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Research Report

Innovative research for organic 3.0 - Volume 1: Proceedings of the scientific track at the Organic World Congress 2017, November 9-11 in Delhi, India

Thünen Report, No. 54,1

Provided in Cooperation with:
Johann Heinrich von Thünen Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries

Suggested Citation: Rahmann, Gerold (Ed.) et al. (2017) : Innovative research for organic 3.0 - Volume 1: Proceedings of the scientific track at the Organic World Congress 2017, November 9-11 in Delhi, India, Thünen Report, No. 54,1, ISBN 978-3-86576-177-4, Johann Heinrich von Thünen-Institut, Braunschweig, https://doi.org/10.3220/REP1510907717000

This Version is available at:
https://hdl.handle.net/10419/171337

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THÜNEN

Innovative Research for Organic 3.0
Volume 1

Proceedings of the Scientific Track
at the Organic World Congress 2017

November 9-11 in Delhi, India

G. Rahmann, C. Andres, A.K. Yadav, R. Ardakani, H.B. Babalad, N. Devakumar, S.L. Goel, V. Olowe, N. Ravisankar, J.P. Saini, G. Soto, H. Willer

Thünen Report 54

Bibliografische Information:
Die Deutsche Nationalbibliothek verzeichnet diese Publikationen in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet unter www.dnb.de abrufbar.

Bibliographic information:
The Deutsche Nationalbibliothek (German National Library) lists this publication in the German National Bibliography; detailed bibliographic data is available on the Internet at www.dnb.de

Bereits in dieser Reihe erschienene Bände finden Sie im Internet unter www.thuenen.de

Volumes already published in this series are available on the Internet at www.thuenen.de

Zitationsvorschlag – *Suggested source citation:*
Rahmann G, Andres C, Yadav A K, Ardakani R, Babalad H B, Devakumar N, Goel S L, Olowe V, Ravisankar N,Saini J P, Soto G, Willer H (2017) Innovative Research for Organic 3.0 - Volume 1 : Proceedings of the Scientific Track at the Organic World Congress 2017 November 9-11 in Delhi, India. Braunschweig: Johann Heinrich von Thünen-Institut, 549 p, Thünen Rep 54, Vol. 1 DOI:10.3220/REP1510907717000

Die Verantwortung für die Inhalte liegt bei den jeweiligen Verfassern bzw. Verfasserinnen.

The respective authors are responsible for the content of their publications.

THÜNEN

Thünen Report 54 - Volume 1

Herausgeber/Redaktionsanschrift – *Editor/address*

Johann Heinrich von Thünen-Institut
Bundesallee 50
38116 Braunschweig
Germany

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www.thuenen.de

ISSN 2196-2324
ISBN 978-3-86576-177-4
DOI:10.3220/REP1510907717000
urn:nbn:de:gbv:253-201711-dn059307-6

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Thünen Report 54

with support from
GOVT. OF INDIA
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Thünen Report 54 - Volume 1

Braunschweig/Germany, im November 2017

Foreword

Innovative Research for Organic 3.0

The future challenges in food production and consumption appear clear:

- Feed 9 to 11 billion people in the next 30 to 80 years with enough, affordable and healthy food.
- Protect the environment (e.g. soils, water, air, biodiversity and landscapes) whilst increasingly under pressure to achieve greater levels of intensification.
- Mitigate greenhouse gas emissions and adapt to climate change in all farming systems and value chains.
- Incorporate novel ethics, food habits, demographics and lifestyles into the food chains.
- Produce food on limited farmland and fossil (non-renewable) resources efficiently and profitably.

Several findings from scientific research and practical applications suggest that organic food and farming systems can help in tackling these future challenges.[1]The 'low external input' approach, risk minimizing strategies and ethically accepted production practices of organic food and farming systemscan help to produce more affordable food for an increasing number of people while minimizing environmental impacts. However, resource efficiency, low-meat diets and reducing food waste are also essential factors that have to be considered.

From a global perspective, organic food and farming systems is still a niche sector, as less than 1% of global farmland is managed organically and only a small proportion of the global population is consuming organic food in significant amounts. Production yields are relatively low, and the goals of organic food and farming systems, described in the principles and standards, are not achieved on every farm. This needs further development based on scientific evidence and good management practices.

A lot has been done already to develop organic food and farming systems. Nevertheless, to assure, that organic food and farming systems becomes a significant part of the solutions for the future challenges in the food and farming sector, there is still much to do.

The Scientific Track at the Organic World Congress 2017 in Delhi, India, will contribute to the global discussion on Organic 3.0, and taking the opportunity to answers some of the challenges in the context of the Indian subcontinent in particular. After a double-blind review, done by 120 reviewers from various disciplines from many experienced research institutions throughout the world, about 183papers from 50 countries have been accepted.

All the papers in these proceedings can be also foundon the database "Organic Eprints" (www.orgprints.org).

The Scientific Board of the Organic World Congress 2017 Delhi, November 2017

[1]A review paper about the Organic 3.0 discussion can be found under Rahmann, G., Reza Ardakani, M., Bàrberi, P. et al. (2016): Organic Agriculture 3.0 is innovation with research. Org. Agr. 7 (2016):3, pp 169-197, doi:10.1007/s13165-016-0171-5.

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Citation:

Rahmann *et al*. (2017): Innovative Research for Organic 3.0 - Proceedings of the Science Track at the Organic World Congress, November 9-11, 2017 in Delhi, India. Sprint/Delhi, pp 526

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Hapur Road, Kamla Nehru Nagar, Ghaziabad-201002

Phone: 0120-2764-2764906,2764212, Fax 0210-2764901; Email: nbdc@nic.in

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Content

Title of the paper	Authors	Country	page
Soil - Europe			**1**
Integrated soil quality assessment as an indicator for a successful conversion to organic agriculture	Koen Willekens, Jane Debode, Lieven Waeyenberge, Bart Vandecasteele	Belgium	2
Identification of deep-rooting crop species in arable subsoil by the minirhizotron technique	Eusun Han, Lisa Havmøller, Dorte Bodin Dresbøll, Kristian Thorup-Kristensen	Denmark	6
Challenges in the establishment of living mulch in a temperate climate – a case study with cabbage	Lukas Bender, Sabine Gruber, Wilhelm Claupein, Sabine Zikeli	Germany	10
May mycorrhizal symbiosis be boosted by agro-ecological service crops?	Alessandra Trinchera, Corrado Ciaccia, Elena Testani, Gabriele Campanelli , Fabrizio Leteo, Valentina Baratella, Sara Sestili, Francesco Riva, Stefano Canali	Italy	14
Nitrogen budgets in organic and conventional cropping systems – The efficiency-sustainability dilemma	Mayer, J., Jarosch, K., Hammelehle, A., Dubois, D., Gunst L., Bosshard, C., Frossard, E., Mäder, P. and Oberson, A.	Switzerland	18
How reliable are microbial inoculants in agriculture for improving yield and nutrient use efficiency? a meta-analysis of field studies from 1981 to 2015	Lukas Schütz, Andreas Gattinger, Matthias Meier, Adrian Müller, Thomas Boller, Paul Mäder, Natarajan Mathimaran	Germany	22
Effects of using compost mulch and conservation tillage on the productivity of organic zucchini	Zoltán Dezsény, Tímea Jung	Hungary	26
Soil - Global			**30**
Organic inputs improving soil microbiology for sustainable agriculture and higher yields	Viviane Yargeau, Simon Neufeld, Michael Warren	Canada	32
Nitrogen leaching in organic, low-input and conventional vegetable production systems in northern China	Hui Han, Yanmin Teng, Xi Wang, Hefa Yang, Ji Li	China	36
Effects of nano porous Activated Carbon on reducing Extraction coefficient by spinach (Spinacia	Sara Darvishi Aghajani, Mohammad Reza Ardakani, Saeed Vazan, Hossein Ghafourian, Farzad Paknejad and Amir Hossein Faregh	Iran	40
Title of the paper	**Authors**	**Country**	**page**

The development and use of cyanobacteria microbe fertilzer	Chang Nam Pak	DPR Korea	44
Concerning microbes in organic agriculture: with reference to the growth of rice plants under SRI agroecosystem	Febri Doni, Anizan Isahak, Che Radziah Che Mohd Zain, Norela Sulaiman, and Wan Mohtar Wan Yusoff	Malaysia	48
Organic farming system with animal and forest waste to increase anthocyanin and vitamin C content of rabbiteye blueberry on a heavy soil	Girish Kumar Panicker, Ananda Nanjundaswamy, Juan Silva, Frank Matta	USA	52
Invitro evaluation of soil isolates from organic fields for their antagonistic activity against phytopathogenic microorganisms	N. Devakumar, Latha B, Lavanya G, Rameshkumar C.	India	56
Studies on soil microbial population in organic paddy as influenced by liquid organic manures and Palekar's method of cultivation	S. Shubha, N. Devakumar, G.G.E. Rao	India	60
Isolation and screening of Phosphate solubilizing bacteria from rhizospheric soil of Mung bean	Sangeeta Pandey and Naleeni Ramawat	India	64
Nutrient Management Options Through Organics in Greengram (Vigna radiata L.) – Rabi Sorghum (Sorghum bicolor L.) System under Rainfed Conditions	Satyanarayana Rao, B.K. Desai and R.Venkanna	India	68
Impacts of Organic Farming on Soil Organic Matter	Elham A. Ghabbour, Geoffrey Davies, Reem A. Alami, Erin M. Askounis, Nicholas P. Cuozzo, Alexia J. Filice, Jennifer M. Haskell, Andy K. Moy, Alexandra C. Roach, Tracy M. Misiewicz, Jessica Shade	USA	72
Farming Systems - Europe			**76**
True nutrient cycles: Organic 3.0 and the use of recycling fertilizers from wastewater	Olivier Duboc, Jakob Santner, Franz Zehetner, Walter Wenzel	Austria	78
The role of intuition in managing Organic farm system health	Rebecca Paxton, Milena Klimek, Anja Vieweger, Thomas Döring, Ralf Bloch, Johann Bachinger, Lawrence Woodward	EU	82
The IFOAM principle of health – how do organic farmers apply it in practice?	Anja Vieweger, Thomas Felix Döring, Ralf Bloch, Johannes Bachinger, Milena Klimek, Rebecca Paxton, Lawrence Woodward	EU	86
Title of the paper	**Authors**	**Country**	**page**

Nutrient flows in organic field vegetable production: Survey results from Southern Germany	Verena Koch, Sabine Zikeli, Kurt Möller	Germany	90
The role of Biochar in biological nitrogen fixation and N2O emissions	Hans-Martin Krause, Michael Scheifele, Paul Mäder, Andreas Gattinger	Switzerland	94
Improving UK agro-forestry: A participatory approach to identifying, developing and field-testing innovations	Jo Smith, Anja Vieweger, Kostantinos Zaralis, Martin Wolfe	UK	98
Organic cropping systems tend to be more sustainable than low- input ones - A case study in Brittany, France	Alexandre Joannon, Matthieu Carof, Patrice Cotinet, Aurélien Dupont, Anne Guezengar, Djilali Heddadj, Stanislas Lubac, Christophe Naudin, Jean-Luc Giteau	France	102
Quantum-Based Agriculture: the Final Frontier?	Julia Wright, Henk Kieft, Saskia von Diest	UK	106
Why are there composition differences between organic and conventional foods? Evidence from the long term Nafferton Factorial System Comparison fields trials	Leonidas Rempelos, Marcin Barański and Carlo Leifert	UK	110
Farming Systems - Global			**116**
Profitability of cacao agro-forestry systems and monocultures under organic and conventional management	Laura Armengot, Pietro Barbieri, Christian Andres, Monika Schneider	Bolivia	118
The potential of organic agriculture and agro-ecology for sustainable intensification of tropical agro-ecosystems	Christian Andres, Gurbir Singh Bhullar	Global	122
To what extent does land use differ between organic and conventional farming? A global scale analysis	Pietro Barbieri, Sylvain Pellerin, Thomas Nesme	Global	128
Model for productivity improvement in default organic system and its up-scaling in drylands of India	Arun K. Sharma , D.K. Painuli and N. Patel	India	132
Organic rice production in irrigated agriculture using the rice intensification system (SRI)	Ehiabhi Cyril Odion, Idris Ahmadu, Uthman Arunah, Abdullazeez Shero Isah, Rilwanu Yahaya and Bashiru Babaji	Sudan	136
Title of the paper	**Authors**	**Country**	**page**
Agroforestry is more productive than monoculture, and organic agroforestry is competitive with its conventional counterpart –	Christian Andres, Monika Schneider, German Trujillo, Freddy Alcon, Patricia	Bolivia	140

First result from a long-term field trial in Bolivia	Amurrio, Eusebio Perez, Franco Weibel, Joachim Milz		
Can mineral nutrients be limiting factors to organic agriculture expansion at the global scale? – A spatially explicit approach	Pietro Barbieri, Sylvain Pellerin, Thomas Nesme	Global	144
Conventional versus organic farming systems: decoding comparisons to improve cereals organic breeding strategies	Rolland B., Heumez E., Oury F.-X., Le Campion A.	Global	148
Biodynamic Agriculture; A Boon for Small Farmers for India	Binita Shah, Sanjay Roman, Khadse, Bhale, Nilesh Teli, Sarg Vikas Samiti	India	152
Ecology			**156**
A complex monitoring of biodiversity of organic apple orchards could uncover the impact of agro-management strategies	Vladislav Haralampiev Popov, Evgenia Kostadinova, Emilia Rancheva, Hristina Yancheva	Bulgaria	158
A place based development of organic farming to tackle water pollution problems	Audrey Vincent, Philippe Fleury	France	162
Nature conservation achievements on organic farms with suckler cows in north-eastern Germany	Frank Gottwald, Karin Stein-Bachinger	Germany	166
Effective and economically viable organic agriculture under Inhana Rational Farming (IRF) Technology towards mitigation of climate change impact.	A. Seal, R. Bera, A. Datta, S. Saha, R. Roy Chaudhury, A. Chatterjee and A.K. Barik	India	170
A Comparison of the impacts of organic and conventional dairying on the aquatic environment	Alan Thatcher, David Horne, Ian Brookes	New Zealand	174
Equal yield-scaled and lower area-scaled nitrous oxide emissions in organically managed soils	Gattinger Andreas, Colin Skinner, Maike Krauss, Paul Mäder	Switzerland	178
Contribution of organic farming to public goods in Denmark - a knowledge synthesis	Lizzie Melby Jespersen,Niels Halberg	Denmark	180
Energy efficiency and greenhouse gases emissions in organic, integrated and conventional olive orchards in Greece.	Vasileios D. Gkisakis, Nikolaos G. Volakakis, and Emmanouil M. Kabourakis	Greece	184

Title of the paper	Authors	Country	page
Agro-biodiversity adaptation for resilience to climate change: paradigm for sustainability in perpetuity	Thomas Abraham	India	188

Agroecological service crops as a tool to manage the agrobiodiversity in organic orange orchards: a case study	Corrado Ciaccia, Anna la Torre, Elena Testani, Francesco Riva, Valerio Battaglia, Filippo Ferlito, and Giancarlo Roccuzzo	Italy	194
Carbon sequestration in long term on farm studies in Organic and Biodynamic Agriculture, Sweden	Artur Granstedt, Lars Kjellenberg	Sweden	198
The role of organic in controlling nitrogen pollution	Laura Cattell Noll, Allison M. Leach, Verena Seufert, Jim Galloway, Brooke Atwell, Jan Willem Erisman, Jessica Shade	USA	202
Organic farming increases soil C sequestration via changes in crop litter quality	Pablo García-Palacios, Rubén Milla, Andreas Gattinger	Spain	206
Plant Production - Africa			**210**
Recovery of organic tomato residues through vermicomposting for organic vegetable production	Azim Khalid, Soudi Brahim, Erraji Hassan, Roussos Sevastianos and Thami Alami Imane	Morocco	212
Organic farming makes cotton production the most cost effective: Case study from Benin	Silvere Tovignan, Simplice Vodouhe	Benin	216
Sustainable management of the diamondback moth, Plutella xylostella L. (Lepidoptera: Plutellidae) on cabbage	Ken Okwae Fening, Ethelyn Echep Forchibe, Kwame Afreh-Nuamah	Ghana	220
Towards Enhanced Kale (Brassica Oleracea) Productivity through Application of Rock Phosphate, Farm Yard Manure and (White lupin (Lupinus Albus L)) and Chickpea (Cicer arietinum L.) Integration in farming systems of Kabete Sub-County, Kenya	Richard Onwonga, Caroline Chepkoech, Quinter Genga, Raphael Wahome, Henning Jensen	Kenya	224
Appropriate time to apply organic fertilizer to sesame and soybean in the humid tropics	Victor Idowu Olowe, Patience Odueme, James Fadeyi, Ganiyu Adisa	Nigeria	228
Effect of mycorrhizal symbiosis on the production of organic durum wheat	Khaled Sassi, Rim Bel Hadj Chedli, Ghassen Abid and Tarek Jarrahi	Tunesia	232
Effect of different organic substrates on reproductive biology, growth and offtake of the African night crawler earthworm (Eudrilus eugeniae)	Fred Kabi, Denis Kayima, Abasi Kigozi, Eric Zadok Mpingirika , Ronald Kayiwa and Dorothy Okello	Uganda	236
Title of the paper	**Authors**	**Country**	**page**
Impact of vetiver prunes compost application on the growth and yield of jews mallow	Adebayo Abayomi Olowoake	Nigeria	240

Effect of Poultry Manure and Defoliation on Organic Sesame Production in Guinea and Sudan savannahs of Nigeria	Ruth Saleh Ardzard, Ehiabhi Cyril Odion, Abdullahi Namakka, Abdulazeez Shero Isah	Nigeria	244
Effects of companion crops on insect pest infestation, yield, and postharvest quality of cucumber (Cucumis sativus) fruit	Oluyinka Benedicta Adewoyin	Nigeria	250
Synthetic pesticide-free grain storage in Africa: Options, efficacy evidence and uptake challenges	Brighton Marimanzi Mvumi , Tanya Stathers, Alex Abraham Chigoverah	Zimbabwe	254
Plant Production - America			**258**
Improving soil structure by using minimum-till permanent raised beds for vegetable crops	Denis La France, Maryse Leblanc, Maxime Lefebvre, Germain Moreau, Anne Weill, Serge Préfontaine, Luc Belzile, Yvon Houle	Canada	260
Orchard Floor Management Affecting the Growth of Young Organic 'Honeycrisp' Apple Trees	Julia Reekie and Eric Specht	Canada	264
Participatory research about foliar fertilizers in a chilli pepper crop at an organic family farm in Peru	Manuel Gabriel Velásquez, Pedro Francia, José Francia, Roberto Ugás	Peru	268
Minimum Risk Pesticides and Organic Farming Systems	Brian Paul Baker and Jennifer Ann Grant	USA	272
Changes in the Organic Blueberry Industry in Oregon: 2015 and 2016 Results of In-person, On-site Interviews with Growers	Javier A. Fernandez-Salvador, Bernadine Strik and Larry Lev	USA	276
Plant Production - Asia			**280**
A Comparison Study on Quality of Organic and Conventional Rice and Wheat	Xi Yunguan, Jin Shu, Wang Lei, Chen Qiuhui, Tian Wei	China	282
A short review on applications of signal transduction and xerophytophysiology in organic crop production	Hui-Lian Xu and Qicong Xu	Japan	286
The effects of wood vinegar and soursop (Annona muricata L.) plant extract on soil microorganisms	Noraini Md Jaafar, Joel Jia Le Khor and Nur Saidahtul Nadiah Harun	Malaysia	290

Title of the paper	Authors	Country	page
Performance Evaluation of Roselle (Hibiscus sabdariffa L.) Accessions under Organic Conditions	Rodel G. Maghirang, John Marty C. Mateo and Claudette D. Oraye	Phillipines	294

Validation and Documentation of Organic Production Systems for Lowland Rice in Camarines Sur, Philippines	Carmelita Nidea Cervantes, Felipe P. Laynesa, Jobelly B. Pacis	Phillipines	300
Effects of cultivation sites and varieties on ascorbic acid contents in organic vegetables	Siwaporn Thumdee, Benjamas Comekan , Ashariya Manenoi	Thailand	304
Comparing the rate of growth of organic greenhouse cucumber in different growth media fed with two humic acid levels	Amir Abbas Yousefi, Mohammadreza Rezapanah, Maryam Moarefi	Iran	308
Promising biological activity of Cydia pomonella granulovirus (CpGV) isolates for organic apple protection	Mohammadreza Rezapanah	Iran	312
Life Cycle Environmental Impact Assessment of long term organic rice production in Subtropical area China	Xueqing He, Yuhui Qiao	China	316
Total dry matter, nutrient uptake and yield of summer mungbean as influenced by organic management practices	Sharvan Kumar Yadav, Hanamantraya Bhimaraya Babalad[1], Shanti Kumar Sharma, Mahendra Kumar Yadav, and Roshan Choudhary	India	320
Organic nutrient management and intercropping for improved rainwater conservation and productivity under rain fed maize-barley rotation	Pawan Sharma, Vinod Kumar Bhatt, Sathiya, Krishnamurthy, Harish Sharma, and Lekh Chand	India	324
Development of a growing media for producing organic tomato (Solanum lycopersicum L.) in greenhouse	M. Reza Ardakani, Mehdi Sharifi	Iran	330
Study on The Utilization of Pig Manure in Vermicomposting Production by Earthworm (Eisenia andrei)	Po-Chin Chang, Yung-Song Chen	Taiwan	334
The Use of Neem and Pyrethrum Botanical Insecticides on Controlling Crocidolomia pavonana	Agus Kardinan	Indonesia	338
Plant Production - Europe			**342**
Organic farming with livestock raising vs. stockless farming - Development of soil organic matter stocks and cash crop yields	Franz Schulz, Andreas Gattinger, Christopher Brock, Günter Leithold	Germany	344

Title of the paper	**Authors**	**Country**	**page**
Participatory breeding for improved Phytophthora-resistance in the Organic Outdoor Tomato Project	Jonas Lange, Rahul P. Raj, Bernd Horneburg	Germany	348
INBIODYN: Integrated, bio-organic and biodynamic viticulture. A comparative study over	G. Meißner, J. Döring, M. Friedel, M. Stoll, R. Kauer	Germany	354

a 10-year-period.

