plastic covered method (data not shown), indicating that humidity may be more important than local temperature in the spread of the fungus.

Conclusions

A thin non-woven fabric sheet significantly reduced anthracnose in pepper growth season. The use of a fabric sheet reduced more the spread of anthracnose than the plastic method. This sheet with fungicide application suppressed anthracnose even more. The application of fungicide in non-woven fabric sheet was reduced 34% of anthracnose and increased 17% of yield than black plastic and untreatment. We are recommended for mulching of nonwoven fabric sheet because this sheet promotes fruit yield and reduces pepper anthracnose.

Acknowledgments

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Efficacy of bioagents against apple scab in organic orchards. preliminary results.

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Key words: apple scab, Venturia inaequalis, Trichoderma asperelum, Pythium oligandrum, plant extracts, preventative treatment

Abstract

Protective sprays with copper are included in spray schedules for apple scab control in organic fruit growing. Using of copper is under discussion and now some alternatives products to copper are screened here. For preventative treatments were tested plant extracts based on Artemisia absinthum, Urtica dioica and Equisetum arvensae. The alcohol extracts were applied as foliar sprays at 2% concentration. Two microbial products based on Trichoderma asperellum and Pythium oligandrum were tested also in concentration 0.5% and 0.05%, respectively. Microorganisms were applied alone or in combination with plant extracts. Only 1,47 % of area leaf was infected by pathogen after Trichoderma treatment. Combined treatments with Trichiderma and Artemisia sp., Urtica sp. and Equisetem sp. were efficacy also (14.88, 3.5 and 17.38%, respectively).

Introduction

Apple scab, caused by *Venturia inaequalis* (Cooke) G. Wint. is one of the most important disease in apple production. In organic apple growing scab control is focussed on the protective use of sulphur, lime sulphur and copper (Jamar et al., 2007). Products containing sulphur could influence fitotoxity symptoms, using of copper is often criticized. Control of apple scab depends on frequent application of copper fungicides. Permitted amounts are reduced during the following years to avoid environmental risks. It is important to develop the novel antagonists' contained product for biological control of apple scab and offer alternative options for disease control. The aim of this work was to evaluate the effectiveness of antagonistic microorganisms used alone or combined with plant extracts.

Material and methods

The experiments were conducted in 2009 and 2010 in organic apple orchards. For preventive efficiency against apple scab were tested plant extracts based on such plants as Artemisia absinthum, Urtica dioica and Equisetum arvensae. The alcohol extracts were delivered by trade company and were applied as foliar sprays at 2% concentration. Two microbial products based on Trichoderma asperellum and Pythium oligandrum were tested. The plant growth promoter named Trifender WP (s.a. T. asperellum) was used, one gram of the product contents 5x108 of conidium, isolate T1 (NCAIM 68/2006). Polyversum WP (it is PPP) containing 106 of oospor of P. oligandrum in 1 gram of product was used as second microbial product. Dose of mentioned products were established at 0.5 and 0.05%, respectively. Treatments were applied using a spray volume of 500 l water per hectare. Microorganisms were applied in part of 5 days from plant extracts. Preventative applications with knapsack were performed. All treatments were performed three times during vegetation season – the stage of first leaves, the stage of blossom fall and the stage of fruit setting. All trials were carried out in established apple orchards with mixture of cv Golden Delicous, Idared and Gloster under organic management. Trees were grafted on M9 rootstock. In the orchard planting distances were 4 m between rows and 2 m within row. The alleys between rows were sown with grass and white clover and were regularly cut. To compare the different treatments, a randomized complete block design with 4 replicates per treatment and with 4 trees per plot was used. To prevent border effects, each plot was bounded by guard trees. In all trials the incidence of apple scab on leaves in % of infected area of leaf (observed on 10 branches from each tree) was assessed twice, at the end of the primary infection period and in secondary infection period (autumn). Weather conditions in 2009 were differ in compare to 2010, when high and repeated rainfalls occurred. All data were evaluated by test Tukey's ($p<0,05$). Date expressed in percentages were arc sin transformed.

Results

In primary infection period (May) was noted that only 1,47 % of area leaf was infected after treatment with T. asperellum, other combinations were surprising less effective comparing to untreated trees (2.24%) (Table 1). In secondary infection period (September) the apple scab incidence was noted on 31.65 % of area evaluated leaves collected from untreated trees. The lowest incidence of disease was noted on all trees treated with T. asperellum alone or in combination with plants extract.

Table 1. The incidence of apple scab on leaves in spring and autumn time (2009-2010)

No.	Treatement	Mean % affected leaves during primary infection period (spring time)	Mean % affected leaves during secondary infection period (autumn time)
1	*T. asperellum*	1,47*	3,88*
2	*T. asperellum* + *Urtica dioica*	3,17	3,50*
3	*T. asperellum* + *Artemisia absinthum*	4,75	14,88*
4	*T. asperellum* + *Equisetum arvensae*	3,17	17,38*
5	*P. oligandrum*	8,75	19,63*
6	*P. oligandrum* + *U. dioica*	4,20	47,63
7	*P. oligandrum* + *A. absinthum*	4,15	49,00
8	*P. oligandrum* + *E. arvensae*	4,42	72,25
9	Untreated (water)	2,24	31,65

* - statistically different from untreated trees

In case of T. asperellum treatment was observed the lowest level of scab symptoms (3.88%). It seems to be similar to combinations with U. dioica extract (3.5%). These were the most successful combinations.

Combined treatments with Trichoderma and Artemisia sp. or Equisetum sp. were efficacy also. Results obtained from these trials were 14.88 and 17.38%, respectively. After application of P. oligandrum was observed the incidence of apple scab on 19.63%, other combined treatments with P. oligandrum and plant extracts were no satisfied and apple scab symptoms were observed more severe then on untreated trees (Table 1).

Discussion

During the spring observation only in case of trees treated with *T. asperellum* decreasing level of scab symptoms was noted. According to Hinze and Kunz (2010) the efficiency of the antagonistic fungi strongly depended on the moment of application during the infection process. In the second observation (autumn) infection level significantly decreased after multiple treatment with *Trichoderma* and *Pythium* alone. The mean area of infected leaves was 3,88 and 19, 63%, respectively compared to 31,65% on untreated trees. Combined treatments *Trichoderma* with plant extracts were satisfied also.

It is difficult to obtain high efficacy of biocontrol agents. Antagonists should be cold-tolerant and drought-tolerant (Köhl and Molhoek 2001). None of the control agents tested by mentioned above authors had a high efficacy during the entire infection process. However, it was possible to select a few antagonistic fungal isolates which suppressed sporulation of *V. inaequalis* for more than 80%. It was confirmed in orchards experiments conducted in two different years, with multiple applications of isolate obtained by Hinze and Kunz (2010). Authors described significant reduction of *V. inaequalis* conidia production by 31- 69%. Rossi and Pattori (2009) notice that *Trichoderma* reduced the total number of conidia *Stemphylium vesicarium*, relative to the control by about 50%. In laboratory experiments. *Trichoderma* could colonize plants and produce abundant conidia. After 6 weeks, *Trichoderma* reduced production of pathogen conidia even by 99%. Biological control with epiphytic living antagonists (*e.g*., bacteria, yeast and other fungi) could help to avoid or to reduce the intensive application of pesticides and minimize their residues in the crop (Köhl 2009).

The investigation on the relationship between the antagonist, the host plant and the pathogen could offer a new approach for understanding the mechanism of biological control of plant diseases. It is possible that major role in antibiosis has endochitinase produced by *Trichoderma* (Bolar 2001). In results obtained by Pfeiffer et al., (2004) showed that there is a promising potential in some plant extracts like AGROMIL, *Inula viscosa* or *Quillaja*-saponin. According to these results in scab control the plants extract were used as the second protective and preventive factor. There were no synergetic or additive effects of scab control.

In presented work the incidence of disease in autumn were observed even more severe after plants extract treatment It is possible that the use of plant extract reduced control potential of antagonistic microorganisms. Plant extract could damage antagonistic *P. oligandrum* existing on apple leaves surface. After extract treatment were observed more severe symptoms of scab on sprayed leaves (47.63 to 72.25 % of leaves area with symptoms) than on untreated trees (31.65 % leaves area with symptoms). Scab epidemics during summer are driven by conidia produced only on apple leaves. In this situation, different fungi present in the phyllosphere may interfere with conidia of the pathogen during sporulation or infection and decreased infection level (Pfeiffer 2004). In Africa, Mahlo (2010) indicated the antifungal activity of plant leaf extract against *Aspergillus niger, A. parasiticus, Colletotricum gloeosporioides, Penicillium janthinellum, P. expansum, Trichoderma harzianum and Fusarium oxysporum*. That suggested the high influence of plant extract not only on pathogenic, but also on antagonistic (beneficial) microorganism.

The general conclusion of this project is that alone *T. asperellum* used multiple could replace of copper and could be developed as an alternative strategy. Timing of spray applications is very important. Efficacy of *P. oligandrum* used alone was recorded only during secondary observation, in combination with the plant extracts it was no satisfied. It is probably more susceptible for antifungal side effects of plat extracts comparing to *Trichoderma*.

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Organic control of oilseed rape pests through natural pesticides and mixed cultivation with turnip rape

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Keywords: rapeseed, turnip rape, pyrethrum, spinosad, rock powder

Abstract

*A mixed cropping system of rapeseed and 10 % turnip rape as trap crop was compared with oilseed rape in pure stand to demonstrate the reduction of infestation by insect pests. Furthermore the application of bio-pesticides like pyrethrum/rape oil (Spruzit® Neu), spinosad (SpinTor), diatomeen earth (SiO_2) /sunflower-oil and rock powder/water was tested. Oilseed rape showed a higher infestation by stem weevils (*Ceutorhynchus *spp.) in the mixed cropping system compared to rapeseed in pure stand. The reduction of the pollen beetle (*Meligethes aeneus*) on the rapeseed buds resulted from higher attractiveness of turnip rape as a consequence of advanced growth. The faster development of turnip rape seems to be the important key of successful pollen beetle regulation. The application of pyrethrum and spinosad against *Ceutorhynchus *spp. had no effect, spinosad was the only agent that caused a reduction of the pollen beetle.*

Introduction

In organic oilseed rape cultivation, insect pests frequently cause substantial yield losses because effective organic strategies to control them are lacking. Consequently, the amount of organic oilseed rape planted in Germany is relatively small (only 2300 ha in 2008) and insufficient to meet the increasing demand for this crop. At the end of 2008, a three-year research project funded by the Federal Organic Farming Programme was launched to address this problem. The tests are being conducted at an EU-certified organic farming site (Control No. D-ST-043-48291) operated by the Julius Kühn Institute in Dahnsdorf, Germany. It has sandy loess (sL) soil, a soil quality index of 48, and a mean annual precipitation of 587 mm. The aim is to determine the pest-reducing potential of mixed cultivation of oilseed rape with turnip rape (t. rape) compared to cultivation of oilseed rape alone and to assess the efficacy of different natural pesticides. Stem weevils (*Ceutorhynchus* spp.) and pollen beetles (*Meligethes aeneus*) are the main target organisms studied.

Materials and methods

Studies were conducted at two test fields in 2009 and 2010. Monocultures of oilseed rape (OR -varieties Oase in 2009 and Robust in 2010) and mixed cultures of OR (varieties Oase in 2009 and Robust in 2010) with 10% turnip rape (TR - Largo 00-quality) were laid out for four replications (sowing rate: 70 seeds/m²). Each replication was divided into four subplots of 34×25 m (monocultures) and 26×25 m (mixed

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cultures), respectively (Table 1). The date of treatment was determined based on the pesticide application thresholds recommended for integrated pest management, i.e., the time of peak occurrence (yellow traps). The efficacy of stem weevil (SW) control was determined by measuring infestation densities on 20 OR and TR plants randomly selected from the middle of each plot. The main stem was cut open and the larvae were counted and taxonomically identified under a microscope. The efficacy of pollen beetle (PB) control was determined by counting the number of beetles on 50 OR and TR plants (10 TR plants in 2009) randomly selected from the middle of each plot. Counts were conducted from the beginning of the flight period to the beginning of flowering. The plants were harvested with a plot combine on 21 July 2009 and on 30 July 2010.

Table 1: Efficacy of biopesticide treatment on stem weevil (SW; Ceutorhynchus spp.) and pollen beetle (PB; Meligethes aeneus) infestation. Active ingredient (a.i.): pyrethrum 4.59 g/l, spinosad 480 g/l (BBCH = standardised description of plant development stages)

2009	BBCH	2010	BBCH	target pest
(1) untreated control	-	(1) untreated control	-	-
(2) 8 l ha^{-1} pyrethrum	50–51	(2) 0.2 l ha^{-1} spinosad	19–20	SW
(3) 8 l ha^{-1} pyrethrum 0.2 l ha^{-1} spinosad	50–51 57	(3) 0.2 l ha^{-1} spinosad 0.2 l ha^{-1} spinosad	19–20 53–59	SW PB
(4) 8 l ha^{-1} pyrethrum 12 kg ha^{-1} diatomeen earth & 12 l ha^{-1} sunflower-oil	50–51 57	(4) 0.2 l ha^{-1} spinosad 12 kg ha^{-1} rock powder	19–20 53–59	SW PB

Results

In 2009, stem weevil infestation rates in turnip rape were up to 5 times higher than those in oilseed rape (Oase) in mixed cultures (Figure 1). Nonetheless, this did not result in the anticipated diversion of pests from oilseed rape. In fact, stem weevil infestation in oilseed rape in mixed cultures was worse than in monocultures. Significant differences were not detected due to the high degree of scatter. In 2010, infestation rates for TR and OR ("Robust") in mixed cultures were approximately equal and, as in 2009, the rate of stem weevil infestation in oilseed rape was higher in mixed cultures than in monocultures. The difference was statistically significant in 3 out of 4 variants. The biopesticide used in 2009 (pyrethrum) did not achieve a significant reduction of infestation and, in some cases, more stem weevils were found in the plots where it was used. The same applies to the product used in 2010 (spinosad). In mixed cultures in 2009, infestation levels with pollen beetles in turnip rape were higher than those in oilseed rape, particularly in the early bud stage. Although this effect decreased with increasing development, it remained significant in most cases. Preferential infestation of TR did not result in a decrease in OR infestation in mixed cultures compared to monocultures. No phenological advance in TR versus the OR variety "Oase" “ was observed.

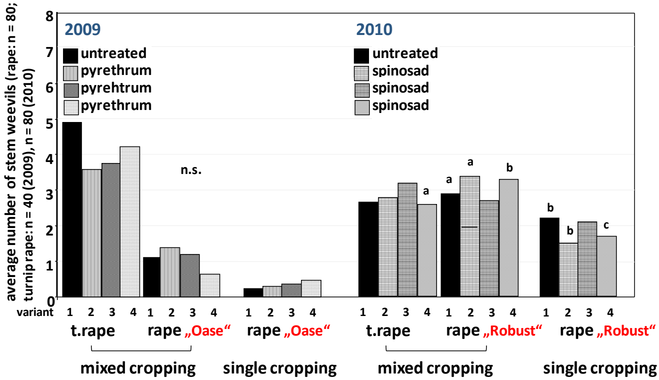

Figure 1: Effects of the four treatment variants on stem weevil infestation.

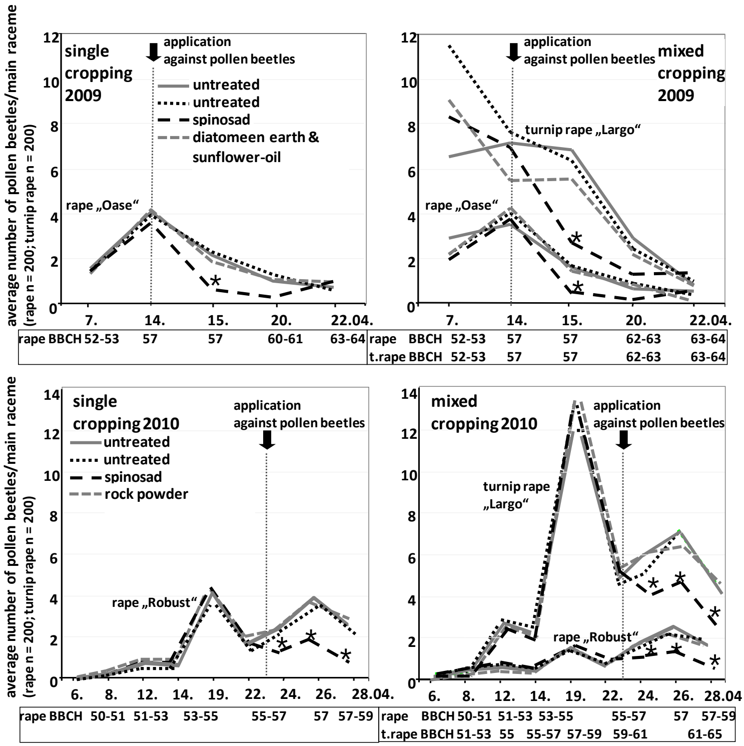

Figure 2: Pollen beetle (*Meligethes aeneus*) infestation over time as a function of treatment variant; * = significant for α = 5 % Wilcoxon test.

In 2010, pollen beetles displayed a significant preference for TR over OR ("Robust") in mixed cultures. At times, the difference was greater than a factor of ten. Consequently, PB infestation levels on oilseed rape in mixed cultures were significantly lower than those in monocultures. Moreover, a distinct phenological advance of turnip rape was clearly detectable in 2010. Regarding the biocontrol agents used in 2009, spinosad resulted in a distinct—in some cases significant—reduction of PB infestation, and diatomeen earth plus sunflower oil (SO) exhibited a tendency towards PB reduction. Efficacy for up to 6 days after treatment (Abbott's formula) was ≤ 78% for spinosad and +21 % to -33 % for diatomeen earth + SO. In 2010, spinosad again achieved a distinct and significant reduction of PB infestation, whereas rock powder did not. Efficacy for up to 6 days after treatment was ≤ 68 % for spinosad and +8 % to -19 % for rock powder.

Discussion

Stem weevil infestation in oilseed rape was higher in mixed cultures than in monocultures in both years studied, which is in line with the findings of other studies (Strauch 2009, Büchs & Katzur 2004). The preferential infestation of turnip rape by pollen beetles only has an infestation-reducing effect on oilseed rape when the phenology of turnip rape is advanced by several days relative to that of oilseed rape, as was observed in the two-year comparison. Neither pyrethrum nor spinosad was effective in reducing stem weevil infestation. Only spinosad achieved successful pollen beetle control with an efficacy distinctly higher than 70%, which is comparable to that of the corresponding conventional pesticides. The other products tested—rock powder and deatomeen earth + sunflower oil—had no infestation-reducing effect. No repellent effect was detected based on analysis of the extent of damage (number of blind stalks in podless stalks). This may be because the concentration (12 kg ha^{-1}) was too low. Doses of 25 kg/ha produced distinct effects in Switzerland (Breitenmoser, 2008).

Conclusions

Based on these preliminary results, mixed cultivation of oilseed rape with turnip rape cannot be recommended as a method of oilseed rape pest control. Even if this had an infestation-reducing effect on pollen beetles, it would be negated by increased stem weevil infestation which would be problematic because, currently, there is no selective treatment for the control of stem weevils. The pollen beetle treatments studied either resulted in no yield benefits or in yield benefits that were too small to compensate for the costs of treatment. Our recommendation for agricultural practice is continue to use an early-flowering oilseed rape variety and to ensure optimal crop management (weed control and fertilization) in order to fully exploit the enormous compensation potential of oilseed rape crops.

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Pest management using parasitoids and organic materials for cabbage production at highland region in Korea

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Key words: Cabbage, Diamondback moth, Cabbage armyworm, Parasitoid, Highland

Abstract

To estimate the parasitic effectiveness of Cotesia glomerata L. and Microplitis mediator Haliday for the control of diamondback moth, Plutella xylostella L. and cabbage armyworm, Mamestra brassicae L., field release of parasitoids with spraying organic materials simultaneously was conducted in cabbage field, 2,000 m^2, from June to July in 2007. Totally 1,000 of C. glomerata for DBM control and 100 of M. mediator for CAW control were release 30 days after transplanting cabbage seedlings in experiment field located on 500 meter a.s.l. in Gangwondo Province, Korea. DBM and CAW larvae were collected and reared in laboratory, and then counted cocoons formed near larva body to calculate parasitism. During growing period, none of synthetic pesticides were sprayed, except three kinds of organic materials registered officially to lower DBM density at the time of abrupt increase. As a result, C. glomerata and M. mediator were established and parasitism reached 53.8% and 30.0%, respectively. Therefore, it is confirmed the possibility of actual utilization of biological control agents and organic materials for the control of cabbage pests in the fields.

Introduction

Cabbage, *Brassica oleraceae var. capitata* L., is an important vegetable crop in Korea, where 5,859 ha was planted nationwide and produced 317,031 ton in 2008. In particular, one sixth of cabbage cultivated area was located at highland fields (over 400 meter a.s.l.) around Gangwando Province in Korea. Among the 15 species of arthropod pests of cabbage reported in Korea, diamondback moth (DBM), *Plutella xylostella* L. and cabbage armyworm (CAW), *Mamestra brassicae* L. are very serious insect pests for the cabbage production (Kwon *et al*. 2006). DBM has became an important pest of cabbages from the late 1980s, and it is found in most parts of the Korean Peninsula, from the southern island, Jejudo, to the northeast highland area, Daegwallyeong (NIAST 2000). If not properly managed during the early growth stage of the crop, these may adversely affect quantity and quality of yield. DBM caused 52% loss in market yield in cabbage (Krishnakumar *et al*. 1986). In the most

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countries, control of DBM and CAW by conventional chemical insecticides has so far been the only practice (Hama 1986). This have led to several problems; increasing incidence of pesticide poisoning of the farmers, presence of insecticidal residues on marketed brassicas, hazards to other organisms in the ecosystem, and spiraling costs of crop production (Talekar & Shelton 1993). In the work presented here, we evaluated the potential of natural enemies, *C. glomerata* to DBM and *M. mediator* to CAW, and organic materials, non-insecticide-based items, by integrating these agents for controlling DBM and CAW in cabbage field.

Materials and methods

1. **Test insects and Rearing parasitoids**

Larvae of DBM and CAW were collected from cabbage fields at highland region in Ganwondo Province in 2004, and have been reared successively on potted-cabbages at 23±2℃, 75% RH, and a photoperiod of 16:8 (L:D) without any exposure to insecticides since then. The parasitoids, *C. glomerata* and *M. mediator*, were collected from each host insect larvae parasitized in the fields at the same region. Over two hundred cocoons of *C. glomerata* were kept in a petri dish, and placed it into acrylic cylinder (Φ15×30cm), where involved a fresh cabbage leaf with 200 second instar DBM larvae. After exposing the DBM larvae for 48 hours for parasitization, the common cabbage leaf with parasitized larvae was removed from the cylinder and placed on a fresh 6-week-old potted cabbage. Rearing of *M. mediator* for CAW was similar with that of *C. glomerata*.

2. Integrated application of control agents

Totally 1,000 *C. glomerata* cocoons and 100 *M. mediator* cocoons were released into cabbage field (2,000 m^2) five times started from 20th June in 2007, at an interval of seven days. For the introduction of parasitoids, a release station with A-type wooden house (1 m high) was built inside the field for adult emergence. Sticky plate was pasted reversely on the low part of the station pole in order to protect parasitoid cocoons from being attacked by harmful animals such as spiders, ants and flogs till emergence. On 27 June, density of DBM larvae increased unexpectedly due to favorable condition, so that three kinds of organic materials manufactured for insect control; solbichae (Bt-based, Green Biotech Co., Korea), engsami and jinsami (plant extract-based, Korea Bio Co., Korea), were sprayed before 2^{nd} release of parasitoids. Parasitism was calculated using the following equation; No. of parasitoid cocoons/(Sum of parasitoid cocoons + normal DBM or CAW pupae) x100. The last investigation was performed on 25^{th} July.

Results

The population of DBM larvae of *C. glomerata* released plots and its parasitism are given in Fig. 1. The population was 1.1 per plant at initial time, and reached peak at two weeks after release, 5.5 larvae per plant. To lower larvae density, we sprayed three kinds of organic materials. After 5^{th} release, the population density reduced to 0.5 larvae per plant. Parasitism of *C. glomerata* increased continuously reaching 60% at final investigation on 25 July. In CAW, population was relatively low in the cabbage field examined in comparison with DBM population. The population of CAW larvae of *M. mediator* released plots and its parasitism are given in Fig. 2. The initial population was 3 per 10 plants, and reached peak at two weeks after release, which showed similar tendency as DBM larvae. Also, three organic materials were treated to test plot to lower larvae density. After 5th release, the population density reduced to 3 larvae per 10 plants. Parasitism of *M. mediator* increased continuously during first three weeks, but reached 33.30% at final investigation on 25 July.

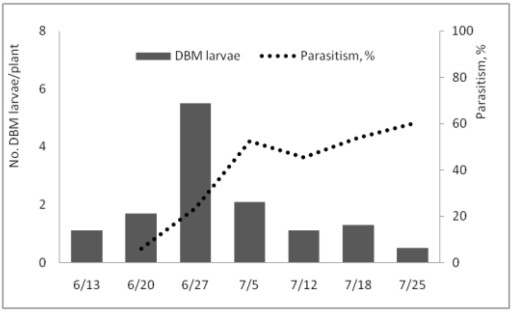

Figure 1: Population of P. xylostella larvae, and parasitism by C. glomerata in cabbage field (2,000 m2), Hongcheon, Gangwondo Province, Korea, in 2007. Totally 1,000 cocoons of C. glomerata released five times from 20 June to 18 July. Organic materials (solbichae, engsami and jinsami) sprayed on 27 June.

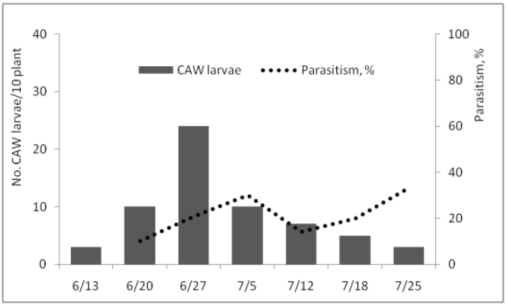

Figure 2: Population of M. brassicae larvae, and parasitism by M. mediator in cabbage field (2,000 m2), Hongcheon, Gangwondo Province, Korea, in 2007. Totally 100 cocoons of M. mediator released five times from 20 June to 18 July.

Discussion and conclusions

In this work, *C. glomerata* was chosen as a biological control agent to DBM. This parasitoid is well known for gregarious endoparasitoid to cabbage butterfly, but it can parasitize within the larvae of DBM also as a solitary larval endoparasitoid (Kwon & Lee 2004). *C. glomerata* released in the field showed a promising result against DBM with a parasitism rate of 5.9% to 60.0% (Fig. 1). This parasitoid has reared in the laboratory at Highland Agriculture Research Center, National Institute of Crop Science under Rural Development Administration (RDA), Korea, and released every year into the cabbage fields in Gangwondo Province since 2006. The parasitism rate of *C. glomerata,* less than 60% during growing period, means that DBM can be controlled using parasitoid. Actually, most of farmers need higher control efficacy around 80~90%. That's why we used three organic materials to control pests. In short, it will be recommended to use both biological control agent and organic materials simultaneously if DBM infested much higher unexpectedly. In this experiment, however, none of organic materials would have been treated if abrupt increase of DBM density did not occurred. According to guideline of organic agriculture, organic materials can be used to control disease and insect pests for the production of organic agro-produces. In 2010, 264 materials including insect natural enemies were registered as official organic materials for insect pest control by the Korean Government. In case of CAW, we applied *M. mediator*, the major parasitoid braconid that attacks CAW in Korea (Kwon & Lee 2004). As shown in Fig. 2, density of CAW larvae was too lower to estimate an effectiveness of parasitoids. Although initial parasitism was low, parasitism at harvest time showed higher, 33.3%. If inundative release of *M. mediator* will be conducted at long-term periodically every year, organic farming will continue without introducing chemicals into fields. Although these parasitoids; *C. glomerata* and *M. mediator*, gave a definite role in the management of cabbage pests, it is important to recognize that its full impact is often affected by several factors such as pest-resistant cultivars, adoption of cropping system, monitoring with sex pheromone or bait trap, as well as both safe materials and natural enemies. To perform a satisfactory integrated pest management, the enrichment of natural enemy fauna and bloom weed flora (Hickman & Wratten 1996) would be very useful strategy. Therefore, we have to make an effort to conserve natural environment around cultivating fields.

This study revealed that inundative release of parasitoids into cabbage field, where summer temperatures are relatively low due to highland region, gave a satisfactory control efficacy for the control of DBM and CAW larvae. Although CAW was incompletely controlled with the release of *M. mediator* during experiment, its parasitism increased to about 40% gradually at harvest time. We recommend organic farmers to use both biological control agent and organic material simultaneously if insect pests infested much higher unexpectedly. Field release of natural enemies should be approached with long-term strategies. Because if bio-control agents were once successfully established within agro-ecosystem, the effect could be continuous, which means less DBM density and less effort will be needed to manage pests.

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Seasonal occurrences of major insect pests and disease in organic cultivation areas of welsh onion in Central and Northern regions of Korea

Kim, D. G1, Yi, E. S.1 & Kim, S. K.[2]

Key words: Welsh onion, Organic cultivation, Liriomyza chinensis, Thrips tabaci

Abstract

This study was conducted to investigate seasonal occurrences of Liriomyza chinensis, Thrips tabaci, Spodoptera exigua, Acrolepiopsis sapporensis, and Alternaria porri in two different regions (Yeoncheon, Namyangju) and under field and greenhouse conditions in which welsh onions were cultivated. Liriomyza chinensis occurred from late May to late October, with peak occurrence in late June to early October. Thrips tabaci occurred from late May to early November under greenhouse conditions, and from early June to late October under field conditions, with peak occurrence in early June to late October. Occurrence was higher in greenhouse conditions than that of field conditions. Spodoptera exigua occurred from late May to late October with peak occurrence in late June to early August. Acrolepiopsis sapporensis occurred from late May to late October with peak occurrence in late June to late September. Alternaria porri occurred from late June to late September, with peak occurrence in early July to early September. The principal insects and disease of welsh onion occurred more frequently in the Namyangju region than in the Yeoncheon region, but the occurrence times and tendency were similar.

Introduction

Insects species which were damaging welsh onion's leaves were 13 species in 1992 (Goh et al., 1992), and were increased by 20 species in 1998 (Ahn et al., 1998). Goh et al. (1992) and Ahn et al. (1991) surveyed leaf damaging insect species to welsh onion, and their abundance was analyzed. 6 species of 13 species were identified on welsh onion. The dominant species on welsh onion which require control were *Liriomyza chinensis*, *Thrips tabaci*, *Spodoptera exigua*, and *Acrolepiopsis sapporensis*, etc. (Goh et al., 1992).

Few studies on insects and diseases of welsh onion were conducted in Korea. Most of the studies investigated *Liriomyza chinensis* on welsh onion. Studies of other insects and diseases on welsh onion were not many. First injury by *Liriomyza chinensis* was reported in 1978 noting that it occurred during all periods of welsh onion growth from seedling to harvest time in Korea (Kim and Lee, 1978). Seasonal occurrences of insects and diseases on welsh onion were not important in conventional cultivation compared to organic cultivation. It is necessary to investigate

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seasonal occurrences of the dominant insects and diseases on welsh onion for optimum timing to control insects and diseases in organic cultivation of welsh onion.

Materials and methods

Survey of seasonal occurrence of which welsh onion's dominant insects (*Liriomyza chinensis, Thrips tabaci, Spodoptera exigua, and Acrolepiopsis sapporensis*) and disease (*Alternaria porri*) was conducted during late April to early November under field and greenhouse conditions in the Yeoncheon and Namyangju regions. In 2007, the seasonal occurrences of welsh onion's dominant insects and disease were monitored in fields and greenhouses in the Yeoncheon region. In 2008, the seasonal occurrences of welsh onion's dominant insects and disease were monitored in fields and greenhouses in the Yeoncheon and Namyangju regions. Leaves damaged by *Liriomyza chinensis, Spodoptera exigua*, and *Acrolepiopsis sapporensis* were monitored and the population density of *Thrips tabaci* was calculated. Sizes of black ring spots were calculated for *Alternaria porri* occurrence.

Result and Discussion

Liriomyza chinensis occurred from late May to late October, with peak occurrence in late June to early October. According to regions, occurrence rates of *Liriomyza chinensis* were a little higher in the Namyangju region than in the Yeoncheon region, but occurrence time and tendency was similar (Fig. 1).

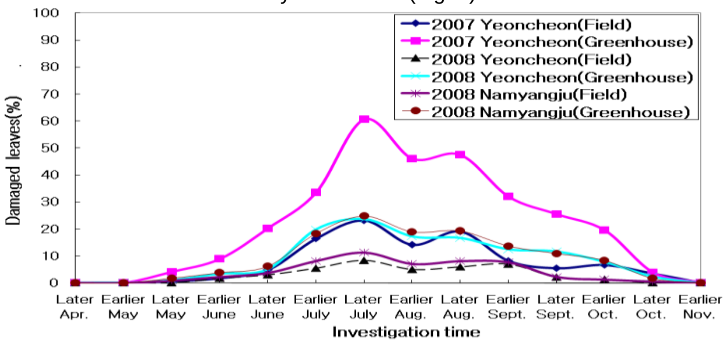

Figure 1: Seasonal changes of leaves damaged by *Liriomyza chinensis*

Thrips tabaci occurred from late May to early November in greenhouse conditions, with peak occurrence in early June to late October. The occurrence was higher in greenhouse conditions than in field conditions (Fig. 2).

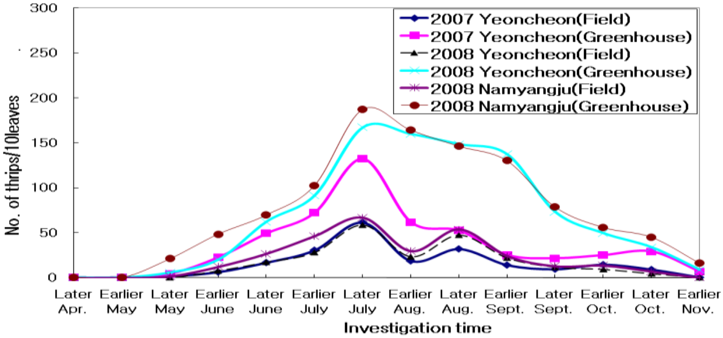

Figure 2: Seasonal changes of No. of *Thrips tabaci*

Spodoptera exigua occurred from late May to late October, with peak occurrence in late June to early August. The occurrence rates showed no significant differences in regions and seasonal occurrence in 2 years (Fig. 3).

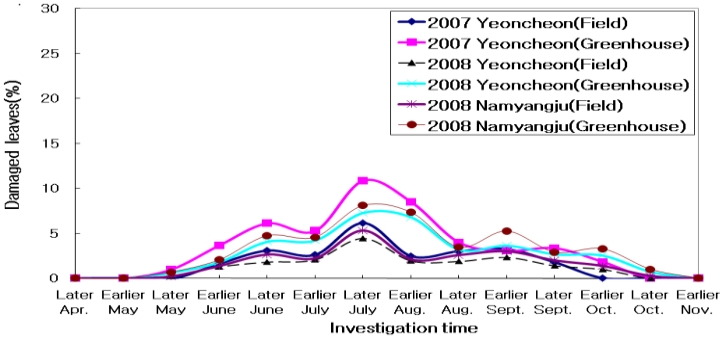

Figure 3: Seasonal changes of leaves damaged by *Spodoptera exigua*

Acrolepiopsis sapporensis occurred from late May to late October, with peak occurrence in late June to late September. The occurrence rates showed no significant differences in regions or seasonal occurrence (Fig. 4).

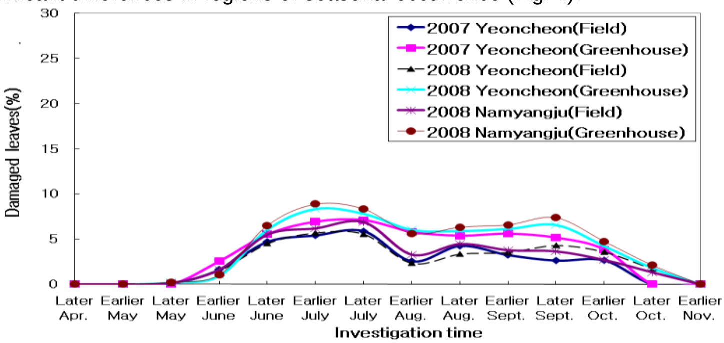

Figure 4: Seasonal changes of leaves damaged by *Acrolepiopsis sapporensis*

Alternaria porri occurred from late June to late September, with peak occurrence in early July to early September. The occurrence rates showed no significant differences in regions, but the occurrence was higher in field conditions than in greenhouse conditions (Fig. 5).

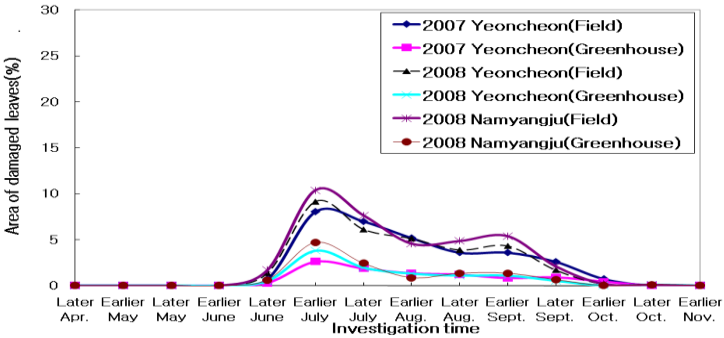

Figure 5: Seasonal changes of leaves damaged by *Alternaria porri*

Conclusions

The principal diseases and insects of welsh onion occurred more frequently in the Namyangju region than in the Yeoncheon region, but the occurrence times and tendency were similar.

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Vector competence of two aphid species, *Aphis gossypii* and *Myzus persicae*, on paprika plant

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Key words: Wing formation, *Aphis gossypii*, *Myzus persicae*, Cucumber mosaic virus, Vector competence

Abstract

Aphids respond indirectly to change of plant infected by non-persistent viruses such as Cucumber mosaic virus *(CMV). Indirect responses between two aphid vectors,* Aphis gossypii *and* Myzus persicae*, and their transmission efficiency of CMV were compared in paprika host plant; life history traits, wing formation, and transmission efficiency of CMV. The developmental time of* A. gossypii *significantly decreased on the CMV-infected plants.* A. gossypii *produced significantly more winged adults than* M. persicae*. Transmission efficiency of CMV by the winged adults of* A. gossypii *was significantly high in laboratory or greenhouse experiments. Therefore, it is suggested that indirect interaction between virus and aphid vector is more effective to transmission of virus than development of aphid species, and it may cause higher severity of CMV infection in paprika greenhouse according to dominant occurrence of* A. gossypii*.*

Introduction

The main harvest season for paprika is winter after summer sowing in greenhouse and flying aphids increase in numbers when the plants are a young stage (Sep ~ Oct) and the viral diseases follow the outbreak of aphids (Ko *et al*., 2005). Most of the occurrences and outbreaks of aphid on pepper plants are caused by *Aphis gossypii* and *Myzus persicae* in Korea (Vuong et al., 2001). These major aphid species are responsible for transmission of the non-persistent viral diseases. It is not clear, however, which of these two aphids is more worrisome as a viral vector in paprika greenhouse. This information will be provided by study about impact of viral infection on population dynamics of aphid species and vice versa. Thus, we investigated the impact that is indirect interaction between virus and aphid species for efficient and integrated management for aphid and virus.

Materials and methods

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Plants, virus and aphids

The four-five leaf stage of paprika (Capsicum annuum var. grossum) was used to maintain virus and aphids, and as test plants for bioassays. The plants were cultivated in a growth room illuminated with fluorescent light (LD 16:8 h) at 20±3 °C. For the greenhouse experiments, plants were transplanted in winter season (23.5 ±6.0 °C, 54.5±15.5 % R.H.), and used at the 7-8 leaf stage. Cucumber mosaic virus, Fny strain was used in all experiments. Virus detection in plant was determined with directed-antibody-coated enzyme-linked immunosorbent assay (DAC-ELISA) using commercial monoclonal antibodies (Clark and Bar-Joseph, 1984). The two aphid species, *Aphid gossypii* and *Myzus persicae*, used in the present study were maintained as stock colonies in cages containing virus-free paprika plants at 20±3 °C under a photoperiod of LD 16:8 h. All aphids were winged or wingless parthenogenetic virginoparae.

Performances of *A. gossypii* and *M. persicae* on paprika

Quantification of the life-cycle parameters of aphid species were conducted on paprika in greenhouse. In this experiment, the aphids' performances were investigated on healthy and virus-infected plants. Three wingless adults were placed on the 5^{th}-7^{th} true leaves of a plant and enclosed with clip cages. The aphids were removed after reproducing for 24 h, and one new-born nymph was left in the clip cage for investigation of development time.

Estimation of transmission efficiency of CMV

Consecutive transmission experiments were conducted under laboratory conditions using winged and wingless adults of the two aphid species. A group of 3 aphids was infested on a plant at a time, and transferred to total 10 plants consecutively. Virus transmission efficiency was also tested in the greenhouse. Three wingless adults were placed onto a test plant with a clip cage for 24 h.

All data were analysed statistically using SAS GLM (SAS Institute, Cary, North Carolina).

Results

Performances of *Aphis gossypii* and *Myzus persicae* on paprika

Life cycle parameters of the two aphid species were not significantly different. However, development time of *A. gossypii* was significantly short in CMV-infected plant (Tab. 1). The number of winged forms developing increased logarithmically with increasing colony size (Figure 1). Especially, *A. gossypii* produced more winged adults than *M. persicae*. However, the proportions of winged adults on healthy and CMV-infected plants were not significantly different (data omitted). Thus, CMV infection of paprika had little affected on performances of aphid except that the time to reproduction in *A. gossypii* was shorter.

Transmission efficiency of CMV

There was significant difference in transmission efficiencies of CMV between the aphid species both in laboratory and greenhouse (Tab. 2). Especially winged adult of *A. gossypii* was the most effective as virus vector. Thus, the infection rates of CMV in paprika greenhouse were estimated according to colony increase and winged form production of the two aphid species using these CMV-transmission efficiencies of each aphid form. As shown in Figure 2, the estimated values of CMV-infection rate were significantly different between the two aphid species, and increased related to increase of colony size.

Tab. 1: Life cycle parameters of A. gossypii and M. persicae on paprika in greenhouse*

Plant	Aphid species	Pre-reproductive period (days)	Fecundity (nymphs)	Longevity (days)
Healthy	A. gossypii	11.8±1.4a	87.8±19.8a	44.8±12.3a
	M. persicae	10.8±2.0ab	74.8±27.0a	35.0±16.8a
CMV-infected	A. gossypii	9.3±1.2b	82.7±23.3a	43.9±16.7a
	M. persicae	10.2±2.9ab	77.5±15.1a	34.4±11.4a

* Means followed by same letters in a column are not significantly different (P<0.05).

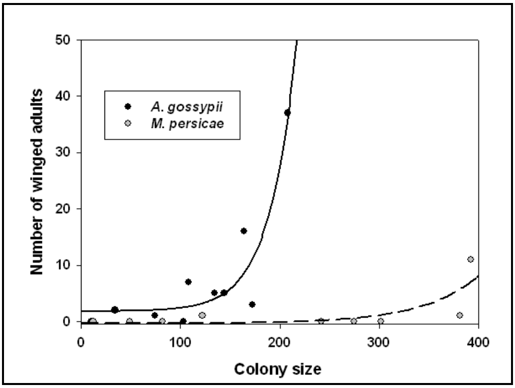

Figure 1: Number of winged adults and colony sizes developing 15 days after infestation of paprika with winged adults in greenhouse. A. gossypii (solid line: P<0.0001, R^2=0.87, n=10) and M. persicae (dash line: P=0.0082, R^2=0.66, n=10).

Tab. 2: CMV-transmission efficiencies of the two aphid species in laboratory and greenhouse

Species	Form of vector infested	Transmission (%)*	
		Laboratory	Greenhouse
A. gossypii	Winged	86.7±3.3a	-
	Wingless	53.3±8.8b	40.8±25.8a
M. persicae	Winged	53.3±3.3a	-
	Wingless	63.3±13.3ab	15.7±6.4b

* Means followed by same letters in a column are not significantly different (P<0.05).

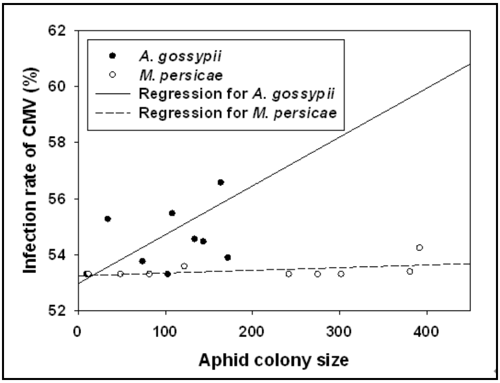

Figure 2: Estimated infection rate (%) of CMV related to colony increase of each aphid species in greenhouse.

Discussion

This study examines the biology of two colonizing aphid species and their vectoring capability for non-persistent virus disease, CMV, of paprika. The data suggest that A. gossypii is the most effective vector of CMV. More importantly, *A. gossypii* develops more rapidly winged forms than *M. persicae* (Tab. 1 & 2, Figure 1). In this study, performance and wing formation of the two aphid species are not influenced by the CMV infection of paprika except for a faster development time in *A. gossypii*. The present data will contribute to the improvement of paprika cultivation under greenhouse conditions. Most paprika is produced in the winter season, and many flying aphids are observed in autumn. However, each aphid species may differ in peak of flying period, and it is necessary to study more about the host-selection processes, seasonal occurrence and distribution pattern of the major aphid species (Powell et al., 2006; Hooks and Fereres, 2006).

Conclusions

CMV infection in paprika greenhouse may more problematic in dominant occurrence of *A. gossypii*.

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Reduction of *Cercospora Sojina* by environmentally friendly agricultural material and cultivation method

Lee, J. H.[1], Lee, Y. S., Kim, S. K. & Yi, E. S.

Key words: Soybean, Frogeye leaf spot, *Cercospora sojina*, Environmentally friendly agricultural material

Introduction

Frogeye leaf spot (*Cercospora sojina*) mainly occurs in the soybean leaf, trunk, pod, and seed, and it wreaks havoc on major centers of bean production worldwide through a massive reduction in bean output (Dashiell & Akem, 1991). Soybean yield loss due to frogeye leaf spot is estimated at 10-50% in the U.S. (Lavilolette et al*.* 1998) and over 60% in the tropical climate of Nigeria (Dashiell & Akem, 1991).

In Korea, frogeye leaf spot has not attracted enormous attention due to insufficient studies on soybean disease even though the initial outbreak was confirmed in 1928. Preventive measures against frogeye leaf spot can be classified into elimination of diseased botanical part, crop rotation (Hartwig & Edwards, 1989), vinyl mulching cultivation, utilization of resistant varieties, and chemical control. The use of resistant varieties can offer the optimal solution in some sense, but chemical control or other prevention should be undertaken in those areas where resistant varieties are not developed despite the habitual occurrence of frogeye leaf spot. However, recent expansion of organic soybean cultivation enables us to speed up the technological development in eco-friendly agricultural material and cultivation.

For further progress of environmentally friendly and organic soybean cultivation, this study aims to provide efficient countermeasures against frogeye leaf spot, a major soybean disease, through selection of eco-friendly agricultural material and cultivation methods via vinyl mulching and pinching.

Material and methods

- Outbreak of frogeye leaf spot after application of eco-friendly agricultural material

As for the screening of eco-friendly agricultural material against frogeye leaf spot, we applied four types of microbial fungicide together with Thiophanate-methyl+triflumizole (control agent), thereby investigating their hindrance against mycelial growth and the resultant disease reduction in the field (Tab. 1). In an indoor test, we covered the PDA (Potato Dextrose Agar: Potato Dextrose Broth 24.0g/L, Agar 15.0g/L) medium with eco-friendly agricultural materials, inoculated it with a conidial suspension of frogeye leaf spot (5-6×104spores/㎖), cultivated it at 25±1℃ for three days, and examined antagonistic activities against frogeye leaf spot. In a field experiment, we applied five types of agents to soybean (*Glycine max* L. Merrill) seen as a susceptible variety

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twice at intervals of 10 days during the flowering season to examine the outbreak rate of frogeye leaf spot and soybean yield (kg/10a).

Tab. 1: Application concentration by environmentally friendly agricultural material

Environmentally Friendly Agricultural Material	Dilution Multiple
Bacillus substilus	300
Cooking oil + egg yolk (egg yolk oil)	267
Bacillus vallismortis	1,000
Paenibacillus polymyxa AC-1	200
Thiophanate-methyl+triflumizole (WP)	1,000

- Outbreak of frogeye leaf spot after application of vinyl mulching and pinching

In 2007, we organically cultivated soybean (*Glycine max* L. Merrill) in a crop rotation area in Oksan-ri, Yeoncheon-gun, Gyeonggi Province, Korea. To examine the control effect of black vinyl mulching on leaf disease, we experimented on soybean according to four types of application methods: vinyl mulching and pinching, vinyl mulching, pinching, and non-treatment. As part of examination of leaf blight, we checked the outbreak rate of frogeye leaf spot every 15 days, and we checked soybean yield (kg/10a) by application type during the harvesting season.

Result and discussion

- Outbreak of frogeye leaf spot after application of eco-friendly agricultural material

We measured antagonistic activities against frogeye leaf spot based upon mycelial creation and conidial formation around three days after application of eco-friendly agricultural materials (not shown). Application of Thiophanate-methyl+triflumizole (control agent) and egg yolk oil resulted in partial occurrence of mycelium, but it recorded no mycelial growth.

Tab. 2: Antagonistic activity against frogeye leaf spot by environmentally friendly agricultural material

Environmentally Friendly Agricultural Material	Antagonism ᒧ
Bacillus substilus	+++
Cooking oil + egg yolk (Egg yolk oil)	++
Bacillus vallismortis	+
Paenibacillus polymyxa AC-1	+++
Thiophanate-methyl+triflumizole(WP)	++
Non-treatment	-

ᒧ - absence antagonism, +: feeble antagonism, ++: middle antagonism, +++: strong antagonism

Application of eco-friendly agricultural materials such as *Bacillus substilis* and *Paenibacullus polymyxa* AC-1 generated no mycelial occurrence, thereby demonstrating strong antagonism against frogeye leaf spot. Application of *Bacillus vallismortis* and the non-treatment case indicated no or low level of antagonism against frogeye leaf spot while recording mycelial growth.

The outbreak rate of frogeye leaf spot by eco-friendly agricultural material was 8.3% in the control agent, 21.0% in *Bacillus substilus*, 27.3% in *Paenibacillus polymyxa* AC-1, 28.8% in egg yolk oil (cooking oil + egg yolks), 29.4% in *Bacillus vallismortis*, and 52.9% in non-treatment. soybean yield (kg/10a) by eco-friendly agricultural material was 252.5kg/10a in Thiophanate-methyl+triflumizole, 196.8kg/10a in *Bacillus subtilus*, 181.6kg/10a in *Paenibacillus polymyxa* AC-1, 170.7kg/10a in *Bacillus vallismortis*, and 170.2kg/10a in egg yolk oil, and consequently there was no significance in eco-friendly agricultural materials (Tab. 3).

Tab. 3: Outbreak of frogeye leaf spot and bean yield by environmentally friendly agricultural material

Environmentally Friendly Agricultural Material	Outbreak Rate	Damage Rate	Yield (kg/10a)
Bacillus substilus	21.0	0.8	196.8[a]
Cooking oil + egg yolk (Egg yolk oil)	28.8	1.0	170.2[a]
Bacillus vallismortis	29.4	1.0	170.7[a]
Paenibacillus polymyxa AC-1	27.3	0.8	181.6[a]
Thiophanate-methyl+triflumizole(WP)	8.3	0.1	252.5[b]
Non-treatment	52.9	1.4	160.5[a]

※ DMRT at 5% level, means with the same letter are not significantly different.

- Outbreak of frogeye leaf spot after application of vinyl mulching and pinching

The outbreak of frogeye leaf spot by vinyl mulching and pinching was as shown in Tab. 4. Overall, vinyl mulching generated lower level of frogeye leaf spot, and application of pinching produced a slightly lower rate of frogeye leaf spot outbreak than non-application of pinching. Consequently, the combination of vinyl mulching and pinching proved effective for control of frogeye leaf spot. Vinyl mulching plus pinching also recorded the highest outcome in bean yield (207.9kg/10a), followed by vinyl mulching (192.3kg/10a), pinching (186.3kg/10a), and non-treatment (170.5kg/10a).

Tab.4: Outbreak of frogeye leaf spot and bean yield by cultivation method

Cultivation Method	Outbreak Rate	Damage Rate	Yield (kg/10a)
Pinching	35.4	2.9	186.3 [a]
Vinyl Mulching	17.6	1.5	192.3 [a]
Vinyl Mulching + Pinching	15.8	1.1	207.9 [a]
Non-treatment (Standard Culture)	55.8	3.4	170.5 [a]

※ DMRT at 5% level, means with the same letter are not significantly different.

Discussion

This study was conducted to investigate efficient and environmentally friendly control of soybean disease. In the screening of eco-friendly agricultural material, *Bacillus substilus* and *Paenibacillus polymyxa* AC-1 proved to be highly effective for control of frogeye leaf spot. In terms of cultivation methods, vinyl mulching and pinching hindered the occurrence of frogeye leaf spot. For efficient control of frogeye leaf spot in organic bean cultivation, it is necessary to perform vinyl mulching and pinching prior to the flowering season and to apply *Bacillus substilus* and *Paenibacillus polymyxa* AC-1 2 in late July, when frogeye leaf spot is expected to occur.

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A new phytostimulating treatment for Maize seeds germination

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Key words: Maize, SOP, Germination, Phytostimulation, Fertilizer

Abstract

Early sowing is an agronomical technique that is really worthwhile for corn growers, because it prolongs the vegetative cycle of the plant, even though it increases the risk of being affected by frost; Zea mais is really sensitive to chill damages, especially in the early stages of development. The aim of this study is to evaluate the efficacy of a treatment called "SQG 377" on the germination speed of Maize caryopsis, which interacts with the membrane transport systems of the vegetal cell . These products are formulated on inert materials treated with the physics based treatment SIRIO OPERATING PROCESS®, SOP, in order to grant them a stimulating action. 4 series of plastic pots were sown with two varieties of maize belonging to two different classes of precocity (FAO 400 and FAO 700) and kept in field conditions. The germination trend was evaluated by counting the number of plants that germinated in the period between May 6th –May 11th 2009. Results highlighted an accelerated germination in the thesis that received treatment with the inert material + SQG 377, anticipating germination by 24-36 hours compared to the control thesis and the one treated with a conventional fungicide product.

Introduction

Early germination stages are very critical for many maize hybrids (*Zea mais*) because of their sensibility to low temperatures. This is becoming a really important aspect with the diffusion in Europe and North America of the early sowing technique, in order to increase the harvest potential (Lyons, 1973; Graham and Patterson, 1982). Improved performance at low temperature would result in greater light interception early in the growth season and increase productivity through a timely onset of grain filling (Dugan, 1944; Iba, 2002). Moreover, the great increase in *Diabrotica virgifera* attacks made early sowing indispensabile, (Murphy *et al.,* 2010). The SQG 377 treatment uses the influence of ELF (Extremely Low Frequency) on the apical meristem system, influencing the mechanism of ion transportation of the cell membrane.The periodic movement of ions in the heterogeneous medium results in

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nonlinear effects influencing ionic strength and pH near the membrane and the release of some peripheral proteins in the water phase (Aksionov *et al.,* 2001). This mechanism enhances germination speed and root growth.

The physics based treatment SIRIO OPERATING PROCESS® (SOP) is not carried out directly on the seed or on the plants but on inert materials allowed in organic farming (used as seeds dressing) granting them a phytostimulating action. This has brought about the commercialization of a completely new generation of products for organic farming.

Materials and methods

This experimentation was aimed at comparing two varieties of maize belonging to two different classes of precocity: class 400 hybrid LG 33.9, class 700 hybrid LG AZUAGA. Both tyopes of seeds were not dressed.

The samples for each class were:

1. Undressed control
2. Dressed with inert material+SQG 377 200g/ha (recommended standard dosage)
3. Dressed with inert material+SQG 377 300 g/ha
4. Dressed with a conventional fungicide at the recommended dressing dose

Undressed seeds suitable for the use in organic farming were used for the preparation of the samples and the seeds were dressed just before they were placed in the pots.

The pots were rectangular, made of plastic and contained 20 seeds each. Their total number was 32. In order to avoid any germination differences due to the water used in the dressing, the controls were moistened in the same way as the other seeds, without, obviously, adding any product.The pots were prepared using a base of expanded clay, weighed so that there was the same amount in all of the pots, the same amount of coarse soil was placed on top of the expanded clay and the same amount of soil, which had been previously sifted through a 2 mm diameter earth sieve, was placed on top of the coarse soil. The seeds were then sown using a "mask" to guarantee the same positioning of the seeds in the pots and they were subsequently covered with a 3 cm layer of soil (by weighing) previously sifted through a 2 mm earth sieve.

The watering of the pots was carried out using a computerized tank which controls the water amount equipped with a bar which emits micro-drops so as to avoid as much as possible the formation of a surface crust. Each watering used 2.5 mm, this quantity was chosen because it fitted the field absorption capacity of the soil. The quantity of water was regulated by a rain gauge placed among the pots. The pots were positioned randomly outside, in a shady area and every day they were turned around to avoid that their position influenced emergence. After a few days, even if the distribution of the water was "micronized", it was necessary to break the (very slight) surface crust to avoid any differences impeding or modifying the results. The seeds were sown in the pots on 24th April 2009.

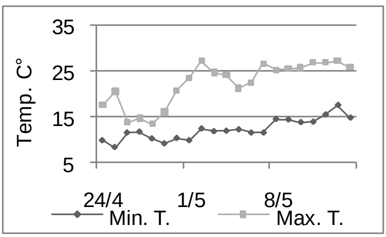

Figure 1: Weather Data in the period of Pots Trial:Temperature

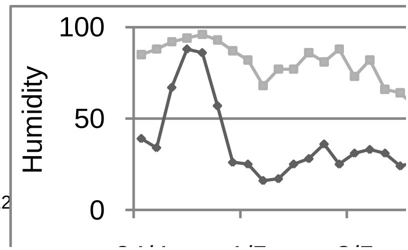

Figure 2: Weather Data in the period of Pots Trial: Humidity

Results

Table 1: Results of the Germination trial with SQG 377 treatment

Thesis	Average n. of seeds germinated class 400				Average n.of seeds germinated class 700			
	May 6th	May7th	May 9th	May 11th	May 6th	May 7th	May 9th	May 11th
1	6.3	16.5*	19.0	19.8	5.0	16.5*	18.3	19.0
2	10.8*	16.5*	17.8	19.0	12.0*	17.5*	18.0	18.0
3	8.0	17.0*	18.8	19.0	6.5	14.8*	16.5	18.5
4	1.8	5.3	10.8	17.8	1.0	3.3	8.8	15.8

* statistically significant for P< 0.05

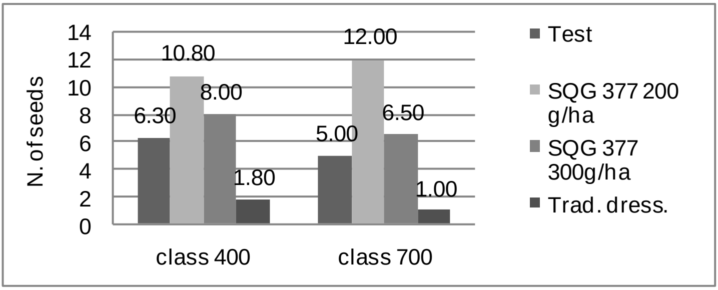

Figure 3: Emergences average at 12 days from sowing

Discussion & Conclusions

The experimental design was chosen because it is already widely used in agronomy, and it satisfied all the requirements of this experimentation. Data was elaborated using SPSS v.16, Analysis of Variance and the DUNCAN test with P<0.05 was performed. For class 400 the Duncan's test showed these differences:

May 6th , Thesis 2 performed best with *significant for P<0.05.

May 7th, Thesis 2 even if resulting the best from a statistical point of view was equalled by Thesis 3 and 1, always with *significant for P<0.05. We can say that there was no dosage/effect for SQG 377, which was attended working on the membrane system and it would be interesting to make further investigations into the molecular aspects of the biostimulation, in order to look into possible modifications of the molecular receptors on the cell membrane.

May 9th, there were no more statistical differences, even though all seeds germinated thesis 4 has 2 seeds that had not yet emerged – they emerged 2 days later.

We expected germination of Thesis 4 to be delayed in germination due to the effect of the fungicide dressing.

For class 700 the Duncan's test showed the following differences:

May 6th, Thesis 2 performed best with *significant for P<0.05 and a double number of germinated seeds.

May 7th, Thesis 2 even if resulting the best from a statistical point of view was equalled by Thesis 1 and 3 still with * significant for P<0.05.

May 9th, Differences were the same as May 7th with * significant for P<0.05 for Thesis 4. Significance, obviously, tended to decrease as time went by, until total disappearance at 7 days after emergence. Even if it was not supported by statistical evidence, a difference remained with Thesis 4 which was always the slowest to germinate. The effect of the SQG 377 treatment as germination speed enhancer on maize caryops is evident and the results obtained in this trial were further confirmed by an in vitro experimentation on Petri dishes; therefore, the advantage that this treatment can give to Maize farming due to its action of emergence enhancer can be applied to early and late sowing. In early sowing the advantages of a rapid and contemporary emergence are evident in case of Diabrotica attacks, meanwhile in late sowing a greater emergence uniformity results in a more effective exploitation of the soil humidity and consequently a greater uniformity in the maturation stage at harvesting.

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Pesticidal activity of environment friendly agricultural materials (EFAMs)

Park J.H. 1, Han E.J., Hong S.J., Ahn N.H., Kim Y.K., Jee H.J.

Key words: EFAM, pest, acaricidal activity, insecticidal activity

Abstract

Environment friendly agricultural material products (EFAMs) in current market were evaluated for their insecticidal or acaricidal activities. EFAMs were evaluated against Tetranychus urticae, Plutella xylostella, Myzus persicae and Nilaparvata lugens in spray method. Several EFAMs indicated high control value in spray method. Hatchability of T. urticae was relatively high after EFAM treatment. some materials show high insecticidal activities against P. xylostella larvae but not against eggs. Few meterials showed more than 80% insecticidal activities against M. persicae and N. lugen. The control value of more than half the materials for pest control was lower than 60%. EFAMs containing S. flavescens, neem oil and Rape showed higher control value

Introduction

Pest management is very important in organic agriculture but effective methods are not enough in organic farming. So, many organic farmers in Korea often use commercial Environment friendly agricultural materials (EFAMs). But the effect and function of EFAMs are not clear. In this study, EFAMs in current market were evaluated for their insecticidal or acaricidal activities.

Materials and methods

We procured EFAMs commercially available in Korean market and surveyed the raw materials of EFAMs. Pesticidal activity of EFAMs was evaluated against major pests in organic farming. Adults of mite (*Tetranychus urticae*), adults of aphid (*Myzus persicae*), nymph of brown plant hopper (*Nilaparvata lugens*) and larvae of diamond back moth (*Plutella xylostella*) were used in this study. These insects and mites were reared and tested under controlled condition of 25 ±1℃ and 60% relative humidity. EFAMs were diluted at recommend concentration of each product and treatment of EFAMs on insect and mite was conducted by Spray method. Test of *N. lugens* was conducted on nursery paddy in test tube and tests of *P. xylostella* and *M. persicae* were conducted on Chinese cabbage leaf on petri dish. 10 insects were used in each replicate. Test of *T. urticae* was conducted in kidney bean leaf disk on petri dish and 10 adults were placed onto each leaf disk. All treatments were triplicated.

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Table 1. Active materials in IEFAM (Insecticidal Environment Friendly Agricultural Material)

Materials	No. of products
Sophora flavescens	5
Silicic acid	1
Machine oil	1
Neem oil	7
Garlic	3
Wood vinegar	1
Pine needle	1
Rape	1
Tea	1
Chitosan	1
Yeast	1
B.T	2
Korean medicine	5
unknown	11

Table 2. Insecticidal activities of IEFAM against pests

Pests	No. of products				Total
	100 %	80-100%	60-80%	0-60%	
T. urticae	12	1	2	21	36
M. persicae	0	1	3	22	26
P. xylostella	11	1	3	22	37
N. lugens	4	3	4	22	31

Tab. 3: Insecticidal activities of IEFAMs against pests (%) in terms of materials

Materials	*T. urticae*	*M. persicae*	*P. xylostella*	*N. lugens*
S. flavescens	100.0	24.3	100.0	60.8
ilicic acid	12.0	13.5	20.6	6.7
Machine oil	-	-	100.0	26.7
Neem oil	57.9	21.7	63.1	52.7
Garlic	55.4	7.9	16.7	10.0
Wood vinegar	12.0	12.0	30.9	3.3
Pine needle	-	-	79.4	100.0
Rape	100.0	5.4	61.9	74.1
Tea	2.2	92.1	6.7	100.0
Chitosan	-	-	0	20.0
Yeast	44.6	-	20.6	13.3
BT	15.2	-	23.1	5.0
Korean medicine	31.0	32.4	16.2	55.8

Results and Discussion

Products made by *S. flavescens* (7) and Neem oil (5) are most common in EFAMs that are commercially available in Korean market. EFAMs were evaluated against *Tetranychus urticae, Plutella xylostella, Myzus persicae* and *Nilaparvata lugens* in spray method. 12 pesticidal EFAMs showed 100% acaricidal acitivity and 3 EFAMs indicated control value more than 60% by spray method. Hatchability of *T. urticae* was relatively low after EFAMs treatments. 11 prducts showed 100% insecticidal activity and 3 EFAMs indicated more than 60% control value against *P. xylostella* larvae. Eventhough the products showed high insecticidal activities against larvae, thier acitivity were low against eggs. Few meterials showed more than 80% insecticidal activities against *M. persicae* and *N. lugen.* EFAMs containing *S. flavescens*, neem oil and rape showed higher control value. More than half of EFAMs showed less than 60% of pesticidal activity against all insects and mites in this study. In many case, even some EFAMs showed high pesticidal activity against one pest, but were often ineffective to others. This result is assumed to be due to various ingredients of EFAMs which have different pesiticidal activities against different pests. Plant oils are normally effective to small sized pests such as mite. Microogarnisms like *B. thurenguensis* are insecticidal only to specific species. Some plant extracts such as *S. flavescens* have neurotoxin show pesticidal activity against broad range ofpests

Conclusions

EFAMs available in Korean market showed broad pesticidal activity against *T. urticae, P. xylostella, M. persicae* and *N. lugens.* Most of EFAMs which have no mark as pesticide showed low insecticidal activity. EFAMs for pest control often has low control value depending on pests. So when organic farmers choose EFAMs they should select appropriate products according to target pest.