Benefits of grass-clover in an arable crop rotation: a case study from The Netherlands	Roos de Adelhart Toorop, Jan de Wit, Walter Rossing, Chris Koopmans	Netherlands	358
VASO Program 2.0, three decades of participatory plant breeding towards the chain value	Pedro Mendes Moreira, Isabel Dinis, Daniela Santos, Maria Carlota Vaz Patto	Portugal	362
On-arm management and site-specific adaptation. A case study with lentil.	Michael Ruland, Barbara Wedemeyer-Kremer, Heiko C. Becker, Bernd Horneburg	Germany	366
Bioporing: yield insurance during dry spells?	Miriam Athmann, Timo Kautz, Andrea Herkenhöner, Ulrich Köpke	Germany	370
Use of ducks in weed control in organic maize compared to other weed control techniques	Paulo Miguel Pereira, Carla Neves, Tiago Martins, Hélia Marchante, Daniela Santos, Filomena Miguens, Pedro Mendes Moreira, Óscar Crispim Machado, Maria Antónia Conceição	Portugal	374
Bioactive component prediction of oat by portable diffuse reflectance field spectroscopy	Tina Kovács, András Jung, Lyudmila Lyubenova, Ismail Cakmak, Bence Bolgár, Elek Dinya, Dagmar Janovská, Michael Vohland and Dóra Drexler	EU	380
Effect of soybean inoculation in high latitude environments	Insa Kühling, Bianka Hüsing, Nina Bome, Dieter Trautz	Germany	384
The use of copper pesticides in Germany	Stefan Kühne, Dietmar Roßberg, Jörn Strassemeyer, Peter Röhrig, Friedhelm von Mering, Florian Weihrauch, Sonja Kanthak, Jutta Kienzle, Wolfgang Patzwahl, Eckhard Reiners	Germany	388

Title of the paper	Authors	Country	page
Optimizing breeding strategies and crop management for enhancing legume ecosystem services in organic farming	María José Suso and Carmen Mateos	Spain	392
Strategies to reduce or replace the use of copper for truly sustainable agriculture	Anna La Torre, Giacomo Pascali, Federica Caradonia,	Italy	398

	Lorenzo Righi, Francesco Riva, Corrado Ciaccia and Valerio Battaglia		
Are old varieties less productive than modern ones? Dismantling a myth.	Carranza, G. Guzmán, G.I. Torremocha, E., Aguilera, E., González de Molina, M.	Spain	404
Screening of stand-alone and mixture of cover crops for ground cover management in a temperate organic peach orchard	Claude-Eric Parveaud, Johanna Brenner, Gilles Libourel, Sophie-Joy Ondet, Claude Bussi, Vincent Mercier	France	408
Optimising organic soybean growth under reduced tillage by inline fertilisation with rock phosphate and elemental sulphur	Sahar Brahim, Daniel Neuhoff, Ulrich Köpke	Germany	412
Agro-ecological Service Crops with roller crimper termination enhance ground-dwelling predator communities and pest regulation	David Navarro-Miró, Berta Caballero-López, José M. Blanco-Moreno, Alejandro Pérez-Ferrer, Laura Depalo, Antonio Masetti, Giovanni Burgio, Stefano Canali, F. Xavier Sans	Spain	416
Assessing the productivity of organic rotations using the NDICEA model	Laurence Smith, Adrian Williams, Guy Kirk	UK	420
Plant Production - India			**424**
Evaluation of Nutrient Management Practices for Organic Chickpea (Cicer arietinum L.)	S. K. Sharma, Roshan Choudhary and Amit Trivedi	India	426
Comparative performance of organic vis-à-vis inorganic management practices in potential vegetable cropping sequences	JP Saini, Rameshwar and Raj Kumar	India	430
Nutrient management recommendations for smallholder organic Basmati rice production in Northern India	Lenora Ditzler, Tor Arvid Breland, Charles Francis, Monojit Chakraborty,D.K. Singh, Ashish Srivastava, Frank Eyhorn, Jeroen C.J. Groot, Johan Six, Charlotte Decock	India	436
Seaweed an organic fertilizer source for boosting the productivity of crops	C.S. Singh, M.K. Singh, S.K. Singh and Shikha Singh	India	440
Title of the paper	**Authors**	**Country**	**page**
Agricultural waste recycling: a new method to produce good quality compost at large scale	Shiva Dhar	India	444
Response of various inputs on yield, fruit quality and economics of organic production of mango cv. Mallika	Ram Awadh Ram, Anil Verma, Gundappa and Supriya Vaishya	India	446

Growth and yield of organic capsicum (Capsicum annuum L. var. grossum) as influenced by different sources, levels of organic manures and panchagavya application	B Boraiah, N Devakumar, K B Palanna, S Shubha	India	450
Organic production is safe, sustainable and profitable: Evidences from tuber crops	Girija Suja, Alummoottil Narayanan Jyothi, Janardanan Sreekumar, Ambikakumari Radhakrishnan, Seena Radhakrishnan, Cherian Lintu Maria and Rakhi Kanjiramthottiyil Raj	India	454
Influence of different levels of jeevamrutha and panchagavya on yield and quality parameters of organic frenchbean (Phaseolus vulgaris L.)	Basavaraj Kumbar, Devakumar N.	India	458
Effect of Farm Yard Manure (FYM) and Jeevamrutha on yield attributes and yield of Fieldbean (Dolichos lablab L.)	Siddappa, K. Murali, N. Devakumar and Ninganna Biradar	India	462
Influence of organic liquid formulations on soil beneficial microbial population of organic frenchbean (Phaseolus vulgaris L.)	Ninganna Biradar, K. Murali, N. Devakumar and Lavanya G	India	466
Efficient method of composting for production of good quality manure from hard crop residues	Tarak Kate, Sonali Phate	India	472
Influence of Organic in different methods of rice (Oryzae sativa.L) cultivation – SRI vs NTP on microbes, soil health and productivity	Rapolu Mahender Kumar, Kuchi Surekha, S. Gopalakrishnan, Ch Padmavathi , P.C. Latha and V. Ravindra Babu	India	476

Title of the paper	**Authors**	**Country**	**page**
Biofertilizer and bioirrigation: Tools for sustainable pigeon pea and finger millet production in India	Natarajan Mathimaran, Ansgar Kahmen, Ashok Ettigi Gurubasappa, Thimmegowda Matadadoddi Nanjundegowda, Sathish Ayappa, Bhavitha Nayakanahalli Chikkegowda, Shashidhar Gurudevarahalli Chikkathamegowda,	India	482

	Manjunatha Baiyapalli Narayanswamy, Prabavathy Vaiyapuri Ramalingam, Jegan Sekar, Yuvaraj Perisamy, Bagyaraj Davis Joseph, Thomas Boller and Paul Mäder		
Organic Rice farming – A viable option for sustaining Productivity, Grain quality, Soil health and Economic returns	Surekha Kuchi, Sreenivasa Rao Illuri and Mahender Kumar Rapolu	India	484
Yield and yield attributes of organic frenchbean (Phaseolus vulgaris L.) as influenced by farm yard manure and liquid manures	Basavaraj Kumbar, Devakumar N.	India	488
Effect of various sources of Zinc with particular reference to Nano Zinc carrier on Growth and Yield parameters in Rice (Oryza sativa.L)	M.R. Apoorva, P. Chandrashekar Rao	India	492
Dry matter accumulation and nutrient content in frenchbean (Phaseolus vulgaris L.) as influenced by organic liquid formulations	Ninganna Biradar, K. Murali and N. Devakumar	India	496
David against Goliath - Participatory non-GM cotton breeding in India	Monika M. Messmer, Amritbir Riar, Seraina Vonzun, Yogendra Shrivas, Lokendra Mandloi, Mahesh Birla, Ishwar Patidar, Ramprasad Sana, Gobinda Mahapatra, Arun Ambatipudi, H.G. Kencharaddi, Shreekant S. Patil	India	502
Soil health response to Organic nutrient management in vertisols under aerobic rice (Oryza sativa L.) cultivation	Jaffar Basha S, R. Basavarajappa and H. B. Babalad	India	506

Soil - Europe

Title	Author/s	Country
Integrated soil quality assessment as an indicator for a successful conversion to organic agriculture	Koen Willekens, Jane Debode, Lieven Waeyenberge, Bart Vandecasteele	Belgium
Identification of deep-rooting crop species in arable subsoil by the minirhizotron technique	Eusun Han, Lisa Havmøller, Dorte Bodin Dresbøll, Kristian Thorup-Kristensen	Denmark
Challenges in the establishment of living mulch in a temperate climate – a case study with cabbage	Lukas Bender, Sabine Gruber, Wilhelm Claupein, Sabine Zikeli	Germany
May mycorrhizal symbiosis be boosted by agro-ecological service crops?	Alessandra Trinchera, Corrado Ciaccia, Elena Testani, Gabriele Campanelli , Fabrizio Leteo, Valentina Baratella, Sara Sestili, Francesco Riva, Stefano Canali	Italy
Nitrogen budgets in organic and conventional cropping systems – The efficiency-sustainability dilemma	Mayer, J., Jarosch, K., Hammelehle, A., Dubois, D., Gunst L., Bosshard, C., Frossard, E., Mäder, P. and Oberson, A.	Switzerland
How reliable are microbial inoculants in agriculture for improving yield and nutrient use efficiency? a meta-analysis of field studies from 1981 to 2015	Lukas Schütz, Andreas Gattinger, Matthias Meier, Adrian Müller, Thomas Boller, Paul Mäder, Natarajan Mathimaran	Germany
Effects of using compost mulch and conservation tillage on the productivity of organic zucchini	Zoltán Dezsény, Tímea Jung	Hungary

Integrated soil quality assessment as an indicator for a successful conversion to organic agriculture

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Key words: soil quality, soil management, ley, tillage, fertilization

Abstract

The results of an extensive soil quality assessment on conventionally managed fields were compared with the soil quality on a reference field as a result of a multi-year organic management. Application of soil improving management practices in conventional agriculture will facilitate the conversion to organic agriculture. Inclusion of a ley is a promising practice to increase the organic matter content and sustain soil quality, however, its management might be decisive for reaching that goal. Ca and Mg input by fertilization should be equilibrated, as a factor affecting the Ca:Mg ratio and therefore soil structure. Correct application technique and timing of soil improving fertilization should prevent reduced root growth due to bacterial decomposition activity.

Acknowledgments

This field survey was executed by ILVO on behalf of the regional landscape 'Rivierenland' with financial support of the Flemish Environment Department.The authors gratefully acknowledgethe farmers involved in this surveyand Foeke Van Weverberg for the selection of farmers' fields. We also thank the field staff and lab technicians from ILVO for their technical assistance.

Introduction

Organic farming sustains soil quality by proper soil management practices, e.g., regular organic fertilization, a broad crop rotation with cover crops and reduced tillage practices. However, awareness of soil quality issues is growing in conventional farming resulting in a more frequent application of soil quality sustaining measures by conventional growers, inspired by neighbouring organically growing colleagues or informed by extension programs. It is likely that conventional farmers who already take care of soil quality have a good chance to be successful in the conversion to the organic production method when triggered by more attractive market conditions for the organic sector. Therefore we made a profound assessment of soil quality on 3 conventional farms that are applying or intend to apply a clear soil quality improving strategy and compared with an organic farm. Because of the soil complexity, our survey focused on all kinds of soil quality aspects.

Material and methods

One organically managed farm participated in the survey with the reference field 3. Three conventionally managed farms participated, i.e., two with one field (fields 1 and 2) and one with two fields (fields 4 and 5). All farms apply some soil improving practices.
Field 1 belongs to a farm that combines horticultural with arable crops. Onions, carrots and potatoes are grown in a rotation with cereals. Ruminant beef production was abandoned 8 years ago. Cover crops are regularly used and soil improving fertilization forms (compost, animal manure, …) are applied before sowing the winter cover crop (e.g., *Tagetes* in 2015). Additionally, mineralfertilization is applied in spring before installing the main crop (potatoes in 2016).

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Mouldboard ploughing (depth < 30 cm) is the main tillage practice. Field 2 was leased land by a conventional dairy farmer till 2014 for the cultivation of maize, with little investment in soil fertility building. Upon acquisition of the land by a vegetable grower, it was ploughed (depth 40 cm) and a ley of Italian ryegrass was installed in the autumn of 2015 (after a black fallow period) as a soil fertility building crop that was grown until spring 2017. The grass was not removed but mulched and cattle slurry was applied after the second mulching, i.e., short before soil sampling. Field 3 had a long history of organic cultivation (conversion of an orchard in 1978, which was installed after deforestation in 1958). Intensive vegetable cultivation started in 1993. Non-inversion tillage was executed in 2014 and 2015, but in spring 2016, the field was ploughed (depth 25 cm) in order to destroy a grass sward installed as a cover crop after cauliflower in 2015 and to incorporate 20 Mg farm yard manure per ha. Fields 4 and 5 belonged to the farm that combines animal and crop husbandry. A vegetable crop sequence is alternated with a ley phase. For field 4, 2016 was the first year that vegetables (headed cabbage) were grown after a ley phase of 10 years. The ley was ploughed in spring 2016 after chemical destruction. A base mineral N dressing was applied at planting (160 kg N ha^{-1}). On field 5, a temporary ley was installed in the autumn of 2014 after ploughing (depth 35 cm) to incorporate the residues of a cauliflower crop. In 2015 the grass was either mowed or grazed, and received cattle slurry once. After a first late cut in 2016, 20 Mg cattle slurry per ha was injected, i.e., shortly before soil sampling.

The 0-20 cm top layer of all fields was sampled under a standing crop in the beginning of August (fields 1 and 2 on 3 August and fields 3-5 on 9 August). At that time the moisture content of the soil was considerably high due to the rainy weather conditions. Based on the Belgian soil classification the dominant texture was light sandy loam except field 3 of which the texture was loamy sand. Each soil profile showed a cambic (B) horizon and they were classified as 'moderately wet' with regard to drainage condition. Inherent soil characteristics were quite similar between fields, which was important for the evaluation of the differences in soil quality related to the applied soil management practices.

Physical soil quality was also visually assessed under the standing crop. The soil was analysed for biological and chemical parameters. Biological assessment was done by i) bacterial counts t1 and t2 according to Rusch (2014) (t1 is in line with the bacterial decomposition activity, whereas t2-t1 is a measure for the 'rhizosphere' activity), ii) phospholipid fatty acids (PLFAs) analysis quantifying different microbial functional groups of the soil food web (non-specific bacteria, gram-positive and gram-negative bacteria, actinomycetes, fungi and mycorrhizal fungi) (Frostegård et al., 1991) and iii) nematode community analysis (Ferris et al., 2001). Nematode communities were characterized and classified according to their trophic level and way of life to evaluate the structure of the soil food web and the disease supressiveness. Considered chemical parameters were total organic C (TOC), total N content (Ntot), pH-KCl, hot water extractable C (HWC) and plant available nutrient reserves (P, Ca, Mg, K) extracted with ammonium lactate.

Results

Visual assessment of physical soil status

On both fields with grass, fields 2 and 5, the soil was seriously compacted in the lower part of the arable layer and had a blue shine due to anaerobic soil condition. In contrast, under the potatoes, celeriac and headed cabbage on fields 1, 3 and 4 respectively, the soil showed a nice crumbly structure.

Chemical parameters

The organically managed field 3 showed the highest soil organic matter level, followed by field 4 which had a 10 year history as pasture land. The other fields had a reasonable content (Table 1). The P status of all fields is above the target zone due to regular application of animal manure and

compost. The Ca:Mg ratio was extremely low on fields 2 and 5 and high on field 3, which coincided respectively with very low and high NO_3^- : NH_4^+ ratios (Table 1).

Table 1. Chemical soil characteristics: total C (TOC) and N content (Ntot), pH-KCl, hot water extractable C (HWC) and plant available nutrient reserves (P, Ca, Mg, K); Ca:Mg and NO_3^- : NH_4^+ ratios; measurement values for fields 1-5

Field	TOC	Ntot	C:N	pH-KCl	HWC	P	Ca	Mg	K	Ca:Mg	NO_3^-:NH_4^+
	%	%			ppm	mg per 100 g dry soil					
1	1.9	0.13	14.7	6.5	1131	45	143	21	16	4.1	1.2
2	1.5	0.12	12.8	5.7	1327	23	79	21	10	2.3	0.0
3	3.4	0.22	15.4	6.1	1648	28	210	16	32	8.2	2.9
4	2.3	0.20	11.4	5.9	1925	29	130	39	11	2.0	1.0
5	1.6	0.15	11.0	5.2	1542	23	65	18	19	2.2	0.1

A low NO_3^- : NH_4^+ ratio might be indicative for a lack of aeration causing a hindered nitrification. Lack of aeration was likely to happen in the visually compacted soil in the lower part of the arable layer of fields 2 and 5, along with a high soil moisture content at sampling. Moreover, the compaction can be explained by very low Ca:Mg ratios for both fields. The highest Ca:Mg was found for field 3 which coincides with a high NO_3^- : NH_4^+ ratio, indicative for a high nitrification rate.

Biological parameters

Fields 1 and 3 showed the highest bacterial decomposition activity (t1), whereas fields 4 and 5 showed the strongest 'rhizosphere' (t2-t1) (Table 2). High t1 values reflect the presence of undecomposed organic residues, derived from incorporated *Tagetes* and stable manure in fields 1 and 3, respectively, the decomposition of which might have caused reduced root growth.

Table 2. Bacterial counts according to technique 1 (t1) and technique 2 (t2) of the Rusch test

Field	t1	t2	t2-t1	t2 : t1
1	176	356	180	2.0
2	70	235	165	3.4
3	173	362	189	2.1
4	82	421	339	5.1
5	83	400	317	4.8

HWC seems to be correlated with total microbial biomass as quantified by PLFA analysis (Figure 1). HWC would be the easily available C fraction. PLFA values of specific microbial groups were correlated with values of total microbial biomass (results not shown).

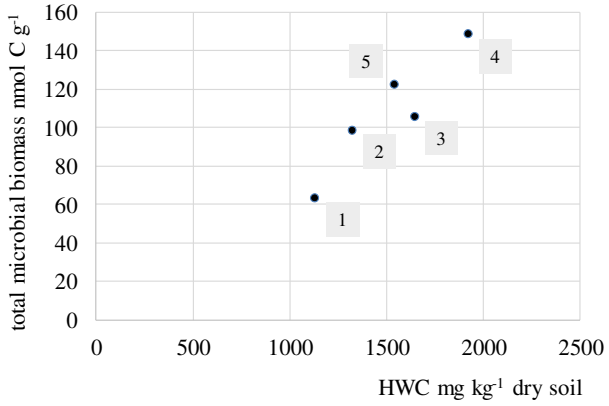

Figure 1. Total microbial biomass quantified by PLFA analyses versus hot water extractable C (HWC) in the 0-20 cm soil layer of fields 1-5

The combined use of an 'enrichment' (EI) and 'structure' index (SI) derived from the classification of the nematodes according to their trophic level and mode of life, pointed out that both fields 3 and 4 showed a recovering soil food web, with the presence of omnivorous and predator nematodes, whereas the other fields showed a more disturbed soil food web, especially field 1 with an extremely low SI (Figure 2).

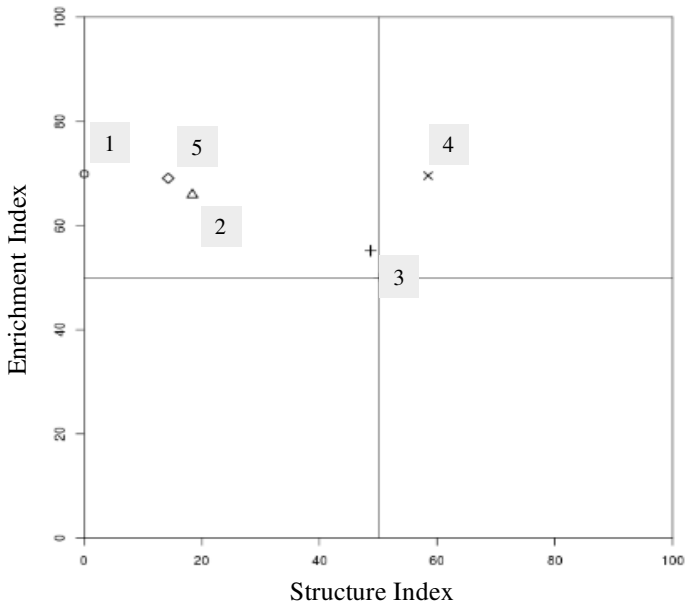

Figure 2. Soil food web analysis based on the nematode community in the 0-20 cm top soil of fields 1-5

Discussion

This investigation shows that soil quality on conventionally managed fields where farmers apply multiple soil improving practices may approach a level comparable with that of an organically managed field over a multi-year time span. Inclusion of a ley is a promising practice to increase the organic matter content and sustain soil quality, however, its management might be decisive for reaching that goal. Ca and Mg input by fertilization should be equilibrated, as a factor affecting the Ca:Mg and therefore soil structure. A proper incorporation technique and application time of stable manure and crop residues should prevent hindrance for root growth due to bacterial decomposition activity. Working on soil quality issues is a big step in advance to conversion to organic agriculture.

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Identification of deep-rooting crop species in arable subsoil by the minirhizotron technique

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Key words:deep roots, maximum rooting depth, root intensity, perennials, cropping system

Abstract

Our current understanding of the plant deep root system and its relevance for crop production is limited. A field trial was established in order to monitor the root growth of various deep-rooted crops down to 5 m of soil depth with the minirhizotron technique. Root intensity (RI: intersections m^{-1}) and maximum rooting depth (m) of seven different crop species indicate varying degree of root penetration capacity among the tested crops. Overall, within one season over 89 % of RI was concentrated at 0-1.0 m of soil depth. Sugar beet (1.4 m) as an annual crop showed the most rapid root growth rate (10.6 mm day^{-1}). On average the perennials resulted in 0.7 m of maximum rooting depth (5.6 mm day^{-1}), which indicates their potential to establish deep root systems in coming seasons.

Acknowledgments

This study was part of the **DeepFrontier** project funded by the Villum Foundation.

Introduction

Arable subsoil is a hidden but important part that comprises of potentially-reachable soil resources (Lynch and Wojciechowski 2015). Therefore, promotion of plant *deep roots* within a cropping system is essential to enhance crop productivity without further increasing the use of external inputs (Thorup-Kristensen et al. 2012); this is one of the aims of organic agriculture (Köpke et al. 2015). Despite the previously reported capacity of numerous crop and grass species for deep-rooting (see Canadell et al. 1996), investigation on the root system in arable fields is often limited to a relatively shallow range of soil depths (e.g. 0.3-1.0 m) unlike the majority in forestry or agroforestry (e.g. 3.0 m of soil depth; da Silva et al. 2011). Therefore, the objective of our study is to extend the range of agronomically relevant subsoil down to 5 m of depth by identifying deep-rooted crops and cropping systems.

Material and methods

A field trial was established at the experimental station of the University of Copenhagen in Taastrup, Denmark (55 °40'N; 12 °18'E). The soil was classified as an Agrudalf as sandy loam. Detailed description on the study site is available in Dresbøll et al. (2016). The experimental design was a strip-split design. Seven crop species were involved in the study (see Table 1). Prior to the crop season, 6 m long minirhizotron tubes were inserted in the plots at an angle of 30° from vertical covering approximately 0.0-5.2 m of soil depth. Multispectral images were taken along the minirhizotron tubes at each 0.05 m-length interval by a Videometer lab instrument (Videometer

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A/S, Hørsholm, Denmark). Image-taking took place from Aug 9 to Sep 6 in 2016 to 3.0 m of soil depth at maximum. Light illumination setup for UVA, violet, amber, red and NIR was adjusted to 365, 405, 590, 660 and 970 nm, respectively. The size of each of the images was 40 mm * 50 mm (width * height) consisting of 2048 x 2448 pixels. The images were analyzed with the VideometerPreview (Videometer A/S, Hørsholm, Denmark) software as Pseudo RGB.Root intensity (intersections m^{-1}) was calculated as the number of roots intersecting a grid overlaid the images divided by the total length of grid lines (0.89 m per image). Maximum rooting depth (m) was calculated as the soil depth where the roots were identified at the deepest depth within one minirhizotron tube. Sowing dates for the crops and root measurement dates are indicated in Table 1. Statistical analysis was done with the R version 3.3.0 (R Core Team 2016). A mixed-effects model (Pinheiro and Bates 2000) with log-transformed variables was used as univariate analysis, and if required, post hoc tests (Tukey's HSD, $P \leq 0.05$) were carried out.

Table 1: Crops, Latin names, sowing dates/density and measurement date

Crop	Latin name	Sowing date	Sowing density	Measurement date
Curly dock	*Rumex crispus* L.	29/05/2016	0.4 g m^{-2}	9/08/2016
Intermediate wheatgrass	*Thinopyrum intermedium*	7/04/2016	2.5 g m^{-2}	24/08/2016
Lupine	*Lupinus albus* L.	11/04/2016	0.5 g m^{-2}	24/08/2016
Mugworth	*Artemisia vulgaris* L.	28/05/2016	0.2 g m^{-2}	6/09/2016
Silphium	*Silphium perfoliatum* L.	30/05/2016	9 plants m^{-2}	1/09/2016
Sugar beet	*Beta vulgaris* L.	11/04/2016	9 plants m^{-2}	24/08/2016
Sweet clover	*Melilotus officinalis* L.	14/04/2016	0.6 g m^{-2}	8/09/2016

Results

Among the tested crops, sugar beet resulted in the highest maximum rooting depth (1.43 m) followed by lupine (0.93 m), intermediate wheatgrass (0.93 m), silphium (0.82 m), sweet clover (0.67 m), curly dock (0.42 m), and mugworth (0.27 m; Figure 1). In the same manner, the highest root growth rate was also observed with sugar beet (10.6 mm day^{-1}) and mugworth revealed the lowest root growth rate (2.7 mm day^{-1}). Below 0.5 m of soil depth sugar beet showed the highest RI (5.15 intersections m^{-1}; Table 2). Mugworth did not deploy any roots beyond the topsoil (i.e. >0.5 m) at the time of measurement. Proportional distribution of RI showed that lupine allocated 31.5 % of roots below topsoil followed by sugar beet (30.3 %), the intermediate wheatgrass (22.3 %), silphium (9.3 %), curly dock (1.8 %) and sweet clover (0.5 %).

Discussion

It is plausible to observe that establishment of deep roots beyond 1 m of soil depth was already possible in one season of cultivation. For the perennials (e.g. silphium and curly dock), a substantial increase in rooting depth in coming season is expected as duration of growth influences the root growth in deeper soil horizons (Thorup-Kristensen et al. 2009). Ability of plants to establish deep roots mainly depend on their root diameter (Materechera et al. 1992); this corresponds with the higher root growth of the taprooted crops such as sugar beet (e.g. Thorup-Kristensen et al. 2012) and lupine (e.g. Pennisi 2008). Also our observation might be the first report showing the root growth of the intermediate wheatgrassunder European soil conditions, which showed a strong tendency to intensify its root system in the subsoil as did in its origin in the U.S. (Cox et al. 2006).