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Effects of eggplant rootstocks on root-knot nematode(*Meloidogyne arenaria,* race 2.

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Key words: eggplant, *Meloidogyne arenaria*, rootstock, root-knot nematode

Abstract

Root-knot nematodes cause a significant damage on fruit yield and quality of green house growing crops. To asses the effect of eggplant rootstock, Torvum vigor', 'TaibyouVF' and 'Daitaro' were grafted on eggplants(Solanum melongena cv. Chookyang) and planted in root-knot nematode infested microplot in green house and compared their fruit yield, quality and plant growth with non-grafted control. Eggplant grafted with Torvum vigor had the highest fruit yield and top growth and followed by Daitaro. Non-grafted eggplant had lower yield but had higher root weight because of heavy root-knot nematode infection. Rootstock grafting in eggplant farming is a good alternative technique in root-knot nematode infested green houses without compromising fruit yield and can be applied instantly as organic farming practice.

Introduction

Eggplant (*Solanum melongena*) is one of main cash crops in S. Korea, as it grows in 1,000ha and annual production is more than 47,000 M/T.

Root-knot nematodes occur many green houses in southern part of Korea and among them, *M. arenaria* is a dominant species, occur in 62% of areas and followed by *M. incognita*(Cho *et. al*. 2000). In green house condition, root-knot nematodes reproduce several times and cause a significant damage to vegetable crops such as eggplant.

The influence of root-knot nematode on yield reduction and fruit quality deterioration are well studied in oriental melon (Kim, 2001a, 2001b), but in eggplant, the magnitude of damage caused by root-knot nematode was not fully studied.

Several diseases occur in eggplant, especially bacterial wilt (*Ralstonia solanacearum*) and damping off (*Pythium, Phytophtora* and *Rhizoctonia*). Some eggplant farmers are recently practicing rootstock grafting technique to minimize disease infection and promote plant growth, but the effect of rootstock grafting for the control of root-knot nematode is not described well.

So, this research reports the effect of three rootstocks in root-knot nematode infested soil in a green house.

Materials and methods

Thirty days old eggplant seedling, *Solanum melongena cv. Chookyang*, was grafted on each of three rootstock varieties: 'Torvum vigor' (*Solanum torvum, Takii &*

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Company, Japan), 'TaibyouVF' (*Solanum spp*.) and 'Daitaro'(*Solanum melongena., Takii & Company, Japan*). After 14 days of curing period, grafted plants were transplanted to microplot. Forty days old non-grafted seedling *cv. Chookyang* was transplanted at the same day as a control.

Microplots, sized 30×60×20cm (W×L×H), were filled with root-knot nematode infested soil. Initial population density of root-knot nematode in each microplot was adjusted to 10 juveniles per 100cm^3 of soil. Root-knot nematode, *Meloidogyne arenaria* (race 2), infested soils were collected from oriental melon grown green house and population density of second-stage juvenile(J2) counted by the method of Barker(1985). To estimate the multiplication of root-knot nematode, soil temperature was measured by Onset HOBO series (USA, MA) and degree days temperature was calculated based on 5℃(DD_5).

Fruits were harvested, counted and weighed for every 2 days during the harvesting season (June to October, 2008) and plant top part and root growth was measured at the end of the season.

Plots were completely randomized with 5 replicates for each treatment. Statistical analysis was performed by the Duncan's Multiple Range Test (*p*=0.05, SAS inst. USA).

Results

Soil temperature ranged between 20-30℃ during the experiment and degree days calculated ca. 1,800DD_5(Figure 1). Based on degree days, root-knot nematode could multiplied at least 3 generations(Roberts*, et. al*. 1981) which should each enough nematode population density to evaluate the effect of rootstock grafting on eggplant. Population of J2 nematodes were reached to 1,000 in 100cm^3 of soil in non-grafted eggplant microplot at the end of the experiment.

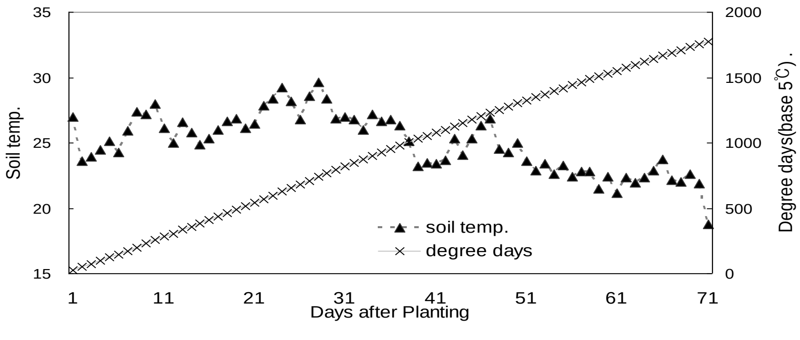

Figure 1: Soil temperature at 10cm depth and degree-days(DD_5) during the experiment(June-Oct. 2008)

All three rootstock grafted eggplant yield more than non-grafted eggplant and *Torvum vigor* grafted eggplant produced the highest yield (Table 1). There was no statistical differents among rootstock varieties(*P*=0.05). The result shows that rootstock grafting is a good practice to prevent yield loss in root-knot nematode infested soil.

Tab. 1 : Comparison of fruit yield between non-grafted and rootstock grafted eggplant *cv. Chookyang* in *Meloidogyne arenaria* infested soil.

Rootstock	Yield per plant(gram)	Yield per 10a(kg)	Yield index
non-grafted	3,923b*	3,629b*	100
Torvum vigor	6,778a	6,277a	173
TaibyouVF	5,936a	5,490a	151
Daitaro	6,175a	5,712a	157

*Values followed by the same letters are not significantly different at *P=0.05* by Duncan's multiple range test.

Tab. 2 : Comparison of plant growth between rootstock non-grafted and grafted eggplant *cv. Chookyang* in *Meloidogyne arenaria* infested soil.

Rootstock	Fresh wt.(gram)		T/R ratio**	Stem diameter (mm)
	Top	Root		
non-grafted	922b*	207a*	4.4	20a*
Torvum vigor	2,105a	90b	23.4	26a
TaibyouVF	1,718a	131b	13.1	23a
Daitaro	1,891a	124b	15.2	22a

*Values followed by the same letters are not significantly different at *P=0.05* by Duncan's multiple range test

**T/R ratio: weight of top plant/weight of root

Growths were significantly different between grafted and non-grafted eggplant. In case of non-grafted eggplant, fresh weight of top part was light but root weight was heavy compared to rootstock grafted eggplant (Table 2). So, T/R ratio was 3.0-5.3 times higher in grafted eggplant and lower in non-grafted eggplant. It means that in case of non-grafted plant, the root system is severely infected with root-knot nematode, thus heavily galled, so weighted more. As a result, growth of top part of plant was suppressed. Because galled roots were heavier than non-infected root, difference in T/R ratio clearly indicate the magnitude of root-knot nematode infection in eggplant. Eventually the poor growth of top part resulted lower fruit yield. There were significantly less number of egg mass in hairy root in rootstock varieties (data not shown). There were no differences in stem diameter between treatments.

Tab. 3 : Comparison of fruit quality and yield between rootstock non-grafted and grafted eggplant *cv. Chookyang* in root-knot nematode infested soil.

Rootstock	Yield (kg per plant)			Marketable yield per 10a(kg)	Rate of unmarketable fruit(%)
	Early**	Mid	Late		
non-grafted	1.2	1.5	1.2	2,718b*	25a*
Torvum vigor	1.3	3.2	2.2	5,398a	14b
TaibyouVF	1.5	2.8	1.6	4,501a	18b
Daitaro	1.1	2.9	2.1	4,227ab	26a

*Values followed by the same letters are not significantly different at *P=0.05* by Duncan's multiple range test

**early: June 20-July 31, mid: Aug. 01-Sep.10, late: Sep.11-Oct.20.

Non-grafted eggplant had about two times more unmarketable fruits than grafted eggplant(Table 3). In early harvesting period, fruit yield were similar among treatments. But in mid and late season, non-grafted eggplant produced markedly lower fruit yield than grafted eggplant, it as interpreted as that population density of root-knot nematode increased during the period and inhibited the development of root system.

Discussion

In Korea, most of eggplants are produced in green house condition and crop rotation is difficult because of limited land space. For farmers, root-knot nematode is a big problem because crops are continuously cultivated in green house year around. In most of the case, farmers couldn't have enough time for practicing nematode control such as water drench, crop rotation or fumigation. For organic farming, nematicides and fumigants are not allowed, so another kind of definite method is demanded. Grafting may require additional cost and time, but when farmers choose a suitable rootstock for their eggplant cultivar, grafting can be a useful technique to practice organic farming especially in root-knot nematode infested soil.

Conclusions

From this research we have evaluate the effect of rootstock grafting in root-knot nematode infested soil. In addition to the advantage of resistance to several diseases, rootstock grafted eggplant produced good yield and provide satisfactory protection from root-knot nematode. Therefore, we can propose that *Torvum vigor* rootstock grafting is recommendable for organic eggplant farming in root-knot nematode infested green house condition without use of chemicals.

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Ecology of thrips infesting oriental melon (*Cucumis melo* L.) in vinyl-greenhouse

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Key words: Injury symptom, Oriental melon, Thrips.

Abstract

Four types of injury symptom by thrips on oriental melon were observed: pale yellowing and red color exudates of petal, brown spots with silver tint on fruit surface, and leaf spot near shooting apex. Thrips did not move during the night (twenty to six o'clock) and the highest density was observed at fifteen to eighteen o'clock. Flower thrips (Frankliniella intonsa Trybom) was dominant species and blue colored sticky trap was the best to lure three species of thrips. Western flower thrips (Frankliniella Occidentalis Pergande) and flower thrips preferred male flower to female. Palm thrips (Thrips palmi Karny) was only observed at shoot apex. At 3rd survey time (May 15-30), 1,507 thrips were lured by trap and injury fruit ratio was 91.4%. Coefficient between density of thrips captured by yellow color trap and injury ratio of oriental melon fruit by thrips was 0.73374.*

Introduction

Oriental melon (Cucumis melo L. var makuwa Makino) is one of the cash crops in Korea, and transplanted during winter season (Dec.-Jan.) and grown for almost 10 months in plastic greenhouse.

In collective cultivation area of oriental melon, Seong-ju county of Korea, density of non-native harmful insects, Thrips, sweet potato whitefly (Bemisia tabaci Gonadius), and america serpentine leaf miner (Liriomyza trifolii Burgess), is gradually increasing. To properly control these insects infesting fruiting vegetables, cucumber, melon and oriental melon, to understand ecology of theirs is necessary, especially for organic farming.

Flower thrips is known as native to Korea, but western flower thrip was found in Japan in 1990 (Saeki, 1998) and observed at tangerine orchards for the first time at Jeju island of Korea in 1993 (Han et al., 1998). Three species of thrips, flower, western flower and palm thrips, are possible to inhabit on oriental melon. Flower thrips was observed on oriental melon field in 2000 (R.D.A.), and western flower and palm thrips were observed in 2001 (R.D.A.) and 2004 (Park et al.).

They are also known to have habitat selection, flower and western flower thrips prefer flower, but palm thrips mainly inhabits in leaves. Only, Injury symptom by thrips infesting on oriental melon, brown spots on fruit surface, was reported (R.D.A., 2000, 2001), and research data about thrips infesting oriental melon were restricted.

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In this study, we try to reveal symptoms of injury, incidence of thrips on oriental melon in vinyl-greenhouse, and relation between density of thrips and harvesting of marketable fruit.

Materials and methods

This experiment was conducted in a vinyl greenhouse at Seongju Fruit Vegetable Experiment Station in 2005-2007. Oriental melon (*C. melo* cv. Super-geumssaragi) seedlings grafted onto Shintozoa (*Cucurbit maxima* × *C. moschata*) rootstocks were planted at 45 cm interspacing on the last part of Jan. Collection and count of thrips were done every 2 weeks and 3 hours schedule using yellow, white and blue colored sticky trap. After collection, identification of thrips species was processed under dissecting microscope. Classification of thrips is based on body color of female, number of antennaria, absence of campaniform sensillum, and length and number of stinging hair on prothorax and near compound eyes. After collecting thrips from ten flowers, five leaves, five shoot apexes and a fruit, we made slide specimen after keeping in 70% of ethyl alcohol and classified species under dissecting microscope. Injury symptoms by thrips were frequently observed at fruit, leaves, shooting apex and flowers by naked eyes. To elucidate relation between thrips density and malformed fruit occurring, density was counted based on trap color and part of plant at harvesting time.

Results

We observed that 4 types of Injury symptoms by thrips on oriental melon. The symptoms were pale yellowing and red color exudates of petal, brown spots with sliver tint on fruit surface, and leaf spot near shooting apex. Number of thrips collected by trap color at a day was in Tab. 1. Blue trap was effective to capture thrips. Thrips did not move during the night (20-6 o'clock), it began to move in the morning (6-9 o'clock) and the highest density of thrips was observed at 15-18 o'clock.

Tab. 1: Number of thrips captured by trap colors during a day.

Trap color	Survey time (o'clock)					
	6-9	9-12	12-15	15-18	18-20	20-6
Blue	30	30	48	54	42	0
Yellow	18	30	30	30	24	0
White	8	5	9	18	19	0

Flower thrips was dominant species and blue trap was the best to lure three species of thrips in oriental melon field (Tab. 2). Total density of thrips collected from all plant part was index 100, blue trap was above 607-2,400% than total from plant. Western flower and flower thrips preferred male flower to female flower. Palm thrips was only observed at shoot apex. At leaf, we could hardly observe except western flower thrips.

Tab. 2: Comparison between capturing methods of thrips.

Classification		Density of thrips (No. of individual)					
		Western flower		Flower		Palm	
		Number	%	Number	%	Number	%
Trap	Blue	80	681	296	607	120	2,400
	Yellow	48	409	76	156	40	800
	White	8	68	28	57	26	520
Plant	Female flower	4	34	14	28	0	0
	Male flower	7	55	34	70	0	0
	Shoot apex	1	4	1	2	5	100
	Leaf	1	6	0	0	0	0
	Total	13	100	40	100	5	100

Injured fruit by thrips was begun to observe from April 12-21. At 3th survey time (May 15-30), 1,507 thrips were lured by trap and injury fruit ratio was 91.4%. At 5th, 134 thrips were captured, but injured fruit was not found (Tab. 3).

Tab. 3: Injury ratio of oriental melon fruit and thrips density during harvesting.

Survey time	Density of thrips (No. of individual)			Ratio of injury fruit
	Western flower	Flower	Total	
1st (Apr. 12-21)	182	18	200	7.4
2nd (Apr. 27-May 15)	505	16	521	53.2
3th (May 15-30)	1,485	22	1,507	91.4
4th (May 30-Jun 16)	110	58	168	6.5
5th (Jun 16-Jul. 25))	30	104	134	0
6th (Jul. 22-Aug. 9)	4	36	40	0

We observed correlation between thrips density and fruit injury as: Coefficient between thrips density captured by yellow trap and injury ratio of oriental melon fruit by thrips was 0.73374*.

Discussion

Lewis (1973) and Ananthakrishnam (1982, 1984) reported Injury symptoms by thrips, silver tint and paling of leaves, we observed similar symptoms, but from different parts of plant. Pale yellowing, red color exudates of petal and leaf spot were occurred by high density of thrips. Red color exudates of petal were plant sap leak of injured plant tissue. Similar symptom is observed at oriental melon stem, vascular and phloem tissue damaged, infected by gummy stem blight. To earlier control of thrips, it is necessary to use sticky trap, especially blue trap. In the farm field, reliance on observation by naked eyes is not a proper method. Since, thrips does not move at night and its activity was the highest at afternoon, a further study to set spray time for control should be conducted. At male flower, higher density of western flower and flower thrips was found, because pollen was known as a major food by thrips. Pale yellowing and red color exudates of petal, and brown spots on fruit surface were presumed as symptom by injuring of these species. Since, palm thrips was only found at shoot apex, leaf spot near shooting apex is presumed as symptom by its infesting.

To produce a proper marketable yield of oriental melon, a careful observation to thrips density should be taken, because 168 individuals of thrips begun to injury fruits in our study, and thrips directly injured fruits. Therefore, for economically feasible farming, we suggest that thrips density should be managed below at least 130-200 individuals per trap.

Conclusions

Thrips infesting oriental melon injured several parts of plant, petal, fruit and leaf. Petal injury by thrips is observed for the first time. We revealed that flower thrips was dominant species and thrips moved in the daytime, it can help to select control methods and set spraying schedule. Also, we found that high density of thrips injury fruit, so thrips density should be managed below 130-200 individuals per trap for economically feasible farming.

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Biological control of *Botrytis cinerea* on tomato using antagonistic bacteria

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Key words: Biological control, *Botrytis cinerea*, antagonistic bacteria

Abstract

Botrytis cinerea *infects stems and leaves of greenhouse tomatoes and can cause serious economic losses. This study was conducted to develop environment-friendly control method against tomato gray mold. Antagonistic microorganisms (bacteria) were screened for control activity against* Botrytis cinerea*, both in vitro and in vivo, using stem sections. One hundred bacterial strains were isolated from the rhizospheric soil of various plants including tomato. These strains were screened for growth inhibition of* Botrytis cinerea *on agar plate by the dual culture and thirty strains showing strongly inhibitory effect against the pathogen were selected first. Among thirty strains, JB 5-12, JB 22-2, JB 22-3, U 4-8 and U46-6 reduced significantly disease incidence, when applied simultaneously with the pathogen. These results suggested that five antagonistic bacteria strains selected have the potential to control tomato gray mold in organic farming.*

Introduction

Botrytis cinerea is a well-known plant pathogenic fungus with a wide host range that causes heavy yield losses in tomato. The fungal pathogen infects stems, flowers and fruits by direct penetration or through wounds caused by cultivation practices. Fungicides are the primary strategies to control gray mold of tomato. By contrast, chemical control may have several side effects, including the development of resistant strains and environmental contamination. Synthetic fungicides are gradually becoming ineffective. Consequently, consumer concerns and regulatory restrictions over pesticide residues on foods have emphasized the need for replacing synthetic chemicals with other methods for gray mold control. Biological control using natural antagonistic microorganisms has been extensively studied, and some fungi and bacteria have been demonstrated to be effective against gray mold. In the present paper, the objectives were to (i) survey a collection of antagonistic bacteria isolated from various origins and antagonistic bacteria strains selected for their potential

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biocontrol activity in controlling gray mold of tomatoes, and (ii) investigate the efficacy of antagonistic bacteria strains selected in reducing gray mold in tomatoes.

Materials and methods

Isolation and screening of antagonistic bacteria strains(*In vitro*)

Bacterial strains were isolated from the rhizospheric soil of various plants including tomato. All 100 bacteria strains isolated were initially screened *in vitro* to assess their antagonistic ability against *Botrytis cinerea* based on the modified methods of dual cultures. Dual cultures were started with bacteria strains and the pathogen placed 4 cm apart on PDK plates(9 cm diameter). Plates were incubated in a growth chamber at 20℃. After seven days, the inhibitory effect of antagonistic bacteria strains was evaluated considering the ability of the bacteria strains to reduce the pathogen mycelium growing.

In vivo biological control activity

The *in vivo* antifungal activity of bacterial metabolites was investigated using stem section bioassays. The method of stem section bioassay was as follows : the terminal ends of stem sections, 40mm long, were dipped to a depth of 5mm in a *Botrytis* spore suspension(1×10^5 spore/ml), and air-dried for 1-2h. The terminal ends were then dipped in a suspension of antagonistic bacteria strains. Treated sections were placed three or four per petri-dish(unmoistened) and incubated in dry sealed boxes. The stem sections were incubated in a controlled temperature incubator(15℃) without lighting. The percentage of infected stem sections was assessed after 11-15 days.

Identification of antagonistic bacteria strains

Antagonistic bacteria strains were identified by PCR amplification and partial sequencing of the 16s ribosomal DNA(rDNA), using the primers 8F and 1492R.

Results

Screening of antagonistic bacteria strains(*In vitro*)

One hundred bacterial strains were screened for growth inhibition of *Botrytis cinerea* on agar plate by the dual culture and thirty strains showing strongly inhibitory effect against the pathogen were selected first(data not shown).

In vivo biological control activity

Among thirty strains, JB 5-12, JB 22-2, JB 22-3, U 4-8 and U46-6 reduced significantly disease incidence, when applied simultaneously with the pathogen. (Tab. 1).

Tab. 1: Effect of Antagonistic bacteria on *Botrytis cinerea* using stem section bioassays.

Bacteria strains	Disease incidence (%) original suspension	10× dilution suspension	100×dilution suspension	original suspension density(cfu/ml)
B 5-12	0	0	0	5.0×10^7
JB 2-9	5.6	66.7	66.7	7.5×10^6
JB 8-8	0	66.7	77.8	2.8×10^7
JB 22-2	0	0	5.6	1.2×10^8
JB 4-7	11.1	55.6	44.4	1.2×10^7
JB 24-11	0	55.6	50.0	3.1×10^7
JB 37-2	27.8	61.1	61.1	3.1×10^7
JB 22-1	27.8	44.4	66.7	2.1×10^7
JB 11-8	0	88.9	77.8	2.1×10^7
JB 23-5	0	11.1	33.3	9.7×10^7
JB 24-5	27.8	50.0	77.8	2.6×10^7
JB 8-11	27.8	77.8	55.6	1.2×10^7
JB 22-3	0	0	0	1.8×10^7
JB 5-2	22.2	77.8	72.2	4.2×10^6
88-7-2	0	88.9	72.2	1.3×10^7
U 46-6	0	0	0	3.5×10^7
NH 31-5	5.6	61.1	66.7	1.1×10^6
U 4-8	0	0	0	5.8×10^7
EH 23-5	5.6	27.8	77.8	2.5×10^7
Y 6-5	0	38.9	66.7	9.7×10^7
K 39-10	0	50.0	66.7	1.9×10^7
MH 40-2	0	88.9	55.6	2.6×10^7
KH 38-1	0	27.8	77.8	4.0×10^7
KH 32-6	0	61.1	50.0	3.2×10^7
CNB-2	0	27.7	22.2	4.1×10^7
CNB-3	16.7	38.8	88.8	4.1×10^7
OMC	0	44.3	55.5	2.4×10^7
EHR	0	50.0	72.2	7.6×10^7
SEC	0	61.0	66.7	3.2×10^7
SEB	16.7	27.7	50.0	8.5×10^7
fungicide	0			
control	88.9			

Identification of antagonistic bacteria strains

According to 16S rDNA sequence data, five antagonistic bacterial strains were identified as *Pseudomonas chlororaphis, Pseudomonas* sp., *Bacillus amyloliquefaciens, Pseudomonas fluorescens, Streptomyces* sp.(Tab. 2).

Tab. 2: Identification of five antagonistic bacterial strains against *Botrytis cinerea* according to the Sequence similarity of 16S rDNA

strains	Identification	Similarity(%)
JB 5-12	*Pseudomonas chlororaphis* subsp. *aurantiaca*	99
JB 22-2	*Pseudomonas* sp.	99
JB 22-3	*Bacillus amyloliquefaciens*	99
U 46-6	*Pseudomonas fluorescens*	99
U 4-8	*Streptomyces* sp.	99

Discussion

Biological control has been considered as one of most promising alternatives to chemical fungicides, which employs antagonistic bacteria to protect fruits and vegetables from infection by phytopathogens. In this study, we isolated and identified three *Pseudomonas* sp. strains, one *Bacillus amyloliquefaciens,* one *Streptomyces* sp. from the rhizospheric soil of various plants. *In vitro* activity analysis indicated that these strains produced diffusible antifungal compounds. The stem section bioassay demonstrates the ability of five antagonistic bacterial strains(JB 5-12, JB 22-2, JB 22-3, U 46-6, U 4-8) to control *Botrytis* infecting wounded stem tissue. Also, five antagonistic bacterial strains maintained strongly inhibitory effect against *Botrytis cinerea* at 100 time dilution suspension. These results indicate that five antagonistic bacteria strains selected could be developed as microbial agents for the control of Botrytis diseases. Accordingly, further studies are required for mass-production and formulation for commercialization.

Conclusions

Our data showed that five antagonistic bacterial strains had potential biocontrol activity against gray mold caused by *Botrytis cinerea* in tomato.

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Attractiveness of agricultural insect pests to solar traps with different colour lights

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Key words: Insect pests, Solar trap, Color lights, Attraction

Abstract

This study was conducted to investigate the effect of different light lamps by solar trap. which solar energy turned into electric energy using two small solar panels. The experiment was conducted in 2010 at the cereal crop fields of the Department of Functional Crop, National Institute of Crop Science, Milyang, Korea. Classified positive phototaxis agricultural insect pests were moths, leaf hoppers, plant hoppers, stink bugs, beetles and weevils. Moths such as common cutworm, Spodoptera litura Fabricius, beet armyworm, Spodoptera exigua Hubner, and oriental tobacco cutworm, Heliothis assulta Guenee were most attracted to blue light black (BLB) lamp, followed by blue light and white light lamp. Green leaf hopper, Nephotettix cincticeps Uhler, was clearly most attracted to BLB lamp, followed by white light lamp, light converting lamp, green light lamp, electric incandescent bulb and blue light lamp. Stink bugs such as bean bug, Riptortus pedestris Fabricius, sloe bug, Dolycoris baccarum Linnaeus, one-banded stink bug, Piezodorus hybneri Gmelin, sorghum plant bug, Stenotus rubrobittatus Matsumura and etc. were also most attracted to BLB lamp, followed by blue light, white light and red light lamp. Lastly, plant hopper, weevils and beetles were also attracted to BLB lamp significantly. Therefore, BLB lamp was most effective to mass attraction of various agro-insect pests in agricultural fields.

Introduction

The ultimate resource of farmers in order to control insect pests of agricultural crops is mainly the use of chemical pesticides. This control strategy is environmentally hazardous and highly toxic chemical pesticides are being added in the agro-ecosystem (Burkett *et al*., 1998; Ashfaq *et al*., 2005). Giving attention to such non-chemical insect pests control technologies is a promising one (Beerwinkle, 2001). In Western countries, light traps have been successfully used against house hold pests and this technology could be adapted in agriculture to control agricultural insect pests. Investigating the phototaxis of insects to different light colours and photo wave-lengths is a promising technology which is ecologically sound and environmentally friendly management strategies of agricultural insect pests (Jessica & Curis, 2001). Flying agricultural insect pests having positive phototaxis can be effectively controlled by using solar trap. However, such trap required with species-specific lamp and light-emitting diode as cited by Chu *et al.* (2004). Hence, this study tried to benchmark

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information on the photoreceptor ability and identifying the phototactic responses influenced by certain different light colours of solar lamp.

Materials and methods

Experimental area and target insect pests: Solar traps were installed at the functional cereal crops area (Fig.1). Tested leguminous crops were foxtail millet, millet and sorghum at the department of functional crop, National Institute of Crop Science, RDA, Milyang, Korea. The study was conducted early part of August to late October, 2010. Different light colored lamps and pheromones were used to mass trap moths and stink bugs to determine the photoreceptor ability and phototactic ability. Positive phototaxis trapped insect pests were observed for quantitatively and qualitatively every 5-day interval.

Light color lamps, pheromones and solar trap: Solar trap equipped with light sensor, rain sensor, temperature sensor, auto-controlled system and electric fan was operated by DC 12 voltage charged with 2 solar panels. Light lamps (DC 5W) were lighted from started from 20:00 to 06:00 PM. A total 7 light lamps were used in the experiment. These includes 6 different light colour lamps such as blue, green, red, yellow, white and blue light black (BLB) and 1 converting light lamp in which light emitted colour was changed from one colour to other colour ranging from blue, green, red, yellow and white light every 5 seconds. Aggregation pheromones were also such as E2-hexenyl-Z3-hexenoate, E2-hexenyl-E2-hexenoate, myristyl isobutyrate, octadecylisobutyrate and E2-hexenyl-E2-hexenoate for *Riptortus pedestris* and *Piezodorus hybneri, respectively*. Sex pheromones that were used: Z9,E12-14:AC:Z9-14:OH:Z11-16:AC, Z9,E11-14AC:Z9,E12-14:AC, Z9-16:Al:Z11-16:Al:Z9-16:Ac to attracts *Spodoptera exigua*, *S. litura* and *Helicoverpa assulta*, respectively. The above pheromones were used determine species-specific attraction of insects. Trapped insects attracted in the collecting net of solar trap were classified into each order, group and species (Fig. 2).

Fig.1 Photographs of developed solar traps equipped with different light colours established at the cereal crop fields

Fig. 2. Photographs of collected insect pests by solar traps equipped with different light colours established at the cereal crop fields.

Results

Significant and promising results were obtained from the study. Insects were identified according to species and the average numbers of collected insects were observed. Highest attraction of agricultural insect pests such as moths, stink bugs, leaf/plant hoppers, weevils and beetles were observed in the blue light black (BLB) lamp solar trap. Identified insects which were positive phototaxis were moths, leaf hoppers, plant hoppers, stink bugs, beetles and weevils. Moths such as common cutworm, *Spodoptera litura* Fabricius, beet armyworm, *Spodoptera* exigua Hubner, and oriental tobacco cutworm, *Heliothis assulta* Guenee were most attracted to blue light black (BLB) lamp, followed by blue light and white light lamp. Green leaf hopper, *Nephotettix cincticeps* Uhler, was clearly most attracted to BLB lamp, followed by white light lamp, light converting lamp, green light lamp, electric incandescent bulb and blue light lamp. Stink bugs such as bean bug, *Riptortus pedestris* Fabricius, sloe bug, *Dolycoris baccarum* Linnaeus, one-banded stink bug, *Piezodorus hybneri* Gmelin, sorghum plant bug, *Stenotus rubrobittatus* Matsumura and etc. were also attracted to BLB lamp followed by blue light, white light and red light lamp. Lastly, plant hopper, weevils and beetles were also most attracted to BLB lamp significantly. Therefore, BLB lamp was most effective to mass attraction of various agro-insect pests in agricultural fields. There was an increase attraction of stink bugs to BLB light by 12% when BLB solar lamp was equipped with aggregation pheromone.

Conclusions

The results derived from the study proved that insect pests such as moths, stink bugs, leaf/plant hoppers, weevils and beetles are positive phototaxis because they responded well to BLB solar lamp trap. It means that these insects were positively responded to BLB light. These insects were classified as positively phototaxis-insects. Mass trapping of the above insects therefore is effective on this type of color light. Significant interaction effects of BLB solar lamp with aggregate pheromones were highly effective because of its increase efficiency to trap more flying insects. Therefore, effectiveness of BLB solar lamp increases if it is combined with the use of such pheromones. The experiment further recommends the detection of photo-wavelength to determine which insects are species-specific.

Acknowledgments

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Control effect of soil solarisation on soil-borne disease in greenhouse

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Keywords: Soil-borne disease, Lettuce, Fusarium wilt, Soil solarisation

Abstract

This experiment was conducted from 1999 to 2001 to determine the control effect of soil solarisation on Fusarium wilt affecting lettuce cultivated in Hanam, Gyeonggi Province. Soil solarisation after the rainy season is the most effective method to control soil-borne diseases. The control effect on Fusarium wilt was maintained until April of the following year. The required solarisation period was more than 35 days before rainy season and 25 days after rainy season. The possible solarisation timing was estimated to be higher 24oC at 10cm underground. Accumulated soil temperature higher than 41oC at 10cm underground could be estimated by measuring the average temperature of soil at 10cm underground and the duration of sunshine.

Introduction

Detrimental factors in vegetable productivity include poor physical properties of soil, growth deterrent, salinization, and expansion of soil pathogens due to regional clustering and consecutive cultivation. In particular, soil pathogen is the biggest buffer against crop productivity, and that is why numerous studies have been long focused on soil pathogens. Various soil bone pests can be controlled is related to the intensity, depth, and duration of soil temperature. Studies of soil solarisation are currently under way to mulch the soil with a transparent polyethylene film for extermination or control of soil pathogens, thereby ensuring effective and long duration of solar heat. If the soil is mulched with a polyethylene film (0.03mm) after sufficient irrigation and the soil temperature rises accordingly, it can exert sterilizing effect of 94-100% on soil up to 5 cm underground and 54-63% on soil up to 25cm underground against *Verticillium dahliae and Fusarium oxysporum* f.sp. *lycopersici* (Kartan et al., 1976). In strawberry cultivation, polyethylene film mulching can exterminate *Fusarium oxysporum* f.sp. *fragariae* at 45oC in 6 days and at 50oC in 2 days, and at 55oC in 12 hours, and it can prevent the outbreak of Fusarium wilt among strawberries and watermelons during summer season provided that a greenhouse is tightly closed for two weeks (Kodama et al., 1979). Against this backdrop, this experiment was conducted to gauge the possibility and suitability of soil solarisation in *Gyeonggi Province.*

Materials and methods

For analysis of control effect of soil solarisation on Fusarium wilt, we experimented with greenhouse lettuce under consecutive cultivation in Mangwol-dong, Hanam-si, Gyeonggi Province, plagued by lettuce Fusarium wilt from 1999 to 2000. To identify

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the control effect of soil solarisation by period, we applied soil solarisation for 30 days in spring (Apr. 21-May 20, 1999), 30 days before the rainy season (Jun. 5-Jul. 4, 1999), 31 days after rainy season (Jul. 21-Aug. 20, 1999), and 32 days in autumn (Sep. 5-Oct. 6, 1999). In each application, we followed the soil solarisation method tested by Kodama, and organic farming-based soil solarisation pursuant to the Korea Organic Farming Association's recommendations. Soil solarisation was combined with organic materials with rice straw 500 kg per 10a or animal compost 3,000kg per 10a. We experimented with red curled lettuce. We measured soil temperature via an unmanned automatic meteorological instrument (CR10, Campbell) at 10cm underground at the center of each treatment plot prior to the vinyl covering after the furrowing, and via a temperature sensor that was built at the height of 1.5m inside the greenhouse. We collected soil samples right before and after soil solarisation to gauge the density of *Fusarium* sp., and we looked into the aggregate of fungi per 1g of soil via the Komada medium. We checked the outbreak of lettuce Fusarium wilt and lettuce yield during the harvesting period.

Results and discussion

We classified soil solarization periods into four types to identify the optimal timing of soil solarization, and recorded the resultant change in soil temperature as shown in Fig. 1.

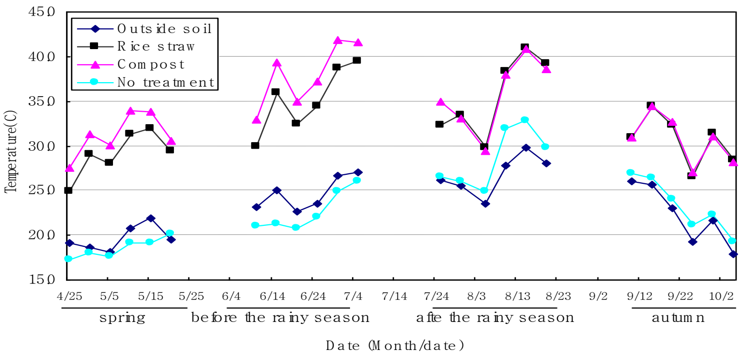

Figure 1: Soil temperature change at 10cm underground by soil solarization period

The underground soil temperature went up during soil solarization in spring, before rainy season, and after rainy season, whereas it declined during soil solarization in autumn. Both in spring and before rainy season, organic farming-based soil solarization resulted in higher underground soil temperature than soil solarization via rice straw because additional heat was generated by the decomposition of soil micro-organisms inside cow dung and pig manure in organic farming-based soil solarization. As shown in Tab. 1, Fusarium oxysporum could be exterminated at temperature of 41°C or more, and it took 84 hours to kill Fusarium oxysporum at 41°C. But, it took 3 days to kill these pathogens at 45°C, which was the same as 3 days reported by Kodama but shorter than 7 days mentioned by Ki, K. U.

Tab. 1: Temperature and time for extermination of pathogen for lettuce Fusarium wilt (Fusarium oxysporum)

Temperature (^oC)	39	41	45	48	51
Time to death (Hour, day)		84h (3.5 days)	72hr (3 days)	48hr (2 days)	24hr (1 day)

Fig. 2 shows the duration of soil temperature above 41^{o}C, the minimum temperature for extermination of *Fusarium oxysporum*. Organic farming-based soil solarization rich in compost recorded longer duration than soil solarization via rice straw, so its duration above 41^{o}C also amounted to 171 hours in spring. Soil solarization via rice straw posted longer duration after rainy season than before rainy season. This was attributable to a steady rise in the underground soil temperature driven by a high temperature and abundant solar radiation after rainy season.

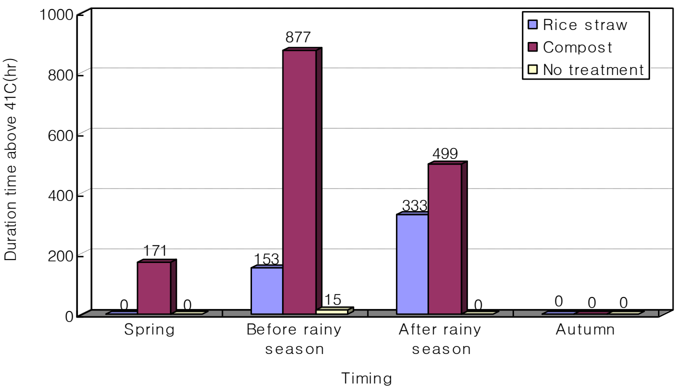

Figure 2: Duration of underground soil temperature above 41^{o}C during solar soil solarization

We analyzed *Fusarium oxysporum* density, the outbreak of lettuce Fusarium wilt, and lettuce yield. Not only soil solarization via rice straw but also soil solarization via compost completely exterminated *Fusarium oxysporum* as shown in Tab. 2. However, rice straw-based soil solarization recorded less outbreak of Fusarium wilt and higher level of lettuce yield than also soil solarization via compost. In soil solarization via compost, organic matters like compost promoted pathogenic intrusion and lower total output through deterioration of chemical properties of soil.

Tab. 2: Control effect of soil solarization after rainy season on lettuce Fusarium wilt and lettuce yield

Treatment	Density of *F.oxysporum*		Disease severity		Lettuce yield (kg/10a)
	Before heating (CFU)	After heating (CFU)	Diseased plants (%)	Dead plants (%)	
Rice straw Soil S.	9.0×10^3	0×10^3	8.9	0	1,412
Compost Soil S.	20.0×10^3	0×10^3	21.9	3.3	1,262
No treatment	14.0×10^3	25.3×10^3	100	100	0

Conclusions

To examine the control effect of soil solarisation on lettuce *Fusarium* wilt recently prevalent in consecutive cultivation areas, we undertook an experiment at a farmhouse in Hanam-si, Gyeonggi Province from 1999 through 2001. The underground soil temperature rose during soil solarization in spring, before the rainy season, and after the rainy season, whereas it tended to decrease during soil solarization in autumn. Organic farming-based soil solarization in spring and before rainy season resulted in higher underground soil temperature than soil solarization via rice straw. *Fusarium oxysporum* could be exterminated at temperature of 41^{o}C or above, and it took 84 hours to kill *Fusarium oxysporum* at 41^{o}C. Soil solarisation via rice straw and soil solarization via compost after rainy season led to complete extermination of *Fusarium oxysporum*, but rice straw-based soil solarisation showed less outbreak of Fusarium wilt. Rice straw-based soil solarisation generated higher lettuce yield than organic farming-based soil solarisation.

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Insecticidal activities of plant extracts against *Tetranychus urticae*

Lee, G. Y.[1], Han, Y. H.[1], Soh, H. S.[1], Lee, H. J.[1] & Kim, S. K.[1]

Key words: Plant extract, *Tetranchus urticae*, Insecticidal activity

Abstract

To find an alternative for synthetic pesticides, methanol extracts from 69 plant samples were tested for their insecticidal activity against two spotted mite (Tetranchus urticae Koch). Seven plant extracts including Angelica japonica showed over 80% insecticidal activity at 5000 mg/L. Extract of Prunus armeniaca seed showed high insecticidal activity at 3000 mg/L. As a naturally occurring pesticide, P. armeniaca could be useful as a new botanic insecticide.

Introduction

Generally, controls of insects are dependent on the application of synthetic pesticides. However, application of a synthetic pesticide may cause environmental pollution and also increase pesticide resistance among insects. Using bio-pesticides on plants would be better in terms of being more environmentally safe. Many researchers have been focusing on using plant extracts to develop bio-pesticides and some, such as *Sophora flavescens* and *Azadirachta indica*, have already been developed and used. Two spotted mite (*Tetranchus urticae* Koch) is a destructive pest of crops throughout the world and can cause damage to vegetables and fruit trees. To find an alternative pesticide, methanol extracts from plants samples were tested for their insecticidal activity against this particular insect.

Materials and methods

Plant materials and sample preparation

Plant samples were dried in the shade, and then ground into powder by using a mill. They were extracted with methanol for 48 hrs at room temperature and then concentrated using a rotary evaporator at 40 °C

Insecticidal activity assay on two-spotted *T. urticae*

The insecticidal activities of plant extracts against *T. urticae* were tested on bean (*Phaseolus vulgaris*) seedlings. Leaves of bean grown in greenhouse were collected, and a disk (2 cm diam.) was taken from each leaf. Twenty female adults specimen of *T. urticae* were placed onto the leaf disks in petri dishes. Three leaf disks were sprayed with the solution for 30 sec. After evaporation in a hood for 2 hrs, each petri dish was held in a room at 25±2 °C, under 50-60% RH, and a photoperiod of 16:8 (light/dark).

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The plant extracts were dissolved in 5% methanol and suspended in distilled water containing triton X-100 at a concentration of 250 μg/ml. Insecticidal activities were applied with three replicates per treatment.

Results

The plants were selected according to relevant literature. Firstly, the plant extracts were tested at a concentration of 5000 mg/L for *T. urticae*. Insecticidal activities of the plant extracts are shown in Tab. 1. Methanol extracts of *Prunus armeniaca*, *Angelica japonica*, *Artemisia apiacea*, *Trichosanthes kirilowii*, *Astragalus membranaceus*, *Cibotium barometz*, and *Viola manshurica* showed over 80% insecticidal activities on *T. urticae*. Furthermore at 3000 mg/L, insecticidal activities of most plant extracts were decreased (Tab. 2). But *P. armeniaca* extract showed above 80% insecticidal activity on *T. urticae*. Even though the yield of hexane extracts was high, insecticidal activity of the hexane extract was significantly lower than that of methanol extract. More detailed study is necessary for solubility of hexane extract. The control effect in extract of *P. armeniaca* seed was 59.5% in field (data is not shown).

Discussion

In a preliminary test, a concentration of 5000 mg/L of plant extract did not cause any problem, such as solubility and contamination for microorganism (Ahn, 1992). In bioassay with methanol extracts from plant samples, the efficacy varied with plant species. In the laboratory study with methanol extracts, the responses also varied with plant species. Park et al. (2002) pointed out that the most promising botanicals as bio pesticides for anthropod pests are *Zanthoxylum piperitum*. Also Lee (2000) reported that the extracts of *Oryza sativar*, *Panicum milaceum*, *Setaria italic*, and *Sorghum bicolor* showed insecticidal activity against *T. urticae*. In this study, the extract of *P. armeniaca* seed showed significant insecticidal activity among plant tested. The seed of apricot has been reported to be medically effective as an anticancer substance (Park et al., 2002). There are many compounds such as terpenoid, phenolics, and alkaloids in plants. These compounds contribute to biological activities. Further studies are needed to identify active compounds from plants.

Conclusions

This study was to find an alternative to synthetic pesticides from plants. The methanol extract of *P. armeniaca* seed showed strong insecticidal activities against *T. urticae* among plants tested.

Tab. 1: Insecticidal activities of plant extracts against *T. urticae* when applied at 5000 mg/L

Scientific name	Mortality (%)		Scientific name	Mortality (%)	
	24hr	48hr		24hr	48hr
Agrimonia pilosa	15.1	18.7	Paeonia aliflora	44.0	50.4
Aiasarum sieboldii	63.7	64.0	Paeonia lactiflora	15.9	21.6
Ailanthus altissima	29.9	55.7	Paeonia moutan	10.9	16.7
Albizzia julibrissin	33.3	34.8	Pharbitis nil	34.7	39.6
Allium ascalonicum	58.1	61.1	Picrasma quassioides	4.7	10.4
Allium senescens	48.4	57.7	Pinus densiflora	6.5	8.7
Allium tuberosum	64.3	71.8	Plantago asiatica .	50.7	55.9
Angelica japonica	89.9	95.4	Polygala japonica	44.8	50.4
Angelica koreana	33.2	46.7	Polygonum aviculare	32.1	41.5
Ardisia japonica	63.4	75.6	Polygonum cuspidatum	12.6	17.6
Areca catechu	71.6	71.1	Portulaca oleracea	69.0	64.9
Artemisia apiacea	80.2	80.0	Prunella vulgaris	68.1	77.9
Artemisia iwayomogi	34.7	37.9	Prunus armeniaca	61.4	81.6
Astragalus membranaceus	79.3	89.3	Pteridium aquilinum	66.2	67.2
Carpesium abrotanoides	42.4	58.8	Punica granatum	23.5	26.0
Cassia obtusifolia	26.1	49.1	Quisqualis indica	60.7	59.6
Chenopodium album	75.4	76.1	Rhus verniciflua	40.7	50.2
Cibotium barometz	86.7	89.5	Ricinus communis	18.1	28.0
Cinnamomum cassia	11.1	11.8	Rosa multiflora	7.0	16.0
Cirsium japonicum	65.8	65.4	Sambudus williamsii	67.7	72.0
Coix lachryma-jobi	39.9	64.7	Sanguisorba officinalis	11.7	26.7
Cucurbita pepo	52.2	66.8	Sedum sarmentosum	44.7	54.8
Dioscorea tokora	51.3	52.6	Sophora angustifolia	20.1	31.1
Dryopteris crassirhizoma	35.4	42.6	Sorbus commixta	16.6	20.1
Eriobotrya japonica	16.3	25.3	Spirodela polyrhiza	74.4	73.7
Evodia officinalis	37.5	37.6	Stemona japonica	41.0	39.6
Geranium nepalense	75.0	77.6	Syzygium aromaticum	18.8	33.4
Ginkgo biloba	13.1	20.3	Taraxacum platycarpum	70.0	78.2
Kochia scoparia	64.6	77.0	Thalictrum aquilegifolium	16.6	22.3
Lonicera japonica	61.3	46.3	Trichosanthes kirilowii	65.6	98.2
Lycopus lucidus	67.8	73.3	Ulmus davidiana	16.5	25.4
Melia azedrach	35.4	46.3	Viola mandshurica	86.9	89.7
Melia azedrach	19.3	26.7	Zanthoxylum piper	23.3	34.1
Momordica charantin	53.2	53.1			

Tab. 2: Insecticidal activities of plant extracts against *T. urticae* when applied at 3000mg/L

Scientific name	Mortality (%)		Scientific name	Mortality (%)	
	24hr	48hr		24hr	48hr
Aiasarum sieboldii	26.3	26.4	Cucurbita pepo	21.0	39.4
Allium ascalonicum	12.6	20.9	Geranium nepalense	22.4	27.3
Allium tuberosum	6.8	10.1	Kochia scoparia	45.8	71.1
Angelica japonica	15.3	20.9	Lycopus lucidus	11.3	18.6
Ardisia japonica	10.3	15.2	Portulaca oleracea .	49.7	45.4
Areca catechu	14.5	21.2	Prunella vulgaris	35.7	47.1
Artemisia apiacea	10.4	18.0	Prunus armeniaca	50.5	81.9
Astragalus membranaceus	16.0	23.3	Sambudus williamsii	22.6	29.5
Chenopodium album	47.5	49.1	Spirodela polyrhiza	67.7	75.0
Cibotium barometz	52.9	64.2	Taraxacum platycarpum	32.5	42.7
Cibotium barometz	43.5	50.8	Trichosanthes kirilowii	45.2	49.1
Coix lachryma	7.0	15.1	Viola mandshurica	44.5	65.1

Tab. 3: Insecticidal activities of *P. ameniaca* extracts against *T. urticae* depending on extraction solvent

Extraction solvent	Conc. (mg/L)	Mortality (%)		Yield (%)z
		24hr	48hr	
Methanol	3,000	66.5	81.3 a	3.3
	1,500	51.4	61.1 a	
n-Hexane	3,000	22.3	27.4 b	48.8
	1,500	3.2	15.8 b	

Z (D.W. of solvent extract/D.W. of the sample)*100.

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Control efficacy of diluted seawater against powdery mildew and armyworm

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Key words: Seawater agriculture, Pest management, Control efficacy, Salinity stress

Abstract

*For evaluation of control efficacy of diluted seawater against pest and disease in traditional and local agricultural techniques, we investigated effect of diluted saline water from seawater or bay salt solution (NaCl 3.3%) to control powdery mildew (*Leveillula taurica*) on pepper and armyworm (*Spodoptera exigua*) on green onion. Seawater spraying at weekly intervals was conducted over 1 month after the beginning of pathogen infection on pepper and 3 month after transplanting of green onion in field. As a result, conidial production of* L. taurica *on pepper leaf surface was decreased over 52.6-73.9% on leaves treated with 20-30 times diluted saline water compared to water treatment. However, salinity stress in 20 time- diluted saline water caused damage to pepper leaves.* S. exigua *on green onion was controlled preventively with seawater spraying. It was caused by high mortality of egg and 1st larvae of* S. exigua*. Thus, periodically continuous treatment of seawater may cause significantly high control efficacy to* S. exigua *laying eggs on leaf surface of onion.*

Introduction

Saline agriculture or seawater agriculture has been developed dramatically since the first suggestion of seawater irrigation by H. Boyko in 1966 (Pasternak et al., 1985). For this over 2600 halophytes were collected and listed for development of novel crops tolerant to saline stress (Lieth & Mochtchenko, 2003). However, most soil environment of Korea is not contaminated with saline water, and seawater agriculture has not been recognized as main technology that has to be developed. Even though minor interests on seawater agriculture in Korea, many traditional organic farmers have used seawater for natural manure supplying microelements or as pest control agent (RDA, 1997) and seawater, as natural resource, is allowed in Korean organic agriculture. Therefore, it is important to verify scientifically the safety and pest control efficacy of seawater treatment. In this study we test the control efficacy of seawater treatment against fungal pathogen, powdery mildew, and insect pest, armyworm.

Materials and methods

Test Crops and Pests

Pepper and green onion was used as test plants because these are one of the most economic vegetables in Korea, and especially allium plants such as green onion are applied with saline water traditionally in Korea. *Leveillula taurica* on pepper plant and *Spodoptera exigua* on green onion were tested.

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Spraying seawater and diluted saline water

For bioassay, occurrence of pests were monitored after transplanting in field plots, and diluted saline water from seawater or bay salt solution (NaCl 3.3%) were treated at the beginning of infection. Seawater or bay salt solution were diluted as x10 (EC 8.0-8.6 dS m^{-1}), x20 (EC 3.3-3.6 dS m^{-1}), x30 (EC 2.1-2.7 dS m^{-1}), x100 (EC 0.5-0.8 dS m^{-1}) times, and sprayed on leaves; 1 spraying per week (c.a. 1600L/ha), total 3 times on pepper and 12 times on green onion. Damage rate of pathogen and insect pest, and conidial production of *L. taurica* on unit leaf area (cm^2) were observed over a week after treatment. Damage rate of pepper plant was analyzed as disease index compared to the data before treatment. Mortalities of eggs and 1^{st} larvae of *S. exigua* (N: 30 per treatment, 3 repeats) were investigated after spraying of diluted seawater in laboratory. Treated eggs and larvae were maintained under the conditions of 23±2°C, 16L:8D h photoperiod.

Three replicates, and minimum 3 leaves per plot were investigated and analysis of variance was used to determine statistical differences among treatments (SAS, Cary, NC).

Results

Control efficacy to powdery mildew, *Leveillula taurica*

Infection rate of leaf on pepper were decreased with spraying of the 30 time- diluted saline water (Fig. 1). However, saline water of higher NaCl concentration increased severe damage to pepper leaves; osmotic effect, firing, and shattering in the undiluted seawater. Thus disease indices of plots damaged with saline stress were omitted in Fig. 1. Conidial production of *L. taurica* on leaf was significantly decreased related to spraying of saline water; spraying times and NaCl concentration (Fig. 2).

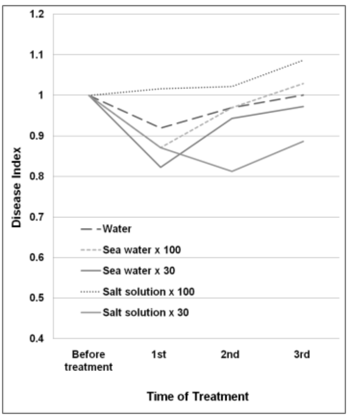

Figure 1: Disease index of *L. taurica* on pepper plant according to treatment of diluted saline water from seawater or bay salt solution (NaCl 3.3%).

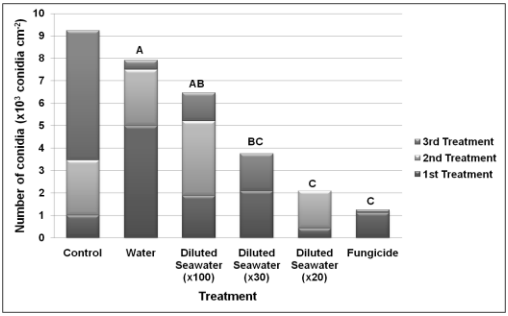

Figure 2: Inhibition effect of saline water against conidial production of *L. taurica* on pepper leaf. Different letters above the bars indicate significant difference among means (P<0.05).

Control efficacy to armyworm, *Spodoptera exigua*

Seawater spraying at weekly intervals reduced leaf damage of green onion by *S. exigua* but more diluted saline water than 20 times did not decrease the damage (Tab. 1). In addition, seawater caused high mortality of egg and 1st larval stage of armyworm as shown in Fig. 3. In contrast, growth of green onion was not stressed by salinity even in undiluted seawater (Tab. 1).

Tab. 1: Effect of saline water on growth of green onion and rate of leaf damaged by *S. exigua**

Treatment	Growth of green onion (mean ± SE)		Damage rate (%, mean ± SE)
	N of Leaf	Width of bulb (cm)	
Control	4.6±0.6a	16.8±2.3a	13.7±5.5ab
Water	4.0±0.1a	12.5±1.0ab	11.7±8.3ab
X100 Diluted saline water	4.3±0.6a	15.9±1.2ab	6.1±3.9abc
X30 Diluted saline water	4.3±0.6a	14.6±2.5ab	7.5±4.8abc
X20 Diluted saline water	4.4±0.6a	13.9±1.3ab	4.2±4.2bc
X10 Diluted saline water	4.4±1.0a	16.1±2.1ab	4.2±4.2bc
X1 Seawater	3.7±0.6a	13.2±1.6ab	2.1±2.1c

* Means followed by same letters in a column are not significantly different (P<0.05).

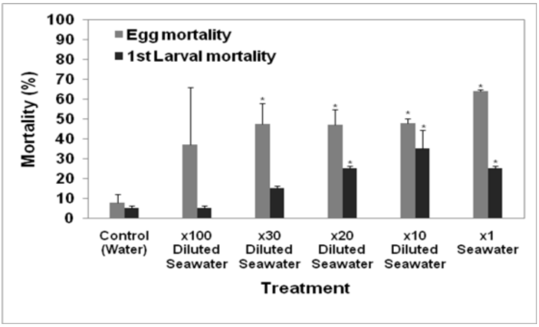

Figure 3: Mortality (mean±SE) of egg and 1st larvae of S. exigua after treatment of seawater and its diluted saline water. *: significantly different (P<0.05).

Discussion

This study revealed that diluted saline water control powdery mildew and armyworm. The decrease of disease index was caused from inhibition of the *L. taurica* conidial production with saline water treatment. The reduction of damage from *S. exigua* was caused from high mortality of egg and 1st larval stage of armyworm. These pest species inhabit on leaf surface during a specific period such as conidia or egg stage in whole life cycle. Thus the spraying effect of saline water to damage pest species at these life stages may decrease damage level from disease or pest. However, crop plant also may be stressed by salinity (Shannon & Grieve, 1999). Therefore, it is important to select dilution concentration optimized specifically to crop and pest species. In this study it is suggested that the 30 time diluted seawater for *L. taurica* on pepper and the 10-20 times dilution for *S. exigua* on green onion are optimal for pest control.

Conclusions

Diluted saline water can control, especially preventively, powdery mildew and armyworm escaping salinity stress to crop plant.

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Studies on the resistance factors of soybean to soybean pod borer, *Leguminivora glycinivorella* Matsumura (Lepidoptera: Tortricidae)

Lee, Y. S., Park, J. S. & Kim, S. K.1

Key words: Soybean, Soybean pod borer, Leguminivora glycinivorella, Resistance

Abstract

This study was carried out to get basic information for breeding of a resistant variety to insect pest, especially soybean pod borer, Leguminivora glycinivorella. To investigate the resistance factors, some external characters of the resistant 30 lines and susceptible 30 lines were selected among 185 soybean lines and compared under field conditions. The upper pods showed more severe damage than the middle or lower ones. Significant correlations were found between pod borer damage and hair density and color, pod length. Soybean pod borer damage was positively correlated with the hair density of pods, and most lines that had a light brown hair showed severe damage from pod borer in both lines. Soybean pod borer preferred pods with 4-5cm length, when the plants were in R4 to R5 stage. These results will be useful for selecting resistant lines and breeding resistance to the soybean pod borer.

Introduction

The soybean (*Glycine max* (L.) Merrill) originates from northern-east Asia regions, such as China and Korea, where it has long been cultivated as a summer crop (Chung et al., 1979). Recently, fermented soybean foods have gained increasing attention in Korea as a functional food as part of the health and well-being trend. Soybean cultivation has recently spread as a replacement for rice.

There are 83 species of insect pests that feed on soybean in Korea (Kim et al., 2001). The most severe lepidopteran species that feed on soybean pod is soybean pod borer (SPB), *Leguminivora glycinivorella* (Fig. 1). The larvae of this moth feed on the seeds in young soybean pods and cause significant crop losses. A mature larva makes a cocoon in the soil in October, overwinters and pupates in mid-August, with the adults appearing from late August to early September.

In Korea, there are several studies about resistance inheritance mode and development of resistant soybean lines to several insect pests, for example, *Riptortus clavatus* Thunberg. But as before, many research studies for management of soybean insect pests through inorganic chemical materials have been carried out. Although soybean has been widely grown and many soybean cultivars have been inbred, there are few studies about resistant factors of soybean cultivars against the SPB. The objective of this study was to evaluate the resistant to SPB, *L. glycinivorella* in soybean cultivars by means of conventional screening method.

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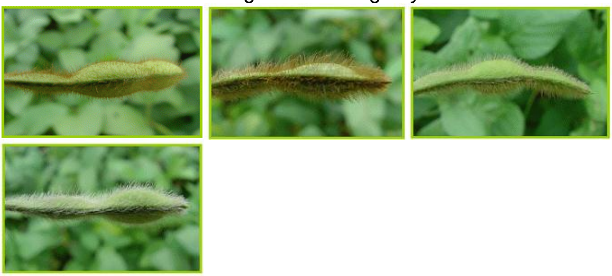
Figure 1: Developmental stage of Soybean pod borer, *G. glycinivorella* and symptoms on soybean pod

Soybean lines. 185 soybean lines sowed in mid-May at the field assessment of SPB infestation in plots located in the northern part of Gyeonggi Province consisting of different lines were used in 2005. Plot size was $10m^2$ per cultivar, and there was no pesticide input at any time during the cultivation period.

Resistant characteristics of soybean to SPB. The investigation of several charicteristics of soybean was conducted under field conditions in the peak season of SPB adult appearance (mid-August). Several morphological (pods of different size, shape, and color, and density of hairs on the pods) and physiological (ecotype) characteristics of soybean were investigated. We found the percentage of damaged grain after harvest for selection of the most susceptible (0-0.5%) and the most resistant (2.0-5.0%) cultivars, and analyzed the relations between soybean characteristics and the degree of damage by SPB.



B-L-90˚ B-Mu-45˚ PY-Mi-90˚ PY-Mi-45˚

Figure 2: Different color, amount and angle of hairs on the pods on soybean
(B; Brown, PY; Pale yellow, L; Few, Mi; Middle, Mu; Many)

Results

Resistant ecotype of soybean to SPB. The later the maturitye, the more the damage of soybean is increased (Fig. 3). Especially, the grain loss of early maturing cultivars that had been harvested before September 6 was nearby zero. But, the grain loss cultivars that had been harvested after September 13 were not significantly different. In consideration of the seasonal prevalence of SPB, early maturing cultivars could probably be avoiding the laying eggs time of the SPB female adult, or be harvested when the newly emerged SPB larva could not attack the pod of the soybean. Therefore, when cultivating the early maturing cultivars they should be harvested before early September. This is one of the methods to reduce the damage from SPB in Korea.

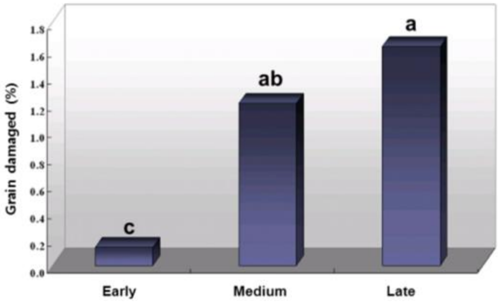


Figure 3: The rates of grain damage by SPB at different ecotypes of soybean

Resistant characteristics of soybean to SPB.

The resistant characteristics of the pod of resistant lines were investigated. SPB preferred the green colored pod (Fig. 4A). The brown or black colored pod showed relatively low damage. It is caused by avoiding the laying eggs time of SPB female adult by reason of early maturing lines. It was found that SPB preferred 4-5cm pods (Fig. 4B). The 3cm or less and 6cm or more sized pods showed no damage. It is caused by avoiding the laying eggs time of SPB female adult by reason of early maturing lines or too late maturing lines. The hair color of the pod did not have any effect on the resistance to SPB (Fig. 4C). However, the amount of hairs of the pod seems to be related with resistant to SPB(Fig. 4D). SPB did not prefer to lay eggs at the pod with few hairs. It is caused by avoiding the laying eggs time of SPB female adult by reason of protection of the eggs against natural enemies.

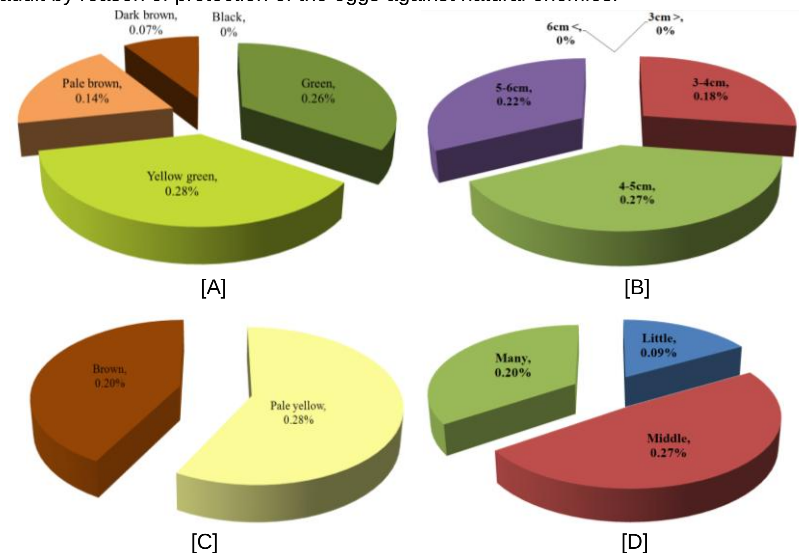


Figure 4: Several pod characteristics of resistant soybean lines to SPB,
(A; Pod color, B; Pod size, C; Hair color, D; Hair density)

Discussion

Host plant selection by herbivorous insects, approximately one quarter of all described species on earth, would be an impressive topic of behavioral ecology and adaptation. Preference of SPB, as well, to soybean may be attributed to the morphological, physiological or chemical factor. In this study, factors in host choice (or feeding preference) of SPB seems to be the optimum nutritive value and enemy-free space (Hirai, 1987). It is caused by the consideration of the female adult for the next generation when she lays her eggs. Further study is needed about the nutritive value or attraction materials of soybean to SPB.

Since soybean is a low-input cash crop in Korea, it would be beneficial for growers to have economically feasible management strategies and tactics against the soybean pod borer. One possibility is to study the preference of the soybean pod borer to soybean varieties. These results will be useful for selecting resistant lines and breeding resistance to the soybean pod borer.