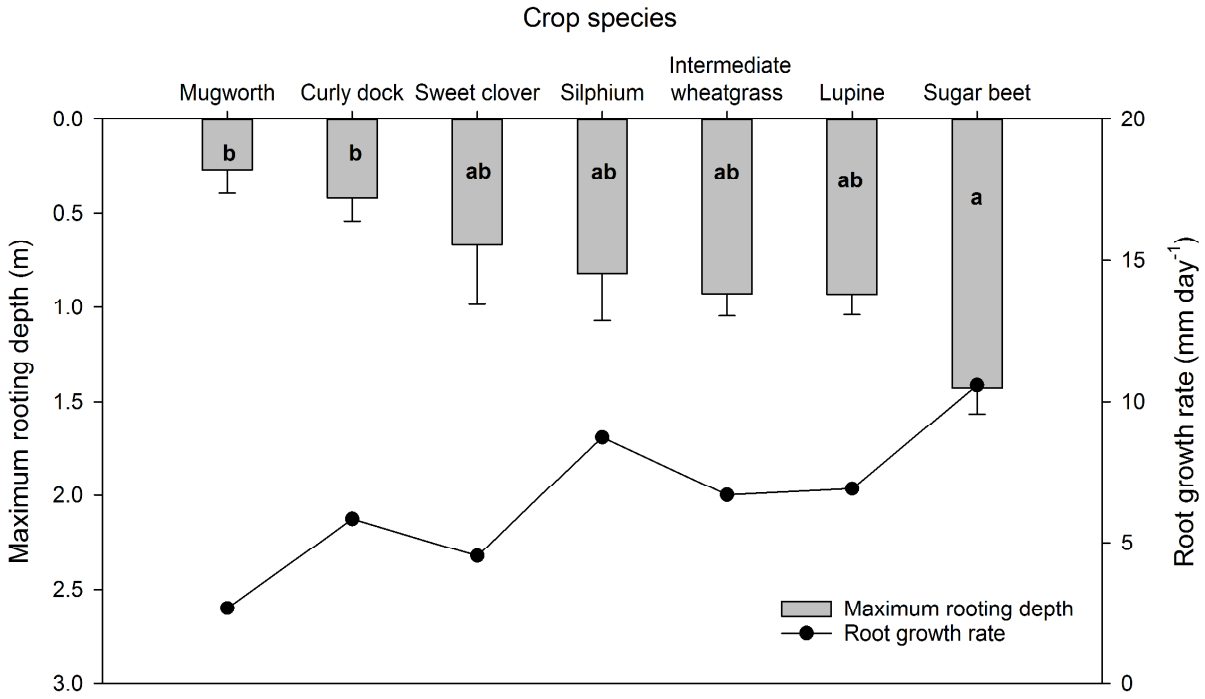

Figure 1. Maximum rooting depth (m) and root growth rate (mm day^{-1}) of the seven crop species. Different small letters indicate significant differences between the crop species (Tukey's HSD; $P \leq 0.05$). Analysis was done with log-transformed variables but mean (one±SE) values are shown here (root growth rate was not analyzed).

Development of deep roots can be beneficial for the standing plants as they gain more access to the limiting nutrients and water. Deep-rooted crops also positively influence the following crops as they function as N catch crops. In addition, they provide preferential pathways for roots of the following crops by the increased biopore density.

Table2: Rootintensity (RI; intersectionm^{-1}) measuredat 0.0-0.5 m, 0.5-1.0 m, 1.0-1.5 m, 1.5-2.0.mand 2.0-2.5 mofsoildepth

Soil depth (m)	Sweet clover	Curly dock	Intermediate wheatgrass	Lupine	Mugworth	Silphium	Sugar beet
0.0-0.5	11.06 bc	42.56 a	22.48 bc	11.33 bc	12.30 bc	8.56 c	25.17 ab
0.5-1.0	0.06 b	0.78 b	6.70 bc	5.24 b	0	0.92 b	13.69 a
1.0-1.5	1.18 b	0	0.95 b	0.05 b	0	0.42 b	6.38 a
1.5-2.0	0	0	0	0	0	0	0.02
2.0-2.5	0	0	0	0	0	0	0.50

Different small letters indicated significant differences between the crop species within the soil depth (Tukey's HSD; $P \leq 0.05$).

Our study indicates that crop plants have potential to establish deep root systems in arable subsoil. Organic management should consider the deep soil as an alternative nutrient reservoir and formulate crop sequence/rotation to better exploit the deep soil nutrients. Future study should focus on activity of deep roots under field conditions by developing methods applying nutrient tracers in deep soil horizons.

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Challenges in the establishment of living mulch in a temperate climate – a case study with cabbage

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Key words: Intercropping, mineralization, competition, vegetables, weeds

Abstract

*The use of living mulch for erosion control is discussed in organic vegetable production. Supposed challenges are competition between crop and mulch, and sufficient weed control. A two-factorial field trial was conducted in 2015 in SW Germany to test effects of living mulch on yield and weeds in cabbage. White cabbage (*Brassica oleracea *convar* capitata *var.* alba*; both a round and a pointed variety) was intercropped with perennial ryegrass (*Lolium perenne*; RG) or white clover (*Trifolium repens *L.; C), or grown without living mulch (control). Total head yield was 38.8 > 2.8 > 2.1 t ha^{-1} fresh mass (control > C > RG) across varieties. Up to 11 times more weed plants than in the control were recorded in living mulches. The share of marketable heads of pointed cabbage ranged from 88%>18%>0.9% and for round cabbage from 72%>5%>0.5% (both control>RG>C). Competition early in the year and low mineralization due to reduced soil disturbance are assumed to be the main reasons for the low yields.*

Acknowledgments

We thank Oliver Hübner and our other colleagues from the research station for organic farming Kleinhohenheim for their invaluable support at any time.

Introduction

The production of vegetables is frequently linked to soil erosion caused by wide row spacing during early stages of development, poor soil cover for long periods of time, intensive tillage before transplanting or sowing, and mechanical weed control. Fertile soils, which are most suitable for vegetable production, are often prone to erosion due to their texture, e.g. a high percentage of silt. Intercropping with living mulch (LM) might reduce soil erosion when the soil surface is covered by the leaves of LM, and when the root network stabilizes and maintains the soil structure. On the other hand, disadvantages such as competition between mulch and crop, and difficulties in weed control are expected. To understand the issue, and to define problems and solutions associated with the LM system, we set up a field trial with cabbage in 2015. The aim of the study was to determine yield and weeds of cabbage-LM intercropping, and to develop improvements and adaptations of the cropping system.

Material and methods

The University of Hohenheim experimental station for organic farming, Kleinhohenheim, is located in South-West Germany, at 435 m above sea level, with an average mean temperature of 9.7 °C and an average annual precipitation of 736 mm. The soils are Luvisols developed from loess, with soil depths of up to 2m. The farm is certified by the organic farming associations Demeter e.V., Bioland e. V., and Naturland e.V. and has been managed organically since 1994. Crops preceding white

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cabbage (*Brassica oleracea* convar *capitata* var. *alba*) were grass clover ley (*Trifolium pratense*, *T. repens*, *Lolium perenne*; 2014), emmer (*Triticum dicoccum*; 2013), onions/carrots (*Allium cepa*/*Daucus carota*; 2012), and spring wheat (*Triticum aestivum*; 2011). The trial was a two-factorial row-column design (due to a slope in two directions) with cabbage variety (pointed: "Filderkraut"; round: "Dottenfelder Dauer") being factor one, and living mulch being factor two in three levels: white clover (*Trifolium repens* cv. Riesling; "C"); perennial ryegrass (*Lolium perenne* cv. Leon; "RG"), and control (bare soil). Plot size was 7.0 × 4.5 m with six rows of cabbage per plot and inter-row spacing of 0.75m. The intra-row spacing was 0.65m for pointed cabbage and 0.35 m for round cabbage, i.e. 65 and 120 plants per plot or about 2.1 (pointed) and 3.8 (round) plants m^{-2}. Cabbage was transplanted in strips 0.25m wide tilled by a rotary harrow into the mulch when the plantlets had 3–5 foliage leaves at the end of May 2015 (Table 1). No additional fertilizer was applied. Before primary tillage in spring, mineral nitrogen (Nmin) content was 30 kg ha^{-1} (0–90cm depth), while Corg was 1.24% in the topsoil (0-30cm). To control competition during the growing season, the living mulch plots were mown twice with a hand mower, and the cut material remained on the area (Table 1). On July 14 a strip of 10cm alongside each cabbage row was tilled with a goosefoot-shaped chisel to reduce competition from the mulch strips. Cabbage was hand weeded in the rows. The trial was irrigated several times using sprinkler irrigation with about 75 mm in total, independent of the treatment.

Table 1: Actions before and during the cabbage growing season on the experimental field in Kleinhohenheim in the year 2015 (dd/mm), for mixed cropping of cabbage with living mulch (LM).

Operation	Date	Operation (continued)	Date
Soil tillage by chisel plough	01/04, 15/04, 29/04	Irrigation approx. 15 l m^{-2} per date	04/06, 13/07, 17/07, 21/07, 11/09
Sampling N_{min} (0-90 cm)	30/04, 27/10	Mowing of LM close to the ground	18/06, 08/07
Sowing of LM (white clover: 10 kg ha^{-1}, ryegrass: 30 kg ha^{-1}	30/04	Tillage by goosefoot chisel close to the cabbage rows	14/07
Tillage by rotary harrow (control plots)	25/05	Hand weeding and hoeing in rows (control)	15/07
Cabbage transplanting	26/05	Sampling of living mulch and weeds	19/08, 15/10
Weed record	03/06, 03/07, 11/08	Harvest of cabbage	20/10
Hoeing of the control	17/06, 26/06, 14/07		

Weeds were counted five times per plot in an area of 0.05 m² between the rows. An area of 4 x 0.125 m² was cut twice to determine the biomass of living mulch and weeds. At harvest, three cabbage heads per plot were taken randomly to determine average head weight. The cabbage yield of the four inner rows (21 m²) was measured by hand-harvesting mature heads. Threshold for marketability was a head weight of about 0.4 kg (round cabbage) and about 0.6 kg (pointed cabbage).

Results

The year 2015 was exceptionally dry and hot for long periods during the growing season. There were no major losses recorded through insects and fungi (data not shown). During the season, the number of weeds was significantly higher when cabbage was intercropped with living mulch

compared to the control, particularly at the beginning of the season (Figure 1). *Chenopodium album* and *Matricariaspp*. were the dominant weeds. Less abundant weeds were grouped under "other". These were *Galium aparine*, *Cirsium arvense*, *Capsella bursa-pastoris*, *Thlaspi arvense, Sonchus arvensis*, and *Echinochloa crus-galli*.

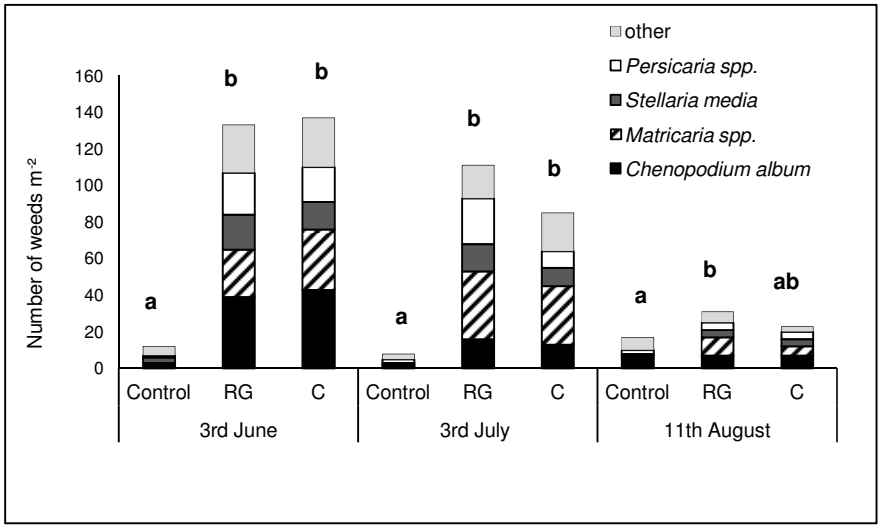

Figure 1: Weed numbers m^{-2} between cabbage rows (across varieties) with or without living mulch (control: bare soil, RG: perennial ryegrass, C: white clover) at three dates, experimental station Kleinhohenheim, 2015. Different letters indicate significant differences (P<0.05) between treatments, comparison only within the same date. SEM 3rd June: ± 13.32; 3rd July: ± 14.11; 11th August: ± 3.29. *Persicaria spp*.: *P. maculosa* and *P. lapathifolia*

Weed numbers converged over time (Figure 1) and weed biomass was relatively equal among the three treatments at the time of harvest in mid-October (Figure 2). The total biomass (fresh mass of cabbage, mulch and weeds) was two to three times higher in the control than in the living mulch treatments when recorded at harvest. At that time, cabbage contributed 93% and weeds 7% of the total fresh biomass in the control, while cabbage represented only 22% and 16% of the total biomass in mixed cropping with RG and C, respectively (Figure 2). Weeds represented 38% (RG) or 11% (C), and living mulch had a share of 40% and 73% in RG and C, respectively.
The individual mean head mass of pointed cabbage was higher than that of round cabbage (Figure 2). The pointed cabbage yielded 18.3 t ha^{-1} compared to 10.4 t ha^{-1} for round cabbage across treatments (not shown). Approximately 90% of the pointed, and 70% of the round cabbage met the standards for marketable heads when grown in the control. In the living mulch, however, the marketable yield was below 20%, and below 1% in white clover living mulch (Figure 2).

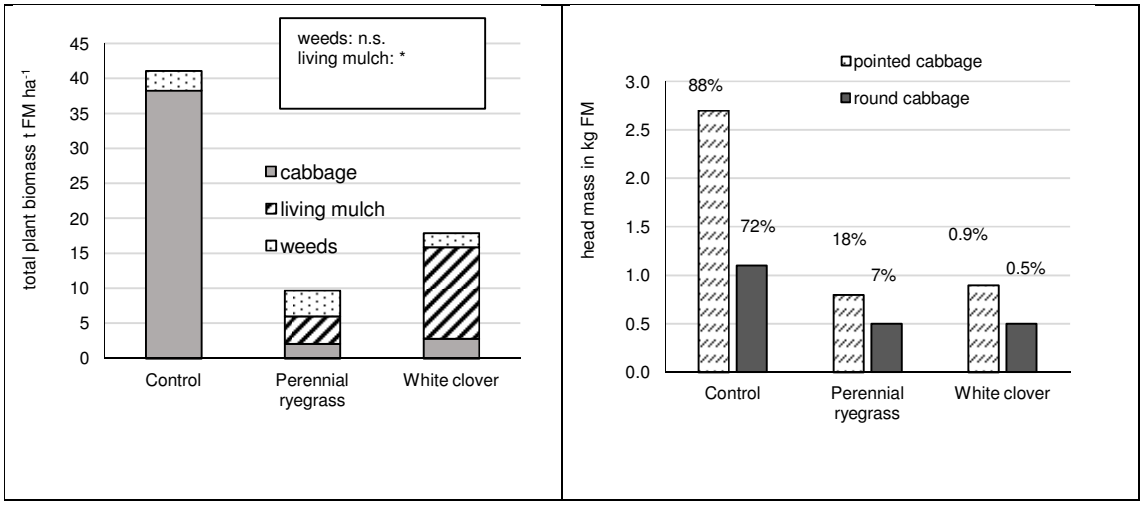

Figure 2: Total fresh biomass (FM) of vegetation (cabbage, living mulch weeds) at harvesting in October 2015, *significant at P<0.05 (A), and FM of cabbage heads (B) when intercropped with living mulch (ryegrass, clover), Kleinhohenheim, Germany. No statistics for cabbage yield due to inhomogeneity of variance. Top of the columns in B: share of marketable heads.

Discussion

The low marketable yields clearly indicate that intercropping cabbage with living mulch did not work in 2015. We assume three reasons: reason 1 being that the low mineralisation and associated reduction in nutrient uptake in the mulch plots had a high impact, while the side-effect of common (but not performed) mechanical weed control by a hoe – stimulating N mineralisation – was very low. This effect might have been strengthened by reason 2: the unusual drought period from May to July, which may have further reduced mineralisation and limited nutrient uptake by soil water, leading to an increased competition for water and nutrients between the living mulch and the crop (Pfeiffer et al. 2016). The amount of irrigation water has not been adapted to the treatments, but this would be an option for following years and in practical farming. Reason 3 was likely an unsuitable match between mulch variety and/or the time and the method of establishing and transplanting of mulch or cabbage (Montemurro et al. 2016).

Suggestions for tackling future challenges

In principle, we still believe in the value of living mulch systems, and suggest (i) to use mulch with a very low competition capacity, (ii) to maintain the tillage using a chisel tine close to the cabbage row, (iii) to reduce the width of the mulch strip compared to ours, (iv) to adapt the amount of irrigation to the water-use of the living mulch, (v) to consider dead mulch from a non-frost-tolerant species such as annual clovers (e.g. *Trifolium subterraneum*), and (vi) to apply organic fertiliser to minimize competition for nutrients.

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Can mycorrhizal symbiosis be boosted by agro-ecological service crops?

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Key words: mycorrhizal root, interference, weed, artichoke, spelt, rye

Abstract

The RizoSem project "Study of rhizosphere interaction and interference among crop and weeds in organic horticultural systems" was aimed to clarify the role of root mycorrhization on crop-weed interference, as affected by agro-ecological service crops. The research showed how the introduction of a mixed intercropped living mulch or different allelopathic cover crops were able to promote the belowground plant-fungi interactions in organic agro-ecosystems, boosting the root mycorrhizal colonization and the mycelial network formation, so as to: i) increase P uptake by the cash crop, being this behaviour cultivar-dependent; ii) modulate crop-weed competition and allelopathy.

Acknowledgments

Thanks are due to the PQA V Office "Organic farming" of the Italian Ministry of Agriculture, for funding the RizoSem project: "Study of rhizosphere interaction and interference among crop and weeds in organic horticultural systems" (2013-2015).

Introduction

The ecological significance of plant root mycorrhization and the mycelial network formation has been already recognized in natural woody systems as an effective strategy for increasing root adsorbing surface and, thus, water/nutrient uptake by coexisting plants. In an organic cropping system, characterized by a high level of plant diversity, the crop-weed interference, that means allelopathy and competition, is also mediated by root mycorrhization and fungi mycelial network establishment. When the agro-ecological service crops (e.g., living mulch, cover crops, etc.) are used in tailored organic cropping systems, they share the belowground environment with the cash crop and/or the weed, influencing not only the interference, but also the mycorrhizal mycelial network formation. This paper discusses how the agroecological service crops are able to promote rhizosphere interactions by implementing the root-fungi positive symbiosis and the following mycorrhizal network development, leading to i) increase soil P availability and the P uptake by the cash crop; ii) influence the crop-weed competition and allelopathy.

Material and methods

Two in field experiments were carried out at the Vegetable Research Unit of the CREA (Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria), located in Monsampolo del Tronto (AP, Italy).

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Experiment 1. – In 2013-2014, in a multi-annual organic artichoke (*C. cardunculus* subsp. *scolymus*) field, a mixed living mulch (*Trifolium incarnatum* L., *Vicia villosa* L., *Vicia faba* L. var. *minor*, *Coriandrum sativum* L., *Fagopyrum esculentum*, *Alyssum* spp., *Pisum sativum* L., *Brassica rapa* L., *Phacelia tanacetifolia* Benth) was intercropped with artichoke for weed management. Two Italian local artichoke cultivars, *Mazzaferrata* (Ma) and *Jesino* (Je), were tested in a split plot ($3\times6m^2$) design, with three replicates. Two factors were considered: the living mulch and the artichoke cultivar. The first factor had two levels: no living mulch (control, no LM) and unweeded living mulch (LM). The effect of LM on Ma and Je artichoke root morphology was evaluated by Scanning Electron Microscopy (SEM), while the root mycorrhizal colonization intensity (M%, Trouvelot *et al.* 1986, partially modified)was determined by optical microscopy.At harvesting, the artichoke yield, the soil available P and the crop P uptake were measured.

Experiment 2.– In November 2014 and 2015, in a four-years organic rotation and in a completely randomized block design with three replications (each plot area: $3\times6m^2$), the spelt (*Triticum dicoccum* L.) and the rye (*Secale cereale* L.) were sown as allelopathic winter-cereal cover crops for managing weed, in comparison with an unweeded control (CNT). At the end of April 2014 and 2015, corresponding to the rye full flowering and the spelt boot, for each cover crop and the five more representative weed species (*Rumex crispus* L., *Stellaria media* L., *Veronica persica* L., *Polygonum aviculare* L. and *Anagallis arvensis* L.) the density (D_i, pp$\times m^{-2}$) and the mycorrhizal colonization intensity (M_i %) were recorded. Then, in CNT and in rye and spelt cover cropping systems, the contribution of each plant species to mycorrhizal network development was expressed as $M_i\times D_i$ ("i" referred to each cover crop or weed species).

Results

Experiment 1 –The LM effect on Je and Ma artichoke root mycorrhization is shown in Fig. 1.

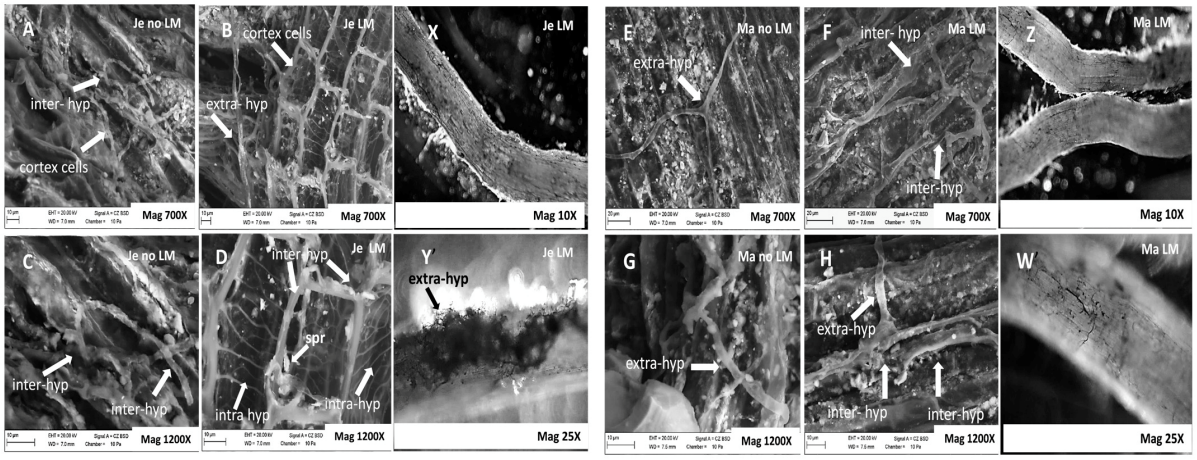

Figure 1. Root mycorrhization in Je and Ma artichokein absence of living mulch (no LM) and in presence of living mulch (LM). A-H are referred to 700X and 1200X magnifications by SEM; X-W to 10X and 25X magnifications by optical stereo-microscope. Arrows indicate: cortex cells; extra-, inter- and intra-hyp = mycorrhizal hyphae; spr = spores. (Ma: cv. Mazzaferrata; Je: cv. Jesino) (from: Trinchera et al. 2016).

The presence of LM increased the mycorrhizal colonization of Je roots, attested by the presence of abundant intra- and inter-hyphae in cortex cells, not present in Ma cultivar roots. This finding was quantitatively confirmed by intensity of root mycorrhizal colonization, which was significantly higher in Je LM (M = 43%) respect to Je no LM (M = 15%), being the same in Ma LM (M = 23%) and Ma no LM (M= 21%). Moreover, the LM induced the proliferation of root hairs in Je artichoke roots, that means an increase in root absorbing surface. Root morphological changes were cultivar-

dependent, being recorded only in Je artichoke and not in Ma one (Trinchera et al. 2016). Evidently, the Je artichoke, characterized by a lower productivity respect to the Ma one, had a great benefit by increasing mycorrhizal root colonization: actually, no decrease of Je yield was recorded respect to the Je no LM, being instead the P uptake improved in Je LM respect to the Je no LM (Trinchera et al. 2016). This was the first evidence that, by promoting mycorrhization of the "weakest" artichoke cultivar, the use of agro-ecological service crops (as the intercropped mixed living mulch) improves the ability of Je artichoke roots in utilizing phosphorous, as shown by the reduction of bulk soil P and the decrease of rhizosphere P in the P depletion root-zone of Je artichoke at the end of the cropping cycle (Trinchera et al. 2016).

Experiment 2. – The contribution of each "i" plant species *(Secale cereale*, *Triticum*, *Rumex*, *Stellaria*, *Veronica*, *Polygonum* and *Anagallis*) to mycorrhizal network development was represented by the $M_i \times D_i$ values, reported in Fig. 2. In 2014, *Anagallis* was the more abundant and mycorrhized weed species in the CNT, while the rye was the plant species most responsible for mycorrhizal colonization in that cover cropped system (Fig.2-A). As far as the spelt is concerned, both the cover crop (*Triticum)* and the *Stellaria* weed equally contributed to mycorrhizal network formation. In 2015, the competitive effect of the cover crop on weed growth was more pronounced, being the rye (*Secale)* and the spelt (*Triticum)* the species that mainly influenced theagro-ecosystems' mycorrhization, with the exception of the *Anagallis*, again the more abundant and mycorrhized weed also in the unweeded CNT.