Conclusions

Main factors in host choice (or feeding preference) of soybean pod borer seems to be the optimum nutritive value, and enemy-free space. Further study is needed about the nutritive value or attraction materials of soybean to SPB. These results will be useful for selecting resistant lines and breeding resistance to soybean pod borer.

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Biological characteristics of *Propylea japonica* and the effect for control of aphids at pepper in greenhouse

Lee, J. G.[1], Hong, S. S., Kim, J. Y., Lee, H. J. & Lim, J. W.

Key words: *Propylea japonica,* Natural enemy, Aphid

Abstract

This study was carried out to investigate the native natural enemies of agricultural pest in Korea and develop P. japonica as a new natural enemies. The developmental period from egg to adult emergence was 12 days at 25°C. The head width and the lengths of 1st to 4th instar larvae were 0.34-0.74mm and 1.89-5.88mm respectively and the deviation of the head width was less than that of the length. The number of eggs oviposited from a female was 1,024, the life span of female was 101.7 days, and male was 120.0 days. Aphid consumption was increased for each successive instar and 1st instar larva and adult fed 14.7 and 57.0 of nymph of Aphis gossypii, respectively. In the red pepper greenhouse, the adult of P. japonica efficiently controlled the aphids when treated at beginning stage of aphids. These data suggest that P. japonica can be used as an effective natural enemy for control of aphids at greenhouse.

Introduction

The cotton aphid, *Aphis gossypii*, is one of the major pests of pepper, cucumber and cotton (Blackman & Eastop, 2000). To control the aphid, chemical insecticides have been used and been effective until a recent date. However, the negative factors of insecticides such as resistance and environmental pollution, and the awareness of healthy eating stimulate safer and more environmentally friendly strategies for control of harmful insects. This includes biological control using a natural enemy. In the biological control of aphid, two types of natural enemies are used in the green house: parasitoids, for example *Aphidius colemani*, and predators, for example *Harmonia axyridis.* The multicolored asian lady beetle, *Harmonia axyridis*, has been considered a good natural enemy for control of aphid and investigations about its biological characteristics have been done (Choi & Kim, 1985; Kim & Choi, 1985; Lee & Kang, 2004; Seo & Youn, 2000). *Harmonia axyridis* is a good natural enemy but it is necessary to search and develop more various natural enemies for a wider range of circumstances. *Propylea japonica* is a small ladybug (approximately 4mm) which is found everywhere in Korea. Thus, this study was conducted to investigate the biological characteristics of *Propylea japonica* and develop the ladybug as a natural enemy in greenhouse cultivation.

Methods and materials

Propylea japonica and Aphis gossypii were maintained in the laboratory and greenhouse, respectively. P. japonica was reared on Aphis gossypii in the room at 25°C, 80% RH, and a photoperiod of 16:8 (L:D)h. Aphis gossypii was reared on the

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leaves of pepper and cucumber plants. Colonies of Propylea japonica and Aphis gossypii were replenished with collected individuals in the field. All experiments were conducted in a rearing room at 25°C, 80% RH, and a photoperiod of 16:8 (L:D)h, except for one experiment. For the investigation of the developmental period of each stage, one egg just oviposited was put in the petri dish (Ø10×4cm) with Aphis gossypii on the leaves of pepper, and investigated two times a day. In the investigation of morphological characteristics of larva, one egg just oviposited was put in the petri dish (Ø10×4cm) with Aphis gossypii on the leaves of pepper, pictured everyday and measured under the stereo-microscope. To search the number of aphids consumed by P. japonica, one adult was put in the petri dish (Ø10×4cm) with about 100 nymphs of Aphis gossypii on the leaves of pepper, and the remaining aphids were checked after 24h. To study the effect of Propylea japonica for control of aphids, pepper was planted at April 21, 2009. The adult ladybugs were treated with density of 1.5 bugs/plant at June 25, and the density of aphids was investigated every week.

Tab. 1: Developmental period of each stage of *Propylea japonica*

Division	Egg	Larva				Prepupa	Pupa
		1st instar	2nd instar	3rd instar	4th instar		
Developmental period (day)	2.89 ±0.36	1.50 ±0.37	1.13 ±0.23	1.13 ±0.23	1.88 ±0.25	0.79 ±0.25	2.82 ±0.25

※ Prey: *Aphis gossypii,* Rear condition: 25°C, 16:8(L:D)

Tab. 2: Morphological characteristics of larva of *Propylea japonica*

Division	1st instar	2nd instar	3rd instar	4th instar
Head width (mm)	0.34±0.019	0.46±0.016	0.57±0.024	0.74±0.025
Body length (mm)	1.89±0.459	3.35±0.439	4.66±0.566	5.88±0.741

※Prey: *Aphis gossypii* , Rear condition: 25°C, 16:8(L:D)

Tab. 3: Number of aphids consumed by *Propylea japonica*

Division	Larva				Adult
	1st instar	2nd instar	3rd instar	4th instar	
No. of prey	14.7±7.2	29.5±9.2	32.0±7.2	50.7±6.2	57.0±4.4

※Prey: Nymph of *Aphis gossypii,* Rear condition: 25°C, 16:8(L:D)

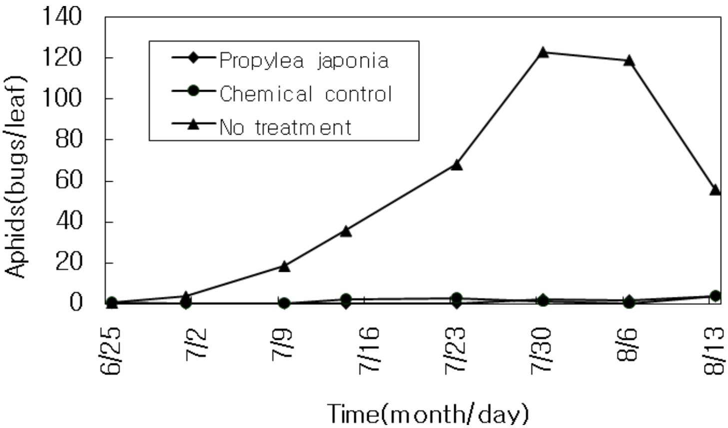

Figure 1: The change of aphids density after treatment of *Propylea japonica*

※Time of pepper planting : April 21, 2009
Time of *Propylea japonica* treatment (30bugs/20plants) : June 25, 2009

Tab. 4: The production of pepper according to treatment of *Propylea japonica*

Treatments	Production of pepper(g/plant)			
	Ⅰ	Ⅱ	Ⅲ	Mean┘
Propylea japonica	255.6	243.0	308.1	268.9a
Chemical control	277.3	268.7	279.5	275.2a
No treatment	200.1	217.9	191.4	203.1b

※ Time of pepper planting: April 21, 2009
Time of *Propylea japonica* treatment (30bugs/20plants): June 25, 2009
Time of harvest: Aug. 20, 2009
┘DMRT(5%)

Results and Conclusions

The developmental period of *P. japonica* was 2.9 days at egg, 1.5 days at 1st instar, 1.1 days at 2nd instar, 1.1 days at 3rd instar, 1.9 days at 4th instar, 0.8 days at prepupa, 2.8 days at pupa(Tab. 1). The period from oviposited egg to adult emergence was approximately 12 days at 25°C. At 26°C on a diet of *Acyrthosiphon pisum*, the mean duration of *Harmonia axyridis* was 2.8 days at egg, 2.5 days at 1st instar, 1.5 days at 2nd instar, 1.8 days at 3rd instar, 4.4 days at 4th instar, 4.5 days at pupa (LaMana & Miller, 1998). The head width and the lengths of the instar were 0.34, 1.89mm at 1st instar, 0.46, 3.35mm at 2nd instar, 0.57, 4.66mm at 3rd instar, 0.74, 5.88mm at 4th instar, respectively, and the deviation of the head width was less than that of the length (Tab. 2). Aphid consumption increased for each successive instar, so 1st instar larva and adult fed 14.7 and 57.0 of nymph of *Aphis gossypii* respectively (Tab. 3). Seo & Youn (2000) reported that the aphid consumption of *Harmonia axyridis* was 120 of *Myzus persicae.* The difference of aphid consumption between *Propylea japonica* and *Harmonia axyridis* may be due to the difference of their size. The density of aphids was maintained very lowly by *P. japonica* and chemical control but increased to 150 aphids/leaf at no treatment (Fig. 1). The production of pepper at treatments of *P. japonica* showed no difference at chemical control and increased by 30% compared to no treatment(Tab. 4).

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Control effect on root-knot nematodes by hot water dipping treatment in kiwifruit

Ma, K.[1], Cho, Y.[2], Jeong, B.[3] & Choi, D.[4]

Key words: root-knot, nematode, kiwifruit, hot water dipping

Abstract

When kiwifruit root system infected with nematodes was treated by hot water dipping treatment, the maximum temperature for this treatment was suggested as 50℃. The lowest killing temperature of internal root-knot in the root tissue was 48℃. Consequently, root-knot nematodes could be killed without damaging root tissues by the hot water dipping treatment at 48℃ for 10 minutes. This could be useful for organic production and distribution of kiwifruit seedlings by avoiding the synthetic nematicides which are not easily decomposed in soil once applied.

Introduction

There are 78 root-knot nematodes globally (Jepson 1987) and 6 species in Korea(Cho et al. 2000). Among them, northern root-knot nematode (Meloidogyne hapla, rkn) is one of the problematic rkns and kiwifruit is a favoured host plant of 51 host plants in Korea (Choi 2001). This rkn is easily found in major kiwifruit cultivation area in Korea (Ma 2008). One of the reasons for the wide spread of nematodes is attributed to the nursery infection where kiwifruit seedlings are raised in the nematode infected soil and distributed to individual farmers. Nevertheless, it is not easy to find nematode-free soil to raise seedlings. When kiwifruit root system was infected with nematodes the vigour of kiwifruit vine decrease (Ma et al. 2007) and the maturity and fruit size of kiwifruit were also influenced (Rodriguez 1987). Although some control methods are practiced in farming such as soil sterilization by solar heat and chemical nematicides (Dale and Mespel 1972, Sharma and Nene 1990), those can not be applied for organic farming system in open fields. Meanwhile, the seasonal occurrence of rkns in soil showed that rkn population started to increase at early spring and decrese during hot summer season (Ma 2008). Generally the optimum temperature for rkn reproduction is 15℃ to 20℃ and the maximum temperature for survival is 35℃ (Wallace 1964). The hot temperature sensitivity of rkns can present new strategy to control nemadoes (Sharma and Nene 1990).

Materials and methods

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Young kiwifruit seedlings (*Actinidia deliciosa* cv 'Hayward') were raised in the soil infected with rkns for 1 year. 1 year later, the root system of all kiwifruit seedlings (approximately 50 to 80cm tall in plant height, 1cm thick in shoot diameter at bottom) got infected with rkns. Each root systems developed about 200 to 1,000 root galls (avg. size 2mm in diameter). 30 kiwifruit seedlings were used for each treatment. Root systems were dipped in a big circulating hot water bath at each temperature for 5 or 10mins. After treatment, all the seedlings were replanted into a plastic pot with sterilized soil (sand media) because rkns are prosperous in more porous soil than clay (Wallace 1964). All pots were placed under shade net for 3 months to allow nematodes in the root galls to revive. 3 months later, the separation of nematodes from pot soil was performed by 'Sieve & Baermann funnel technique' (Southey 1986). The counting of nematodes was done under steromicroscope (50 to 75X) after boiling nematodes-extracts in water bath at 80℃.

Results and Discussion

Young kiwifruit seedlings did not survive of which root systems had been treated with over 52℃ for 5 mins (Tab. 1). Partial root damage occurred at 50 to 51℃ treatment. As a consequent, the critical condition for dipping treatment was 5mins' dipping at 50℃ or below.

Tab. 1: Growth characteristics of kiwifruit seedlings followed by hot water dipping treatment

Temperature (℃)	Dipping time (mins)	Shoot length (cm)	Leaf size (cm)		Damage symptom of lateral roots
			Length	Width	
45	5	6.0 abz	7.4	5.6	None
	10	9.8 a	7.5	6.3	None
50	5	4.6 ab	7.4	7.0	None
	10	3.7 ab	6.8	5.8	Partial browning
51	5	2.8 ab	5.2	5.0	Partial browning
	10	1.3 b	3.0	2.5	Partial browning
52	5	2.3 ab	7.3	4.8	Completely dead
	10	0.0 c	0.0	0.0	Completely dead
Control	-	8.1 a	7.9	5.8	None

zDuncan's multiple range test at 5% level. *Growth at 90 days after water dipping treatment.

Although the gall number of root system and rkns were significantly were reduced by hot water dipping between 45℃ and 47℃, there were escapes. At lower temperature, rkn could not produce eggs so rkn might not reproduce in next generation (Westphal *et al.* 2002). Nonetheless, if it is considered that rkn has very short life cycle as about 40 days and the number of egg laid during 1 adult reaches up to 1,000 at a time (Taylor and Sasser 1978), small number of rkns' survival should not be allowed in nursery field. However, 10 mins at 48℃ and over temperature did not show any galls in root system. The number of juvenile nematode of 2nd developmental stage was observed at 48℃ for 5 mins but no nematodes was found at 48℃ for 10mins dipping and over temperature as well (Tab. 2). From above, the hot water dipping temperature and time duration for complete killing of rkns within kiwifruit root tissue could be suggested as 48℃, 10mins at least and 50℃, 5mins at maximum considering root system damage by hot water dipping. This temperature range was slightly lower than that for grape root treatment (52℃, 5 mins) (Lear and Lider 1959). As known from the previous study (Wallace 1964), rkn is not easy to survive over 35℃, so, the critical factor can be the time duration following the temperature. In this study the set of time duration was only 5 and 10mins for each temperature set. Further study could be focused at the precise time duration at certain temperature at over 35℃ because the lower the temperature, the less root tissue damage would occur.

Tab. 2: Nematodes control effect of kiwifruit root tissue by hot water dipping treatment

Temp. (℃)	Dipping time (mins)	Gall number per 1g root weight	Juveniles *Meloidogyne* number at 2nd stage per 100㎤ soil
45	5	62.2 dz	168.9 f
	10	62.6 d	128.9 f
46	5	27.8 c	105.6 e
	10	22.5 c	14.4 d
47	5	8.6 b	7.8 c
	10	8.1 b	3.3 b
48	5	0.3 a	1.0 a
	10	0.0 a	0.0 a
49-60	5-10	0.0 a	0.0 a
Control	-	91.6 e	287.8 g

zDuncan's multiple range test at 5% level.

Conclusions

In order to prevent the wide spread of rkns from kiwifruit nursery at the opening stage of kiwifruit orchard, hot water dipping of root system can be useful and effective. The optimal condition for this is recommended as 48℃ for 10 mins. This may also reduce the use of chemical nematocides. Some synthetic nematocides are very long lasting in soil and toxic for human health such as fosthiazate, fenamiphos, oxamyl and cadusafos (Ma 2008). This dipping could help organic growers or newly starting their orchard organically with rkn-free health seedlings. For example, many nurseries use nematocides of kiwifruit root system before selling seedlings so the seedling will be free of rkns. Some trading companies are using fumicides or similar nematocides for quarantine. For these purposes, hot water dipping can be useful tool as well as good for soil environment against chemicals.

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Evaluation of fungicide alternatives for the management of powdery mildew on pepper in greenhouse conditions

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Key words: Powdery mildew, Pepper, Control, Fungicide

Abstract

Organic material, inorganic fertilizer salts and compost tea were evaluated to control the powdery mildew (PM) caused by Leveillula taurica on greenhouse pepper leaves, by foliar applications. Control efficacy of phosphoric acid, cooking oil plus yolk mixture (COY) and potassium bicarbonate (PB) plus cooking oil after four applications were 87.3%, 81.8% and 83.6%, respectively. However, chitosan, pyroligneous acid plus brewing vinegar and compost tea for organic agriculture had low effect on powdery mildew of pepper. Mixed applications of sodium bicarbonate, cooking oil and lecithin (SCL) and phosphorus acid(PA), cooking oil and lecithin (PCL) were found to significantly reduce the powdery mildew on capsicum. The control efficacy of SCL and PCL were 75.8% and 79.1%, respectively, by three applications. The effect of these treatments for powdery mildew also lasted for 23 days above 65.6%. Phytotoxicity was found on pepper leaves treated with double treatments of COY, potassium bicarbonate(PB) and phosphorus acid(PA)*. The number of conidia on pepper leaves treated with SCL and PCL was very low due to inhibiting the conidial germination. These results suggest that SCL and PCL are promising fungicide alternatives to manage powdery mildew.*

Introduction

Pepper is one of the most important vegetable crops in Korea. Most green pepper is grown in plastic greenhouse conditions, with a total cultivation area of up to 5,704ha, 233,112 M/T (2009). Powdery mildew (PM) caused by *Leveillula taurica* on pepper is the most serious air-borne disease in the world. In Korea, this disease is more severe in greenhouse cultivation. In general, PM spores are dispersed on the leaf surface in dry weather conditions in the spring and autumn seasons. When the disease get worse, leaves turn yellow and drop off the plant. In Australia, this disease is also the main open-field problem for capsicum crops. In Queensland, under very warm and dry weather, pepper leaves are damaged by falling from plants, which is also one reason for sun scales on capsicum fruits. Recently, there has been a lot of research into environmentally friendly agricultural practices concerning the control of the disease, according to the increase of organic cultivation areas. Inorganic materials were reported to control the powdery mildew and gray mold (Bombelli et al., 2006; Fallik, 1997; Palmer et al., 1997) and some organic materials, such as cooking oil, were also used for controlling the PM on cucumber, lettuce and eggplant (Gee et al., 2005). Therefore, this research was carried out over a two year period in 2008 and 2009 to seek new safe and environmentally friendly materials which can replace fungicides in terms of effective management of powdery mildew on pepper.

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Materials and methods

This research was carried out in a plastic greenhouse of Gyeonggi ARES. Pepper was planted on April 25 and each treatment was organized as a randomized block design with 3 replications. Eco-friendly materials most commonly used in organic farming such as chitosan, brewing vinegar, pyroligenous acid, cooking oil and compost tea were examined. In addition, inorganic phosphoric acid was tested which was also used for the management of *Phytophthora* diseases. Inorganic materials, potassium bicarbonate and sodium bicarbonate were also tested for the control of powdery mildew. Microorganism agents that are sold as a commercial agent (*Bacillus* sp.) were also used. Also, 0.1% oil and 0.05% lecithin were used as an additive of inorganic minerals in a blender and then diluted with water. The treatments of each material at a constant rate were sprayed on leaves at 7-day intervals and no treatment was treated with tap water equally. These experiments were conducted in a greenhouse where powdery mildew occurs naturally on pepper. Rates of diseased leaves were investigated by examining 100 pepper leaves after 3 or 4 sprays with tested materials.

Results

Effect of a single treatment of organic material

Control efficacy was investigated by spraying of eco-friendly materials three times for PM of pepper. In general, control effects of chitosan and a mixture of vinegar and pyroligneous liquor(PL) were 19.3% and 13.7%, respectively, which was widely used in organic farming (Tab. 1). However, control effect of egg yolk including vegetable oil(COY) treatment was 84.6%, which was lower than the fungicide treatment of 94.6%. Thus, this treatment would be practical for the control of powdery mildew. The effect of phosphorus acid (PA) on powdery mildew was 87.3%, potassium bicarbonate (PB) was 60.9% and mixed treatment of PB and edible oil was 82.7%, respectively. Mixed treatment of minerals with a vegetable oil showed better efficacy compared to a single treatment of minerals (Reuveni, et al., 1998). The control effect of four times treatment with eco-friendly materials was almost similar to that of 3 times while successive treatment of egg yolk made the saprophytes in the leaf surface. As a result, the usage of continuous leaf sprays of egg yolk needs to be reviewed. The duration of control effects was surveyed after treatment 4 times of eco-friendly material. The effect of egg yolk treatment at 12 and 19 days after application was reduced to 42.0% on Sep. 16 and 28.9% on Sep. 23. Control effects of inorganic phosphorus acid, 12 days after the treatment, were reduced to 69.4% and 19 days after treatment, reduced to 31.4%. However, control effect of a fungicide was maintained above 99%. Therefore, mixed treatments of inorganic materials with other additives were studied because the single treatment of inorganic material was insufficient in managing the PM for long periods.

Tab. 1: Control effects of eco-friendly materials for PM on pepper (2008)

Classification	Treatment*	Dilution (%)	% of diseased leaves**	Control efficacy (%)
Organic materials	Chitosan	0.1	30.0[bc]	19.3
	Vinegar + PL	1	31.7[bc]	13.7
	Egg Yolk(COY)	0.5	5.7[a]	84.6
Inorganic materials	Phosphorus acid(PA)	5	4.7[a]	87.3
	Potassium Bicarbonate(PB)	0.1	14.3[ab]	60.9
	PB + oil + lecithin	0.1+0.1+0.05	6.3[a]	82.7
Microorganism	*Bacillus* sp.	0.17	15.0[abc]	59.1
Fungicide	Tetraconazole EW	0.05	0.7[a]	98.2
No treatment	Tap water	-	36.7[c]	-

*Three sprays were applied at 7 day intervals (8/14, 8/21, 8/28) and surveyed on Sep. 2, 2008.
**Mean separation within columns by Duncan's multiple range tests at 5% level.

Evaluation of mixed treatment for the management of PM

Effect of combined treatment of organic materials, sodium bicarbonate (SB) + oil + lecithin was 69.1%, phosphorus acid (PA) + oil + lecithin was 79.7%, which showed good control efficacy, while compost tea was not effective for PM control (Tab. 2). The effect of fungicides, sulphur and tetraconazole, was 62.9% and 94.7%, respectively. SB + oil + lecithin treatment was 75.8% and PA + oil + lecithin was 79.1% at 14 days after the final spray. SB + oil + lecithin treatment was 65.5% and PA + oil + lecithin was 72.1% at 23 days after the final spray. Most of the organic material such as chitosan and vinegar did not cause phytotoxicity. A 0.5 percent egg yolk spray resulted in no phytotoxicity while 1 % of egg yolk made the leaves of saprophytic fungi. Egg yolk treatment including 1% or more oil or heavy spray at 2 or 3 day intervals can induce the growth inhibition by interfering with the respiratory quality and physiology of the leaves (Gee et al., 2005).

Discussion

The use of inorganic materials can be an effective alternative in controlling PM while it also can induce phytotoxicity. Phytotoxicity occurred on the leaves treated with excessive concentration of minerals, making the destruction of the cells on the young leaves in the high temperature greenhouse condition (Homma, et al., 1981). Although chemical materials including phosphorus acid and potassium bicarbonate have an efficacy on PM on pepper, they are not usually available on organic farm.

Tab. 2: Control effects of mixed treatment of eco-friendly materials for PM on pepper (2009)

Treatment*	Dilution	% of diseased leaves**	Control efficacy (%)
SB + oil + lecithin	0.2%+0.2%+0.05%	11.7^{bc}	69.1
PA + oil + lecithin	0.1%+0.2%+0.05%	7.7^{ab}	79.7
PB + oil + lecithin	0.1%+0.2%+0.05%	17.3^{c}	54.0
Compost tea	1%	36.7 ^{d}	-
Sulfur WG	0.2%	14.0^{ab}	62.9
Tetraconazole EW	0.05%	2.0^{a}	94.7
No treatment (water)	-	37.7^{c}	-

*Three sprays were applied at 7 day intervals (6/29, 7/6, 7/13) and surveyed on July 21, 2009. **DMRT (0.05)

Conclusions

Cooking oil and lecithin can be effective alternatives for controlling PM in organic farm (Jee et al., 2005). SCL and PCL were promising fungicide alternatives for the control of powdery mildew while they can also have a possibility of phytotoxicity. Therefore, it is important to reduce the resultant phytotoxicity by not allowing excessive residue of the minerals on the leaves.

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Management of powdery mildew and leaf mould on tomato organically cultivated under controlled structured condition

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Key words: Disease management, tomato, leaf mould, gray mould

Abstract

Powdery mildew and leaf mold were major diseases in organic cultured tomatoes. $NaHCO_3$ and KH_2PO_4 were selected as control agents for controlling tomato powdery mildew. Control effect of the selected control agents was increased when they were treated with oil-egg yolk mixtures (OEYO). Also four organic materials used commercially including copper hydroxide and sulfur, showed high control effect more than 90% in green house. Also two organic matters, copper hydroxide and sulfur showed high control effect in farmer's field. When tomatoes were cultivated in plastic house installed with circulation fan, incidence of powdery mildew and leaf mold was reduced by 56% and 60%, respectively.

Introduction

Leaf mould and powdery mildew mould caused heavy economic losses on tomato cultivated organically under controlled structure in the farm house. Therefore various control measures have been used to control the diseases. Because synthetic chemicals can’t be used in organic culture system, alternatives for the chemical have been used including environmental friendly organic materials. Until now alternatives for chemicals with high control efficacy to control the two diseases have not been reported yet. This study was conducted to select environmental friendly organic materials and to investigate effect of installation of circulation fan for controlling powdery mildew and leaf mould in the farmhouse.

Materials and methods

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Selection of inorganic salts and and organic materials for controlling tomato powdery mildew and evaluation of their control effect In other to select environmental-friendly control agents(EFCA) for controlling tomato powdery mildew, calcium salts, potassium salts, sodium salts were treated at different concentration against tomato powdery mildew caused by *Erysiphe chichoracearum*, their control effects were investigated. Control effect was evaluated by investigating diseased leaf areas by *7days after* EFCA treatment. In addition additive effects of OEYO were investigated by comparing control effect in mix-treating with each EFCA and control effect in single-treating each EFCA. Finally control effect of commercial products of microbial pesticides and two EFCA were investigated against tomato powdery mildew.

Suppressive effect of installation of circulation fan on development of powdery mildew and leaf mould of tomato In order to investigate effect of installation of circulation fan on disease development, disease incidence of powdery mildew and leaf mould were investigated in the plots installed with circulation fans and installed without circulation fans, respectively.

Results

Selection of inorganic salts and organic materials for controlling tomato powdery mildew $NaHCO_3$, $Ca(NO_3)_2$, KH_2PO_4 showed high control values(more than 90%) for controlling tomato powdery mildew. When they were treated with OEYO, their control effects were increased comparing to single treatments of each inorganic salts (Table 1).

Table 1. Suppression of tomato powdery mildew by sodium and potassium salts, and oil-egg yolk mixture in green house

Treatment	Concentration	Diseased leaf area (%)		Control value (%)	
		Only	OEYO added x)	Only	OEYO added a)
$NaHCO_3$	0.11%	2.6 a y)	1.0 a	92.3	97.0
$KHCO_3$	0.1%	5.3 a	8.0 bc	84.4	76.4
NH_4HCO_3	0.1%	25.2 c	1.1 a	25.8	96.7
Na_2CO_3	0.1%	4.5 a	2.9 a	86.7	91.4
Baking soda(a.i. 20%)	0.1%	12.6 b	3.0 a	62.9	91.1
Cooking soda(a.i. 40%)	0.1%	2.4 a	5.3 a	92.9	84.4
Oil-egg yolk mixture	200 times diluted	7.2 bc	-	78.8	-
Untreated check	-	34.0 d	-	-	

x) 200 times diluted-OEYO.

y) Values represent the means of three replicates.

Finally control effect of commercial products of microbial pesticides and two EFOM were investigated against tomato powdery mildew. Two microbial pesticides, copper hydroxide and sulfur showed high control effect more than 90%. The other microbial pestcides showed control effect about 50%.

Environmental-friendly organic materials, two kind of copper hydroxide and one sulfur formulations showed also high control efficacy in the farmhouse conditon(Table 2).

Table 2. Suppression of tomato powdery mildew by organic materials used commercially in farmer's house (field test)

Treatment	Diseased leaf area (%)				Control efficacy (%)
	Rep. 1	Rep. 2	Rep. 3	Average	
Copper hydroxide	0.8	0.7	1.5	1.0	82.8
Sulfur 1	0.6	2.3	0.3	1.1	81.0
Sulfur 2	10.8	6.0	1.3	6.0	-
Untreated check	9.1	4.2	4.2	5.8	-

Suppression of tomato powdery mildew and leaf mould by installation of circulation fan When circulation fan was operated to reduce relative humidity under plastic film house in the night time, incidence of tomato powdery mildew and leaf moulds was reduced by 56% and 60%, respectively, compared to those in plastic film house in which circulation fans were not installed.

Discussion

In this study tomato powdery mildew could be controlled easily by copper or sulfur formulation, but tomato leaf mold could not be controlled easily. Therefore in order to control tomato leaf mould, preventive control measures, such as disease forecasting, circulation fan installation, planting resistant varieties and using cultural methods, must be developed. Small(1930) reported that temperature and relative humidity are important factors for controlling tomato leaf mould. Palmela (2009) reported that plant disease incidence can be reduced by raising ambient temperature and reducing relative humidity in the controlled structure. Cerkauska (2004) also reported similar research results. Kang (1988) developed disease forecasting model for controlling tomato leaf mould. Afterward control scheme against major tomato diseases using cultural, physical, biological methods, should be established that tomato may cultivated organically.

Conclusion

Our research results showed that the selected calcium, potassium and sodium salts can control tomato powdery mildew and installation of circulation fan reduces a little the incidence of tomato powdery mildew and leaf mould.

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Evaluation of fungicide alternatives for the management of tomato foliar diseases in greenhouses

Kim, J. Y.[1], Hong, S. S., Lee, J. G. & Lim, J. W.

Key words: Tomato, Powdery mildew, Leaf mold, Late blight, Fungicide

Abstract

Chemical alternatives were used as treatment to control the main diseases of tomato, i.e. leaf mold, powdery mildew and late blight in plastic greenhouse for environmental-friendly disease suppression. Tested materials, vinegar, plant oil, pyroligneous liquor, plant extract of ginkgo and phosphorus acids were selected for controlling leaf mold on tomatoes. In the field test for leaf mold, control efficacy of phosphorus acid, olive oil, vinegar and charcoal extract was 86.8%, 80.2%, 76.3% and 68.4%, respectively. After 3 times treatment, control efficacy of phosphorus acid was 75.4% at 15 days after final treatment. In the field test for powdery mildew, olive oil, phosphorous acid, charcoal extract and Bacillus sp. showed 79.6%, 75.3%, 73.1% and 59.1% control efficacy, respectively. In the field test for late blight, phosphoric acid and copper hydroxide showed 95.4% and 88.8% control efficacy, respectively. Phosphorus acid would be a promising alternative for managing tomato foliar diseases in plastic greenhouses.

Introduction

Recently, with the advent of the wellbeing trend, tomatoes have become one of the most popular vegetables in Korea. Cultivated areas of tomato in Korea were increased from 3,218ha in 2001 to 6,338ha in 2006. Thus, the cultivation area was doubled in recent years. The area in the Gyeonggi Province reached approximately 476ha (MAF, 2006). Until now, 30 species of diseases have been reported on tomatoes (List of plant diseases, 2009). Among them, three kinds of disease, i.e. leaf mold caused by *Fulvia fulvum*, late blight caused by *Phytophthora infestans* and powdery mildew *Erysiphe cichoracearum* were the most common and serious in greenhouse cultivation (Kim et al., 1998). In general, chemical fungicides have been widely used with the development of new chemicals for controlling the disease during the past decades. However, less chemicals or organic farming are getting popular as many consumers demand more safe food and worry about overuse of pesticides causing environmental harm and side effects. In this respect, antagonistic and plant growth promoting microorganisms have been frequently used in the field as alternatives to chemical fungicides, but there are not much practical or widespread usage yet. Nowadays, many natural products isolated from plant extracts or various organic materials have been used such as chitosan, vinegar and brown rice vinegar, pyroligneous liquor and inorganic minerals. In addition, surfactants and cooking oils were also tested and verified on the control of vegetable diseases (Gee et al., 2009). This experiment was carried out to select the eco-friendly materials, chemical-free

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and organic alternatives for the control of tomato diseases and to develop practical skills in the farm for two years from 2007 to 2008 in greenhouses.

Materials and methods

Eco-friendly materials used in this test

Tested products for disease management were selected among the materials widely used by organic farmers over the past few years. Organic materials, vinegar and brown rice vinegar in the commercial market were used in this test. Pyroligneous liquor (Korea Co.) and chitosan (Kumho Co.) are certified products, and inorganic minerals including potassium bicarbonate (BF-1), phosphorous acid and cooking oil (olive oil) were also used.

Field test

Control efficacy for three kinds of diseases, i.e. leaf mold, powdery mildew and late blight were verified in the greenhouse by spraying 2 or 3 times every 7 days using a motorized sprayer on the leaves of tomato cultivar "Supeodotaerang". Plant extracts such as Ginkgo (5%), brewing vinegar (1%), pyroligneous liquor (1%), olive oil (0.5%), phosphorous acid (10%), soil microbial agents (*Bacillus vallismortis*, 0.2%), inorganic material (potassium bicarbonate(BF-1), 0.2%), phosphorous acid capsule (Palm Korea Co., 0.1%), Eugenol (Nantong Shenyu Green Medicine Co., 0.1%) were used as treatment. Treatment of tap water was used in a control plot. Treatment of triflumizole WP (0.03%) and copper hydroxide (0.2%) were used in a fungicide plot at 7 day interval. The treatment effect was examined by investigating 200 leaves in the treated plots. Phytotoxicity was also observed every 3 day after spraying the materials by surveying the fruit abnormalities and total growth based on the degree of 0 to 5.