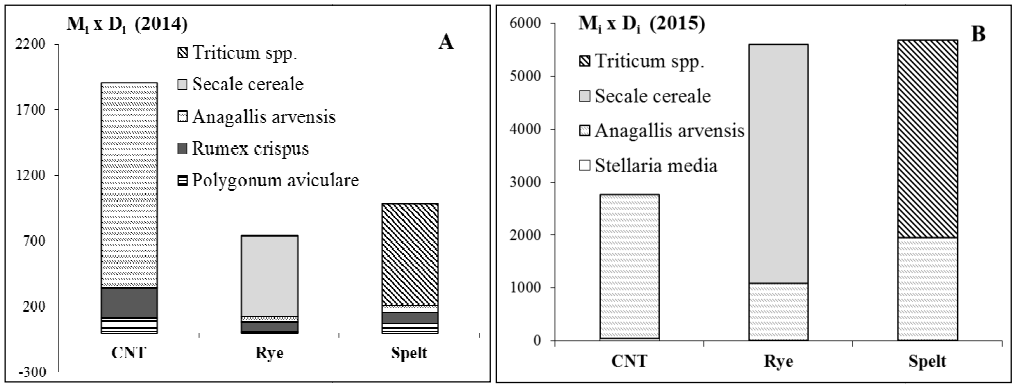

Figure 2. Contribution of cover crop (rye and spelt) and weed to MN formation in the compared agro-ecosystems (CNT, rye, spelt) in 2014 (A) and 2015 (B).

The different results obtained in relation to the mycorrhizal network formation were strongly influenced not only by the presence of the cover crop, but also by the climatic conditions: in 2014, under high and not-well distributed rainfalls from November to April, the studied agro-ecosystems resulted globally highly infested and slightly mycorrhized, being mainly regulated by cover crop-weed allelopathic interactions (Trinchera et al. 2015). Moreover, previous *in vitro* tests on *Rumex crispus* seeds showed the strong allelopathic effect of rye extract in inhibiting root elongation and suppressing mycorrhization at weed emergence (Trinchera et al.2015). In 2015, the regular rainfall and the highest average temperatures led to a greater competition within the considered agro-ecosystems, where the mycorrhization of cover crops and weed played a key-role, influencing plant water and nutrient uptake.

The effect of environmental conditions (year-effect) and the cover crop introduction (cover crop-effect) on the mycorrhizal network development is represented in Fig. 3. The spelt was the most promising cover crop in promoting mycorrhizal network formation in studied agro-ecosystems in both the years, giving to this winter-cereal cover crop a potential, additional agro-ecological value.

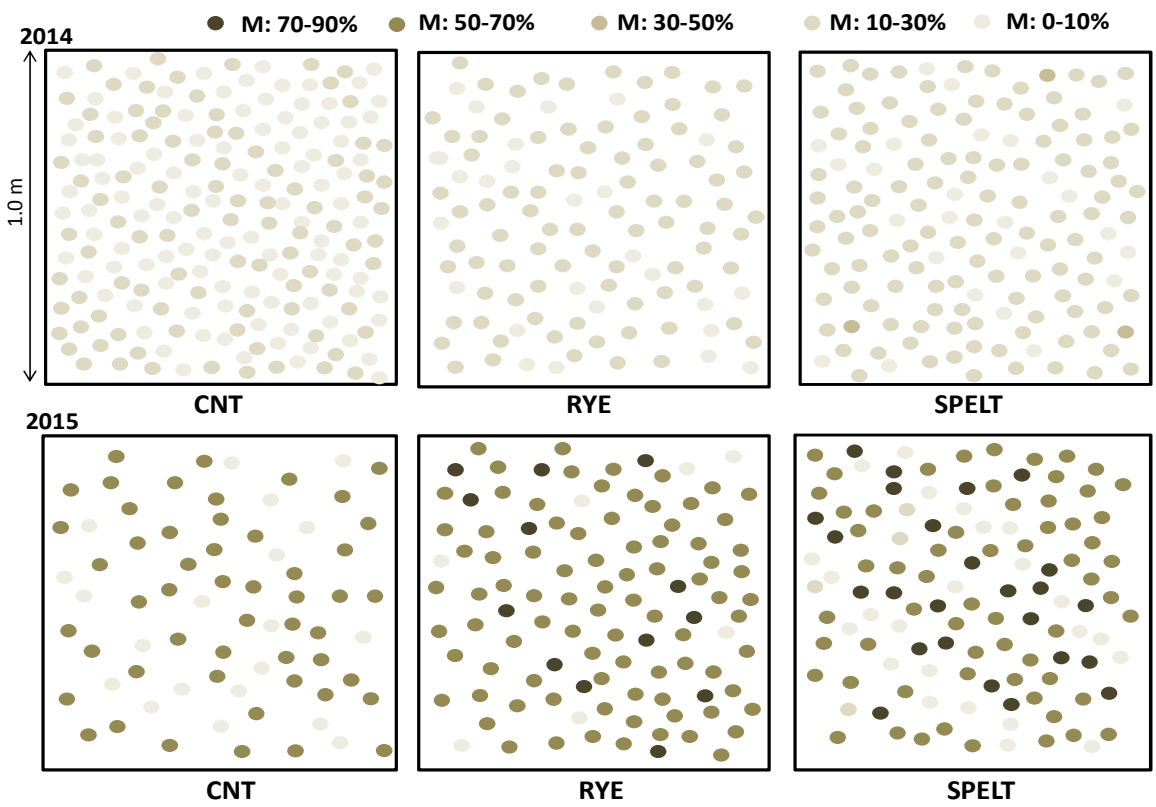

Figure 3. In 2014 and 2015, root mycorrhizal colonization in CNT, RYE andSPELT agro-ecosystems is represented. Into 1.0 m^2reference area, each randomized coloured point represents a single plant (cover crop or weed).Increasing colour darkness represents increasing range of M%, above reported. Total points in each area correspond to the total number of pp×m^{-2} (as the sum of cover crop plants and weeds per square meter).

Discussion

Mycorrhizal symbiosis was recognized as an ecosystem service provider influenced by the agro-ecological service crops. The low-yield *Jesino* cultivar increased the artichoke root mycorrhization under LM as an effective eco-physiological response to ensure the proper P availability to the crop, guaranteeing contemporary a good standard yield. Furthermore, the rye and the spelt affected the mycorrhizal root colonization in the agro-ecosystems: the highest one was recorded under spelt, corresponding also to a satisfactory weed control through competition and allelopathy. Obtained results suggest to address future research to exploit the nutrient-mining properties of plant-soil organisms, by strengthening the mycorrhizal network development in organic agro-ecosystems. Phosphorous solubilising effect of crops, coupled with biofertilisers based on mycorrhizal fungi should be considered under real farming conditions, for promoting nutrient cycling and carbon sequestration.

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Nitrogen budgets in organic and conventional cropping systems - The efficiency-sustainability dilemma

Mayer, J. [1], Jarosch, K.[1], Hammelehle, A.[1,2], Dubois, D.[1], Gunst L.[1], Bosshard, C.[1], Frossard, E.[2], Mäder, P.[3], Oberson, A.[2]

Key words: Nitrogen budget, nitrogen use efficiency, soil nitrogen stocks

Abstract

N-budgets over 35 years from the DOK trial are presented and combined with N-stock changes in DOK treatments on different fertilisation levels. Results strongly indicate an N efficiency-sustainability dilemma: DOK treatments with a high nitrogen use efficiency (NUE) lose more soil stock N than those with a lower NUE but higher N losses from the system. The biodynamic system showed little advantage in terms of soil N stocks sustainability while the solely mineral fertilised conventional treatment had highest NUE across all inputs including soil N change.

Introduction

Nitrogen (N) is the main yield limiting nutrient in organic farming systems. It is provided from two primary sources a) the biological nitrogen fixation, and b) the atmospheric deposition. Other sources like N from soil stocks or N in manure are based on these two primary sources. Nutrient budgets on a field scale in long term field experiments, like the DOK trial in Therwil, Switzerland give detailed information about N-supply, N-efficiency and potentials for N losses of the whole system. Furthermore long term experiments allow tointerlink results from N budgets with sustainability indicators such as the long term soil quality development. This allows new insights in the valuation of N budgets and relativizes "state of the art" knowledge. In this study we considered, besides N budgets, the management dependent change of the soil N stocks. The DOK trial allows in addition the comparison of organic and conventional cropping systems and the effect of different fertilisation intensities.

The objectives of the study were i) to calculate the N budget of the DOK systems over a period of 35 years and derive the N use efficiency (NUE) from these data, and ii) to compare the N budget with the soil N stock changes as one indicator for soil quality and thus give a new interpretation of the NUE – sustainability interactions.

Material and methods

The DOK long-term systems comparison (start 1978) compares bio-**D**ynamic (D), bio-**O**rganic (O) and conventional (**K**onventionell) (K) mixed cropping systems (Mäder et al. 2002). Additionally the experiment includes a zero fertilisation treatment (N0) and a conventional treatment with sole mineral fertilisation (M2, since 1985). The soil management of treatments D, O and K are in line with regular practice. The systems D, O and K have two fertilisation levels: 1 = half dose fertilisation, 2 = full dose fertilisation. Level 2 receives manure according to 1.4 livestock units (until 1991: 1.2 livestock units); level 1 receives 50% of it. Treatment M2 receives mineral fertilisers at full dose according to Swiss fertilisation guidelines (Flisch et al. 2009). In treatment K

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the respective amount of mineral fertilisers is added to the amount applied with manure. The field experiment design (Latin rectangle) has four replicates and a seven-year crop rotation which is replicated thrice in a shifted design.

The N budget was calculated by a difference of N inputs versus outputs for the period 1978 – 2012 (M2 since 1985), equation (1):

$$Budget\ year^{-1} = Input\ year^{-1} - output\ year^{-1} \quad (1)$$

The inputs comprise i) fertilisation, ii) atmospheric deposition, iii) seeds, and N from biological N_2-fixation (Ndfa). The outputs comprise N in crop yields and by-products, when removed from the field. For the fertilisers applied and the yield products removed we had yearly data (dry matter weights and nutrient concentrations) while atmospheric deposition and seeds were estimated by literature data. The biological N_2-fixation was estimated on the basis of above ground yield data, clover proportions in the clover grass ley and own data on below ground N inputs (roots+rhizodeposition) of clover and soybean. The N-transfer from clover to grass was taken into account. For the proportion of Ndfa we used own measurements and the data from Oberson et al. (2007) for soybean und Oberson et al. (2013) for clover.

The change of the soil N stocks over time in (0-20 cm) was calculated with yearly soil analysis and normalised with soil density data on a weight of 2500 t soil ha^{-1}.

Results

The inputs consisted 110 (N0) to 300 (K2) kg N ha^{-1} and year; the outputs were 140 (N0) to 250 (K2) kg (Fig. 1). In treatment N0 outputs exceeded inputs by 25 kg N ha^{-1}. In the half dose fertilisation treatments D1, O1, K1 and full dose M2 inputs and outputs were more or less equilibrated. In the full dose mixed farming treatments the inputs exceeded the outputs leading to positive budgets of 33 kg N ha^{-1} and year for D2 and O2, but a distinct larger value with 50 kg for K2 (Fig. 1).In contrast soil N stock change were largest where N budgets were negative or equilibrated. Treatment N0 without any fertilisation lost about 30 kg N ha^{-1} and year, followed by M2 with full dose mineral fertilisation with 20 kg. Treatments with half dose fertilisation (level 1) lost about 16 kg, full dose (level 2) treatments O2 and K2 lost 7 kg. Exceptionally D2 showed an equilibrated N-budget (Fig. 2).

Considering the NUE (kg N Output / kg N input) of the treatments without taking into account the N supply from changing soil N stocks, a NUE >100% results for N0. The NUE was about 100% for the half dose treatments D1, O1, K1 and the full dose M2, and it was 85% for full dose mixed cropping systems D2, O2, K2. Taking into account the real input from the soil (kg N output / (kg N input + Δ soil-N)) the NUE is reduced to more realistic values below 100% (Fig. 2)

Discussion

The N budget of the DOK trial was calculated based on a very solid long-term experimental data basis (crop yields, nutrient concentrations of crops and soil, Ndfa measurements, below ground inputs, etc.) and it is the first N budget study which can be supported by such a broad data fundament. With exception of gaseous losses and leaching losses, it was possible to measure or estimate all parameters with a high precision. Surprisingly all treatments showed a high to very high NUE (81 – 96 % of N input). The half dose fertilisation treatments (level 1) and the conventional mineral fertilised treatment at full dose (M2) showed equilibrated budgets which is the target when planning the N supply of an organic farm. They gained the highest NUE of about 93% of N input. Organic and conventional systems did not differ. However, NUE decreased with an increasing N budget surplus at full dose fertilisation level 2 with 85% for D2 and O2 and a bit lower for K2 with 81%. The soil lost most of its N stock where N budgets were equilibrated or negative and in

consequence had the lowest potential for N losses. The price for a more sustainable soil management (treatments D2, O2, K2) - here indicated by soil N stock change - were higher N losses. The potential for N losses (N budget surplus) were 34, 39 and 56 kg ha^{-1} and year for D2, O2 and K2, respectively.

The soil system budget of the DOK trial showed clearly the N efficiency-sustainability-dilemma of agricultural land use. Soil N sustainability can only be achieved with higher N losses. The concept of N use efficiency has to be redefined if further studies confirm our results.

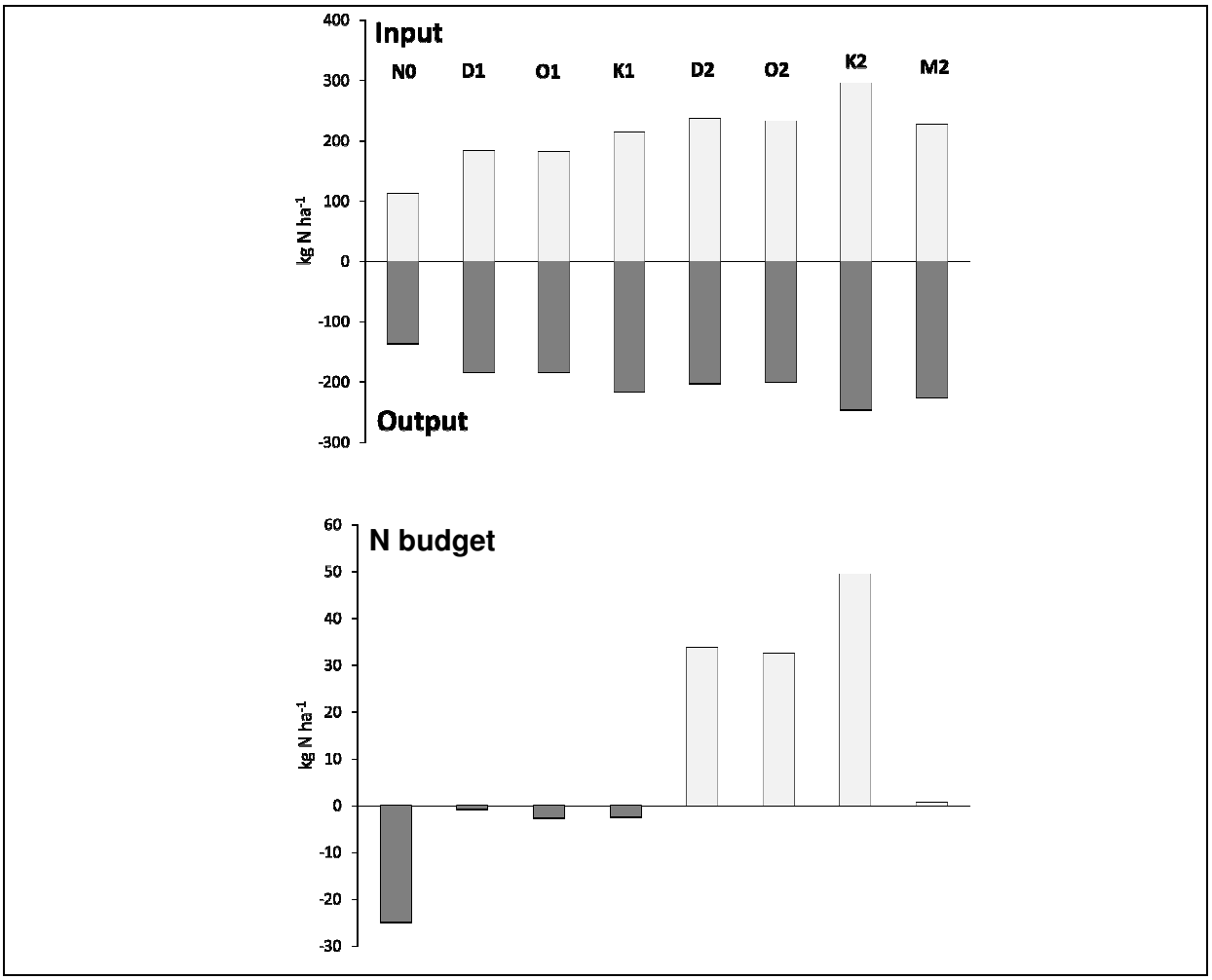

Figure 1. N inputs and outputs as well as N-budget in the DOK experiment from 1978-2012 (n=12) in kg N ha^{-1} and year.

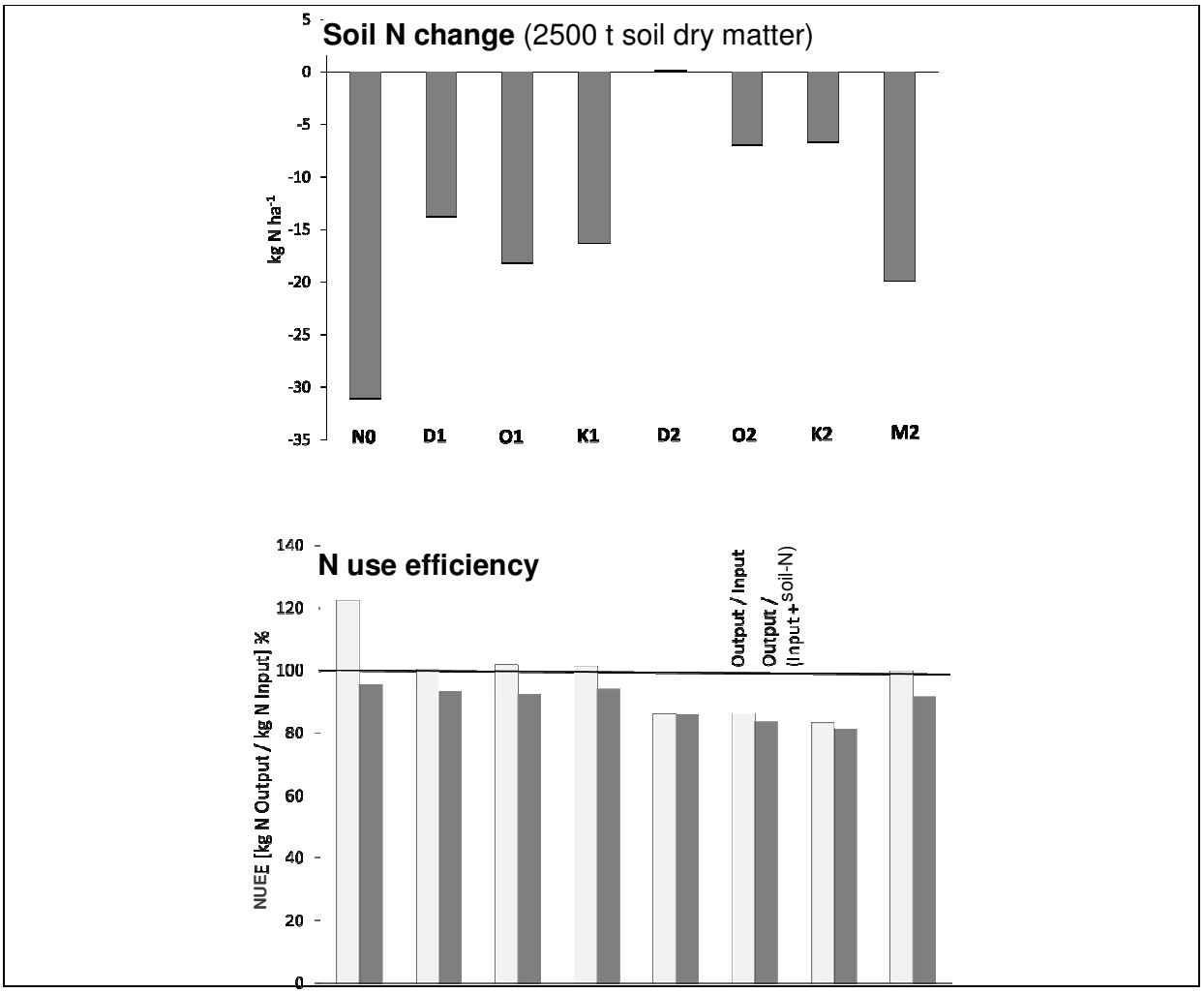

Figure 2. Change of soil N stocks (normalized for 2500 kg soil dry matter, 0-20 cm) in kg ha^{-1} and year and N use efficiency (NUE) of the cropping system based on inputs without and with soil N delivery in the DOK experiment from 1978-2012 (n=12).

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How reliable are microbial inoculants in agriculture for improving yield and nutrient use efficiency? a meta-analysis of field studies from 1981 to 2015

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Keywords: biofertilizer, microbial inoculants, agricultural productivity, nitrogen use efficiency, phosphorus use efficiency, arbuscular mycorrhizal fungi

Abstract

Microbial inoculants or biofertilizer are a promising technology for future farming systems. Various taxa are in use, utilizing their capacity to access nutrients from fertilizers and soil stocks, to fix atmospheric nitrogen, to improve water uptake or to act as biocontrol agents. But soils and climate are highly variable, the success of inoculation is difficult to predict. We have conducted a meta-analysis to quantify benefits in terms of the three effect sizes yield increase, nitrogen use efficiency and phosphorus use efficiency. A total of 633 peer reviewed publications studies published between 1981 and 2015 were screened and 169 studies proved to be eligible for meta-analysis. Major findings were: 1) the superiority of biofertilizers in dry climates over other climates 2) functional traits were dependent on soil available P levels in terms of yield response: arbuscular mycorrhizal fungi (AMF) most effective at low levels and N fixation at high levels 3) Success of AMF inoculation was greater at low organic matter content and a neutral pH.

Acknowledgment

We thank Thimmegowda, University of Agricultural Sciences, GKVK, Bangalore India and Rachit Saxena, ICRISAT, Hyderabad, India in helping us to complete our collection of Indian publications. We thank the Innovative Doctoral Program-Bridges within the Marie-Curie Actions, Indo-Swiss Collaboration in Biotechnology, Mercator II and BIOFECTOR for funding this study.

Introduction

Results of biofertilizer application have been inconsistent, often hindering further adoption. Numerous reviews of microbial inoculants have been published, yet reasons for successful yield increase, nutrient use efficiency (NUE) and phosphorus use efficiency (PUE) are unclear. To overcome the existing knowledge gap on biofertilizers and to identify the most promising areas for application we conducted a meta-analysis. A meta-analysis enables to evaluate the strength of various factors and their interaction. To quantify the effect of biofertilizer, changes in NUEs and yield were calculated as indicators for the different modes of action. To account for the variability of pedo-climatic properties only field trials were considered. The following hypothesis were addressed:

I) Biofertiliser show a positive effect on crop growth and NUE
II) Climate and soil properties are major factors for the desired positive effect of microbial inoculants on yield increase and nutrient use efficiency

Methods

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Peer reviewed publications were searched for between May 2015 and February 2016 in Web of Science by Thomson Reuter, Scopus by Elsevier and Google Scholar with the following keywords "*biofertilizer"*, "*biofertiliser"* and "*microbial inoculants"*. Furthermore, cross references were searched for. Only studies conducted under field conditions, providing separate data for each treatment and written in English language were selected. Studies were only included when pairwise comparison between the application of a biofertilizer to a non-treated control under the same pedo-climatic conditions (e.g. temperature, precipitation, soil texture and type) was possible. Studies which had treatment means of grain yields, its standard deviation (SD) or standard error (SEM) and number of replications (n) to calculate the different use efficiencies and effect sizes were considered as selection criteria for the analysis. Whenever SD or SEM were missing, those were modelled from the studies which included as averages for each crop category. When fertilizer was applied the amount and type of fertilizer was required to calculate nutrient-use efficiencies. Field trials were not included when soils were previously fumigated or sterilized, because nutrients may be released, soil microbial community disturbed and inoculation success might be at risk (Smith and Read 2008). A total of 633 studies fulfilling the criteria were identified, 222 were excluded after a first screening and again 231 because they did not match eligibility criteria. Finally, 169 studies proved to be eligible for meta-analysis, resulting in 1672 comparisons.

Yield response

Yield response was calculated in percent yield increase to normalize absolute yield data, calculated as the log transformed ratio of the mean. Yield is defined as harvested dry main product, thus grain, fruits or tubers. Dry weight had to be calculated for most studies. If the water content was not available, values were taken from Church and Bowes (1966).