Results

Evaluation of leaf mold management on tomato in the field

The control efficacy of plant extract, ginkgo, was 35.4% which was shown to be not effective. For brewing vinegar and pyroligneous liquor the control efficacy was 76.3%, and 68.4%, respectively (Tab. 1). Highly effective materials were vegetable oil and phosphorous acid which showed 80.2% and 86.8% control efficacy, respectively, which were similar to chemical fungicide. The control effects of brewing vinegar and pyroligneous liquor became gradually lower in the condition of rapid disease progress. The efficacy of olive oil and phosphorous acid were 69.9% and 75.4%, respectively, at 15 days after the final treatment.

Evaluation of powdery mildew management on tomato in the field

The control efficacy of plant extract, ginkgo was 30.1% at 7 days after the treatment at two times. For brewing vinegar and pyroligneous liquor the control efficacy was 26.9% and 73.1%, respectively (Tab. 2). Vegetable oil was 79.6%, inorganic phosphorous acid was 75.3%, showing a somewhat higher effect compared to 59.1% of a microbial agent which is commercially available.

Tab. 1: Control effects of eco-friendly materials for leaf mold on tomato

Classification	Treatment*	Concentration (%)	% of diseased leaves**	Control efficacy (%)
Plant extract	Ginko leaves	5	16.3b	35.4
Organic materials	Brewing vinegar	1	6.0a	76.3
	Pyroligneous liquor	1	8.0a	68.4
Edible oil	Olive oil	0.5	5.0a	80.2
Inorganic materials	Phosphorous acid	10	3.3a	86.8
	BF-1	0.2	10.7ab	57.8
Microorganism	Bacillus sp.	0.2	9.0a	64.4
Fungicide	Triflumizole WP	0.03	3.3a	86.8
No treatment	Tap water	-	25.3c	-

*Two sprays were applied at 7 day interval (10/9, 10/17) and surveyed date was Oct. 20. ** Mean separation within columns by Duncan's multiple range tests at 5% level.

The control effect of pyroligneous liquor and phosphorous acid were 61.8% and 64.7%, respectively, which showed similar efficacy with fungicide 79.8% at 7 days after 3 times treatment. Withering symptoms were observed in the leaves after repeated sprays of olive oil, and 2% concentrations of phosphorous acid caused leaf burning symptoms to appear on the edge of leaves. Therefore, sprays of phosphorous acid on the farm were more practical compared to edible oil due to phytotoxicity after repeated sprays of high concentration on the leaves.

Tab. 2: Control effects of eco-friendly materials for powdery mildew on tomato

Classification	Treatment*	Concentration (%)	% of diseased leaves**	Control efficacy (%)
Plant extract	Ginko leaves	5	21.7bcd	30.1
Organic materials	Brewing vinegar	1	22.7cd	26.9
	Pyroligneous liquor	1	8.3abc	73.1
Edible oil	Olive oil	0.5	6.3a	79.6
Inorganic materials	Phosphorous acid	10	7.7a	75.3
	BF-1	0.2	6.7a	59.1
Microorganism	Bacillus sp.	0.2	12.7abc	78.5
Fungicide	Triflumizole WP	0.03	6.0a	80.6
No treatment	Tap water	-	31.0d	-

*Two sprays were applied at 7 day interval (9/25, 10/2) and surveyed date was Oct. 9. ** Mean separation within columns by Duncan's multiple range tests at 5% level.

Evaluation of late blight management on tomato in the field

Materials for the control of tomato late blight were not generally effective but phosphorous acid showed a good effect at 95.4% (Table 3). However, the control effect at 14 days after final treatment was gradually decreased to 76.7%, and commercially available organic materials were decreased to 50% depending on the type of organic materials. Because most commercially available organic materials for disease control were not verified, many follow-up tests will be needed in the future for farmers to use the materials easily. In the test of phytotoxicity, treatment of inorganic material, 10% of potassium carbonate, showed the necrotic spot on the tomato leaves while the others did not show phytotoxic symptoms by successive foliar sprays.

Tab. 3: Control effects of eco-friendly materials for late blight on tomato

Classification	Treatment*	Concentration (%)	% of diseased leaves**	Control efficacy (%)
Microorganism	Bacillus sp.	0.1	48.3g	26.0
Organic materials	BV + PL	1 + 1	43.3f	33.6
Inorganic materials	Phosphorous acid	10	3.0a	95.4
	Potassium carbonate	10	28.0d	57.1
	Commercial P	0.1	11.3b	82.6
Plant extract	Commercial K	0.1	20.3c	68.9
	Commercial A	0.1	70.0h	0.0
	Commercial Y	0.1	34.7de	46.9
Fungicide	Copper WP	0.2	7.3ab	88.8
	Triflumizole WP	0.03	37.7ef	42.3
No treatment	Tap water	-	65.3h	-

*Three sprays were applied at 7 day interval (10/1, 10/8, 10/15) and surveyed date was Oct. 22. ** Mean separation within columns by Duncan's multiple range tests at 5% level. ***BV: Brewing vinegar, PL: Pyroligneous liquor

Conclusions

For the growing demand of eco-friendly tomato production, fungicide alternatives were tested in the greenhouse to manage leaf mold, powdery mildew and late blight. Some organic materials did not show effective disease control while some inorganic materials showed high control efficacy for 3 kinds of tomato diseases. We regard phosphorous acid to be an alternative for reducing the tomato foliar diseases.

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Effect of organic amendment on lettuce wilt caused by *Fusarium oxysporum* f. sp. *lactucae*

Kim, J. Y.[1], Hong, S. S., Lee, J. G., Lim, J. W. & Kim, S. K.

Key words: Fusarium wilt, *Fusarium oxysporum*, Lettuce, Soil borne disease

Abstract

Organic amendment had a good control effect on the disease occurrence in the suppressive soil which reduced the pathogen population and increased the population of Streptomyces sp. in the soil. The disease index of lettuce wilt was 1.0 in oil cake, 2.3 in wheat bran, 2.7 in rice bean and 3.3 in corn powder. Consequently, the efficacy of oil cake treatment showed a 75% reduction of disease. The fresh weights increased to 20.8g in oil cake treatment, 13.8g in wheat bran treatment, 13.7g in corn powder treatment and 11.9g in rice bran treatment compared to 0.9g when untreated. Thus, oil cake treatment can have an influence on lettuce wilt and there was a significant difference among other treatments. The density of Streptomyces sp. in the soil was nearly significantly higher in organic amendment treatments while there were few populations in the untreated plot, so the density of Streptomyces sp. was presumed to be closely related to the reduction of Fusarium wilt. These results suggest that organic amendments in soil play an important role to suppress the soil borne disease severity.

Introduction

Lettuce is one of the important vegetable crops grown in greenhouses. The cultivation area reached about 4,213ha which accounted for approximately 33% of all greenhouse leafy vegetables crops in Korea. The yield was 124,000 M/T and among them, the production of Gyeonggi Province accounts for approximately 82% of the total production in Korea. Lettuce in Gyeonggi Province was cultivated in the boundary area of Seoul Metropolitan City all year around. Fusarium wilt was the most serious disease in lettuce cultivation caused by *Fusarium oxysporum* f. sp. *lactucae*. As the soil borne disease is not easy to control using general chemicals, introduction of resistant cultivars (Grube et al., 2003; Tsuchiya et al., 2004), soil solarization and cultural practices including organic amendment (Park et al., 2001) and crop rotation were tried in order to reduce the Fusarium wilt in greenhouses (Hardy et al. 1991). This experiment was conducted to develop an environmentally friendly cultural method for stable production of lettuce and to verify the organic amendments into the infested soil with *F. oxysporum* on lettuce.

Materials and methods

Soil samples with severe occurrence of lettuce wilt from Heungcheon area, Yeoju County were fermented mixing with organic materials, rice bran, corn meal, oil cake and wheat bran by 1:15 (v/v) mixture for two weeks in greenhouses. The effect of

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disease reduction has been investigated in the contaminated soil with fermented organic materials with 6 repeated pots after 60 days of lettuce planting. For comparing the growth of lettuce, fresh weight of shoots was measured and analyzed in order to compare the disease severity. Changes and microorganism densities in the soil were measured in each culture using each selective medium. The soil was dried in the air temperature and then suspended in selective medium of Komada media (Komada, 1975), Actinomycete isolation agar and Pseudomonas isolation agar for measuring the density of *Fusarium oxysporum*, Streptomyces and Pseudomonas, respectively.

Results

Disease index of lettuce

We investigated how organic amendment reduced the lettuce wilt caused by *F. oxysporum* compared to untreated pots (Tab. 1). The disease index of lettuce wilt was 1.0 in oil cake, 2.3 in wheat bran 2.7, rice bean and 3.3 corn powder. Consequently, the efficacy of oil cake treatment showed a 75% reduction of disease. In addition, the average fresh weight was surveyed for each treatment. The fresh weights increased to 20.8g in oil cake treatment, 13.8g, wheat bran treatment, 13.7g in corn powder treatment and 11.9g in rice bran treatment compared to 0.9g when untreated. Thus, oil cake treatment can have an influence on lettuce wilt while there was no significant difference among other treatments.

Tab. 1: Control effect on lettuce wilt by treatment of organic materials in the greenhouse

Organic material treated	Disease index** (0-4)	Control effect (%)	Fresh weight of lettuce** (g)
Oil cake + FS*	1.0a	75.0	20.8a
Corn powder + FS	3.3cd	17.5	13.7b
Rice bran + FS	2.7bc	32.5	11.9b
Wheat bran + FS	2.3b	42.5	13.8b
No treatment (FS)	4.0d	-	0.9c

*Soil infested with *Fusarium oxysporum* from the farm.

** Mean separation within columns by Duncan's multiple range tests at 5% level.

Density of pathogen and other microorganisms

The density of soil pathogens, however, was not significantly reduced compared to the untreated plot while there was some reducing population of pathogens in most of the organic treatment (Fig. 1A). It was reported that contaminated soil mixed with oil crop residues significantly decreased the pathogen density from 10^5 cfu/g soil to 10^1 cfu/g soil (Zakaria and Lockwood, 1980). It is assumed that complex microbial interactions can influence the pathogen population depending on the kind of organic matter, fermentation period and soil texture. Because the population density of *Pseudomonas* sp. in the no treatment soil in this test was more increased than in the treated soil, there would be no significant effect on Fusarium development (Fig. 1B). However, the density of *Streptomyces* sp. in the soil density was nearly significantly a few populations in the untreated plot, so the density of *Streptomyces* sp. was presumed to be closely related to the reduction of Fusarium wilt (Fig. 2). Organic matter inputs such as livestock manure and wheat bran increased the number of soil microorganism such as fungi, bacteria, and Actinomycetes and reduced the density of the pathogen of Fusarium wilt on spinach (Gina et al., 2008). This trial was also similar for reducing disease related to the inhibition of Fusarium wilt on lettuce. Thus, only organic matter inputs to soil can reduce the disease and it is estimated that the reduction of soil borne diseases is closely related to rhizosphere microorganisms (Landa et al., 2001).

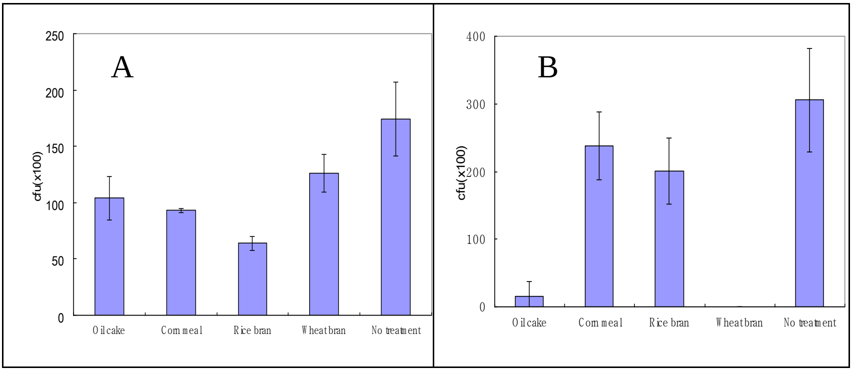

Figure 1: The population density of *F. oxysporum* (A) and *Pusedomonas* sp. (B) after treatment of organic materials in the field

Discussion

Soils naturally suppressive to soil borne plant pathogens harbor active populations of biological control agents that could induce protection of plants to soil pathogens (Boehm et al., 1993). In this test, lettuce roots in suppressive soils had less root rot and were less prone to attack by vasular wilt of *F. oxysporum*.

Conclusion

The organic amendment plays an important role to control soil borne disease in the infested field. Suppressive soil can reduce the population of *F. oxysporum* and increase the population of useful microorganism as biological control agents in the soil.

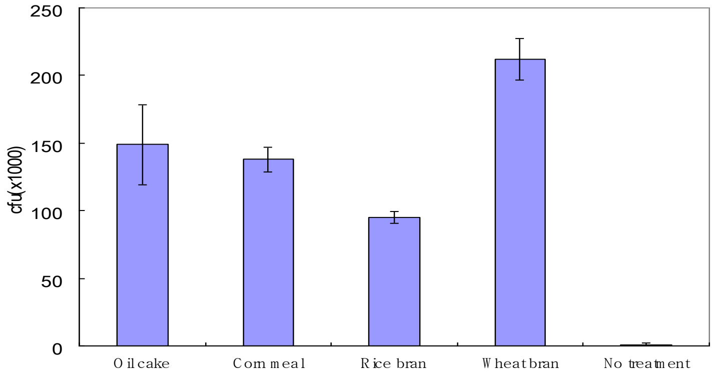

Figure 2: The population density of *Streptomyces* sp. after treatment of organic materials in the field

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Introduction of Korean pear cultivars with high resistance to the scab for organic pear orchard

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Key words: Asian Pear, Chuhwangbae, Gamcheonbae, Manpungbae, Niitaka, Recovery Ability, RDA

Abstract

Disease control is the most difficult problem in organic orchard. Various diseases affect bad influences on pear. The scab is not only common but also severe. Niitaka, a Japanese pear variety, is the major variety cultivating in Korea. However it is vulnerable to various diseases; for example - scab, pear rust, Apple Stem Grooving Virus (ASGV) and so on. So, it is hard to cultivate pear trees by organic system. This problem is improved by RDA (Rural Development Administration). They introduced some varieties which have the resistance to the scab. In this research, we tested the disease incidence of pear scab in these varieties. And we also monitored the scab lesions on the fruits of several cultivars. In the results, we confirmed that Chuhwangbae, Gamcheonbae, and Manpungbae pear varieties have the relatively better resistance on the scab than Niitaka.

Introduction

In organic fruit cultivation, there are many restriction factors. Fertilizing can be a problem and also improving soil condition can be an exacting work. However, the disease control is the most difficult matter in an organic orchard. Because, the use of agricultural chemicals is not allowed in organic orchards. The outbreak of scab, which damages to pear seriously, is caused by *Venturia nashicola* on Asian pears (Ishii *et al*., 1992, Abe *et al*., 1998). But on European pears, it is caused by *Venturia pirina* (Ishii *et al*., 1992, Abe *et al*., 1998). Niitaka, a major variety which is grown in over 80% of Korean pear orchards, is sensitive to scab and pear necrotic spot virus (Cho *et al*., 1985, Shin *et al*., 2004). When pear trees are damaged by scab, leaves and fruits are covered with dark conidia and then they penetrate into the cuticle layer (Park *et al*., 2000). As a result, not only the growth of trees but also the quality of fruits is declined. To solve these problems, we should choose by breeding new varieties of pear which have more resistance and can replace Niitaka variety. Some of scab resistant varieties (i.e., Chuhwangbae, Manpungbae, and Gamcheonbae) are developed by RDA (Rural Development Administration) in Korea. These varieties are

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checked on the disease incidence of pear scab by Pear Research Station, Naju city, Korea. In this research, we could explain the differences of disease incidence among the pear varieties and the relation between the scab resistance and the cell recovery ability.

Materials and methods

Experimental field

Two types of fields are used in our research. One of them is a non-spray treatment experimental field which is located in Pear Research Station in Naju city, Jeollanam-do, Korea. Any agricultural pesticides are not used in this field, except chemical fertilizers. Another second pear orchard is located at the private organic farm. The organic pear orchard is established by the rule of Korean organic agriculture. It qualified organic standards. There were no orchards which contain all varieties to research. Therefore, two private organic orchards should be used to get the results. They are located in Chungcheongnam-do, Korea.

Experimental varieties

In this research, we used eight different varieties. For making comparison, Niitaka (a Japanese pear variety) is used as a control variety. Experimental group are consisted with Whasan (Hosui x Okusankichi), Wonhwang (Waseaka x Okusankichi), Hanaruem (Niitaka x Chuhwangbae), Hwangkeumbae (Niitaka x Nijisseiki), Chuhwangbae (Imamuraaki x Nijisseiki), Manpungbae (Hosui x Okusankichi), and Gamcheonbae (Okusankichi x Danbae).

Investigation method

The design of the experiment is the randomized block design. Experimental varieties were divided into other parts of the field. We checked the necrotic lesion on the leaves. If a spot exist, it is classified as an infected one. Total 300 pieces of leaves are examined in each cultivar. And this process repeated 3 times for each cultivar. Then we calculated an arithmetic mean and a standard deviation.

Results

Experimental varieties, Chuhwangbae and Manpungbae, showed the lesser sensitivity to scab than Niitaka, a control group, in a non-spray treatment field. In an investigation with leaves, the disease incidence of the Niitaka cultivar was the average of 31.7%. Comparing with Niitaka cultivar, Chuhwangbae’s index of disease incidence had an average of 5.5% and Manpungbae showed the average index of 6.9% in the disease incidence. This index means that the probability, Chuhwangbae and Manpungbae would be infected with the scab, is five times lower than control cultivar Niitaka (Tab. 1). This tendency also has been observed in private organic pear orchards. Manpungbae and Gamcheonbae showed the lower disease incidence than Niitaka (Tab. 2). Also, we investigated the changes of lesions caused by the scab on pear fruits from the immature to the mature stage. There were some significant results. The lesions on the Manpungbae, Chuhwangbae, and Gamcheonbae turned smoothly (Data not shown). But Niitaka fruits’ lesions with scab were rather severe. The lesions turned black and fruits had been cracked. Of course, the shapes of lesions were different on fruits in a variety. But the tendency that shows the different recovery ability depending on varieties was clear.

Tab. 1: Comparison of Disease Incidence of Leaves with the Scab on Varieties in a natural field, surveyed in Pear Research Station, Naju city, Jeollanam-do, Korea.

Variety	Disease Incidence (%, mean ± SE)
Whasan	14.4 ± 0.4
Wonhwang	12.8 ± 5.7
Hanareum	12.1 ± 0.6
Hwankeumbae	24.6 ± 4.9
Chuhwangbae	5.5 ± 0.6
Manpungbae	6.9 ± 0.5
Niitaka (control)	31.7 ± 19.8

Tab. 2: Survey of Disease Incidence of Leaves with the Scab on Varieties in Private Organic Pear Orchards.

Region	Variety	Disease Incidence (%, mean)
Cheonan, Chungcheongnam-do, Korea	Wonhwang	3.2
	Whasan	1.8
	Gamcheonbae	1.0
	Niitaka	14.7
Asan, Chungcheongnam-do, Korea	Manpungbae	5.6
	Niitaka	34.0

Discussion

Niitaka is known as a scab susceptible variety (Cho *et al*., 1985). This characteristic probably seems to affect the nature of its descendants (Abe *et al*., 1993). Varieties, one of whose parents is Niitaka, commonly showed the more sensitivity to the scab. This tendency can be confirmed in the case of Hwangkeumbae, its maternal line is Niitaka. This variety showed a relatively high susceptibility on the scab. So, when breeders intend to develop a scab resistant variety, they should consider whether Niitaka would be used as a parent. After we find out that some varieties have the more powerful recovery ability, we could predict a relation between the recovery ability and the scab resistance. If a variety has powerful recovery ability, it probably can be seen as a resistant variety on the scab. This can be explained in these words. Let's suppose that a pear tree is infected with the scab. Infected tissues of the tree would be dead. But if the recovery ability is powerful, the dead cells can be replaced with normal cells soon. This process probably is expressed as a resistance on the scab. To date, there are few trees which have the perfect resistance on the scab (*Venturia nashicola*) in the Asian pears. But we think our investigation can explain the differences between the varieties, and suggest some scab resistant varieties.

Conclusions

After all the analysis, Chuhwangbae, Gamcheonbae, and Manpungbae pear varieties are more resistant to the scab than Niitaka variety. So, if Niitaka is replaced with these varieties, it would be easier to control the scab in organic pear orchards. In this case, we can improve fruit quality and tree growth by replacing susceptible varieties with resistant varieties.

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Arbuscular Mycorrizal fungi (AMF) and *Trichoderma* against *Fusarium wilt* of cotton

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Key words: Arbuscular Mycorrhiza (AM), Trichoderma; Cotton; Biocontrol

Abstract

Fusarium wilt is a major fungal disease in cotton plants. Biological control of Fusarium wilt is widely practiced in various crops. But little is known about the synergistic usage of various biocontrol organisms including Arbuscular mycorrhizal fungi and Trichoderma against Fusarium wilt in cotton. We studied the effect of AM fungi and Trichoderma in cotton plants grown under greenhouse condition against Fusarium wilt. The biocontrol agents and the pathogen were manually applied to the soil according to the treatments, twenty days before sowing. Six cotton seeds were sown to every polybag, and thinned to one after germination. AMF inoculation improved the mycorrhizal colonization within the roots and reduced the disease incidence. Multi-microbial inoculation using various combinations of two AMF species and three Trichoderma species were more efficient than individual inoculations. Disease severity index was calculated at 30, 60, 90 and 120 days after germination. Five replicates were maintained for each experiment. Statistical analysis of the data showed significant increase in disease suppression by the biocontrol agents. Plants which showed disease symptoms at the early days were able to recover during later days by the application of biocontrol agents. AMF inoculated plants were more efficient in recovery. Overall, Fusarium wilt in cotton plants was found to be well controlled by the biocontrol agents.

Introduction

Biological control can be defined as the directed, accurate management of common components of ecosystems to protect plants against pathogens. In this regard, microbial diversity is a key natural resource (Kennedy and Smith, 1995).The control of soil-borne plant diseases using fungal biocontrol agents has elicited considerable research interest in sustainable agriculture since it is based on the management of natural resources. Arbuscular mycorrhizal (AM) associations have proved to reduce pathogenesis and damage caused by soil borne plant pathogens in various crop systems (Azcón-Aguilar and Barea, 1996).

Trichoderma species are common inhabitants of the rhizosphere and are well recognized as biocontrol agents against soil borne plant pathogens (Harman, 2000). Many experimental results confirm the existence of synergistic effects of saprophytic fungi on AMF spore germination and plant root colonization by AMF.The effects of combined inoculation of *Trichoderma* spp. and AMF are contradictory in different plant

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species (Godeas *et al*., 1999).Considering the above facts, the present work was proposed to study the effect of AMF and *Trichoderma* individually and in combination against Fusarium wilt of cotton.

Materials and methods

Two AM fungi, *Glomus geosporum* Nicol. & Gerd. and *G. fasciculatum* (Thaxter) Gerd. & Trappe emend. Walker & Koske isolated from cotton growing-soil, multiplied and maintained using Allium cepa L. in sterile sand: soil (1:1) and served as inocula. Ten thousand propagules of each AMF were applied to respective treatment.

Trichoderma harzianum Rifai, *T. viride* Persifr and *T. virens* Miller Giddens & Foster were isolated from cotton growing-soil using selective medium (Elad and Chet, 1983). Cultures were grown on Potato Dextrose broth, transferred to sterile talc base powder and the inoculum was made containing ca. 5 x 105 propagule per gram. F. oxysporum was isolated from infected cotton plant roots in Czapek-Dox medium. One ml of the broth containing ca.1x 103 propagules per ml of the pathogen was inoculated directly to the soil using a syringe. Acid-delinted seeds of the cotton cultivar LRA5166 was used for the experiment. Six cotton seeds were sown in each polybag containing *ca.* 1.5 kg black soil. Immediately after germination, the seedlings were thinned to one seedling per polybag. The polybags were arranged in a completely randomized block design. Each treatment was replicated five times. Plants were watered as and when necessary, throughout the duration of the experiment. The positions of the polybags were altered once in every 15 days to expose seedlings to uniform conditions.

Treatments

Individual and combined inocula of the microorganisms were tested for their efficiency against Fusarium wilt. The soil was inoculated with AMF and biocontrol agents 20 days prior to pathogen inoculation.Disease severity was assessed by grading the plant and leaves as given below. Soil un-inoculated with *F. Oxysporum* served as the negative control.

Grade 0	:	No disease symptom
Grade 1	:	Epinasty and/or slight yellowing of leaf
Grade 2	:	20 to 50 % yellowing of leaf area / stunted growth / small leaves
Grade 3	:	Complete yellowing or partial wilting
Grade 4	:	Leaf fallen or dried

The average grade was computed for the plant as a whole and divided by 0.04 to give a maximum value of 100. For every treatment, five replicates were analyzed. All data were subjected to Analysis of Variance (ANOVA) and the means were separated using Duncan's Multiple Range Test (DMRT) (Zar, 1984).

Results

Disease severity

Disease severity index of the plants under various treatments showed the influence of AMF and *Trichoderma* in controlling the disease (Table 1). Disease severity was maximum in treatment with artificial infestation of the pathogen alone, and was minimum in the plants inoculated with AMF and *Trichoderma*. Multi-microbial inoculations were more efficient than single inoculations.

Table 1: Disease severity index of cotton plants in response to combinations microbial inoculation

Treatments	Disease severity index			
	30 DAE	60 DAE	90 DAE	120 DAE
T_1-Uninoculated soil	1.5 a	6.5 d	6.5 ef	8 a-d
T_2-*Trichoderma harzianum* (T.h.) + *Fusarium oxysporum* f.sp. *vasinfectum* (F.o.)	17.5 e	30 f	32.5 h	34 h
T_3-*Trichoderma viride* (T.v.) + F.o.	30 f	32.5 g	35 i	35.25 h
T_4-*Trichoderma virens* (T.vi.) + F.o.	10 bcd	9.5 a-d	9.5 e-f	10 def
T_5-*Glomus geosporum* (G.g.) + F.o.	8.5 abc	9.5 a-d	11.5 ef	12 f
T_6-*Glomus fasciculatum* (G.f.) + F.o.	9 bcd	9.5 a-d	8.5 a-d	8.5 a-d
T_7-T.h. + T.v. + F.o.	10 bcd	10.5 cd	11 def	10 def
T_8-T.h. + T.vi. + F.o.	11 cd	11.5 d	12 f	11.5 ef
T_9-T.h. + G.g. + F.o.	9 abc	8.5 abc	7 a	9.5 c-f
T_{10}-T.h. + G.f. + F.o.	8 ab	8.5 abc	9 a-e	8.5 a-d
T_{11}-T.v. + T.vi. + F.o.	12.5 d	13.75 e	17.5 g	19 g
T_{12}-T.v. + G.g. + F.o.	8 ab	8.5 abc	8 abc	9 b-e
T_{13}- T.v. + G.f. + F.o.	9 abc	9.5 a-d	9.5 a-f	10 def
T_{14}-T.vi. + G.g. + F.o.	9 abc	9.5 a-d	9.5 a-f	9 b-e
T_{15}-T.vi. + G.f. + F.o.	8.5 abc	9 bcd	11 def	10.5 def
T_{16}-G.g. + G.f. + F.o.	7 b	7.5 a	8 abc	8 a-d
T_{17}-T.h. + T.v. + T.vi. + F.o.	10 bcd	10.5 cd	10.5 c-f	9 b-e
T_{18}-T.h. + T.v. + G.g. + F.o.	8 ab	8.5 abc	8.5 a-d	8 a-d
T_{19}-T.h. + T.v. + G.f. + F.o.	9 abc	9 abc	10 b-f	9.5 c-f
T_{20}-T.h. + T.vi. + G.g. + F.o.	8 ab	8.5 abc	7 a	6.5 ab
T_{21}-T.h. + T.vi. + G.f. + F.o.	10 bcd	10.5 cd	9 a-e	8.5 a-d
T_{22} -T.h. + G.g. + G.f. + F.o.	8 ab	8 ab	8.5 a-d	6 a
T_{23}-T.v. + T.vi. + G.g. + F.o.	8 ab	8 ab	8.5 a-d	7 a-d
T_{24}-T.v. + T.vi. + G.f. + F.o.	9 abc	9 abc	9 a-e	8.5 a-d
T_{25}-T.v. + G.g + G.f. + F.o.	8 ab	8.5 abc	8.5 a-d	8 a-d
T_{26}-T.vi. + G.g. + G.f. + F.o.	8 ab	8 ab	7.5 ab	6.5 ab
T_{27}-T.h. + T.v. + T.vi. + G.g. + F.o.	8 ab	8.5 abc	9 a-e	7 abc
T_{28}-T.h. + T.v. + T.vi. + G.f. + F.o.	7.5 ab	7.5 a	8 abc	6.5 ab
T_{29}-T.h. + T.v. + G.g. + G.f. + F.o.	8 ab	7.5 a	7 a	6.5 ab
T_{30}-T.h. + T.vi. + G.g. + G.f. + F.o.	7.5 ab	8 ab	7.5 ab	6.5 ab
T_{31}-T.v. + T.vi. + G.g. + G.f. + F.o.	7.5 ab	8 ab	8 ab	6 a
T_{32}-T.h. + T.v. + T.vi. + G.g. + G.f. + F.o.	8 ab	7.5 a	7 a	6 a
T_{33}-F.o.	32.5 g	42.5 h	44.5 j	46.5 i

* Means followed by same letter(s) in a column are not significantly different ($P < 0.05$) according to Duncan's Multiple Range Test (DMRT)

Discussion

Combined inoculations of AMF and *Trichoderma* spp. were promising in disease suppression in the cotton cultivar LRA 5166. This is in accordance with the well-known bioprotective effect of AMF and *Trichoderma* (Azcón-Aguilar and Barea, 1996; Dubský *et al*., 2002). The pathogen populations in AMF and *Trichoderma* inocultated soils were considerably less compared to the control. AMF can reduce plant root diseases and pathogen population in soil through mechanisms that are not well understood. Their action has been attributed to the improvement of plant nutrition which stimulate the host plant disease resistance mechanism, to a direct interaction with pathogen and to an indirect effect through changes in soil microflora (St-Arnaud *et al*., 1995). All the tested bioinoculants proved to be effective in disease reduction compared to the control. Similar effects of AMF on reduction in disease incidence were reported by many workers in different plant species. In the present study, among the two AMF tested, *G. fasciculatum* was superior to *G. geosporum* in disease suppression. These differences in interaction between different AMF and pathogen show that each *pathogen-AMF-plant combination* is unique. *Trichoderma* species are proved to be efficient biocontrol agents against various soil borne plant pathogens (Viterbo *et al*., 2002). In the present study, *T. virens* and *T. harzianum* were found to be more effective than *T. viride* when tested individually or in combination with AMF against the pathogen. This is in parallel with the studies of Larkin and Fravel (1998) where they demonstrated that *T. harzianum* and *T. virens* significantly reduced *Fusarium* wilt of tomato by 37-75% in greenhouse conditions.

Conclusion

In conclusion, cotton plants inoculated with AMF and *Trichoderma* spp. individually or in combination showed substantial reduction in disease incidence. These responses were either marginal or reached upto many folds when inoculated plants were compared with the uninoculated plants. Inoculation of cotton plants with a combination of AMF and *Trichoderma* raises the possibility of improved productivity by reducing the disease incidence. These results could help us to have a better insight into the cumulated effects of AMF and *Trichoderma* on cotton growth as well, by providing theoretical basis for applying these combinations in the field for practical purposes.

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Development and evaluation of a model for management of plant pests in organic cucumber cultivation

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Key words: biological control, chemical pesticide, cucumber, organic cultivation

Abstract

Crop protection strategies in organic horticulture aim to prevent insect pest and plant disease problems through utilization of non-chemical based control means. In order to develop a model for management of plant diseases and insects in organic cucumber cultivation, we compared efficacies between chemical pesticide spraying system and biological control means in semi-forcing and retarding cucumber cultivation during 2005 and 2006. Conventional chemical spray program using various chemical pesticides was applied 5 – 10 days intervals, while two different non-chemical pesticide application programs using two formulated biopesticides Topseed™ and Q-fect™, Suncho ™, and Sangsungje™(biocontrol agents 1) and using egg-yolk and cooking oil(EYCO), Bordeaux mixture, Suncho ™, and Sangsungje ™ (biocontrol agents 2) were applied 5 – 7 days intervals during entire cucumber cultivation period. Efficacy of both biocontrol agents programs was effective to comparable to conventional chemical pesitice spray program to control plant diseases such as powdery mildew and downy mildew as well as insect pests such as aphids and thrips which are known as major threats in cucumber organic cultivation. In this study, we established and evaluated an effective and economic crop protection strategy using various biological resources can be used to control plant diseases and pests simultaneously in organic cucumber cultivation field.

Introduction

Lack of effective and economic crop protection strategy is one of the key factors limiting expansion of organic agriculture in worldwide. Levels of solid borne pathogens and root disease are generally lower in organic systems than in conventional (Van Bruges, 1995). Airborne pathogens do not generally cause serious problems in organic systems, but there are a few exceptions such as powdery and downy mildews in cucumber major pests are generally aphids and thrips in cucumber system (Zitter *et al*., 1996). Most effective control of plant diseases and pest control strategies in crop cultivation systems are mainly preventive rather than curative.

In this study, we designed two different biocontrol strategies based on currently available biological products and plant extract product to use crop protection in organic cucumber cultivation system. The designed strategies were used as preventive and the efficacy of the strategies were compared to conventional chemical pesticide program. The results indicated that the developed

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biocontrol strategy could be an effective and economic crop protection system in semi- forcing cucumber cultivation system.

Materials and methods

Designed biocontrol strategy

To design an effective and economic biocontrol strategy in organic cucumber cultivation system, we decided to use two different biocontrol agents. The designed biocontrol agent 1 is a mixture of the formulated biopesticides(Topseed™ and Q-fect™, Greenbiotech Inc., Republic of Korea), the commercial plant extract product Suncho ™, and Sangsungje™ (BIG Inc., Republic of Korea). The biocontrol agent 2 consists with egg-yolk and cooking oil (EYCO, Jee *et al*., 2005), Bordeaux mixture (Dongwon Inc., Republic of Korea), Suncho™, and Sangsungje™. Topseed™ and Q-fect™, and EYCO are known as effective to control powdery mildew, and EYCO and Bordeaux mixture are effective to downy mildew. Suncho™ is an effective bio-pesticide to aphid, and Suncho™, and Sangsungje™ are effective pesticides for thrips. The conventional plot was sprayed with chemical fungicides and bio-pesticides with 5 – 10 days intervals as standard farming practices. The designed biocontrol agents were sprayed with 5 – 7 days intervals by foliar application

Field trials

A two-year study (2005-2006) was carried out in a semi-forcing cucumber cultivation greenhouse located at Gurye in Jeonnam province, which is located in the South region of Korea. All experiments wre conducted with three replications in a randomized block design. Each plot was 300 m^2 containing 3 plants/m^2. The cucumber was cultivated using standard farming practices without any applications of fungicide or insecticide unless indicated in the experimental details. For assessments of disease incidence of powdery mildew and downy mildew, 30 plants were chosen randomly from each plot and rated disease severity by naked eye at weekly. For assessments of pest incidence of aphids and thrips, 15 plants were chosen randomly from each plot and counted total numbers of insects from 5 leaves/plant.

Results

- **Effect of application of the designed biocontrol agents on control of powdery and downy mildew disease.**

- The severity of both diseases in the conventional spray system and the designed biocontrol spray systems was higher in 2005 than in 2006 in both cultivation systems. The efficacy of the designed biocontrol agents was compared with that of a fungicide treatment in both cucumber cultivation systems (Figure 1). Application of the formulated product resulted in effectively reduction in the incidence of both diseases similar to that of fungicide application in 2006, but slightly lower than that noted with fungicide treatment in 2005 (Figure 1).

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- **Effect of application of the designed biocontrol agents on control of aphids and thrips.**

The severity of both pests in the conventional spray system and the designed biocontrol spray systems was higher in 2005 than in 2006 in both cultivation systems. The efficacy of the designed biocontrol agents was compared with that of an insecticide treatment in both cucumber cultivation systems (Figure 2). Application of the formulated product resulted in effectively reduction in the occurrence of both pests similar to that of chemical insecticide application in 2006, but slightly lower than that noted with fungicide treatment in 2005 (Figure 2).

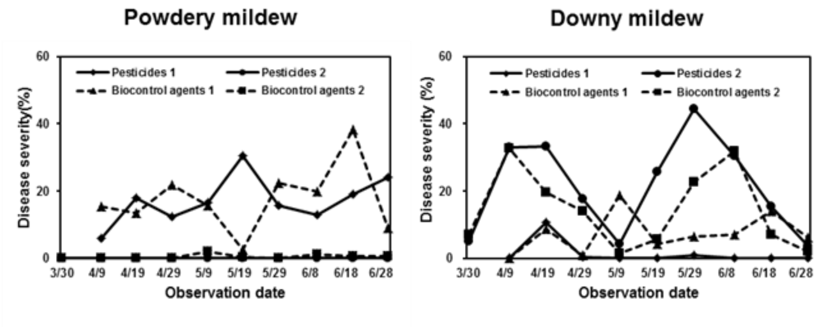

Figure 1: Effect of regular foliar application of the designed biocontrol agents on disease incidence of cucumber powdery and downy mildew in 2005 (treatment 1) and 2006(treatment 2).

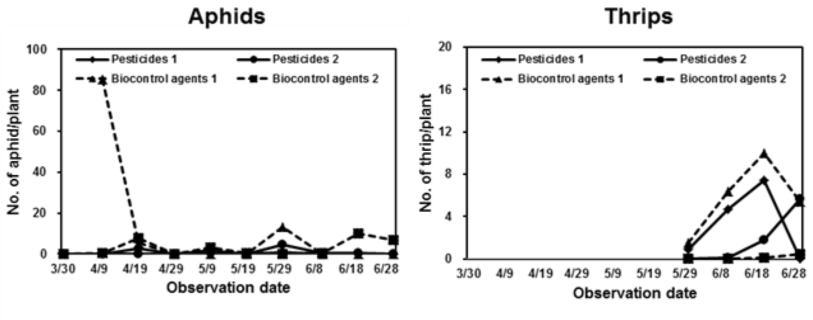

Figure 2: Effect of regular foliar application of the designed biocontrol agents on pest incidence of aphids and thrips in 2005 (treatment 1) and 2006 (treatment 2).

Discussion

In order to control plant diseases and pests in cucumber cultivation greenhouse, a 5 - 10-day interval application method for fungicide and insecticide spraying has been suggested. Powdery and downy mildew disease in organic cucumber have been reported as major diseases, and aphids and thrips are major pests. Chemical fungicides and insecticides are not allowed in organic crop cultivation, although some natural and plant extract-based fungicides and insecticides are applied regularly to control foliar diseases and pests. Biological control of plant diseases and pests is permissible in organic systems, but few products are available because of limitation of effectiveness and economic of the products. This study illustrates the possibility of developing environmentally-friendly control using mixtures of the commercialized products, plant extracts, EYCO, and Bordeaux mixture can be used simultaneous control of powdery mildew, downy mildew, aphids, and thrips. The designed biocontrol agents can be made at low cost by the farmers themselves. Therefore, these control system will be useful for many cucumber growers, organic farmers in particular.

Conclusions

In cucumber fields, powdery mildew, downy mildew, aphids, and thrips have become serious problems in Korea, and control of these relies mainly on intensive application of chemical pesticides. In an effort to develop an effective environmentally-friendly control system, we utilized preventive control approaches by regular foliar applications of the designed biocontrol agents to control plant diseases and pests simultaneously. The control efficacy of the developed biontrol agents were comparable with that of conventional chemical pesticide in two year's field trials, and these system will be useful for many cucumber growers, organic farmers in particular.

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Weed management

Mechanical, thermal and robotic weeding for minimising laborious hand-weeding in row crops

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Key words: Mechanical methods, thermal methods, vegetables, intra-row weeds, robotic weeding

Abstract

Intra-row weeds constitute a major challenge in organic row crops and research has mainly aimed at replacing laborious hand weeding with mechanization. A number of investigations have focussed on optimising the use of thermal and mechanical methods and this paper reviews the major results achieved for horticultural and agricultural row crops. Mechanical methods, such as weed harrowing, finger weeding and torsion weeding, have provided promising results in transplants. In direct-sown row crops, however, successful weed control requires a strategy where mechanical methods applied post-emergence are preceded by pre-emergence flaming for the control of early and problematic weed cohorts. New methods, such as robotic weeding for row crops with abundant spacing between individual crop plants and band-steaming for row crops developing dense crop stands, have been introduced recently. They are seen as the future directions of new solutions for intra-row weed control in row crops.

Introduction

Time consumption for hand-weeding of intra-row weeds constitutes an appreciable financial burden in organic row crops in Europe and elsewhere. Intra-row weeds are those that grow within the line of crop plants of a row crop and they are usually not affected by inter-row cultivation. Manual intra-row weeding can be very laborious in vegetable crops, such as carrot and direct-sown onion and leek, which all have slow emergence and low initial growth rates. Time consumptions of 100 - 600 h ha^{-1} for hand weeding those crops have been reported for Denmark and Sweden. Transplants are far less demanding, requering only 24 - 45 h ha^{-1} for hand-weeding lettuces and cabbages (Melander *et al*. 2005; Van der Weide *et al.* 2008).

Due to the need for manual input in row crops, physical weed control methods has acquired great interest in many European countries. Considerable public research funding has been granted to develop new methods, which has resulted in more information on non-chemical methods for intra-row weed control in row crops. Apart from scientific publishing, most of the European work is discussed and disseminated through the working group on Physical and Cultural Weed Control (www.ewrs.org/pwc) organised under the European Weed Research Society. The group's main activity is its workshops held at 2-3-years interval (proceedings from the meetings are available at http://www.ewrs.org/pwc/archive.htm). A wide range of

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direct physical methods (*i.e.* those used directly in the crop after the crop is either transplanted or sown) have been studied, some of which are new principles, while others are old principles that have been subjected to new research.

This paper reviews the major results achieved with physical control methods and strategies especially adapted for the control of annual intra-row weeds in row crops, such as maize, sugar beet, onion, leek, cabbages and carrot.

Mechanical methods

Mechanical weed control methods are the most common physical methods used in practise and a wide range of implements is available for agricultural and horticultural crops. Most of them are considered low-tech solutions with relatively low purchase and operation costs. The weeding mechanism of mechanical tools is mainly by uprooting and/or burying the weeds.

While inter-row weeds can be removed by ordinary inter-row cultivation relatively easily, mechanical intra-row weeding constitute a major challenge. Several mechanical methods have application for intra-row weed control in row crops but as with most other mechanical weeding implements, operator skill, experience, and knowledge are critical to success. Drawbacks include poor seedbed preparation resulting in soils difficult to till, low work rates, delays due to wet conditions, and the subsequent risk of weed control failure as weeds become larger. Weed harrowing with spring-tine, chain or drag harrows may be used, but the spring-tine harrow with flexible tines is probably the most preferred one with the widest range of applications (Melander *et al*. 2005). It can either be used prior to crop emergence or post emergence, and it involves weeding the whole crop. Torsion weeders, with pairs of tines set on either side of the crop row and lowered 2-3 cm into the soil offer more precise intra-row control but steering becomes crucial, normally including a second operator to specifically steer the implement. Finger-weeders, with flexible rubber tines on ground-driven cone-wheels, were also developed specifically for intra-row weed control. Vertical brush weeding, with brushes rotating around vertical axes and placed in pairs to cultivate either side of the crop row, is a relatively new method that emerged in the early 90s. The torsion weeder, finger weeder, and brush weeder are all mainly developed for post-emergence use in high value vegetable crops because of their low working capacity (Melander *et al*. 2005; Van der Weide *et al.* 2008).

Results with mechanical weed control have been particularly good in transplanted row crops such as cabbage, celery, leek, onion, and sugar beet. Transplanting itself creates very favourable conditions for mechanical weeding, because large crop plants are established in a newly cultivated soil. Provided that the crop plants are well anchored, they can withstand mechanical impact even a few days after transplanting where the first flushes of weed seedlings normally are emerging and need to be controlled. Transplanted crops also gain a competitive advantage over the weeds as compared to sowing the crop, which gives a better suppression of weeds that may have escaped control. However, current techniques for transplanting are only profitable in some highly valuable vegetable crops and need to be further developed to become cost effective in other row crops.

Thermal methods

Flaming prior to crop emergence has been the predominant thermal weed control method in slow germinating row crops such as onion, leek, carrot and partly maize. Pre-emergence flaming is only of limited value in fast emerging crops, such as kale, because the crop may easily emerge before most weeds, making flaming useless. There are two fundamental types of thermal weeders on the market: the covered flamer, flaming to 1900 ^oC, or the infra-red weeder, with essentially no visible flame and heating to 900 ^oC. Both use liquefied petroleum gas or propane/butane mixtures as fuel. The advantages of flame weeding are that it leaves no chemical residues in the soil and water and does not disturb the soil, but it has disadvantages in its high consumption of costly fossil fuels. Flaming kills weeds that have emerged prior to the crop, mainly by rupturing the cell membranes and the indirect effect of subsequent desiccation. The effect of flame weeding varies with plant size; plants at 4–12 leaves required 2–4 fold higher energy rates for control than those at the 0–4 leaf stage (Ascard *et al.* 2007). Band-steaming is a new concept that only heats a limited soil volume of the intra-row area, enough to control weed seedlings that would otherwise emerge in the rows (Melander & Jørgensen 2005). The energy consumption is approx. 600 l ha^{-1} of diesel fuel, which is far less than the 3,500-5,000 l ha^{-1} known for mobile soil steaming on raised beds. Band-steaming provides longer-lasting reduction of seedling emergence than e.g. flaming (Ascard *et al*. 2007). It is applied before crop sowing with no associated crop injuries, since the crop seeds are sown after the soil has cooled down. Inter-row weeds are controlled by cultivation. Band-steamers are now operating on a commercial basis in organic vegetable production in Scandinavia as a result of this work. On-farm studies in Sweden have shown that a nine-row band-steamer, treating 105 mm wide bands, 50 mm deep, consumed 8000 l ha^{-1} of water and 570 l ha^{-1} of diesel fuel to achieve 90% intra-row weed control (Ascard *et al*. 2007). Normally a maximum soil temperature of 80ºC should ensure satisfactory weed control under moist soil conditions, especially if the soil is cultivated prior to steaming to reduce the size of soil aggregates (Melander & Kristensen 2011). The majority of weed species in Danish arable soils emerges predominantly from the upper 0-20 mm soil layer and is thus affected by band-steaming. However, species having large seeds with the ability to emerge from below 50 mm may escape control. With a treatment time of 8 h ha^{-1}, band-steaming becomes very costly but need to be compared to situations where 100-600 h ha^{-1} of hand-weeding is the only alternative in e.g. organic carrot, onion and leek (Melander *et al*. 2005).

Combinations

For direct-sown row crops, mechanical post-emergence methods usually have to be combined with methods applied pre-emergence to minimise problems with low selectivity. Low selectivity means that a high weed control level can be associated with severe crop injuries, because the weeding tools do not discriminate between crop and weed plants. Strategic approaches, in which two or more methods are combined into a specific control strategy adapted to the actual weed problem, have provided some promising results. Pre-emergence methods control the first flushes of weed seedlings that emerge before the crop, and thus delay further weed emergence and growth relative to the crop, allowing the crop to gain a size advantage over the weeds. For example, pre-emergence flaming followed by post-emergence vertical brush weeding gave 90% intra-row weed control over two years of experiments in drilled leek (Melander & Rasmussen 2001). The combined effects of these treatments were not a result of synergistic interactions, but rather that each treatment controlled certain cohorts independently of the preceding treatment.

Future directions

A major problem with many physical methods is that they do not distinguish between weed and crop plants and need to be steered accurately or used in particular robust crops to avoid severe crop injuries. New and advanced technologies for intra-row weeding are regarded as highly important for solving problems with poor selectivity. Advanced technologies with the ability to automatically detect and classify crop and weeds for guiding a weeding devise, operating in the intra-row area, would mean major step forward. Thereby problems with unwanted crop impact from weeding tools can be avoided, meaning that intra-row weed control can be conducted with high selectivity (Van der Weide *et al.* 2008). Most recently two new robotic weeders have been introduced, namely *Robocrop* from England (http://www.garford.com/inrow.html) and *Robovator* from Denmark (www.visionweeding.com). Both systems are vision-based where cameras mounted on the implement are capable of analysing images of the crop immediately in front of the weeder. Thereby the weeding tool can be guided to work a certain area around each crop plant without impacting the crop. Only few experiences have been achieved with the new robotic weeders until now but the technology looks promising when operating in transplants with abundant space between crop plants. Especially, more data on work rate and operational reliability when operating close to the crops plants are needed before making more solid evaluations of their potential for row crops. Band-steaming is still regarded as the most promising method for row crops having dense crop stands in the rows with little space between individual crop plants. Weeding robots are not likely to become operational in such situations unless new technologies turn up. However, any modifications of the band-steaming technology that could reduce the energy input, including changing the energy source from fossil energy to biofuels, should have high priority in future research. Although band-steaming is currently accepted in Danish organic farming, the technology is still controversial in view of potential climate change and the desirability of reducing greenhouse gas emissions.

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Use of competitive crops to reduce *Cirsium arvense*

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Key words: *Cirsium arvense*, crop rotation, competition, oilseed rape, fibre hemp, grass-clover

Abstract

Cirsium arvense is difficult to control and mechanical control may result in yield loss or nutrient leaching. Growing a competitive crop such as grass clover has earlier been seen to reduce the infestation. This paper describes a test of different competitive crops (oilseed rape and fibre hemp) comparing the infestation with that occurring with one or two years of grass clover. Oilseed rape did not grow well and was not very competitive, while C. arvense infestation was reduced the year after growing fibre hemp or grass-clover.

Introduction

Cirsium arvense (Canada thistle) is a problem in organic farming in Denmark and many other countries. *C. arvense* causes yield loss in many crops (Donald & Khan 1992) and the perennial weed is difficult to control. One control method is to carry out stubble cultivation after harvest. While this is the traditional way to control *C. arvense* in Denmark, results from a crop rotation experiment indicated that stubble cultivation did not reduce the *C. arvense* infestation more than growing a catch crop in the autumn (Rasmussen *et al.* 2005). In addition, this type of mechanical control may result in loss of nutrients. In the same experiment there was a tendency towards lower *C. arvense* infestations in a crop rotation with one year grass-clover as green manure, than in a rotation without grass-clover. However, in an arable crop rotation, growing grass-clover may result in lower total yield for the whole rotation, due to the grass-clover not being a cash crop. Thus, it would be interesting for organic farmers with arable rotations if they could grow a crop which was competitive against *C. arvense*, but at the same time gave a marketable yield. Fibre hemp is used for clothes and is becoming increasingly relevant, especially for organic hemp. Seed hemp, which is probably as competitive as fibre hemp, is relevant as oil and protein feed, which is needed for avoiding feedstuffs of foreign and/or non-organic origin. This paper describes a test of the effect of two competitive crops (oilseed rape (*Brassica napus*) and fibre hemp (*Cannabis sativa*)) against one or two years of grass-clover on the infestation with *C. arvense*.

Materials and methods

In plots, that had been run within a crop rotation experiment on a sandy loam at Research Centre Flakkebjerg (annual precipitation 600 mm) in Denmark since 1997 (Rasmussen *et al.* 2006), a test of different competitive crops was carried out. From

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1997 – 2004, the plots were in the rotation: 1) spring barley with undersown grass-clover, 2) one year of grass-clover, 3) winter wheat followed by catch crop and 4) sugar beets. Each crop was grown every year with two replicates. The rotation from 2004 can be seen in table 1. At the start of the test, the plots were in different crops, according to the crop rotation, see table 1. From 1997 to 2004 *C. arvense* had developed from a negligible to a problematic level. During this period, the only weed control of *C. arvense* carried out was that at anthesis of the cereals, all visible *C.arvense* plants in the plots were pulled out. At this time, they were counted and weighed. From 2005 to 2008, stubble cultivation was carried out once or twice after winter wheat (or oats) before the catch crop was sown, and after potatoes. No *C. arvense* plants were pulled out in the growing season. In field 1, oilseed rape was sown at 24 cm row distance in August 2008. Row cultivation was carried out in the end of September and in the middle of April 2009. In March 2009, pelleted chicken manure corresponding to 30 kg N ha^{-1} was applied, and in the middle of April, pig slurry corresponding to 98 kg N ha^{-1} was applied. After harvest, no stubble cultivation was carried out, and volunteer oilseed rape was left to grow. Due to a dry autumn, very few emerged. In field 2 and 3, grass clover was left to grow for one year (2009) and two years (2008 and 2009), respectively. The plots were moved twice, once in the beginning of June, where the crop was removed, and once in the beginning of August, where the crop was left on the plot. In field 4, pig slurry corresponding to 98 kg N ha^{-1} was applied in the middle of April 2009. Fibre hemp was sown in the end of April at 12 cm row distance. Weed harrowing was carried out in the middle of May. The hemp grew to a height of > 2 m. It was harvested in the middle of September, and no stubble cultivation was carried out. All plots were ploughed in the end of November 2009. In 2010, they were all sown with spring barley in the end of April. In fields 1 and 4 pig slurry corresponding to 72 kg N ha^{-1} was applied prior to sowing.

During 2009, *C. arvense* was monitored in the test plots by counting, cutting, drying and weighing in 2-4 quadrates 0.25 or 0.5 m^2 during and/or after the growing season of the crops. When cutting and weighing, the crop was also cut and weighed. In 2010, all *C. arvense* plants in the plot were counted, and 4 quadrates of 0.5 m^2 were cut, split into crop, *C. arvense* and other weeds, dried and weighed. The spring barley

Tab. 1: Crop rotation in the four treatments from 2004-2010.

Year	Field 1	Field 2	Field 3	Field 4
2004	Sugar beets	S. barley	Grass-clover	W. wheat + catch crop
2005	S. barley	Grass-clover	Potatoes	S. oats + catch crop
2006	Grass-clover	Potatoes	W. wheat + catch crop	S. barley
2007	Potatoes	W. wheat + catch crop	S. barley	Grass-clover
2008	W. wheat + catch crop	S. barley	Grass-clover	Potatoes
2009	W. oilseed rape	Grass-clover	Grass-clover	Hemp
2010	S. barley	S. barley	S. barley	S. barley

was harvested in two subplots of each app. 21 m^2 and weighed. Statistical analysis was carried out using GLM of SAS (SAS Stat, 2007) where all the measured variables were dependent on the crop.

Results

Oilseed rape never became a very competitive crop and a lot of *C. arvense* plants were seen during the growing season. Compared to the corresponding rotation, where the crop was spring barley in 2009, there were almost 4 times as many *C. arvense* plants in the oilseed rape (data not shown). After harvest, the volunteer oilseed rape did not establish well, and the *C. arvense* plants left in the field had a good chance to grow. Fibre hemp grew very fast to above 2 m height and the few *C. arvense* plants in the crop withered away. No *C. arvense* plants were found in the field after harvest or later in the autumn. The plots with first and second year grass-clover had a low amount of *C. arvense* plants during the whole season. There were significantly more *C. arvense* plants in oilseed rape in June 2009 than in any of the other crops, see table 2. In the spring barley grown in 2010, there were also significantly more *C. arvense* plants in the plots, where oilseed rape had been grown the year before, see table 2.

There was no significant difference between the biomass of *C. arvense* at any of the harvest times, even though there were tendencies for more *C. arvense* biomass in the plots with oilseed rape in 2009 than in the other treatments, see table 2. There was a tendency for the *C. arvense* plants in the spring barley to be shorter, in the plots where fibre hemp had been grown in 2009, but this was not significant. There were no significant differences between the yield of the spring barley in the plots with different pre-crops.

Tab. 2: *C. arvense* number, weight and length at different times during the experiment

Crop 2009	C. arvense, no. m-2		C. arvense, g m-2		C. arvense, mean length in cm
	June 2009	July 2010	Nov. 2009	July 2010	July 2010
Oilseed rape	14.5a	49.0a	21.8a	453.8a	33.2a
Fibre hemp	1.3b	5.3b	0a	61.8a	17.7a
1st year grass-clover	0.3b	6.5b	2.3a	110.2a	32.8a
2nd year grass-clover	0.1b	7.3b	1.1a	72.1a	34.8a

Results within the same column with the same letter are not significantly different at P<0.05.

Discussion

The test of different crops confirmed that the competitiveness of a crop in one season had an effect on the infestation with *C. arvense* in the next season. We had earlier seen that one year of grass-clover could reduce the infestation compared to a crop rotation without grass-clover (Rasmussen *et al.* 2005), but the results from this experiment did not indicate that two years of grass-clover reduces the *C. arvense* infestation more than one year. A very competitive crop such as fibre hemp reduced the *C. arvense* infestation as much as grass-clover. Even though we found no significant differences between biomass of *C. arvense* in and after the different crops, there was the same tendency as in the number of *C. arvense* plants. Since there were only two replicates, this could be part of the reason why there were no significant differences despite high differences in the means. In an organic rotation with arable crops, where grass-clover may be a non-cash crop, growing a competitive crop which can reduce the *C. arvense* infestation, but also be sold, could be interesting. Since mechanical weed control may either cause yield loss or be very labour intensive (Graglia 2006) this could be an interesting alternative for organic arable farming.

Conclusions

Further work using competitive crops as a way of managing *C. arvense* should be carried out, since this work was only a small test. However the results indicate that in an organic arable rotation, competitive crops such as grass-clover or fibre hemp reduce the *C. arvense* infestation compared to less competitive crops, in this case oilseed rape. If the volunteer oilseed rape had been better established or had manure applied in the autumn, oilseed rape could possibly also have been a competitive crop.

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Manure effects on soil nutrient and salt content and weed populations in organically grown green bean (*Phaseolus vulgaris*)

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Key words: nutrient imbalance, organic transition, purslane, soil quality

Abstract

Weed management is a major constraint to the adoption and management of organic farming systems. Attempts to increase soil fertility by applying composts and manures may increase soil nutrient, organic matter and salt content, all of which have the potential to change weed populations. During the transition to organic certification, partially composted dairy manure at five rates (0, 11.2, 22.4, 44.8 and 89.6 kg ha^{-1}) was applied annually to plots that had been cover-cropped for three or four years with millet and/or buckwheat before planting bush-type green beans. Weed seedlings were counted in each green bean plot and categorized as grass, purslane, or other broadleaf. Soil extractable (Mehlich I) Na, K, and P increased significantly. Purslane proportions increased and grass-type weed proportions decreased; there was no effect on broadleaf weeds or total weed density. Purslane is a salt-tolerant weed and the increase is consistent with an increase in soil salt concentration. Although other explanations are possible, an increase in purslane population would be a concern for organic vegetable growers because purslane is difficult to control mechanically.

Introduction

A major tenet of organic farming is that the farm is a system, and should be understood and managed as such. Adoption of a particular practice, or changes to one part of the system will effect changes in another. An understanding of how production practices affect the whole farm is essential to establish and maintain farm viability. Weed management is frequently cited by organic growers as a major constraint to both production and transition to organic certification (Walz, 1999). Therefore, it is essential that we continue to increase our understanding of weed ecology, including the effects of management practices on weed populations.

To obtain organic certification, growers must demonstrate that soil fertility is improving, a component of which is to increase soil organic matter. Typically this is done with cover crops and green manures, and/or the application of composted or raw animal manure. Using animal manure increases soil organic matter and nutrient storage, which can provide long-term soil fertility benefits. But it has been well-documented that using manures to meet crop nitrogen needs leads to phosphorus accumulation (Eghball & Power, 1999) and increased salt concentrations (Murphy *et al.,* 2005/06).

Purslane (*Portulaca oleracea*) is a salt-tolerant (Grieve & Suarez, 1997), widely distributed, drought-tolerant, prolific, short-lived summer annual weed that produces

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adventitious roots from cut stems. Purslane is a problematic weed for vegetable growers because finely prepared seed beds are needed for direct seeding of small-seeded vegetable crops (Hopen, 1972) and purslane seed can remain viable in soils for years. The most important period for purslane control in table beets and snap beans was during the first two weeks following crop emergence (Venegris & Stacewicz-Sapuncakis, 1971). An additional problem for organic growers that use animal-based composts is that many weeds species, including purslane (Hopen, 1972, Santos *et al.,* 2004) have been shown to be responsive to phosphorus.

Our objectives were to quantify changes in soil nutrient and salt concentrations as a result of using animal wastes and changes in weed populations in organically produced green bean.

Materials and methods

This experiment was a component of a much larger experiment on certified organic transition production systems. Partially composted dairy manure (PDM) rates were chosen so that there were two rates above and two rates below the standard whole-farm experimental rate of 22.4 kg ha^{-1}. The scale of those larger experiments required the application of PDM by volume; a practice repeated in the smaller experiment described here. Greens bean was chosen because it was part of the rotation in the larger whole-farm experiment. Although legumes, green beans are poor nitrogen-fixers and benefit from starter nitrogen.

In early spring 2000, plots measuring 2.44 m x 3.96 m with 0.61 m alleys were established on a soil that was mapped as a Dormont silt loam (fine-loamy, mixed, mesic, Ultic Hapludalf). There were five compost application rates, two sets of plots and four replications (40 plots total) arranged in a completely randomized design. The sets corresponded to the cropping sequence of buckwheat (*Fagopyrum esculentum* Moench) and/or proso millet (*Panicum miliaceum* L.) and bush-type green beans (*Phaseolus vulgaris* L.) such that green bean always followed buckwheat (Table 1). Inoculated green beans were planted in 0.61 m rows, six seeds per 30 cm.

Tab. 1: Four year crop history for each set of plots. Weed populations were measured in green bean plots (Year 1 was 2000)

Set	Year 1	Year 2	Year 3	Year 4
1	Buckwheat	Buckwheat	Green Bean	Buckwheat
2	Millet	Millet	Buckwheat	Green Bean

Every growing season from 2000 through 2003, PDM was applied by volume at rates equivalent to 0, 11.2, 22.4, 44.8 and 89.6 kg ha^{-1} per plot. Care was taken to ensure that compost was uniformly measured and distributed across plots and then immediately incorporated with a rototiller. Soil samples were collected in green bean plots to the depth of tillage (10 cm) two weeks after PDM application and seeding. Soils were air-dried, sieved (< 2mm) and Mehlich 1 extractable Na, K, and P determined. Compost analysis as provided by the West Virginia Department of Agriculture was 0.48% Total Kjeldahl N, 0.45% P, 0.63% K, 0.71% Ca 0.20% Mg, with a pH of 8.1 and a carbon-to-nitrogen ratio of 38:1.

After green bean emergence, six 30 cm diameter sampling rings were established between rows in each plot. Weed seedlings in each ring were counted by hand and categorized as being either purslane, grass, or other broadleaf weed. Weed counts and category proportions were tested for normality) using the SAS procedure PROC UNIVARIATE (v9. SAS Inst. Cary, NC). and transformed (square root and logit). The SAS procedure PROC GLM was used for analysis of variance with compost application rate and year treated as categorical variables. Compost rate treatment effects were compared using mean separations (soil test concentrations) or linear and quadratic contrasts (weed density and proportions).

Results

In general, the addition of PDM increased the extractable Na, K, and P proportionate to the PDM application rate, except that there may have been an application error in 2003 at the 0.4 and 0.8 cm treatments (Table 2). There are no soil test recommendations for Na; a concentration of 50 mg K kg^{-1} and 11 mg P kg^{-1} would be considered sufficient. Concentrations greater than 100 mg K kg^{-1} and 15 mg P kg^{-1} would be considered excessive. Therefore all soils had initially excessive K levels and sub-optimal P levels. By 2003 (four consecutive applications), all PDM treatments resulted in excessive P levels (Table 2). Sodium and K concentrations were extremely high, even in 2002.

Tab. 2: Mehlich 1 extractable Na,K and P (mg kg^{-1}) in green bean plots 14 days after PDM applications (kg ha^{-1}) in 2002 and 2003

PDM rate	2002			2003		
kg ha-1	Na	K	P	Na	K	P
0	8.5	180	6	6	250	5
11.2	16	220	13	14	340	15
22.4	20	290	20	15	430	28
44.8	30	410	42	14	480	41
89.6	54	570	102	33	730	130
LSD	9	100	26	8	131	14

There was an effect of year ($p < 0.0001$) on the relative populations of grasses and ‘other weeds’, but not on the relative population of purslane ($p = 0.2629$). Compost treatment had an quadratic effect on the relative populations of grasses ($p = 0.0042$) and purslane ($p = 0.0010$) but not on the relative population of the ‘other weeds’ category ($p = 0.4703$) (Figure 1). The year by PDM treatment interaction was not significant for the relative population of any weed category. There was no effect of PDM application on weed density ($p=0.011$).

Discussion

Adding compost to soils results in a number of positive effects including pH buffering, nutrient supply, increased soil aggregation and increased water holding capacity. However, because composts are mixed nutrient sources, there is a risk of creating nutrient imbalances. Sustainable compost application rates must consider the effects on crop yield and soil quality.