Change in nitrogen use efficiency (NUE)

NUE was calculated as yield of dry product by N fertilizer input. The change was then calculated as raw mean difference. This calculation is widely used but it is criticized because it does not reflect N inputs from atmospheric deposition, nitrogen fixation and mineralization from organically bound nitrogen (Godinot et al. 2014). These inputs were not reported and are difficult to model. Our calculation is thus an apparent nitrogen use efficiency and needs to be looked at as an indicator for total NUE. Sometimes the nutrient content of organic fertilizers was not available, values were then taken from a booklet by Chandra, 2005, within a national project on organic farming by the Indian government.

Phosphorus use efficiency (PUE)

PUE was calculated as yield of dry main product by P fertilizer input. The change was then calculated as raw mean difference. The calculation follows the general methods used by Batten (1992). Due to lack of information on the soil types of the studies, which are crucial for the absorption of phosphorus, we believe that this method reflects PUE the best. Often it is estimated that only 10 –20 % of P contained in the crop originates from the most recent fertilization, the rest 90 –80 % coming from the reserves accumulated in the soil in earlier fertilizer applications (Sharpley 1986; McLaughlin et al. 1988).

Types of biofertilizer

To structure the effects of the microbial inoculants they were classified for N fixation and P solubilization. Like this it was possible to classify joint inoculation of different inoculants. The information on the main trait of the inoculant was taken from the studies. Thus five groups were formed: Arbuscular mycorrhizal fungi, N fixers, P solubilizers, a combination of both N fixers and

P solubilizers and other biofertilizers which among others includes K and S solubilizers and bacterial combinations with AMF.

Climate

The locations of the studies were classified according to the Köppen climate classification. Thereby the studies were split into dry (Bsh, Bsk, Bwh, Csa) and tropical climate (Aw, Am, Cwa, Cwb, Cwc, Cfa,), continental climate (Dfb, Dsa, Dwa, Dwb, Dsb) and oceanic climate (Cfb). In some cases the experiments were studied under irrigated conditions or planted in the rainy season. Thus the climate classification is often rather an indicator for soil fertility and soil carbon than climate itself. Because regions with mediterranean climate have low soil carbon contents they were grouped into dry climate as well.

Statistical analysis

The meta-analysis was conducted with R Software Version 0.99.491 for Windows by forming meaningful subgroups which were analyzed with the "metafor" package (Viechtbauer 2010). Also the meta-regressions were calculated within this package by designating moderator variables which were used to calculate a mixed effects model.

Results

Overall all groups of biofertilizers showed an increase in yield (+16.2%), PUE (+7.5 kg yield per kg P fertilizer) and NUE (5.8 kg yield per kg N fertilizer) compared to non-inoculation. AMF, other biofertilizer and the application of biofertilizers with both functional traits -N fixation and P solubilization - were the most effective inoculants. The combination of both functional traits was more effective than each single application, suggesting synergies between the two traits. Similar numbers for yield increase after inoculation with AMF were found by Lekberg and Koide (2005), who analyzed 290 glasshouse and field trials in a meta-analysis. Overall all groups of biofertilizers yield was increased the most in dry climates (+21.03%), followed by tropical climates (+15.90%), oceanic climates (+11.29) and continental climates (+10.09%). In dry climates the highest pH and the lowest soil carbon content was found, but also the highest amount of N fertilization. Meta-regression analyses revealed that soil properties modulated efficacy of biofertilizers: yield response due to biofertilizer application was generally small at low soil P levels; efficacy increased along higher soil P levels in the order AMF, P solubilizers and N fixers. Moreover, success of AMF inoculation was greater at low organic matter content and a neutral pH.

Discussion

It is evident that agriculture in the tropical countries, particularly in arid and semi-arid regions will be the most affected by climate change, shifting rain pattern and temperature increases (Laurance et al. 2014). We found that biofertilizers to be most efficient in arid climates showing their high potential for the future. Although this analysis comprises both mineral and organic systems (mineral fertilization 1080 comparisons, organic fertilization 107 comparisons, no fertilizers 354 comparisons, mixed fertilization 211 comparisons) the results are clearly positive and important for both conventional and organic systems. Organic agriculture survives on the nutrients of the farm without external inputs. Biofertilizers are an interesting option to increase availability of existing nutrients or to improve the efficiency of fertilizers. Therefore, through careful selection of biofertilizer, agricultural inputs, particularly the mineral fertilizers, could be considerably reduced without jeoparising the crop yield. The potential of biofertilizer application is even more relevant in organic farming where the crop yield potential can be considerably improved without chemical inputs. Nevertheless, quality control of the microbial products and formulation remains a big challenge (Herrmann and Lesueur (2013).

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Effects of compost mulch and conservation tillage on organic zucchini production

Zoltán Dezsény, Tímea Jung

Key words: you, should, give, max, six, keywords

Abstract

There is growing need for sustainable practices in vegetable production, especially in the use of locally available soil amendments to ensure long-term productivity. Organic zucchini was produced under different tillage intensity regimes and the presence or absence of compost mulch. One-way ANOVA was conducted to determine if the yield of zucchini was different by applying compost mulch, paper mulch and tillage intensity treatments. The effects of these techniques were separated according to three research questions: Is the yield of zucchini different because of using compost mulch, because of intensity of tillage, and because of using paper in compost mulch. The yield increase by usage of compost mulch (12.133, 52,3%, p = .002), by usage of intensive tillage (10,976, 45%, p = .017), as well as by usage of paper in compost mulch (15,268, 62,7%, p = .026) were statistically significant (presented data is mean dif., mean growth in %, and sig., respectively).

Introduction

In Hungary small scale vegetable growers face challenges in producing their crops due to the lack of viable methods of sustainable soil fertility management based on local or regional soil amendment resources. To identify effective soil fertility management options our research focuses on the evaluation of compost and paper mulches, in conjunction with reduced-tillage practices in the function of vegetable yields.

Practices for vegetable and fruit production need to focus on decreasing synthetic inputs, sustainably managing disease and weed control, reducing soil erosion, and maintaining soil structure while producing high-quality fruit and profitable yields (Grassbaugh et al. 2004). Although research on the benefit and use of mulches is extensive, little is known about how to optimize their use in organically managed systems (Law et al. 2006) and how their application method effects the yield of vegetable crops.

Five tillage and organic mulch treatments (Table 1) in four replications were compared in a randomized complete block design in frame of a small scale organic vegetable production system on a clay loam Luvisoil at the MagosVölgy Ecological Farm, Terény, Hungary. Within a 3-year-long tillage and mulch experiment, in the second year in 2016 zucchini were produced on all plots. Treatments were compared regarding their influence on yields. Intensive tillage (IT) treatments were ploughed and rototilled before mulch application and transplanting. In Conservation tillage (CT) treatments soil was only loosened by a hand-driven broadfork and no other soil tillage equipment was used.

Table 1: Treatment specification

Treatment	Tillage intensity	Mulch applied	N source
IT	intensive tillage (IT)	none	none
IT-Cmix	intensive tillage (IT)	none	YWC
IT-C	conservation tillage (CT)	yard waste compost (YWC)	YWC
CT-C	conservation tillage (CT)	yard waste compost (YWC)	YWC
CT-C+P	conservation tillage (CT)	yard waste compost (YWC) + paper mulch (PM)	YWC

Plots comprise of a 15 m long and 1,2 m wide bed. In early June 2016 each plot was planted with 18 zucchini seedlings (cv. Black beauty) on one row of plants 0,78 m apart from each other. Plants were irrigated once after transplanting and then depended on natural rainfall. Yard waste compost (YWC) (1 m3/bed) and Paper mulch (PM) (80 gr/m2) were applied by hand. Intensive tillage (IT) treated plots were rototilled before planting. Compost was mixed with the subsoil in the IT-C mix treatment and left on the surface functioning as a 5 cm thick compost mulch layer in IT-C, CT-C and CT-P+C. In this last treatment the mulch was spread over wrapping paper which entirely covered the bed. Zucchini yield was measured weekly from week 24 (June 15th) throughout a 17-week-long period in the season of 2016. Last harvest happened in week 40 (October 5th). All zucchini fruits over 15 cm length were harvested separately from all plots and the number of zucchini fruits harvested were counted and summed per plot.

The plots were rain fed, no irrigation was applied. The year of 2016 was favorable for zucchini production with adequate precipitation and heat.

Results

The average number of zucchini fruits harvested throughout the season from each zucchini plant in the five treatments is shown in Figure 1. The lowest yield was measured in the IT treatment (1,72 fruits/week) following by CT-C, IT-Cmix,, CT-C+P and IT-C with 2,07; 2,39; 2,46 and 2,52 pieces of zucchini fruits, respectively.

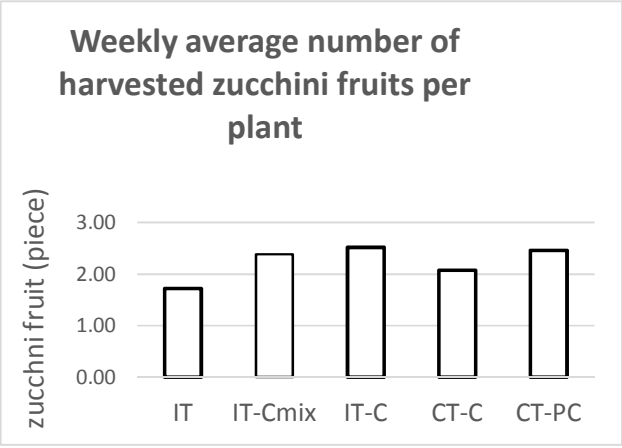


Figure 1. Weekly average number of zucchini fruits per plant

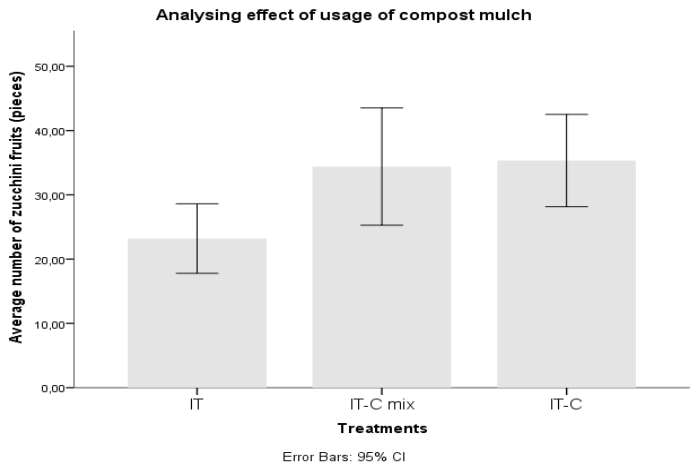
Three statistical tests (one-way ANOVA) were conducted to determine if the number of zucchini fruits (measured in pieces per harvest) was different by applying different production techniques. There were no or deleted outliers, as assessed by boxplot; data was normally distributed for each group, as assessed by Shapiro-Wilk test ($p > .05$); and there was homogeneity of variances, as assessed by Levene's test of homogeneity of variances.

The effects of the treatments were separated according to three research questions:

1) Is the number of zucchini fruits harvested different because of using compost mulch?

2) Is the number of zucchini fruits harvested different because of intensity of tillage?

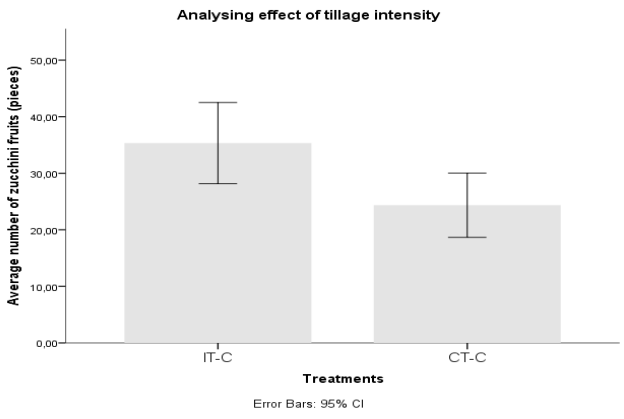
3) Is the number of zucchini fruits harvested different because of using paper in combination of compost mulch?



Usage of compost mulch

Three treatment groups were analysed in this statistical test (IT (n=17), IT-C (n=17), IT-Cmix (n=17)). The average number of zucchini fruits were at treatment of IT 23.2, at IT-C 35.33, and IT-Cmix 34.4. The increase of number of zucchini fruit in case of using compost mulch (IT-C) (12.133, 52.3%, $p = .044$) was statistically significant in comparison with not using compost mulch (IT) (presented data is mean dif., mean growth in %, and sig.).

Figure 2. Yield effect of compost mulch



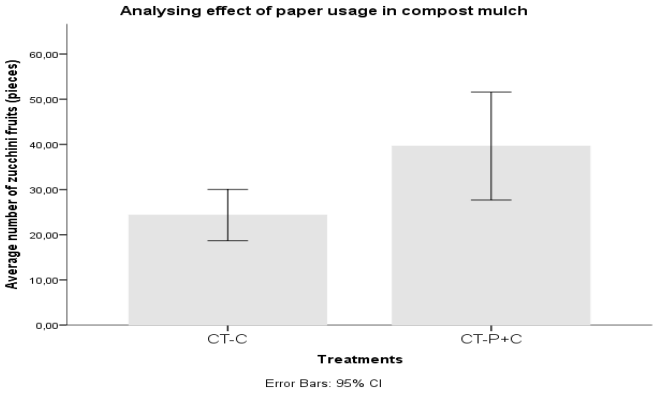
Intensity of tillage

Two treatment groups were analysed in this test (IT-C (n=17), CT-C (n=17)). The average number of zucchini fruits were at treatment of IT-C 35.33, and CT-C 24.36. The increase of number of zucchini fruit by usage of intensive tillage (10,976, 45%, $p = .017$) was statistically significant.

Figure 3. Yield effect of tillage intensity

Usage of paper in compost mulch

Two treatment groups were analysed in this test (CT-C (n=17), CT-P+C (n=17)). The average number of zucchini fruits were at treatment of CT-C 24.36, and CT-P+C 39.63. The increase in number of



zucchini fruits by usage of paper in compost mulch (15,268, 62,7%, p = .026) was statistically significant.

Figure 4. Yield effect of paper mulch

Discussion

The compost mulch application combined with intensive tillage (IT-C) and with paper mulch plus reduced tillage (CT-C+P) had the highest yield in terms of number of zucchini fruits. This may be partially due to the lower weed pressure on these treatments on the vegetable crop (Dezsény 2015). Also, in IT-C treatment the use of rototiller created an optimally loosened topsoil layer in which zucchini plants could easily root whereas the compost mulch applied probably decreased soil water loss compared with IT-Cmix treatment. In CT-C+P the additional paper layer functioned as weed suppressor which decreased the negative effect of the less loosened topsoil and all together seemed an alternative technique especially considering environmental benefits. Compost mulch was proven a viable method compared with compost mixing techniques resulting high yields when saving fossil fuel inputs compared with conventional tillage methods.

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Soil - Global

Title	Author/s	Country
Organic inputs improving soil microbiology for sustainable agriculture and higher yields	Viviane Yargeau, Simon Neufeld, Michael Warren	Canada
Nitrogen leaching in organic, low-input and conventional vegetable production systems in northern China	Hui Han, Yanmin Teng, Xi Wang, Hefa Yang, Ji Li	China
Effects of nano porous Activated Carbon on reducing Extraction coefficient by spinach (Spinacia	Sara Darvishi Aghajani, Mohammad Reza Ardakani, Saeed Vazan, Hossein Ghafourian, Farzad Paknejad and Amir Hossein Faregh	Iran
The development and use of cyanobacteria microbe fertilzer	Chang Nam Pak	Korea
Concerning microbes in organic agriculture: with reference to the growth of rice plants under SRI agroecosystem	Febri Doni, Anizan Isahak, Che Radziah Che Mohd Zain, Norela Sulaiman, and Wan Mohtar Wan Yusoff	Malaysia
Organic farming system with animal and forest waste to increase anthocyanin and vitamin C content of rabbiteye blueberry on a heavy soil	Girish Kumar Panicker, Ananda Nanjundaswamy, Juan Silva, Frank Matta	USA
Invitro evaluation of soil isolates from organic fields for their antagonistic activity against phytopathogenic microorganisms	N. Devakumar, Latha B, Lavanya G, Rameshkumar C	India
Studies on soil microbial population in organic paddy as influenced by liquid organic manures and Palekar's method of cultivation	Devakumar N	India
Isolation and screening of Phosphate solubilizing bacteria from rhizospheric soil of Mung bean	S. Shubha, N. Devakumar, G.G.E. Rao	India
Nutrient Management Options Through Organics in Greengram (Vigna radiata L.) – Rabi Sorghum (Sorghum bicolor L.) System under Rainfed Conditions	Satyanarayana Rao, B.K. Desai and R.Venkanna	India
Impacts of Organic Farming on Soil Organic Matter	Elham A. Ghabbour, Geoffrey Davies, Reem A. Alami, Erin M. Askounis, Nicholas P. Cuozzo, Alexia J. Filice, Jennifer M. Haskell, Andy K. Moy, Alexandra C. Roach, Tracy M. Misiewicz, Jessica Shade	USA

Organic inputs improving soil microbiology for sustainable agriculture and higher yields

Viviane Yargeau[1], Simon Neufeld[1], Michael Warren[1]

Key words: biofertilizer, soil microbial profiling, plant health, water retention, crop yield

Abstract

Consumers are increasingly purchasing organic food products that are free of chemical pesticides or grown without conventional fertilizers, either because of better product taste, concerns for the environment and their health or to promote sustainable farming practices. In this context, farmers are seeking organic inputs to meet the increasing demand. Several products have been implemented on the market and this communication aims at demonstrating, using scientific research, that microbial-based organic inputs offer different modes of action contributing significantly to improved plant health and increased yield.

Introduction

Organic farming is increasingly attractive to farmers wishing to use sustainable farming practices and looking for alternatives to conventional farming based on the use of chemicals requiring energy intensive processes relying on fossil fuels. But transition from conventional to organic farming should not be associated with lower crop yields, and to address this issue, organic inputs are currently developed to ensure sustainable and profitable farming. This paper provides some examples of the results that will be shared with the conference attendees on research, field testing and on-farm applications that have been performed to investigate the modes of action of the biofertilizer and selected microbial strains on plants, and to define the benefits for sustainable agriculture of using microbial-based biofertilizer such as Soil Activator.

Material and methods

Growth chamber experiments were conducted to assess the impact of Soil Activator on yield, plant health, water retention and soil microbiology. This research was conducted by an independent laboratory, A&L Laboratories, Ontario, Canada. For all experiments described here, Soil Activator was added to soil at various rates (0 to 20 g/kg). Untreated soil and/or soil treated with conventional fertilizers were used as control. Unless otherwise stated, experiments were performed using a minimum of three replicates for each treatment.

Field testing was performed by Agriculture and Agri-Food Canada on onion and carrots using a drench application. Three treatments were compared: 1) no fertilizer and no Soil Activator, 2) standard fertilization, and 3) standard fertilization plus Soil Activator. Standard fertilization consisted of 250 lb MAP, 75 lb/acre potash, and 145 lb/acre urea (onions) or 67 lb/acre urea (carrots). Soil Activator was applied as a liquid spray on the soil at the time of planting (8 kg/ha) plus a foliar spray one month after seeding (1 kg/ha).

Results

Growth Chamber experiments

INCREASED BIOMASS PRODUCTION – Wheat seeds planted in soil treated with different doses of Soil Activator (0 to 20 g/kg of soil) were grown for 16 days and then plant biomass was harvested

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and analyzed. Figure 1 demonstrates that the use of Soil Activator significantly increased biomass production in the range of application rates of 2 to 8 g/kg.

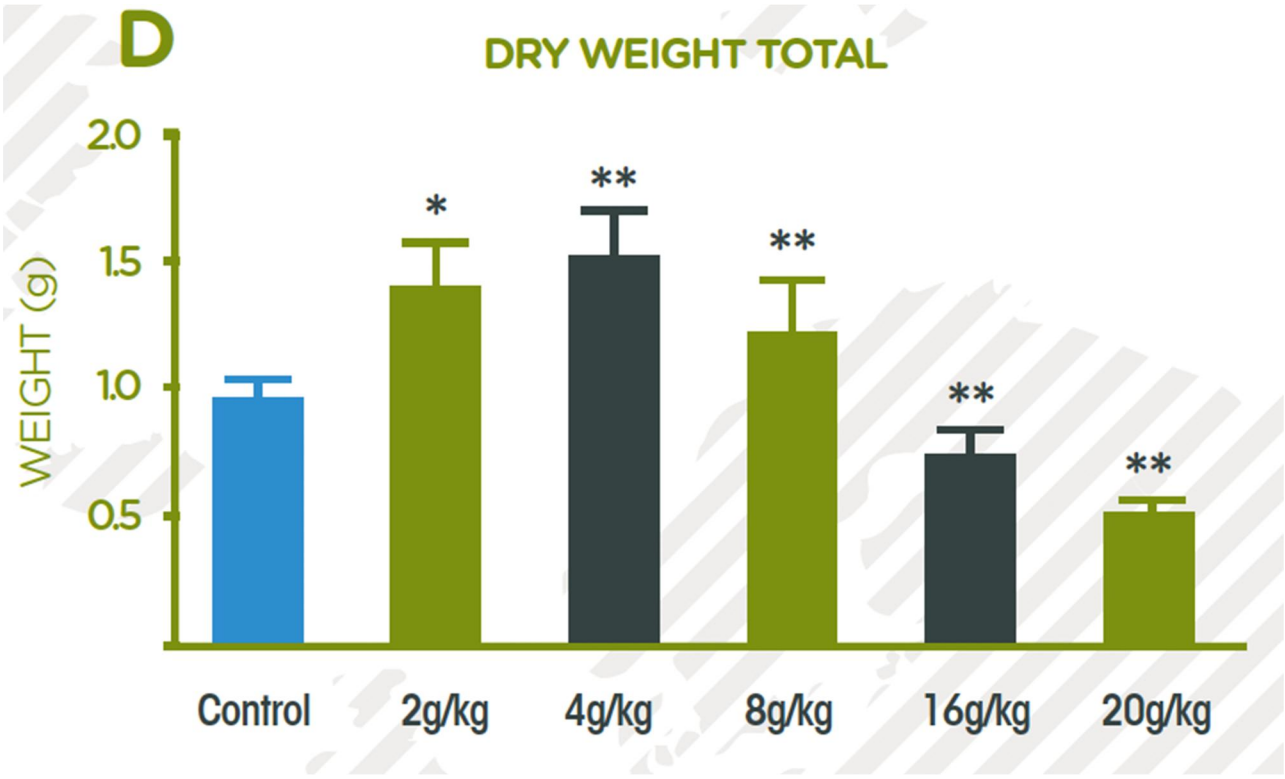

Figure 1 Effect of Soil Activator on total dry weight of wheat 16 days after planting. 5 pots per treatment and 10 seed in each pot, * significant at p < 0.05, ** at p < 0.0001.

VIGOR AND CHLOROPHYLL CONTENT – The increased biomass production obtained in presence of Soil Activator (Figure 1) can be associated with the higher plant vigor observed at the application rates tested (Figure 2A). Increased chlorophyll content was also observed to be significantly increased over the same range, suggesting enhanced capacity to generate energy, which eventually result in yield gain.

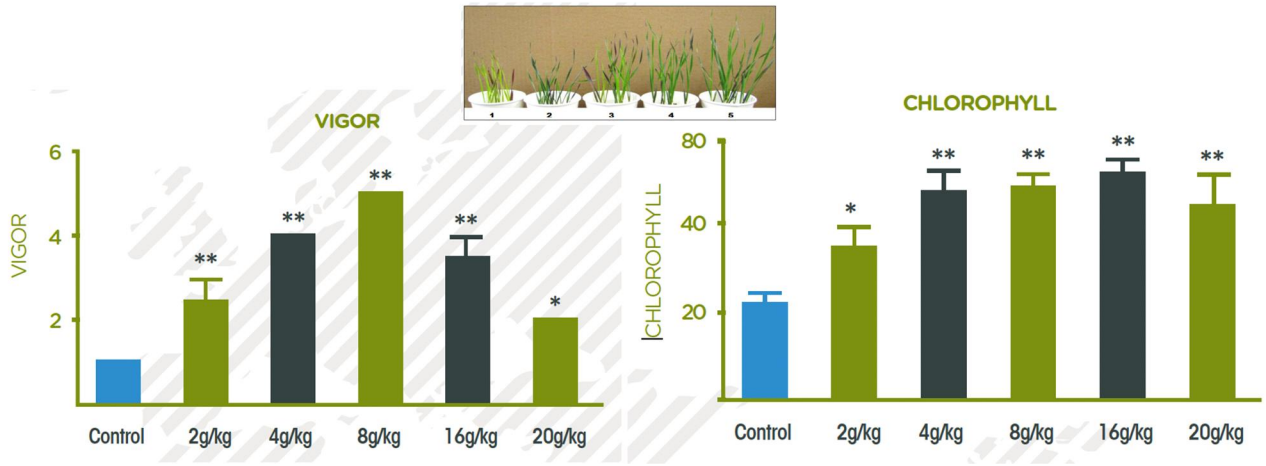

Figure 2 Effect of Soil Activator on (left) Wheat seedling vigor and (right) Chlorophyll content. 5 pots per treatment and 10 seed in each pot, * significant at p < 0.05, ** at p < 0.0001.

WATER RETENTION - Figure 3 indicates that one mode of action of Soil Activator contributing to healthier plants and increased yield is water retention. In presence of Soil Activator, the rate of drying in soils was slowed by up to nearly 5%.

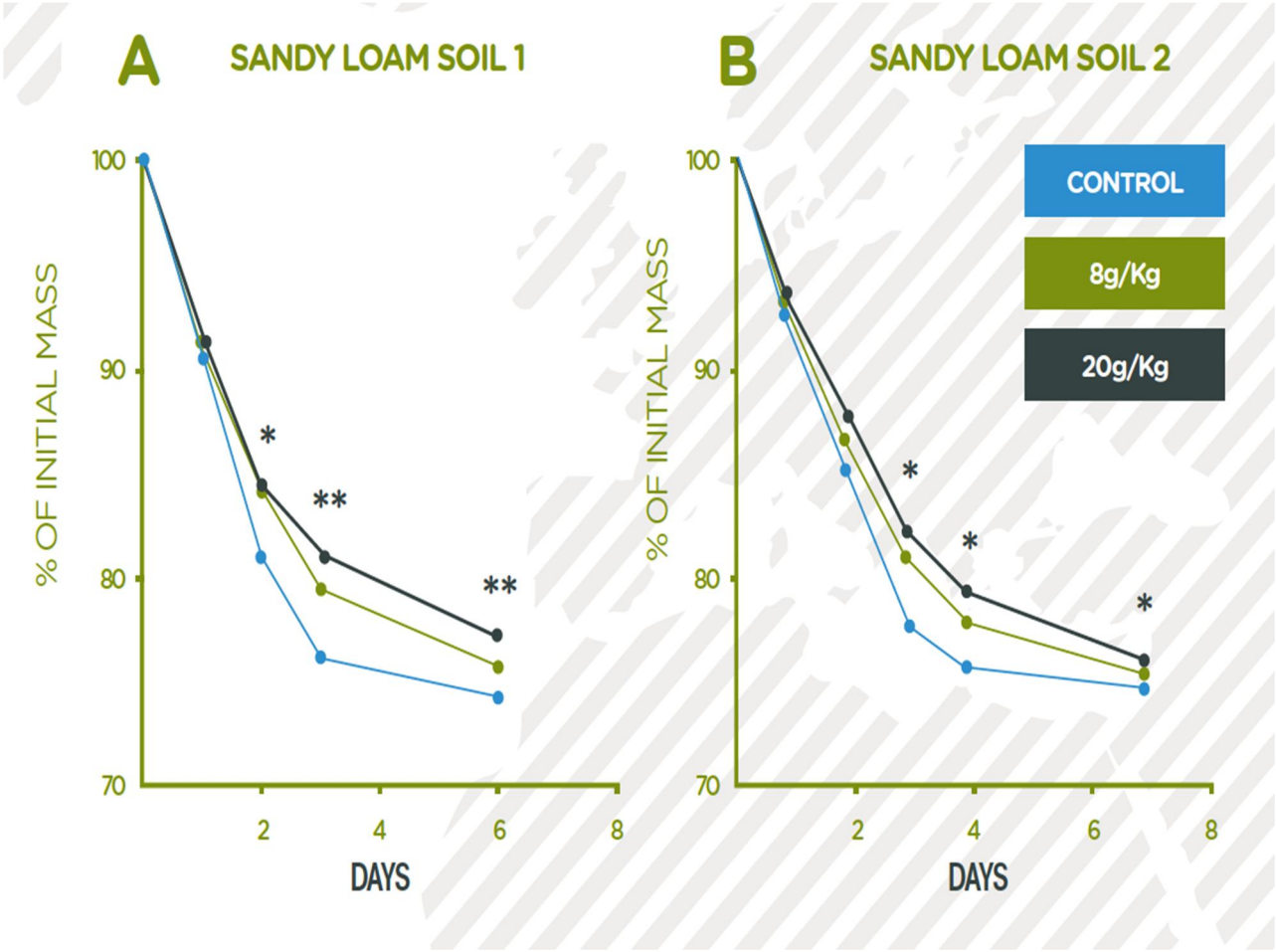

Figure 3 Representation of soil's water retention at different concentrations of Soil Activator for two experiments. n = 3, * significant at p < 0.05, ** at p < 0.0001.

Field testing

INCREASED YIELD - Figure 4 summarizes the results obtained on carrots and onions. Carrots that received Soil Activator plus standard fertilization showed a yield increased by 63% versus the un-fertilized control, and by 32% versus the carrots treated with fertilizer only. The increase in yield versus fertilizer alone was statistically significant ($p < 0.005$). For onions, treatment with both fertilizer and Soil Activator resulted in higher yield but the effect was not statistically significant.

On-farm testing

Increased yield using the microbial biofertilizer was also confirmed during several farm tests. For example, Soil Activator was used in Colombia and applied to banana trees by drenching using application rates from 0 (control) to 30 kg/ha. The grade of bananas was measured based on diameter. While untreated plots generated bananas with a grade of 9.3, bananas from the treated plots averaged 12. Table 1 summarizes the effect on banana bunch weight demonstrating a net increase for application rates up to 25 kg/ha.

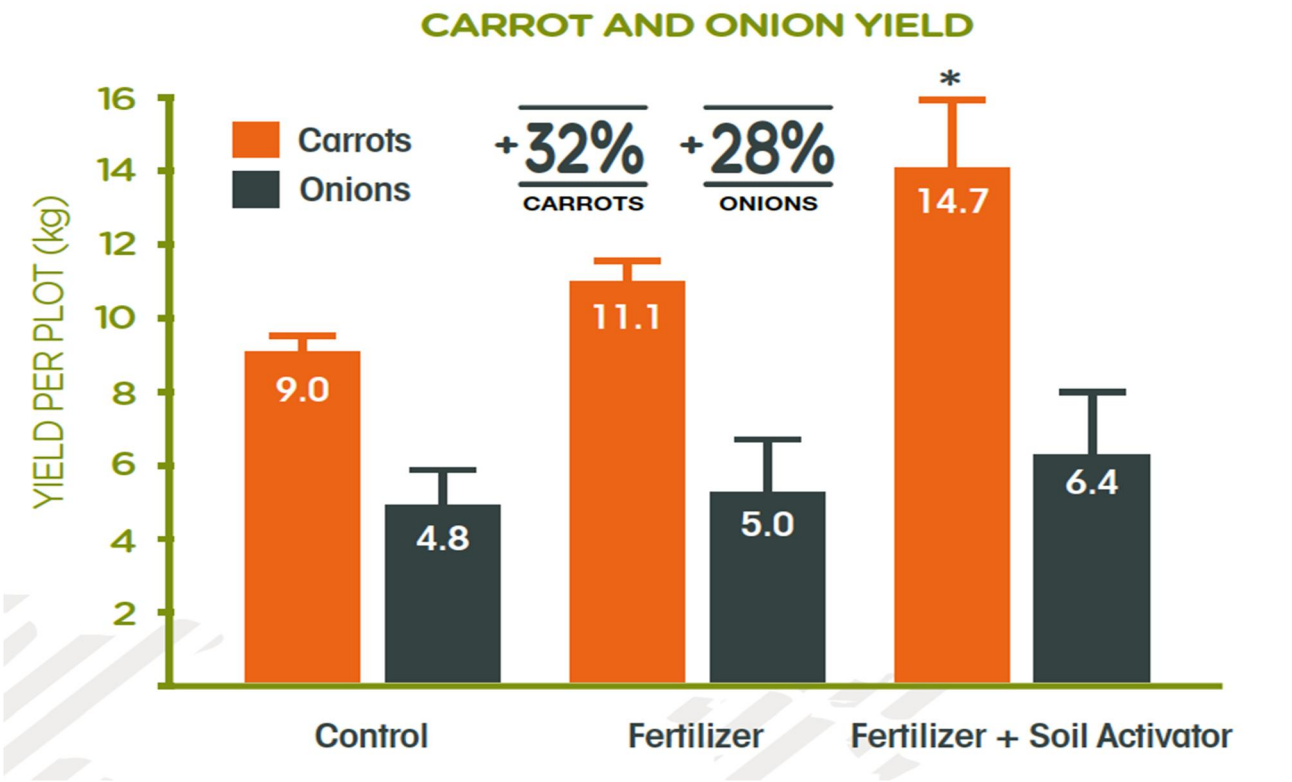

Figure 4 Yields of carrot (orange) and onion (black) when grown without fertilizer (control), with standard fertilizer and with fertilizer plus Soil Activator. Pairwise multiple comparison (Holm-Sidak Method) was used.

Table 1 Effect of Soil Activator on banana bunch weight

Rate of application	Bunch weight (kg)
0 kg/ha	14.8
15 kg/ha	19.5
20 kg/ha	19.1
25 kg/ha	24.1
30 kg/ha	22.7

Discussion

Results presented above, as well as results from soil respiration (Solvita system, Woods End Laboratories, Inc), qPCR and from the analysis of the composition of the soil's microbial communities by terminal restriction fragment length polymorphism (TRFLP) analysis of DNA extracted from soil that will be presented at the conference, clearly demonstrate that the use of biofertilizer has a measurable impact on soil microbiology and characteristics leading to healthier plants and promoting plant growth. Microbial-based inputs must be recognized as playing a key role in positioning sustainable organic farming as a solution to address the environmental and food supplies challenges we are currently facing.

Nitrogen leaching in organic, low-input and conventional vegetable production systems in northern China

Hui Han[1], Yanmin Teng[2], Xi Wang[3], Hefa Yang[4], Ji Li[5]

Key words: production systems, leaching losses, total nitrogen, nitrate nitrogen, ammonium nitrogen

Abstract

A long-term production system experiment, located in northern China, was used in this study to compare nitrogen leaching in three different greenhouse vegetable systems (conventional (CON), low-input (LOW) and organic (ORG)) over 5 growing seasons. Leaching water was collected from 1-m soil profiles using lysimeters. The results obtained indicated that: seasonal cumulative leaching losses of ammonium nitrogen (NH_4^+-N), nitrate nitrogen (NO_3^--N) and total nitrogen (TN) in CON were 0.9-3.2, 1.1-4.5 and 1.1-1.6 times of that in ORG, respectively, while the losses in LOW were between them. Cumulative NH_4^+-N, NO_3^--N and TN losses in ORG were significantly lower ($p \leq 0.05$) than that in CON in 2-3 out of 5 growing seasons. It concluded that ORG may be feasible for reduced risk of N leaching in northern China.

Acknowledgments

This work was supported by the National Science and Technology Pillar Program in rural areas [2013BAD20B01] and China Special Fund for Environmental Protection Research in the Public Interest [201309036]. We would like to thank Chaohui Li and Aiming Shi for their help in managing the field experiment.

Introduction

Nitrogen (N) is necessary to plant growth, but when overused, it negatively affects the environment, such as nitrogen leaching, biodiversity loss, climate change and so on, even threatens human health (Galloway *et al.* 2008). Agricultural activity is recognised as an important contributor to groundwater contamination (Ledoux *et al.* 2007). In this case, organic farming is favoured by more and more people because it's environmentally friendly (Bender and Der Heijden 2015).

Studies aiming at quantifying N leaching in organic farming often focused on cereal crops (Poudel *et al.* 2002). Observations of greenhouse vegetable systems are inadequate.

In this study, we conducted a field experiment to determine N leaching losses using lysimeters from three greenhouse vegetable systems in northern China. The objective was to monitor the amounts of the total N (TN), nitrate-N (NO_3^--N) and ammonium-N (NH_4^+-N) in order to provide references for the development of sustainable system in northern China.

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Material and methods

Experimental site and design

The experiment was conducted from Oct. 2013 to Aug. 2015, Mar. to Jul. 2016 at the Quzhou Experimental Station of China Agricultural University (36º52´N, 115º01´E), Hebei province, North China. The climate in this area is warm and semi-humid with abundant sunlight and heat.

This experiment was carried out in three side-by-side greenhouses with three production systems: conventional system (CON), low-input system (LOW) and organic system (ORG). Cow dung and dry chicken manure composts were applied in all three systems and chemical fertilizers were applied only in the CON and LOW systems. In the CON system, fertilizers were applied according to local farmer's practices; the application rates of composts and chemical fertilizers in the LOW system were half of that in the ORG and CON systems, respectively.

In each greenhouse, three subplots were divided as three replicates, and data were taken from each individual subplot. The greenhouses had an 11-year double-cropping history of vegetable production before this experiment commenced. Vegetable seedlings were transplanted equally into each greenhouse in each growing season. Eggplant seedlings were transplanted in three spring seasons; cauliflower and celery seedlings were transplanted in the autumn of 2013 and 2014, respectively.

Sampling and calculation

Lysimeters were installed in each subplot at a 1.0 m depth in 2011, and its cross-sectional area was 0.5 m × 0.5 m. The soil leaching water from each lysimeter was collected in a PVC tube, and 150 mL sample was taken within 3-5 days after irrigation and frozen for TN, NO_3^--N and NH_4^+-N analyses. Total volumes of leaching water in the lysimeter were recorded when sampling. Concentrations of TN, NO_3^--N and NH_4^+-N were determined using a continuous flow analyzer (TRAACS 2000, Bran and Luebbe, Norderstedt, Germany). The leaching losses were calculated using the following formula:

$$P = \sum_{i=1}^{n} C_i \times V_i \times 10^{-2} / A$$

Where, P is the cumulative leaching losses (kg/ha); C_i is the concentrations of TN, NO_3^--N and NH_4^+-N of the ith measurement (mg/L); V_i is the total volumes of leaching water of the ith measurement (L); A is the cross-sectional area of the lysimeter (here is 0.25 m^2); n is total sampling times.

Statistical analyses

One-way ANOVA in the SPSS 20.0 software package (SPSS Inc., Chicago, USA) and Duncan's test were used to determine significant differences ($p \leq 0.05$).

Results

Seasonal cumulative losses of NH_4^+-N, NO_3^--N and TN in three production systems were showed in figure 1-3, respectively. NH_4^+-N leaching losses in CON, LOW and ORG were 1.22-7.11 kg N/ha, 0.70-7.14 kg N/ha and 0.64-8.30 kg N/ha, respectively. NO_3^--N leaching losses in CON, LOW and ORG were 30.1-111 kg N/ha, 18.1- 98.6 kg N/ha and 14.2- 84.0 kg N/ha, respectively. TN leaching losses in CON, LOW and ORG were 59.0-244 kg N/ha, 38.1-191 kg N/ha and 59.6-186 kg N/ha, respectively. The seasonal cumulative NH_4^+-N and TN leaching losses in ORG were significantly lower than that in CON in the autumn of 2013, spring of 2014 and 2015 ($p \leq 0.05$, Figure 1 and 3), while no significant differences were found among three systems in the other two seasons. For cumulative NO_3^--N losses, significant differences between CON and ORG were only observed in the autumn of 2013 and spring of 2015 ($p \leq 0.05$, Figure 2).

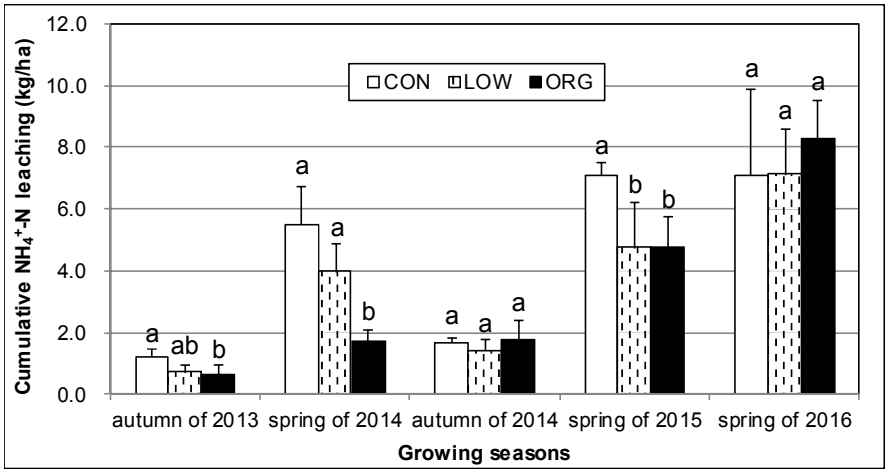

Figure 1. Cumulative NH_4^+-N leaching losses in three production systems

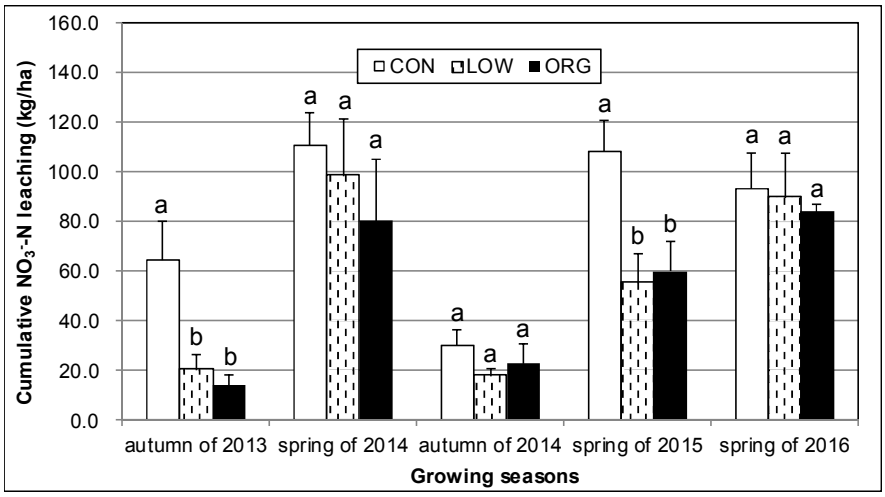

Figure 2. Cumulative NO_3^--N leaching losses in three production systems

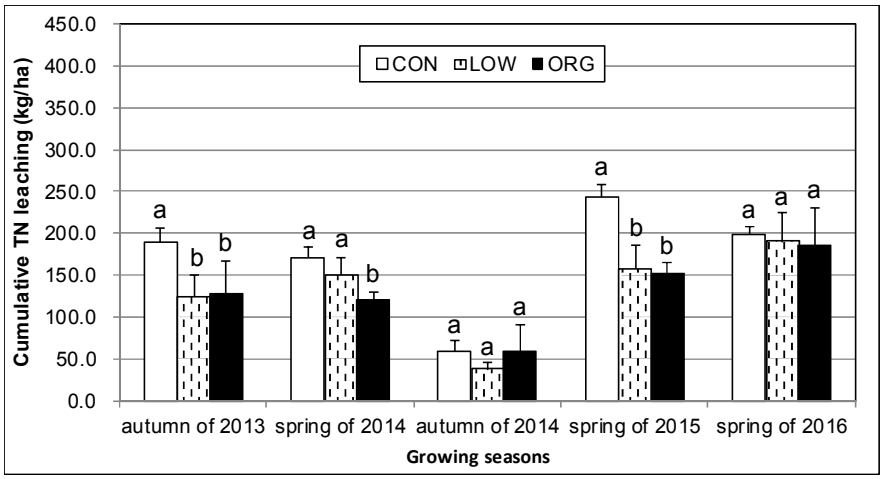

Figure 3. Cumulative TN leaching losses in three production systems

Discussion

Cumulative NH_4^+-N, NO_3^--N and TN leaching losses in ORG were significantly lower ($p \leq 0.05$) than that in CON in 2-3 out of 5 growing seasons. Due to the same sampling times under three systems, N cumulative losses depended mainly on the leaching concentrations and volumes. Concentrations of NH_4^+-N, NO_3^--N and TN in ORG were significantly lower than that in CON ($p \leq 0.05$) in 21%, 35%,

and 21% of samples, respectively. The leaching volumes in ORG were the lowest in each sampling, but no significant differences were found ($p > 0.05$) (results not shown). This phenomenon may be explained by the following reasons: Organic fertilizer application could increase water-stable aggregate and water holding capacity (Zhao *et al.* 2011, Wang *et al.* 2009), enhance ion adsorb ability and delay nutrients release (Zou and Fan 2013, Näsholm *et al.* 2009).

This study showed that the ORG vegetable system reduced N leaching losses to some extent, so it may be feasible in northern China.

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Effects of nano porous Activated Carbon on reducing extraction coefficient by spinach in a lead and cadmium contaminated soils

Sara Darvishi Aghajani[1], Mohammad Reza Ardakani[1], Saeed Vazan[1], Hossein Ghafourian[2], Farzad Paknejad[1] and Amir Hossein Faregh[1]

Key words: Pollutants, Activated Carbon, Extraction coefficient

Abstract

We investigated the capacity of nano porous activated carbons in reducing the absorption of heavy-metals (HM) including lead (Pb) and cadmium (Cd) and dual complex (Pb Cd), on a triplicate Factorial Experiment in a Completely Randomized Design on a pot trial. extraction factor was measured for every each of aforementioned elements. Results imparted, extraction coefficient (EC %) was declined in plants with AC applications in soils exposed to contaminators. The foremost outcome from studying the impacts of AC on (EC %)was observed in 20,000 levels of AC. Results of present paper recommend AC as suitable for decreasing the measured properties in lead and cadmium contaminated soils.*

Acknowledgments

This study was supported by the Agriculture Research Center, Karaj Branch and Authors are grateful to Islamic Azad University, IRAN for their financial aid.

Introduction

Nanotechnology with an extensive range of capabilities in pollution remediation, detection, and elimination and controlling environmental pollutants with prominent qualities in purifications and nano porous activated carbons can be employed for prevention of contamination dispersion and can allegedly be considered as a green technology and a powerful tool in progressing towards sustainable development (Burns *et al.* 1996). In general, bioaccumulation of substances is widely accepted as one of the key factors in understanding and identifying their potential environmental hazard. To produce adverse effects, metals must bioaccumulate in excess of a threshold concentration at the specific site of action (McGeer *et al.* 2003). The aims of the present study were to investigate the impacts of AC on reducing the HM absorption.

Material and methods

Experimental procedure: The experiment was a factorial on the basis of Completely Randomized Design including 3 factors and 3 replicates and was conducted in 2010, at the research greenhouse of Azad university of Karaj, Iran, which is located at an altitude of 1313 meters above sea level with geographic coordinate of 50° 54' longitude and 35° 28' latitude. Based on soil test results soil texture was loam-sand with pH=8.

The experimental treatments consisted as follow:

1-Activated Carbon in 5 levels (0, 5, 10, 15, 20) grams

2-Lead (Pb) in1 levels (Pb4000mg/kg soil (Lead properties: Pb(NO3)2 CHEM- LAB Belgium) 99%

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3- admium (Cd) in 1 levels (Cd80) mg/kg soil (Cadmium properties: CdCl2 2 ½ H2O=228.35 (CHEM- LAB Belgium)

Proper amounts of soil sieved and homogenized before 10kg of soil being repacked in each pot. Proper amount of metal salt and water solution was homogeneously added to pots to contaminate the soil profile in pots accordingly. Afterwards, Pots left undisturbed for 14 days so that the solution reach a stable chemical state, then (AC) incorporated into the soil subsequently. Viroflay variety of spinach *(Spinacia oleracea L)* grown in this study, which has identified as a cold resistance cultivar with big, dark green leaves.15 plants were sown in each plot and after reaching the standing state, thinning performed and 5 plants remained in each pot. Plantation carried out on October 28, 2010 in which the minimum and maximum temperatures were hovering around 15 and 29 degrees celsius, respectively. For the sake of keeping (Pb) and (Cd) constant in soil, a saucer was placed under each pot to prevent drainage losses through irrigation. After harvesting, prior to measuring the dry matter with a digital scale, shoots and roots were placed in a desiccating oven at 70°C for 72 h. Both cadmium and lead concentrations were determined using an atomic absorption spectrometer. The extract of the samples was obtained by placing 2gr of samples in Distillation balloon with acid solutions added. Aliquots of each extract were heated for vaporization to analyze. In ground state, the atoms of (Pb) and (Cd) absorb the radiances of hollow-cathode lamp and the rate of absorbed radiances for (Pb) and (Cd) can be measured in suitable wave length. Extraction coefficient was calculated as follows: Extraction coefficient was calculated as follows: extraction coefficient=element concentration in plant shoot/element concentration in soil.

Results

Table 1: The results of the analysis of variances of the measured properties are presented. Application of Activated Carbon Substantially (P ≤ 0.01) Affected the (EC %)

SOV	Mean Comparison Application of (AC)			
	Degree of Freedom (df)	Plant xtraction of Cadmium	Plant extraction of Lead	
AC	4	0.00063	0.28	**
CONT	1	0.00021	0.04	**
AC*CONT	4	0.00004	0.01	**
ERORRE	20	0.000003	0.007	
C.V(%)		5.83		

* significant at P≤0.05, ** significant at P≤0.01
AC: Activated Carbon;CONT:Contaminators;C.V(%); coefficient of variation.