There was a change in weed species composition that corresponded to increasing rates of PDM application and soil salt concentrations (Na and K). However, there are other factors associated with PDM application that could explain some or all of our observations. The PDM itself may have been a weed seed source (Mt. Pleasant & Schlather, 1994). Although purslane is more commonly a weed of row crops and new

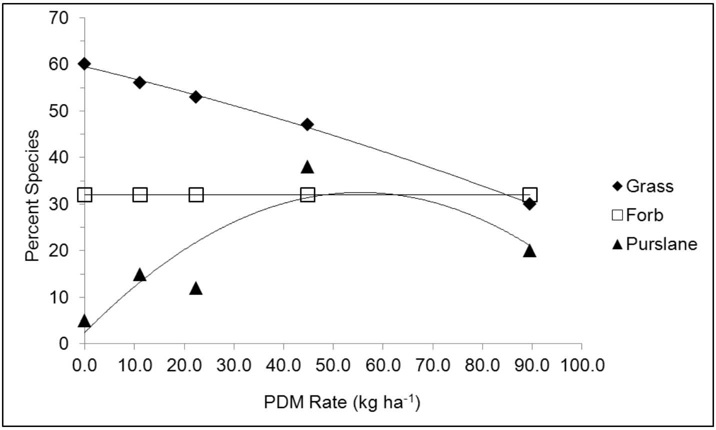

Figure 1: Percentage of each weed type for each PDM rate application

orchards, it has been observed in pastures. Purslane is also known to be responsive to and compete aggressively for soil phosphorus (Santos *et al.,* 1994).

Conclusions

Regardless of whether the shift in weed species composition to one where purslane dominates is due to viable seed in the PDM, a phosphorus response, a salt effect, or a combination of these, the increase in purslane density means that additional resources would have to be devoted to weed management. The resulting nutrient imbalances may also require additional management to correct if crop yield or quality are impacted. Critical weed thresholds for purslane in organic vegetable crops could help organic growers manage this troublesome weed.

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Weed control treated with salt and seawater in organic agricultural upland

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Keywords: Organic agriculture, seawater, salt tolerance, Soybean, weeds control

Abstract

Weed control is the most important issue in organic farming systems that limit crop growth and their yield. Field experiments were conducted in organic soybean (Glycine max Merrill) to evaluate the weed suppression effects of salt and seawater treatment. Weed population and fresh weight were monitored after 6 weeks of salt and seawater treatments. The most important weeds were Digitaria sanguinalis, Portulaca oleracea, Tradescantia reflexa and Chenopodium album var. centrorubrum, but also 6 other species were observed in soybean arable field. Soybean crops under seawater or their solid application were well grown. The results treated with salts and seawater indicate decreases by 13.4~30.8% in weed density and by 18.0~43.2% in their fresh weight and soil hardness increases of up to 2.1-fold. Salt and seawater provided good additional weed control, but they were caused a serious problem in deterioration of soil physical properties.

Introduction

In organic farming systems, weeds can cause a serious reduction of substantial crop production, because they compete with the main crop in using light, water, and nutrients. Many agriculture scientists (Auld and Tisdell. 1985; Kouwenhoven, 1997; Turner et al., 2007; Ulloa et al., 2010; Weih et al., 2008) did research on weed management used to various methods of non-chemicals, mechanicals and other cultivation practices such as rotary hoeing, cover crops and intercropping. Recently, organic as well as conventional farmers in Korea are often the use of salt and seawater for improving crop quality, disease and weed control. The objectives of this experiment were to investigate the possibility of weed control on salt and seawater in organic soybean cultivation.

Materials and methods

Field experiments were conducted in 2010 at the organic soybean farmer's field located in Seosan, province Chungnam. All experimental plots were applied with 8,000kg ha^{-1} compost before sowing of soybean and not fertilized during the crop growing season. We made five treatments of salt 300kg, 500kg ha^{-1}, seawater 10,000 ℓ, 15,000 ℓ ha^{-1} on topsoil and without any application treatment (control). Treatments of salt and seawater were done 3 days after sowing of soybeans. Salt was applied by hand und seawater was evenly sprayed on soil surface using an electric charge power sprayer. At 6 weeks after applications of salt and seawater, weeds in rows

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were removed 1 m^{-2} from each plot and estimated their density and fresh weight except roots. Soil hardness was measured direct using penetrometer (model 350, Fujiwara) after soybean harvest.

Results and discussion

A total of 10 weed species were identified on the experimental plots. The major weed species in organic soybean cultivation plots were *Digitaria sanguinalis*, *Portulaca oleracea*, *Tradescantia reflexa* and *Chenopodium album var. centrorubrum*, and 6 other species irregularly spread in the experimental field. The dominant weed species were increased their growth and biomass production due to supply nutrients in salt and seawater. The results of soybean growth and weed density measurement are showed in Table 1. Soybean crops in all treatment plots were well grown without crop damages. Their growth is improved a little by lower salts levels. Salts under natural condition dissolve quickly by rain. The weed suppression effects were about 13.4 ~ 22.1% of the seawater treatment plots and 21.2~30.8% of the salt application plots contrast with control. Salt application was more effective better than seawater spray for weed suppression. However, average soil hardness in salt application plots was increased by 2.1-folds compared to seawater treatment (Fig.1).

It is considered to be due to the difference in amounts of salt contents between salt and seawater. Seawater and their solids contain various inorganic anion and cations over 75 kinds for plant growth or disease control, and also can be used easy from anywhere in the world as one of the abundant earth natural resources. However, the agricultural use of seawater or solids can utilize unsuitable for salt-sensitive crops because their crop can be damaged due to the accumulation of salts in the soil from increasing high salt levels. Therefore, we are considered that seawater or salt use for weed control would be desirable to use combined with any other agricultural byproducts such as rice straw, wheat straw, rice bran or their chaffs and so on rather than treated only seawater or their solids.

Table 1. Weed control effects treated with salt and seawater in organic soybean cultivation

Treatment (ℓ or kg/ha)	Plant heights (cm)	Weeds			
		density (No. m-2)	Effect (%)	fresh weight (g m-2)	Effect (%)
Seawater10,000ℓ	67.5 ± 4.0b	127 ± 8.3b	13.4	1,997 ± 167b	18.0
15,000ℓ	66.1 ± 0.9b	114 ± 15.1b	22.1	1,384 ± 138b	43.2
Means	66.8 ± 2.5	120 ± 11.7	17.8	1,691 ± 152	30.6
Salts 300kg	64.5 ± 1.0b	115 ± 3.1b	21.2	1,515 ± 174bc	37.8
500kg	65.3 ± 1.8b	101 ± 7.0c	30.8	1,395 ± 197c	42.8
Means	64.9 ± 1.4	108 ± 0.5	26.0	1,455 ± 186	40.3
Control	59.1 ± 2.9a	146 ± 11.5a		2,437 ± 75a	

Values within each columns denoted by same letter are not significantly different at p = 0.05%

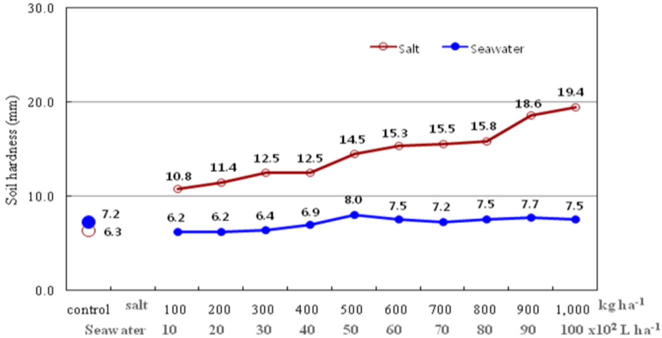

Figure 1. Soil hardness change according to salt and seawater treatment

Conclusion

Based on these results, Soybean crops in seawater or their solids application plots were well grown better than their in control plot. The weed population was simplified by salt and seawater treatments, and the growth of weeds could be suppressed by salt and seawater. Weed suppression effects was by salt application plots better than by seawater spraying plots. Our results showed also that high salt application can considered a serious problem in deterioration of soil physical properties. Weed control in our trails for organic farming may be needed to combine any other additional practices.

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Mulching in Nature Farming with Effective Microorganisms on weed populations in tropical maize and mungbean production

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Key words: Nature Farming, Mulching, Weed management, EM Technology

Abstract

Weeds hinder crop growth in organic systems and mulching could help overcome this problem as proposed in Nature Farming. Field studies evaluated three muilches and the role of Effective Microorganisms (EM) in controlling weeds and on yields of maize and mungbean in the two seasons of tropical Asia. Mulching reduced weeds and increased yields and EM had a synergistic impact, especially with the Tithonia and Gliricidia mulches. Using EM alone had the reverse effect.The beneficial impact of both operations were greater in the minor drier season. The benefits of mulching in Nature Farming with EM in the tropical seasons is presented

Introduction

Weeds are considered the principal obstacle for successful organic crop production Anderson 2010), and mulching is considered a suitable and easy method of weed management (Verdu & Mas 2007; Kristiansen *et al.* 2008). Crop residues and biomass from the hinterlands could easily be used for this purpose in the tropics. Mulching is also a recommended practice in Nature Farming, as advocated by Mokichi Okada of Japan, who emphasized the value of developing a closed ecosystem for successful organic cropping, following the concepts of nature (Amano 2001, Sangakkara & Ito, 2008). As scientific validation of these concepts were required, a field study was carried out using three organic mulches with different C: N ratios and the technology of Effective Microorganisms (EM) to determine the impact of these techniques on weed populations and yields of two popular crops grown in the major and minor seasons of tropical Asia, within a larger program of ecological experiments.

Materials and methods

The study was carried out at an organic farm (125 m above sea level, 8°N, 81°E) located in the low country intermediate zone, Sri Lanka, over the period October, 2005 to August 2006, to encompass the major (WET) and minor (DRY) seasons, that corresponds to the North east and South West monsoons. The soil of the site was an Ultisol (Rhodoult) with a sandy loam texture. The site received 654 mm and 185 mm of rainfall in the major and minor cropping seasons and the mean annual temperatures and humidity were 29°C $\pm$ 2.3°C and 69.5 $\pm$ 2.33% The experiment had 8 treatments per season (Maize *Zea mays* and Mungbean *Vigna radiata* in the major and minor seasons respectively). The individual mulches were Gliricidia (*Gliricidia sepium*) or Tithonia (*Tithonia diversifolia*) leaves and twigs, rice straw and a control with no mulch, replicated four times in a split plot design per season. The mulches either received or did not receive a solution of EM.

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The land was tilled in October, 2006 and May, 2007 with the rains of the major and minor seasons and 32 plots of 3 x 2 m were demarcated on two separate blocks for the two species. In each season, a day prior to planting, farm yard manure consisting

of cattle manure and straw supplying the equivalent of 25 Kg N, 14 Kg P and 20 Kg K per ha) was added to all plots and incorporated to a depth of 25 cm. Thereafter, seeds of maize or mungbean were planted in the plots in the major and minor seasons. The mulches obtained from expernal sources were applied soon after germination to a uniform thickness of 1 cm. The plots receiving the solutions of EM were supplied manually with 4 liters per plot (dilution 1:500 EM: Water) soon after mulching, at 15 days, at flowering and cob (maize) or pod (mungbean) initiation. Plots not receiving EM were supplied with similar quantities of water at the same time, and additional irrigation was not carried out. Weed numbers and their biomass (dry weights – 80°C for 48 hours) were determined using 50 x 50 cm quadrats at silking (maize), flowering (mungbean) and at harvest. Seed yields were determined at crop maturity. The data was subjected to appropriate analysis using a General Linear Model, and ANOVA carried out. Probability values were used to deteremine the significance of observed differences.

Results and discussion

Tab.1. Weed populations at silking and at harvest and seed yields of maize as affected by mulching and inoculation in the major season

Mulch	Inoculant	Weeds at Silking		Weeds at harvest		Yield mt.ha^{-1}
		Number per.m^{-2}	Dry wt (g) per.m^{-2}	Number per.m^{-2}	Dry wt (g) per.m^{-2}	
Rice straw	No	94	142	115	126	2.42
	Yes	65 (30)	116 (18)	74 (35)	145 (15)	2.96 (+22)
Tithonia	No	126	164	142	196	2.84
	Yes	104 (17)	105 (35)	120 (15)	159 (23)	3.10 (+9)
Gliricidia	No	145	185	168	199	2.96
	Yes	127 (12)	169 (8)	144 (14)	165 (12)	3.41 (15)
None	No	195	224	240	274	1.24
	Yes	226 (+5)	259 (+15)	261 (+8)	290 (+5)	1.05 (15)
Probability p=0.05	Mulch	0.004	0.015	0.028	0.009	0.029
	Inoculant	0.006	0.022	0.037	0.031	0.011
	Interaction	NS				

(Numbers in parentheses indicate a decline or + increase when compared to non EM plots)

Mulching reduced weed numbers significantly in the major season (Table 1) The highest beneficial impact was with straw (C:N ratio 54), due to slower decomposition when compared to Tithonia (C:N 35) and Gliricidia (C:N 22). Thus straw could be considered a better mulch for weed management in tropical organic systems, validating the results of Rogers *et al* (2004) in temperate climates. The increase in weed biomass at harvesting time was lower than numbers, implying the presence of small weeds due to later emergence, especially with Tithonia and Gliricidia mulches.

In the non-mulched plots weed numbers increased with EM, due to the stimulation of growth by this inoculant (Javaid & Shah 2010). In contrast, EM and mulches reduced weed populations, the highest impact being with straw for weed numbers and with Tithonia and Gliricidia for weed biomass. This suggests that the temperature build up in the mulch due to EM could inhibit the emergence of weeds, reducing numbers and biomass accumulation, which has not reported in Nature Farming with EM.

Tab.2. Impact of mulching and inoculation on weeds at flowering and harvest and on seed yields of mung beans in the minor season

Mulch	Inoculant	Weeds at flowering		Weeds at harvest		Yield kg.ha^{-1}
		Number per.m^{-2}	Dry wt (g) per.m^{-2}	Number per.m^{-2}	Dry wt (g) per.m^{-2}	
Rice straw	No	125	172	146	195	742
	Yes	75 (40)	126 (26)	89 (64)	104 (46)	925 (+24)
Tithonia	No	140	189	166	225	885
	Yes	82 (40)	124 (34)	94 (43)	129 (42)	964 (+8)
Gliricidia	No	168	213	184	248	1124
	Yes	135 (19)	171 (19)	140 (23)	191 (22)	1325 (+17)
None	No	284	421	342	495	582
	Yes	315 (+10)	465 (10)	329 (3)	524 (+5)	508 (12)
Probability p=0.05	Mulch	0.008	0.017	0.041	0.028	0.041
	Inoculant	0.011	0.027	0.031	0.025	0.010
	Interaction	NS				

(Numbers in parentheses indicate a decline or + increase when compared to non EM plots)

Mulching and EM increased seed yields, which is of most interest to farmers. Mulching increased yields due to the lower weed populations and due to some nutrients provided by the biomass and EM had a synergistic effect on this phenomenon (Javaid & Shah 2010). In contrast, application of EM alone reduced seed yields, which could be due to the greater weed numbers, thus implying that this solution should not be used directly to soil without organic matter. Yield increments with EM and the mulch were highest with straw, which had lower yields without the microbial solutions. The two succulent mulches alone induced higher yields and thus although the use of EM produced the highest yields, the impact was not as great as with straw (Table 1). Mungbean plots had more weeds in the minor season, due to their greater adaptability to the drier season and the lower plant stature of mungbean which facilitates weed growth when compared to maize,. The same trend of results observed in maize was evident with mungbean, with no significant interaction. However the magnitude of benefits in the mulch controlling weeds and of EM enhancing this effect was greater in mungbean implying the importance of these management strategies for weed management in organic farming in the drier minor season. Mulching especially with the succulent green material had a higher impact on seed yields confirming results of Rogers *et al*. (2004). The highest seed yields were with Gliricidia and the benefit of using EM was greater when compared to that in Tithonia, which could be due to the higher nitrogen in Gliricidia.

Conclusions

The study over two seasons with two popular common crops in an organic farm illustrated the benefits of mulching for weed management and higher yields as advocated in Nature Farming. The benefits are greater in the minor drier season, when farmers have problems cultivating crops due to moisture stress. EM enhances the beneficial effects and illustrates that this technology needs to be used with organic matter and not alone. Nature Farming is thus a feasible venture in tropical organic systems, its combination with EM provides a means of controlling weeds, which is a principal problem in most organic systems, while increasing yields.

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Alleviating Egyptian broomrape infestation through oganic methods

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Key words: cotton, pepper, trap crop, declining broomrape infestation, catch crop

Abstract

Current experiment was conducted to compare effects of different crops on the germination rate of Phelipanche aegyptiaca Pers's seeds. Infestations were tested in Polyethylene (PE) bags besides pot experiments. 27 crops, members of different families, were grown in 2-Kg pots containing sterile soil infested with 0.6 g of seeds. While, control pots contained only 0.6 g seeds of P. aegyptiaca. Two month-old plants were incorporated into the soil surface then tomato seedlings (Lycopersicum esculentum Mill.) were planted in the given pots. Cotton in Malvaceae family among cultured plants, which belonged to trap crops, eradicated P.aegyptiaca's threat thoroughly. The most significant reduction in broomrape shoot and capsule number was demonstrated in pots which formerly contained cotton and sorghum accordingly, tomato dry weight significantly augmented. Acquired results of PE bags were in parallel with that of obtained in pot's investigation. P. aegyptiaca's germination% next to given plants in PE bag ranged from 8.333% to 55.333% respectively in millet and pepper. Except for sunflower, vetch, soy bean, chick pea, sainfoin, alfalfa, zucchini, sesame, which were demonstrated to be catch crop , other cultured plants i.e. corn, oat, beet, sugar beet, triticale, caster-oil plant, millet, fiber flax, pepper, cotton and sorghum were determined as trap crops for P .aegyptiaca.

Introduction

Most of species attacked by Orobanche were from the Compositae, Solanaceae, Fabaceae, Umbelliferae, Cruciferae, Cucurbitaceae, Labiatae, Rosaceae, Astraceae, chenopodiaceae plant families (Abanga et al. 2007). The methods used to control of broomrape are expensive and partially effective. Hence, Crop rotation with trap (Ross et al., 2004) & catch has long been proposed and practiced as control measure for broomrape in infested soil (Qasem and Foy 2007). To apply given method having the knowledge of the P. aegyptiaca's host range i.e. false hosts or non-host seems essential. Host plants stimulate parasitic seed germination, tubercle development and

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seed production; false-host plants stimulate parasitic seed germination without tubercle formation; and non-host plants do not stimulate parasitic seed germination or attachment (Joel et al., 2007). In Oregon, USA, wheat (Triticum aestivum L.) was reported to be a false-host of O.minor (Ross et al., 2004), and therefore, has the potential to be implemented in to an integrated O.minor management system. Sorghum (Sorghum Vulgare pers.), maize (Zea mays L.), mung been (Phaseolus aureus Roxb.) and cucumber (Cucumis sativus L.) have been mentioned as trap crops for O.ramosa (Parker and Riches 1993). Allelochemicals present in any parts of the plants, i.e. leaves, roots, fruits, stems, rhizomes and seeds, from where they are released to the soil through volatilization, root exudation, leaching and decomposition of plant residues. Although the degree of selectivity is often not adequate for widespread commercial use, researches with allelopathic mulches and cover crops have shown some promise (Alagesaboopathi 2011). Current study has compared different crops ability to stimulating germination of P. aegyptiaca seeds.

Materials and Methods

Hydroponic Polyethylene Bag study

After healthy seedling randomly was selected among 10-day germinated seeds in germination boxes they were placed in the hydroponic polyethylene bag system as described by Ross et al. 2004. A 19 × 24-cm piece of Whatman GFA glass fiber sheet was placed on each fiberglass sheet of 19× 24 cm, then 3 of given sheets prepared for locating in each polyethylene bag (22.5 × 25-cm). Sheets were mounted with a file hanging rod in a frame wrapped with black plastic to prevent light penetration to the roots. Through next stage each GFA sheet was wetted with sterilized Hoagland nutrient solution (half strength) (Goldwasser et al. 1997). Then surface-sterilized *P. aegyptiaca* seeds around 0.33 mg, approximately 100 seeds, were sprinkled onto Whatman GFA glass fiber paper, then the roots of 10-day-old transplants after washing were mounted on PE bags paper above the parasite seeds. The paper was then inserted in to a clear polyethene bag containing 20 ml sterilized Hoagland nutrient solution (Hoagland and Arnon, 1950) (half strength) (Goldwasser et al. 1997). Polyethylene bags were kept in black containers and placed in a germinator machine with artificial condition of light and temperature (20C°/25C° night/day temperatures, under 100µEm^{-2}s^{-1} fluorescent light during a 14-h photoperiod) and replenished with nutrient solution as needed. Observations of plants growth, parasite seed germination, and radical attachment and development were counted periodically on the entire root system using a stereoscopic microscope (magnification, ×10-×60). Total *P. aegyptiaca* seed number was 3oo in each polyethylene bag. Six plants were put in each bag, 4 replicates were used for each plant. Experiment was conducted twice in a completely randomized design. The synthetic parasitic plant germination stimulant GR24 was used at 0.01 gL^{-1} on seed stock to assess conditions and to establish a standard proportion of *Phelipanche* seed sensitive to germination stimulants.

Pot study

A stock of dry clay loam soil **(**with 55% clay, 25% silt and 20% sand; 7-10% $CaCO_{3,}$ 2% organic matter (OM), and pH 7.1-7.2**)** artificially contaminated with *P. aegyptiaca* seeds (60 mg seeds Kg^{-1}soil, approximately 3 500 seeds) and kept beside non-infested soil. 27 plants (6 plants per pot) i.e. tomato, wheat , barley, rye, sun flower*,* soy bean, chick pea, zucchini, mungbean, corn, vetch, oat, beet, sugar beet, triticale, sainfoin, caster-oil plant, mill, sesame, fibber flax, alfalfa, red been, cucumber, bell pepper, cotton and sorghum were sown in 2-L pots filled with contaminated clay loam soil. Pots containing merely *P. aegyptiaca* seeds, served as control. Pots were placed in the greenhouse and irrigated as needed. Given Plants were kept at 20-25°C, and relative humidity (RH) of 60% with 14h day length. The pots exposed to natural light as well as artificial light producing 100W m^{-2} (14 hd^{-1}). Until whole plants passed the vegetation stage (nearly two months) the foliage was cut then oven dried (70 Cº for 48h). At this stage plants foliage was blended with soil surface in each pot (Kleifeld et al., 1994).

Experiment lasted by sowing three tomato seedlings in each of those pots containing crop's residues. Check treatment pots also were prepared as well. Following emergence of the first trifoliate leaf, tomato was thinned to one plant per pot. Pots were irrigated as needed. Tomatoes and emerged *P. aegyptiaca* plants both were collected after 86 DAP, from each pot and dried via oven (at 70 Cº for 48h). Tomatoes dry weight, *P. aegyptiaca* shoot and capsules dry weight were recorded. The experiment was conducted twice in a completely randomized design in which treatments were replicated 4 times. All F tests were subjected to Duncan's multiple range test at the 5% level of significance.

Results

Hydroponic Polyethylene Bag study

GR24 that were treated in our assay conditions stimulated germination in 53% of *P. aegyptiaca* seeds. All crops except zucchini, cotton, and pepper showed low levels of *P. aegyptiaca* parasitism in comparison with Tomato. *P. aegyptiaca* germinated between 14 and 28 DAP and attached between 28 and 42 DAP. *P. aegyptiaca* germination% response due to catch crop plants ranged from 8.333% in Millet to 55.333% in Pepper. The millet, barely and sesame germinated a smallest percentage of *P. aegyptiaca* seed than did others tested *Poaceae* family. Among *Poaceae* family the highest germination% occurred in *P. aegyptiaca* seeds which were next to sorghum, cotton and pepper roots. Results obtained from our research also others growth chamber experiments indicate that cotton, pepper, sorghum and GR24 can stimulate approximately equivalent proportions of *P. aegyptiaca* germination (up to 55.333%) (Rose et al., 2004; Rodriguez-Conde et al., 2004). *P. aegyptiaca* seeds germinated in the presence of crops from the *Apiaceae, Asteraceae, Alliaceae, Zygophyllaceae, Euphorbiaceae, Pedaliaceae, Linaceae, Malvaceae, Cucurbitaceae, Chenopodiaceae, Poaceae, Solanaceae* and *Fabaceae* families. However, attachment wasn't seen in wheat, barley, maize, oat, sorghum, triticale, millet and rye from *Poaceae* family, wild rue in *Zygophyllaceae*, garlic, peper, beet, sugar beet, castor oil plant and cotton in *Alliaceae*, *Solanaceae*, *Chenopodiaceae*, *Euphorbiaceae*, and *Malvaceae* families respectively (Table1).

Pot study

Cotton, sorghum and pepper growth in the soil infested by *P. aegyptiaca* can subsequently reduce the number of parasitic attachments on grown tomatoes through next planting. All tested plants greatly reduced or completely inhibited parasitic attachment to tomato. Results suggested that cotton, sorghum, vetch, sainfoin, wild rue, soybean, and rye could be utilized to deplete *P. aegyptiaca* capsule's number. The number of *P. aegyptiaca* attachments per tomato plant differed among treatments ($P<0.0001$). For the sake of the instance tomato grown in soil where no former plants were grown averaged 4.66 parasitic attachments in each tested pot. Tomato grown after cotton did not have any parasitic attachments. Germination of *P. aegyptiaca* was significantly higher in pots without any former plants. Dry weight of per *P. aegyptiaca*'s capsule was significantly decreased in pots which formerly contained sunflower, chick pea, soy bean, wild rue and cotton. Whereas, significantly increased in pots which formerly contained tomato and zucchini. Except millet in *Poaceae* family and zucchini in *Cucurbitaceae* family most other cultivated plants as cover crops led to decrease *Phelipanche* seedling dry weight. The most significant reduction in dry weight of broomrape was demonstrated in pots which formerly contained cotton, sainfoin, casteroil, chick pea, soy bean, garlic, wild rue and sorghum (Table 1). However, the least number of *Phelipanche* capsule was seen in pots which formerly contained cotton, sorghum, vetch, sainfoin, wild rue, soybean, and rye. Furthermore, it is demonstrated that cotton decreased early infestation of the parasite; thereby it can significantly augment tomatoes dry weight. It's obvious that all changes in *Phelipanche* germination% also get impact from the allelechemicals that were exuded by plants within the soil.

Discussion

Allelochemicals are present in almost all plants and in many tissues. However, the activity of mentioned chemicals used for *Phelipanche* control will be weak as a result of rapid volatilization. Allelochemicals may offer improved selectivity, better toxicological and environmental safety and increased efficacy. The aqueous leaf, stem and root extracts of *Andrographis paniculata Nees* showed inhibitory effects on seed germination and growth of *Seasmum indicum* L. (Ellu) was investigated. Given investigation also showed that the extracts brought about considerable inhibition in the germination of ellu seeds and in the growth of its root and shoot. The allelopathic effect of leaf, stem and root extracts of *A. paniculata* decreased the seed germination of ellu with increase in the extracts concentration. The inhibitory effect might be due to the presence of these allelochemicals in the extracts of *A.paniculata.* In a Leaucaena leucosephla plantation, Chou (1990) found an almost total lack of understory after 3 to 4 years of growth, except its own seedlings. Decomposing leaves also suppressed growth of plants in pots. This is exactly what we would like to confirm based on extracted results from our recent experiment. Acquired results can also define the allelopathic efficiency of applied plants tissues in our pot experiment. *Phelipanche* infestation declining (90-95%) through Dongola investigation and the yield of tomato was increased by 60% (*Dongola 2006*). Some legume crops increase soil fertility that contributes to the ability of susceptible crops to compete with their parasites. The increase in soil fertility may also stimulate a reduction in the secretion of germination stimulants by the crop roots (*Yoneyama et al., 2007*). List of Some trap crops according to Ferna´ ndez-Aparicio's paper are cotton (*Gossypium hirsutum* L.) (the source of the first isolated germination stimulant strigol) probably for all *Phelipanche* , *Phelipanche* species, linseed (*Linum usitatissimum* L.) for *P. ramosa* and *P. aegyptiaca*, mungbean (*Phaseolus aureus* Roxb.) for *P. aegyptiaca*, Egyptian clover (*Trifolium alexandrinum* L.) for *O. crenata*, sunhemp (*Crotalaria juncea* L.) and mung bean [*Vigna radiata* (L.) Wilczek] for *O. cernua* Loefl. Fenugreek stimulates *P. ramosa* seed germination, but not the seeds of *O. foetida* Poir.; *O. crenata* seed germination is inhibited (*Ferna´ ndez-Aparicio et al., 2008*), which all given traps are able to mitigate *Orobanche* infestation in field. Likewise, we determined that *Poaceae* family consists of barely, wheat, oat, triticale, sorghum, millet, corn & rye as well as pepper, beet, sugar beet, caster-oil plant, cotton, wild rue and garlic between other examined crops are located in trap crop, suicidal agent group. Flax, which has been suggested by many investigators as a trap crop for *Orobanche* (*O. ramosa; O. cernua; O. crenata*), was severely parasitized by *O. aegyptiaca*. Correspondingly, our result introduced flax as a catch crop which is able to reduce the *O.aegyptiaca* constraint in infested soil. Clover was suggested as a trap crop by AlMenoufy (1989) for *O.crenata.* Mung bean was suggested for *O.crenua*; both clover and mung bean were heavily parasitized by *O. aegyptiaca*. Sorghum was mentioned as a trap crop for *O. cernua*.

Conclusion

The application of trap and catch crops should be included in the regularly rotation and fallow management for the infested fields. This path is not only usable to alleviate the weed's invasion but to fortify the soil which is covered by given plants. Needless to stress again that, rotation also has direct and indirect impacts on weeds especially parasitic ones in infested areas. While trap- and catch crops in rotation may reduce to some extent the parasite seedbank, other rotation crops may have allelopathic effects on parasitic seeds. Current study defined the remarkable impacts of crop rotation on *P. aegyptiaca* seed bank as well as on crops yield. The PE bag method enabled us to monitor the parasitism process from germination to inflorescence and identify the stage at which parasitism halted and ceased to progress.

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Tab. 1: Evaluation of cultivating 27 cover crops in order to find one that has the influential rule on declining *O.aegyptiaca* infestation in tomato contaminated field as well as the estimation of tomato yield enhance

Family	Cover crops	LTS [a](mm)	LPS[b](mm)	DWTS[c](mg)	DWPS[d](mg)
Solanaceae	Tomato (*Lycopersicon esculentum* L. Mill.)	190.41 g	109.98 abc	1005 abc	408 abc
	Pepper (*Capsicum annum* L)	216.67 fg	164.67 ab	516.3 abc	402.3 abc
Asteraceae	Sun flower (*Helianthus annus* L)	181.67 g	80.89 abc	335 bc	175 abc
Poaceae	Wheat (*Triticum aestivum* L)	117.33 h	91.11 abc	936 abc	168.7 abc
	Oat (*Avena sativa* L)	115.5 h	41.03 bc	817.7 abc	153.7 abc
	Rye (*Secale cereal* L)	118.33 h	151 abc	779.7 abc	176 abc
	Barley (*Hordeum vulgare* L)	100.41 h	116.77 abc	540.3 abc	408 abc
	Triticale (*Triticum secale Wittmack*)	128.33 h	88.67 abc	705 abc	278 abc
	Millet (*Panicum miliaceum* L)	166.66 h	183.13 ab	348.7 bc	660.3 a
	Corn (*Zea mays* L)	251.00 defg	183.67 ab	437.7 abc	168.7 abc
	Sorghum (*Sorghum vulgare* L)	103 h	41.83 bc	259 c	33.3 c
Fabaceae	Vetch (*Vicia villosa* L)	321.67 bcd	92.25 abc	1043.7 abc	142.7 abc
	Soy bean (*Glycine max* L *Merrill*)	270.00 cdef	56.55 abc	595.7 abc	64.3 bc
	Chick pea (*Cicer arietinum* L)	298.33 cde	62.07 abc	864.3 abc	86 bc
	Alfalfa (*Medicago sativa* L)	296.67 cde	152.33 abc	825.3 abc	372 abc
	Sainfoin (*Onobirichis vignaredista* L)	236.67 efg	37.58 bc	537.3 abc	64 bc
Chenopodiaceae	Beet (*Beta vulgaris* L)	303.33 cde	204.67 a	868 abc	430 abc
	Sugar beet (*Beta vulgaris saccharifera* L)	242.67 defg	87.89 abc	1064 abc	88 bc
Cucurbitaceae	Zucchini (*Cucurbita pepo var. pepo* L)	380.00 ab	71.44 abc	1205 a	573.3 ab
Malvaceae	Cotton (*Gossypium hirsutum* L)	250.00 defg	0 c	1227 a	0 cd
Linaceae	Fiber flax (*Linum usitatissimum* L)	393.33 a	72.08 abc	1072.7 ab	278.3 abc
Pedaliaceae	Sesame (*Sesamum indicum* L)	246.67 defg	149.39 abc	929 abc	196 abc
Euphorbiaceae	Caster-oil plant (*Ricinus communis* L)	308.67 bcde	98.33 abc	1143.7 ab	116 bc
Zygophyllaceae	Wild rue (*Peganum harmala* L)	340.00 abc	54.11 abc	1104.7 ab	81 bc
Alliaceae	Garlic (*Allium sativum* L)	296.67 cde	58 abc	773.3 abc	59 bc
	Control + O	278.67 cdef*	154.72 abc	864.7 abc	367.7 abc

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