Impact of Activated carbon on reducing plant extraction coefficient
As it is illustrated in (Table 1), application of AC substantially (P ≤ 0.01) affected the (EC %) demonstrate that soil contaminations with Pb and Cd acts to elevate the (EC %) but with applications of AC it was declined vis-à-vis the treatments with no AC applications. The absorption of Pb in soil follows the Langmuir relation (Lee *et al*. 1998).The measured (EC %) under field conditions have be found to be lower in comparison with those measured under laboratory conditions(Kumar *et al.* 1995). The biggest challenge in effective phyto-remediation of lead is the low solubility of Pb in soil as only 0.1 % of Pb concentration in soil is readily available for plants for absorption (Huang *et al.* 1997). (Mclaghlin *et al*. 1999) reported that the uptake of cadmium by plants is governed by a number of factors such as pH, temperature, aeration, total cadmium concentration in the soil and the presence of other micro- and macronutrients. Significances (P ≤ 0.01) observed for the interaction effects of

measured EC % (figure 1) and it showed no differences in treatments without AC applications while Pb and Cd were incorporated and the highest value for EC% was recorded in AC0Pb40000Cd80. It can be reasoned that the implemented AC which was made out of lemon wood charcoal had the average pores with (0-5 nm) diameters and absorbed the elements easily and reduced the translocation of pollutants to shoot and roots and acted to reduce the EC%. This higher absorption of (Pb) in (AC 20000 mg/kg) can be

related to the 0.097 nm (+2) Ionic radius of (Cd) in comparison with 0.132 nm (+2) Ionic radius of (Pb). No significance was observed for the interactive effects in measured treatments of (Cd). An opinion exists that phytoextraction will be more economically feasible if, in addition to metal removal, plants produce biomass with an added economical value (Schwitzguébel *et al.* 2002). But those recognized plants with high accumulation capabilities have shown to produce little biomass and this issue has limited the practicality of such methods. In that order application of nano porous activated carbons can provide more feasible techniques to reduced the HM translocation into the plant and decline the deleterious impacts of HM hazards.

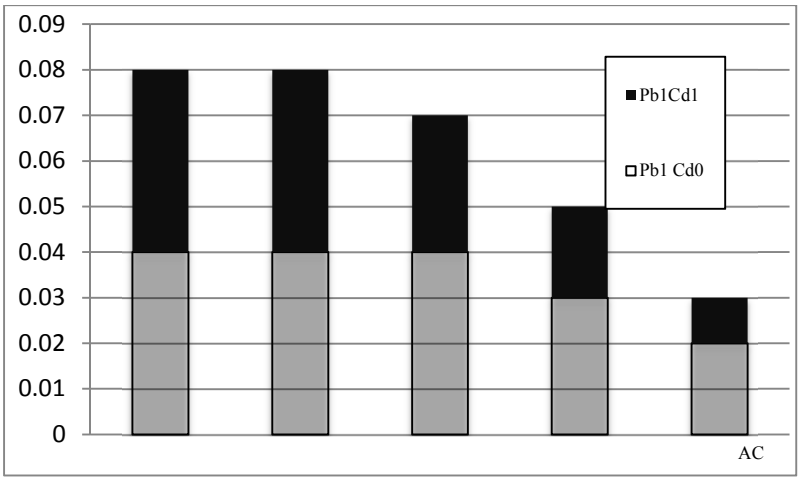

Figure 1. Mean comparison of the interactive effects of contaminators and activated carbon on extraction coefficient of lead by Spinach Pb1= Lead, Cd0: Without Cadmium, Cd1:Cadmium, Pb1Cd1: Lead and Cadmium, AC: Activated Carbon, AC1: 0(mg/kg), AC2: 5000(mg/kg), AC3:10000(mg/kg), AC4: 15000(mg/kg) AC5: 20000(mg/kg)

Discussion

Carbon is very special because it can form so many compounds. In this experiment existence of contaminators in soil caused higher degrees of Pb and Cd accumulations in root and shoots of spinach but the employed AC acted to absorb the majority of such ions. Applications of (PCB) on Clover revealed that (AC) can reduce the soil toxicity (Vasilyeva *et al* 2006).Noting the fact that remediation with the aid of biological extraction requires long periods of time because it needs plants with extensive root systems producing very much shoot biomass while it takes constant monitoring against environmental stresses and eventually suitable methods need to be disseminated for degradation and disposition. Applications of AC dramatically reduced the translocation of Pb and Cd into the plant tissue and as a result extraction coefficientwas declined expectedly.

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The Development and Use of Cyanobacteria Bio-fertilizer as Soil Conditioner

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Key words: cyanobacteria, bio-fertilizer, soil erosion, organic matter

Abstract

Cyanobacteria that are known as pioneer organisms capable to photosynthesize, fix atmospheric nitrogen and secrete polysaccharides. They are increasingly regarded as important bio-agents for improving soil management practices in agriculture and bringing benefits in term of water-holding capacity and mineral nutrient status of the degraded lands. We have explored the effects of Nostoc sp. – a kind of terrestrial cyanobacteria - on the chemical and physical properties of soil and on plant growth in outdoor conditions. The effect of Nostoc on soil properties, when inoculated in a substrate applied to the soil surface resulted in an increase in the organic matter content and enhanced plant growth. The results indicate that the application of Nostoc to soil has a potential for increasing soil organic matter and reclaiming degraded soil ecosystems affected by desertification. This paper presents the results from our work and field experiments carried out by our research team in DPR Korea.

Introduction

Cyanobacteria are the most diverse group of photosynthetic prokaryotic bacteria and characterized by distinctive features such as high biomass yield, growth on non-arable lands and atmospheric N-fixing ability. The capacity of cyanobacteria to increase the nitrogen content as well as the organic matter in the soil is significant (Issa et al., 2014). Several cyanobacteria species are already used as bio-fertilizers, e.g. for paddy cultivation. DPR Korea needs innovative solutions to combat serious land degradation, soil erosion and nutrient depletion. Through cooperation with international organizations such as IFOAM – Organics International, we adopted biodynamic methods and advanced organic agricultural techniques that are in accordance with the conditions and realities of our country. We developed cyanobacteria preparations with common algae in our country, tested them in the field and confirmed that they have high potential to improve the poor soil and increase the yields of crops.

Materials and Methods

This study was conducted in the research field of Ssangun Organic Model Farm. The farm is located in South Pyongan Province, Sukchon County. The experiments were conducted from March to October 2016.

The quality of the soil is clay sandy. This site has a temperate climate with mean annual rainfall varying from 600mm to 800mm, while the yearly average temperature ranges from 15 °C to 35 °C.

The cyanobacteria species used in this study were Nostoc commune.sp and Nostoc spongiaefome.sp isolated from moss of salty fields.

The solution of Nostoc was prepared by mixing red clay, moss and corn flour and after inoculating a cyanobacteria preparation 0.1% in concentration. The results were spread out in the experimental

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testing plots and the bacteria cultivated under conditions of 60~70% humidity, 25~35°C and 500 lux of light intensity.

In April, the Cyanobacteria bio-fertilizer was applied on the plots and in October, the experimental soil was sampled, collecting it from the top 30mm of soil profile.

The soil analysis for N content was done using the Kjeldahl method (Bremner, 2008). A K2O-analysis was conducted using cobalt sodium nitrous acid. The P2O5 analysis was conducted using molybdic acid-hydrochloric acid (Isaac, Ad, & Chain, 1937).

To assess the effects on plant growth key yield parameters were measured for rice and corn such as the number of ears per plant, number of kernels per ear, 1000-grain weight, yield kg/ha.

Results

Effect of Nostoc on soil characteristics

The water holding capacity was assessed using flowerpots filled with dry-clay. The observation pots contained 0.1g of the cyanobacteria preparation; the control pot contained 33g urea. From the control pots water was dried completely after 3 days but at in the observation pot water dried out on days 15-18 and 24-27, as shown in Table 1.

Table 1: State of soil - drying of flowerpot on days

Days (d)	3	6	9	12	15	18	21	24	27	30
Control pot	-	-	-	-	-	-	-	-	-	-
Observation pot	-	-	o	-	o	o	-	o	o	-

-: supply of water, o: non-supply of water.

Effect on chemical soil properties

After the Nostoc application, the soluble potassium per 100 gram of was increased soil by 2.12mg and the content of humus was increased by 0.21mg in the soil of paddy fields compared to control plots that were treated with 10 tons of compost and 450 kg of fertilizers per ha (Table 2).

Table 2: Chemical analysis on rice-soil

№		pH	Content of humus, %	Soluble material, mg/100g		
				N	P_2O_5	K_2O
1	Control	5.5	1.46	3.71	1.61	7.61
2	Observation	6.0	1.67	3.29	1.55	9.73

Control: compost 10t and urea 450kg (conversion by ammonium sulfate 2.2) per hectare
Observation: compost 10t and Cyanobacteria preparation 0.5kg per hectare, spraying with bio-activated water

Table 3: Chemical analysis of maize-soils

№		pH	Content of humus, %	Soluble material, mg/100g		
				N	P_2O_5	K_2O
1	Control	6.0	1.35	4.54	4.94	7.75
2	Observation	5.9	1.56	3.99	5.72	14.5

Control: compost 5t and urea 450kg (conversion by ammonium sulfate 2.2) per hectare
Observation: Cyanobacteria preparations 0.50kg per hectare, spraying with bio-activated water

Cyanobacteria preparations increase the soluble phosphorus per 100 gram of soil by 0.78mg, soluble potassium by 6.75mg and content of humus by 0.21mg in the soil of dry fields, compared to the control plots where 10 tons of compost and 450 kg of fertilizers per ha were applied (Table 3).

Effect of Nostoc on yield

When Nostoc was applied to rice and maize plants the yield parameters were improved compared to the control (Table 4 and 5).

Table 4: Influence of the cyanobacteria preparations on rice yield

	Section	Number of ears per *plant*	Number of grains of rice per ear	Ripe yield, %	1 000 Grain weight, g	Per hectare Yield, t	Yield, %
1	Control	815	130	78	26.0	5.315	100.0
2	Observation	825	142	80	27.2	6.128	115.3

Control: compost 10t and urea 500kg (conversion by ammonium sulfate 2.2) per hectare
Observation: compost 10t, urea 500kg (conversion by ammonium sulfate 2.2) and Cyanobacteria preparations and cyanobacteria preparation 0.5kg per hectare

Table 5: Influence of the cyanobacteria preparations on maize yield

№	Section	Number of ears per *plant*	Number of grains of rice per ear	1 000 Grain weight, g	Per hectare Yield, t	Increased yield, kg	Yield, %
1	Control	15	352.8	281.0	4.461		100.0
2	Observation	15	412	290.0	5.377	916	120.5

Control: compost 10t and urea 500kg(conversion by ammonium sulfate 2.2) per hectare
Observation: compost 10t, urea 500kg(conversion by ammonium sulfate 2.2) and Cyanobacteria preparations 1.0kg per hectare

When cyanobacteria preparations are mixed with chemical fertilizers, yields are increasing in relation to the amount fertilizer applied as shown in Table 6.

Conclusion

Our research generates evidence about the effectiveness of cyanobacteria as bio-fertilizers and is a valuable contribution to the global organic research and innovation for organic agriculture. More research is needed to produce more evidence about the value of such nature-based inputs and substances for soil health and nutrition. Only with evidence we can establish recognition for their contribution to address many challenges in modern agriculture. How can we scientists work together on an international level to not only exchange knowledge, but to cooperate in research for innovation?

Discussion

If applied to the soil cyanobacteria significantly affect the soil characteristics and chemical properties, leading to increased soil organic matter. They also have an effect to soil structure by combining soil

particles into larger ones through sticky matter secreted from the cyanobacteria single cell group. Thus they develop soil structure and improve the soil permeability and humidity. Thus, cyanobacteria preparations interact with the soil, changing the physical property of the soil and improve the water retention ability by 3 times.

Thanks to the ability of increasing the soluble nitrogen, phosphorus and potassium in the soil making them more accessible to plants they work as bio-fertilizers supporting the nutrients availability for crops and improving yields. Therefore, when tested in conventionally cultivated fields, it was possible to decrease the amount of chemical fertilizer by 30% while at the same time improving the yield and the quality of crops (see Table 6).

Table 6: Yield effect depending the amount of fertilizer applied

Crops	Amount fertilizer applied kg/ha	Yield t	Percentage of yield %
Paddy rice	Urea (100)	5.72	100
	Urea (100) + Ammonium phosphate (70)	6.93	121
	Mixtures of cyanobacteria preparations (50)	5.95	104
	Mixtures of cyanobacteria preparations (60)	6.89	120
Maize	Urea (150)	5.21	100
	Urea (150)+ Ammonium phosphate (70)	6.21	119
	Mixtures of cyanobacteria preparations (90)	5.32	102
	Mixtures [a] of cyanobacteria preparations (105)	6.03	116
	Mixtures [a] of cyanobacteria preparations (105)	6.25	120

Mixtures of cyanobacteria preparations: Cyanobacteria preparations mixed with 1% urea

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Concerning microbes in organic agriculture: with reference to the growth of rice plants under SRI agroecosystem

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Key words: System of Rice Intensification, Microbes, Organic Agriculture, Sustainable Rice Production

Abstract

The positive performance of System of Rice Intensification (SRI) method in increasing rice growth and yield can be understood in terms of the interaction of rice plants and microbes in the soil. This is especially true for systems such as SRI which relies on slightly aerobic, unsaturated water soil conditions, absence of synthetic chemical fertilizers and biocides deemed toxic to rice growth. This reports our study on the role of microbes in the enhancement of rice growth and yield under SRI condition. The mechanisms employed by a symbiotic equilibrated microbes-plants interaction (not just rice plants); the production of growth regulating substances, phosphate solubilization, cellulose degradation and siderophore production. Some microbes such as Trichoderma are also involved in cell regulation and signaling in rice plants. Thus the rice ecosystem is understood as an integrated inter-relatedness of all organisms in the soil as well as in the above soil biospheres.

Acknowledgments

This research was funded by Universiti Kebangsaan Malaysia under grant DIP-2015-016.

Introduction

Currently growth of paddy uses a lot of chemical fertilizer and chemical pesticide. Over the years this has led to serious environmental problems such as depletion of soil quality and health, emergence of resistant pathogens and elimination of soil microbes involvement in growth of paddy. The increase of production of paddy must be achieved through improvement in agricultural productivity. Microbes considered as beneficial are key factor in maintaining soil quality and paddy production. As such decades, Interest in beneficial microorganism in rice has increased due to their potential use as plant growth regulator (Doni *et al*., 2013). System of Rice Intensification (SRI) is an agroecological approach of rice planting that has the following features; (1) to select healthy seedlings only and to transplant them to the rice field at the age of 5-7 days. (2) The seedlings are planted at a distance of 25-30 cm to encourage healthy root growth by reducing competition for nutrients. (3) Soil aeration through mechanical weeding to eliminate weed, as well as to aerate the soil, (4) Instead of permanent flooding, SRI rice is flooded only occasionally. This enables better aeration and growth of microorganisms, (5) Using organic fertilizers instead of chemical fertilizers (Anizan *et al*., 2012). Central to the growth of seeds to paddy plant is the effect of effective microbes such as *Trichoderma*. The positive performance of System of Rice Intensification (SRI) method in increasing rice growth and yield can be understood in terms of the interaction of rice plants and microbes in the soil. This is especially true for systems such as SRI which relies on slightly aerobic, unsaturated water soil conditions, absence of synthetic chemical fertilizers and biocides deemed toxic to rice growth. This reports our study on the role of microbes in the enhancement of rice growth and yield under SRI condition.

Material and methods

This research uses primary and secondary data. For primary data, soil samples were taken from SRI test plots. The soils samples were placed in labeled polyethylene bags and immediately transported to the lab where they were stored at 40 C until further processing. Each sample was serially diluted and plated on nutrient agar (for bacteria) and potato dextrose agar (for fungi). Bacterial isolates were identified based on gram staining, colonial morphology and biochemical test according to Buchanan and Gibbons (1974) and Al-Shorgani *et al*. (2013) while fungal isolates were identified based on their morphological, physiological and biochemical characteristics (Domsch *et al*., 1993; Samuels, 1996; Rahman et al., 2011; Devi *et al*., 2012). Whilst, for secondary data, research papers from 1990-2015 on SRI and microbes were screened and noted its conclusion.

Results and Discussion

The positive performance of SRI method in increasing rice growth and yield can be understood in terms of the interaction of rice plants and microbes in the soil (Doni *et al*., 2013). Anas *et al*. (2011) have shown that SRI management can positively influence the soil microbiology. Furthermore, soil microbial activity can contribute to the enhancement of nutrient availability such as nitrogen (N) and phosphorus (P); carbon (C) and nitrogen (N) in the rice rhizosphere. Results by Al-Shorgani et al. (2013), Doni *et al*. (2014a), Doni *et al*. (2014b) reported that the abundance and diversity of beneficial soil microbes such as *Trichoderma, Clostridium,* and *Pseudomonas* are high in the SRI paddy field soils. Our study on microbes isolated from SRI soil plot (Figure 1 and Table 2) has colorful colonies that indicate the higher abundance and diversity of microbes which enables the enhancement of nutrient availability. Furthermore, the suitability of SRI method in increasing microbial plant growth performance were also investigated under gnotobiotic systems in greenhouse conditions (Table 2). The results showed that under SRI conditions *Trichoderma* were significantly increased rice physiological characteristics such as photosynthetic rate and stomatal conductance compared to non-inoculated *Trichoderma* plants (Doni et al., 2014a).

Table 1: Beneficial Microorganisms according to genus found in Ledang SRI Field on three different stages of rice growth.

Vegetative phase	Reproductive phase	Mature phase
Bacteria: Lactobacillus, Bacillus, Pseudomonas*, Azotobacter	Lactobacillus, Bacillus, Pseudomonas, Azotobacter, Clostrisdium*	Lactobacillus, Bacillus, Pseudomonas, Azotobacter, Clostrisdium
Fungi: Trichoderma**, Aspergillus, Candida, Penicillium, *Gliocladium*	Trichoderma**, Aspergillus, Candida, Penicillium, *Gliocladium*	Trichoderma**, Aspergillus, Candida, Penicillium, *Gliocladium*

*Isolates of *Pseudomonas* and *Clostridium* are able to enhance rice seedling growth under green house condition (Doni *et al*., 2014b); **Isolates of Trichoderma is able to enhance rice seedling growth under greenhouse condition (Doni *et al*., 2014a).

Figure 1: Microbes isolated from SRI plot with colorful colony indicates the diversity of microbes.

Treatment	Net photosynthetic rate ($\mu molCO_2\ m^{-2}s^{-1}$)	Stomatal conductance ($mmolH_2O\ m^{-2}s^{-1}$)	Internal CO_2 concentration (ppm)
Trichodema sp. SL1	8.79(0.010)	979.08(0.00009)	358.91(0.037)
Trichodema sp. SL2	8.66(0.007)	412.40(0.00070)	336.97(0.086)
Trichodema sp. SL3	8.47(0.018)	1237.88(0.0022)	363.79(0.046)
Trichodema sp. SL4	6.88(0.009)	752.65(0.0024)	358.60(0.023)
Trichodema sp. SL5	7.38(0.043)	499.54(0.0008)	348.35(0.172)
Trichodema sp. SL6	8.60(0.012)	1084.76(0.0014)	361.75(0.039)
Trichodema sp. SL7	6.74(0.024)	712.38(0.0005)	361.23(0.076)
NPK	2.09(0.007)	340.16(0.0004)	376.69(0.045)
Control	6.21(0.016)	818.30(0.0002)	365.74(0.051)
$LSD_{0.05}$	0.10	0.005	3.70

Standard deviations are given in parentheses (n=36).
All means were significantly different between treatments at $p < 0.05$.

Our present study has therefore proven that high diversity microbes under SRI conditions. The results of the study also showed that SRI method creates such as favorable conditions for microbes to flourish.

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Organic farming system with animal and forest waste to increase anthocyanin and vitamin C content of rabbiteye blueberry

Girish Kumar Panicker[10], Ananda Nanjundaswamy[11], Juan Silva[3], Frank Matta[4]

Key words: organic manures, nitrate-N, worm castings, pine bark, LAI, anthocynins

Abstract

Increased concerns over the last several decades on environmental problems have stimulated farmers to accept organic farming as an alternative to inorganic agriculture. Rabbiteye blueberry (Vaccinium ashei Reade var. Tifblue) was grown on Memphis Silt Loam soil (Typic Hapludalf, silty, mixed, thermic) with another cultivar, Powderblue, for cross pollination. Two organic manure treatments (worm castings, cow manure) were applied in basins around each plant. Control treatment received regular inorganic fertilizer. All treatments received pine bark and pine needle uniformly. Percent canopy cover, LAI, canopy width and height, stem diameter, and yield were significantly higher in organic plants treated with worm castings. The content of vitamin C was higher in fruit treated with worm castings. The leaching of N and P into subsurface layers from inorganic fertilizer was highly significant. Blueberry can be grown successfully on heavy soils with forest waste, and worm castings and cow manure improve yield and fruit quality of this crop.

Acknowledgments

The authors deeply acknowledge the professional and financial support of Alcorn State University, Mississippi State University, and National Institute of Food and Agriculture, United States Department of Agriculture.

Introduction

Blueberries and cranberries are in the family Ericaccae and the genus Vaccinium which contains about 400 species of shrubs, woody vines and small trees (Vander Kloet, 1988). The blueberries are in Cyanococcus which includes lowbush (Vaccinium angustifolium Ait), highbush (Vaccinium corymbosum L.), and rabbiteye species (Vaccinium ashei Reade), although Vander Kloet (1988) combines rabbiteye blueberries into Vaccinium corymbosum. Blueberries are one of the richest sources of antioxidant phytonutrients of the fresh fruits and vegetables (Prior, 1998; Wang et al., 1996; Cao et al., 1993). Compared to other fruit, blueberries have a high level of anthocyanins (Kalt and Dufous, 1997). Increased concerns over the last several decades on environmental quality have stimulated farmers to accept organic farming as an alternative (National Research Council, 1993).

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The objectives of this research were to evaluate the effect of worm castings, cow manure and forest waste on (a) yield and fruit quality of Rabbiteye blueberry, and (b) physico-chemical changes in a heavy soil.

Material and methods

Rows were opened with a mould-board plow on a heavy soil, Memphis silt loam, and pine bark was mixed with the soil with a rotary tiller to increase soil organic matter and moisture retention, improve soil structure, and decrease soil bulk density. One-year-old bare-rooted plants of 'Tifblue' cultivar were raised at a spacing of 1.47m x 3.52m on March, 2002 with another compatible Rabbiteye cultivar, 'Powederblue', for cross pollination. Fresh Pine needle was applied over the rows as mulch. Based on soil and manure tests for nutrient requirements, organic and inorganic manures were applied in basins around each plant in a completely randomized design with four replications for five years (Tables 1) by strictly following the federal regulations on animal waste application (Federal Register, 2001). Fresh worm castings, produced by wriggler worms on decaying organic materials, was bought from a certified organic company for plant nutrients. It was applied in basins of blueberries as a basal dose before the flowering season. No irrigation or chemicals were applied for the duration of the experiment. Phenotypic evaluation on biomass development was recorded each month of vegetative growth period, fruit quality was recorded immediately after each harvest, and soil physico-chemical studies were conducted during dry and hot days to have uniform soil moisture content. Soil core samples collected with soil auger, up to a depth of 100cm, were analyzed for nitrate-N and P movement and water quality. Fresh fruits were analyzed for microbial load, quality, and total anthocyanins, total phenolics, and vitamin C. Total phenolics in blueberry extract were determined with the Folin-Ciocalteu (Fisher Scientific Co.) reagent (Singleton & Rossi, 1965), using gallic acid as the standard. The absorbance was determined at room temperature (21 C) at k = 765 nm using a Lambda 3B UV/Vis spectrophotometer (Perkin-Elmer Co.).

Results

Percent canopy cover, canopy height, stem diameter, fruit weight, and yield were significantly higher in organic plants treated with worm casting. Concentrations of nitrate-N and P were higher in the surface soil with organic manures, but there was no trend in enrichment of these elements in the lower layers of soil. The leaching of N and P into subsurface layers from inorganic fertilizer was highly significant (Table 2). The total anthocyanins were similar for all treatments, but tended to be higher for organic treatments (Table 2). Since pine bark and needle were applied uniformly for all treatments, there was no significant difference in soil moisture, pH, and compaction. There was no significant difference in titratable acidity, fruit pH, degree Brix, and canopy width. Organically cultivated blueberries had significantly higher Vitamin C content than control. Vitamin C content was not significantly different between the organic treatments, however numerically Vitamin C content was highest under worm castings. Blueberries produced under worm castings had 83% higher Vitamin C content compared to control, whereas blueberries produced under cow manure had 65% higher Vitamin C content than control blueberries (Figure 1).

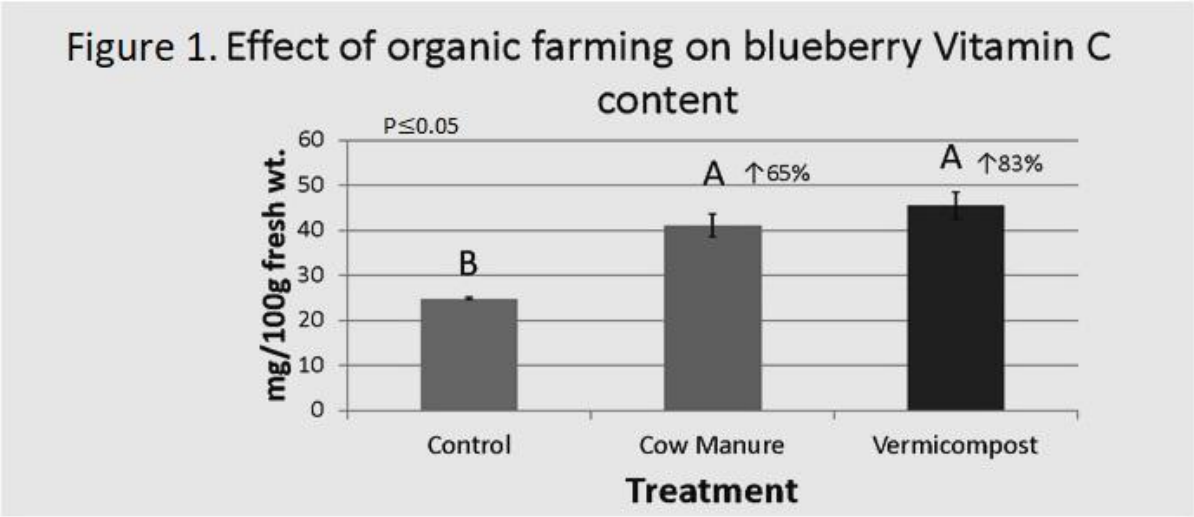
Table 1: Average Nutrient Content of Treatments (%) and Application Rates by Year

Treatments in Kg ha^{-1}	N	P	K	Ca	Mg	S	1st Yr.	2nd Yr.	3rd Yr.	4th Yr.	5th Yr.
Pine needle	1.57	0.09	0.41	0.42	0.11	0.15	15,680	7,840	7,840	5,000	5,000
Pine bark	0.68	0.08	0.17	0.55	0.16	0.08	11,200	…	…	…	…
Worm Castings	1.89	0.47	0.58	5.84	0.33	0.24	….	407	610	813	813
Cow Manure	0.33	0.12	0.23	0.99	0.08	0.05		813	1220	1626	1626
NPK	12.0	10.0	4.00	….	….	…	….	102	204	305	305

Table 2: Effect of treatments on Anthocyanins and Phenolics (mg/100gm) in fruits, and nitrate-N and P concentration in soil

Treatments	Total anthocyanins	Total phenolics	Nitrate-N (mg Kg^{-1}) 66-100cm depth	P (ppm) 66-100cm depth
Worm castings	114.08a	284.25a	5.11b	30.84c
Cow manure	102.78a	284.05a	5.52b	44.68b
NPK	99.20a	280.75a	13.5a	79.4a
LSD	37.85	73.17	0.77	3.99
CV%	22.46	16.15	6.01	4.63

Means within a column followed by the same letter are not significantly different P≤0.05



Discussion

Blueberry is a shallow rooted crop with most of the roots 20 to 30 cm deep. It has only thread-like root mass with no root hairs and hence, cannot be grown on flat lands with heavy soils. They depend on mycorrhizae for soil plant nutrients and prefer low pH. Results of this research suggest that blueberries can be grown successfully with animal waste, and pine needle and bark on heavy soils. Organically cultivated blueberries had significantly higher Vitamin C content than control. Blueberries produced under worm castings and cow manure were 83% and 65% higher in Vitamin C content, respectively, compared to control. Even though not statistically significant, both cow manure and worm castings increased the total anthocyanin content. Worm castings may be an excellent organic manure to improve yield and fruit quality. Controlled application of worm castings on blueberry may be an agronomically and environmentally sound practice.

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Invitro evaluation of soil isolates from organic fields for their antagonistic activity against phytopathogenic microorganisms

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Key words: Organic soil isolates, Inhibition, Phytopathogenic fungi, Organic Farming

Abstract

A laboratory experiment was conducted at Research Institute on Organic Farming (RIOF), UAS, Bengaluru to study the antagonistic activity against phytopathogenic microorganisms from isolates of organic fields treated with liquid organic manures. Xanthomonas sp., Alternaria alternata, Fusarium cepae, Fusarium oxysporum were the phytopathogens used for the study. Bacterial, fungal and actinomycete isolates were screened for their antimicrobial activity against plant pathogens by dual culture technique. Majority of bacterial isolates were found to be antagonistic against Xanthomonas sp. which recorded highest inhibition zone (4 mm) and all actinomycete and some fungal isolates inhibited the pathogens tested. The study suggests that plant pathogens causing pre harvest and post harvest losses can be reduced by antagonistic microorganisms which can reduce pathogenic activity by competing with the pathogen for nutrients, inhibit pathogen multiplication by antibiotics and reduce pathogen population through hyperparasitism which is an eco-friendly approach.

Introduction

Organic farming helps to improve the physical, chemical and biological properties of soil and maintains the ecological balance as well as productivity of life supporting systems (Pathak and Ram, 2006). The major biotic component of soil comprises of the microbiota which harbors millions of microorganisms like bacteria, fungi and actinomycetes. These microorganisms produce secondary metabolites in the later stages of their growth needed for their defense and survival. Biological control of plant pathogens by antagonistic microorganisms is a potential non-chemical means and is known to be a cost effective and eco-friendly method for the management of crop diseases (Cook,1985). Antifungal metabolites produced by bacteria like Pseudomonas sp., Bacillus sp. have been investigated for their antifungal properties (Moita et al., 2005). The aim of this research was to determine, the antagonistic effectiveness of bacteria, fungi and actinomycete isolates from organic fields against important phytopathogenic microorganisms.

Material and methods

Soil samples were collected from experimental plots treated with liquid organic manures viz., jeevamrutha and panchagavya at Research Institute on Organic Farming (RIOF), University of Agricultural Sciences, GKVK, Bengaluru. Soil samples were air dried, sieved and stored in a polythene bag for further use. Jeevamrutha and panchagavya were prepared using cow byproducts viz., cowdung, cowurine, milk, curd, ghee, jaggery and pulse flour. Standard plate count technique was followed to isolate the soil bacteria, fungi and actinomycetes. The medium used for isolation was soil extract agar for bacteria, MRBA for fungi and Kuster's agar for actinomycetes and plates were incubated for 3-4 days. After incubation period, different colonies of bacteria, fungi and actinomycetes were isolated and the isolates obtained were inoculated to respective agar plates and slants. The isolates were named with prefix B for bacteria, F for fungi and A for Actinomycetes and were refrigerated for further use.

Preliminary tests were conducted to the bacterial isolates viz., gram staining, shape of the cell, growth on different agar medium like sperber's, YEMA and Jensen's agar. Bacterial isolates were characterized by Gram staining method. In Gram staining, a smear was prepared on a clean glass slide by air drying and heat fixing it. To the smear, a drop of Crystal violet solution was added and allowed to stand for 60 seconds, and washed with distilled water. A few drops of Gram's Iodine was added and left for 30 seconds, and decolorizing agent was added and the slide was tilted. Finally, Safranine was added and the slide was allowed to stand for 60 seconds. Then the slide was washed, dried and viewed under the microscope under 10X, 40X and 100X

magnifications. These bacterial isolates tested for Sperber's agar medium, N-free agar medium (Jensen's agar medium). Pathogens tested were Xanthomonas sp., Alternaria alternata, Fusarium cepae, Fusarium oxysporum. Bacteria and actinomycete isolates were streaked and fungal isolates were placed at one side of petri dish (one cm away from the edge) containing PDA. A 9 mm disc of bacteria and fungal pathogens (7 day old culture) were placed at the opposite side of petri dish perpendicular to the inoculated isolates and incubated at 270C for 5-7 days. Petri dishes inoculated with fungal discs alone served as control. Three replications were maintained for each isolate. Observations on width of inhibition zone and mycelial growth of test pathogen were recorded and per cent inhibition of pathogen growth was calculated by using the formula proposed by Vincent (1927). Per cent inhibition (I) = C-T/C ×100, where C- mycelial growth of pathogen in control, T- mycelial growth of pathogen in dual culture plate.

Results

Total of 11 bacterial isolates, 2-antogonistic isolates, 8 fungal isolates, 4 actinomycete isolates from organic fields were tested for antagonistic effect against phytopathogenic microorganisms viz., Xanthamonas sp., Fusarium oxysporum, Fusarium cepae and Alternaria alternata. Morphological identification of bacterial isolates showed that B-1, B-4, B-11, B-10 were Gram-ve rod shaped, B-2 and B-6 are Gram –ve cocci shape and B-5 Gram +ve cocci shape, ANT-1 are Gram +ve rod shape and ANT-2 are Gram +ve rods. Bacterial and antagonistic isolates were tested for having capacity to grow in N-free media at 36 hrs after incubation.

Five bacterial isolates could solubilize in sperber's agar medium while other bacterial and antagonistic isolates did not show clear solubilization zone. B-1 and B-7 isolates showed their inability to grow on YEMA media but remaining isolates showed good growth on YEMA media. ANT-1 and ANT-2 showed growth on YEMA media. (Table 1). Among actinomycetes isolates A7 isolates inhibited the growth of mycelia and sporulation in Fusarium oxysporum (75%) followed by other pathogens Xanthomonas sp.(65%), Fusarium cepae and Alternaria alternate (50%). A4 recorded inhibition percentage in Alternaria alternata (50%) followed by Fusarium oxysporum and Fusarium cepae (35%). A5 recorded inhibition percentage in (50%) followed by Fusarium cepae and Alternaria alternate (35%) but no inhibition was recorded by A4 and A5 on Xanthomonas sp. A3 inhibits only the Xanthomonas sp. (35%) but no inhibition was recorded in Fusarium oxysporum, Fusarium cepae, Alternaria alternata. (Table 2).

Table 1: Morphological identification and growth of bacterial isolates on N-free, Sperber's and YEMA media

Isolates	Gram stain +ve/-ve	Shape	Growth on Jensen's agar medium (36hrs)	Growth on Sperber's agar medium (36hrs)	Growth on YEMA medium (24hrs)
B1	+ve	Rods	+	-	-
B2	-ve	Cocci	+	+	+
B3	-ve	Rods	+	+	+
B4	+ve	Rods	+	-	+
B5	+ve	Cocci	+	-	+
B6	-ve	Cocci	+	-	+
B7	-ve	Rods	+	-	-
B8	-ve	Rods	+	+	+
B9	-ve	Rods	+	-	+
B10	+ve	Rods	+	+	+
B11	+ve	Rods	+	+	+
Ant-1	+ve	Rods	+	-	+
Ant-2	-ve	Rods	+	+	+

Note: + indicates growth of colony, – indicates no growth of colony.

With respect to fungal isolates F8 recorded highest inhibition percentage in Fusarium cepae (50%) fallowed by Fusarium cepae and Alternaria alternate (40%), Xanthomonas sp. (20 %), F3 inhibits growth of Fusarium cepae (50%) but no inhibition was recorded in Xanthomonas sp. ,Fusarium oxysporum, ,Alternaria alternata.

F4 and F5 was not recorded the inhibition of all tested pathogens. F6 inhibits only the growth of Fusarium cepae (33%) but no inhibition was recorded in Xanthomonas sp., Fusarium oxysporum and Alternaria alternata. F7 recorded highest inhibition in Fusarium oxysporum (50%) fallowed by Xanthomonas sp. (37.5%), Fusarium cepae (20%). F9 inhibits growth of Xanthomonas sp. (50%) but no inhibition was recorded in,Fusarium oxysporum, Fusarium cepae, Alternaria alternata. Finally F10 recorded inhibition percentage in Fusarium oxysporum and Fusarium cepae (40%) but no inhibition was recorded in Xanthomonas sp. and Alternaria alternata. (Table 3).

Among bacterial isolates, B- 1, B- 2, B- 6, B- 8 isolates inhibited the growth of Xanthomonas sp. (75 %) compared to other bacterial isolates B- 4, B- 7, B- 9, B- 10, B- 11 where the percentage of inhibition ranged between (50-65 per cent). B- 1, B- 4, B- 6 isolates recorded inhibition percentage ranged between 25 to 50 % which mainly inhibited the growth of mycelia and sporulation in Fusarium oxysporum. Fusarium cepae was inhibited by B- 4 and B- 9 zone of inhibition upto 50 %. Alternaria alternata was inhibited by B- 7 (65 %) and B- 8 (35 %) isolates. Antagonistic isolates (Ant-1) were strongly inhibited all pathogens and no inhibition was observed by Ant- 2 against any pathogens tested. Majority of actinomycetes isolates also strongly inhibited all test pathogens inhibition percentage ranged between 35 to 75 % fallowed by fungal isolates ranged between 20 to 50 % (Table 4).

Table 2: **Antimicrobial activity of actinomycete isolates from organic fields against phytopathogenic microorganisms**

Isolates	***Xanthomonas* sp.**		***Fusarium oxysporum***		***Fusarium cepae***		***Alternaria alternata***	
	Growth (mm)	Inhibition (%)	Growth (mm)	Inhibition (%)	Growth (mm)	Inhibition (%)	Growth (mm)	Inhibition (%)
A3	5	35	-	-	-	-	-	-
A4	-	-	4	50	5	35	3	35
A5	-	-	5	35	5	35	4	50
A7	3	65		75	4	50	4	50

Table: 3 Antimicrobial activity of fungal isolates from organic fields against phytopathogenic microorganisms

Isolates	***Xanthomonas* sp.**		***Fusarium oxysporum***		***Fusarium.cepae***		***Alternaria alternata***	
	Growth (mm)	Inhibition (%)	Growth (mm)	Inhibition (%)	Growth (mm)	Inhibition (%)	Growth (mm)	Inhibition (%)
F3	-	-	-	-	8mm	50	-	-
F4	-	-	-	-	-	-	-	-
F5	-	-	-	-	-	-	-	-
F6	-	-	-	-	10	33	-	-
F7	10	37.5	8	50	12	20	-	-
F8	16	20	10	50	12	40	12	40
F9	8	50	-	-	-	-	-	-
F10	-	-	12	40	12	40	-	-

Discussion

All the bacterial, fungal and actinomycete isolates tested against phytopathogens showed a higher inhibitory activity in organic fields treated with liquid organic manures. These isolates from soil belonging to genera viz. Bacillus, Pseudomonas, Penicillium, Aspergillus, Streptomyces have shown antagonism against different pathogens. Coombs et al., (2004) reported that higher number of soil actinomycete isolates belonging to Streptomyces and Microspora showed their ability to inhibit pathogens invitro. Results indicate that some Bacterial and Actinomycete isolates are responsible for inhibition of pathogenic growth and their properties induce strength in the host to resist disease. Antibiotics produced by the endophytic bacterium Streptomyces sp., strain NRRL 30562 isolated from kennetia nigricans, can inhibit invitro growth of phytopathogenic fungi.

Bacilllus sps. have been reported to produce many antibiotic compounds such as Iturin and Zwittermycine (Castillo et al., 2002). This is in conformity with Alikhani et al., (2006) who reported that Some of beneficial biocontrol microorganisms were involved in siderophore production which helps in the suppression of the plant disease as well as it acts as growth factor (Suman et al., 2014).

Table: 4. Antimicrobial activity of bacterial isolates from organic fields against phytopathogenic microorganisms

Isolates	*Xanthomonas* sp.		*Fusarium oxysporum*		*Fusarium.cepae*		*Alternaria alternata*	
	Growth (mm)	Inhibition (%)	Growth (mm)	Inhibition (%)	Growth (mm)	Inhibition (%)	Growth (mm)	Inhibition (%)
B1	2	75	-	-	-	-	-	-
B2	2	75	15	25	-	-	-	-
B3	-	-	-	-	-	-	-	-
B4	3	65	10	50	10	50	-	-
B5	-	-	-	-	-	-	-	-
B6	2	75	10	50	-	-	-	-
B7	3	65	-	-	-	-	3	65
B8	2	75	-	-	-	-	5	35
B9	3	65	-	-	4	50	-	-
B10	4	50	-	-	-	-	-	-
B11	3	65	-	-	-	-	-	-
Antagonists								
Ant-1	3	65	3	65	-	-	3	65
Ant-2	-	-	-	-	-	-	-	-

Conclusion

Inhibition of plant pathogens by different bacterial, fungal and actinomycete isolates showed higher importance in control of soil borne disease incidence. Almost all the phyopathogens were inhibited by the isolates from organic fields. Majority of soil isolates include genera of Bacillus, Pseudomonas, Rhizobium, Aspergillus, Streptomyces which have their role in inhibiting soil borne phytopathogens to a greater extent. Although, this investigation is a primary study, further investigations needs to be embarked upon to determine the type of antimicrobial/antifungal substances produced or the type of effect they cause on the pathogens, under field condition to assess its antagonistic character against other specific pathogenic fungi on suitable crops.

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Studies on soil microbial population in organic paddy as influenced by liquid organic manures and Palekar's method of cultivation

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Key words: Organic farming, palekar method, panchagavya, beejamrutha, jeevamrutha and soil microbial population

Abstract

A field experiment was conducted in transplanted paddy to study the influence of Palekar's method of cultivation with and without panchagavya spray and different liquid organic manures on soil microbial population. The soil microbial population varied significantly in Palekar method (System-I) of cultivation as compared to organic method (System-II) of cultivation, panchagavya spray had maximum influence in both the systems. Maximum of 124X103 CFU/ g of N- fixers and 120X103 CFU/ g of P- solubilizers were recorded at 30 DAT with T15 and minimum was recorded in control plots. However, grain and straw yield of paddy varied significantly due to different organic farming systems and panchagavya spray but seedling treatment did not vary significantly. Organic method recorded maximum grain yield of 45.40 q / ha and straw yield of 47.40 q / ha with panchagavya spray whereas Palekar method of cultivation recorded lower grain and straw yield (39.9 q/ ha and 42 q / ha). Microbial population of N- fixers and P- solubilizers were higher in organic method with panchagavya spray even one month after harvest of the crop.

Introduction

During the last few years with increased awareness on organic farming there has been an increasing interest in the use of panchagavya, beejamrutha, jeevamrutha and other traditional liquid organic formulations. These formulations can be prepared by all farmers in remote villages of our country as the inputs required are only cow based products. Panchagavya and beejamrutha are two organic products which have received wide spread attention and acceptability among organic farming practitioners. Ali *et al*. (2011), Swaminathan et al. (2002) and Devakumar et al. (2008) reported the presence of naturally occurring beneficial microorganism's predominantly lactic acid bacteria, yeast, actinomycetes, photosynthetic bacteria, nitrogen fixers, phosphorus solubilizers and fungi in panchagavya and beejamrutha. An attempt was made to study the effect of seed treatment, panchagavya application and organic farming systems on soil microbial population, growth and yield of transplanted paddy. The objectives are to study the interaction effect of panchagavya spray on two organic farming systems on growth and yield of paddy and microbial population of beneficial groups after harvest of transplanted paddy.

Material and methods

A field study was conducted at ARS Honnavile, Organic Farming Research Centre (OFRC), University of Agricultural Sciences Bengaluru, India. Beejamrutha and jeevamrutha were prepared by following standard procedure given by Palekar, (2006). Panchagavya was prepared by following standard procedure given by Natarajan (2002). Paddy seedlings were treated with beejamrutha, cowurine and liquid biofertilizers by dipping them for about 15 minutes before transplanting. Panchagavya was filtered through a muslin cloth and 3 liters of panchagavya filtrate was diluted in 100 liters of water and sprayed at seedling, tillering and vegetative stages of paddy crop. Grain and Straw yields were recorded and studied microbial population *viz.,* bacteria, fungi, actinomycetes, N-fixers, P- solubilizers present in rhizosphere. Serial dilution and standard plate count methods were used for isolation of rhizosphere bacteria, fungi and actinomycetes using nutrient agar, Martin's rose

bengal agar and Kuster's agar respectively. The media used for free living nitrogen fixers and P-solubilizers using Norri's N- free media and Pikovskaya's media respectively. Inoculated plates were incubated at 32±2 ^{0}C for 3-5 days and the colony counts were recorded. Field experiment consisted of three main factors *viz.,* Organic Farming Systems- F_1- Organic farming system Palekar's method and F_2- Organic farming system II (organic farming), panchagavya (3 %) spray- P_1- with panchagavya and P_0– without panchagavya, seed treatments- S_1 – control, S_2- beejamrutha, S_3- cow urine, S_4- panchagavya (3%), S_5- liquid biofertilizers and experiment was laid out on factorial randomized block design with 20 treatment combinations with three replications. The treatment combinations were T_1: $S_1F_1P_1$, T_2: $S_1F_1P_0$, T_3: $S_1F_2P_1$, T_4: $S_1F_2P_0$, T_5: $S_2F_1P_1$, T_6: $S_2F_1P_0$, T_7: $S_2F_2P_1$, T_8: $S_2F_2P_0$, T_9: $S_3F_1P_1$, T_{10}: $S_3F_1P_0$, T_{11}: $S_3F_2P_1$, T_{12}: $S_3F_2P_0$, T_{13}: $S_4F_1P_1$, T_{14}: $S_4F_1P_0$, T_{15}: $S_4F_2P_1$, T_{16}: $S_4F_2P_0$, T_{17}: $S_5F_1P_1$, T_{18}: $S_5F_1P_0$, T_{19}: $S_5F_2P_1$, T_{20}: $S_5F_2P_0$.

Results

The results indicated that grain and straw yield of paddy varied significantly due to different organic farming systems and panchagavya spray but seedling treatment did not vary significantly (Table 1). Maximum grain yield of 45.90 q / ha and straw yield of 49.40 q/ ha were recorded in organic farming system II and minimum yield of 39.90 q / ha and straw yield of 42.0 q / ha were recorded in organic farming system I (Palekar method). Among seedling treatments higher grain yield (45.10 q / ha and 45.20 q / ha) was recorded with panchagavya and liquid biofertilizers in organic farming system and minimum was with beejamrutha (41.0 q / ha). Straw yield was maximum (48.7 q/ ha) with spraying of panchagavya under organic farming and minimum (40.8 q/ ha) was recorded with beejamrutha application alone.

Table 1. Effect of seedling treatment, Panchagavya application and organic farming systems of cultivation on grain and straw yield of Paddy

Panchagavya Sprays (P)	Grain yield(q / ha)				Straw yield(q / ha))			
	Organic Farming systems (F)				Organic Farming systems (F)			
	System I (F_1)		System II (F_2)	Mean	System I (F_1)		System II (F_2)	Mean
With Panchagavya spray (P_1)	42.00		48.80	**45.40**	44.70		50.20	**47.40**
Without Panchagavya spray (P_2)	37.80		43.00	**40.40**	39.30		48.60	**43.90**
Mean	**39.90**		**45.90**		**42.00**		**49.40**	
	F-test	**S.Em±**	**C.D at 5 %**		**F-test**	**S.Em±**	**C.D at 5 %**	
F	**	0.80	2.13		**	1.11	3.00	
P	**	0.80	2.13		*	1.11	3.10	
F x P	NS	1.00	-		NS	1.57	-	
Seedling treatments (S)								
S_1 – control	39.00		44.90	**41.9**	40.6		49.9	**45.2**
S_2 – Beejamrutha	38.50		43.50	**41.0**	38.1		43.6	**40.8**
S_3 – Cow urine	38.80		43.70	**41.3**	40.7		51.2	**45.9**
S_4 – Panchagavya	41.60		48.60	**45.1**	42.4		53.4	**47.8**
S_5 – Liquid biofertilizers	41.80		48.60	**45.2**	48.0		49.2	**48.7**
Mean	**39.90**		**45.70**		**42.0**		**49.4**	
	F-test	**S.Em±**	**C.D at 5 %**		**F-test**	**S.Em±**	**C.D at 5 %**	
S	NS	1.21	-		*	1.75	4.87	
F x S	NS	0.80	-		NS	2.48	-	

The rhizosphere microbial population varied due to the levels of panchagavya, seed treatment and organic farming systems are presented in table 2. There was three fold increase in microbial population in organic farming system II (organic farming) as compared to organic farming system I (Palekar's method). Among seedling treatments there was minimum difference in control and cow urine treatments. Higher microbial population was found in panchagavya seedling treatment followed by liquid biofertilizers and beejamrutha treatments. Lower microbial population was found in control treatments as compared to other treatments. Treatment T_{15} with panchagavya spray and panchagavya seedling treatment showed higher microbial population with bacteria 136 x 10^7 CFU/ g, N- fixers 124 $\times 10^3$ CFU/ g and P- solubilizers 120 $\times 10^3$ CFU/ g followed by T_{16} without panchagavya spray and with panchagavya seedling treatment. No much difference in soil fungi and actinomycetes were observed. Lower microbial population was observed in T_2 (bacteria- 12X10^7 CFU/ g, N-fixers- 16X 10^3 CFU/ g and PSB- 19X10^3 CFU/ g) without panchagavya spray and without seed treatment.

Table 2. Effect of seedling treatment, Panchagavya spray and organic farming systems of cultivation on soil microbial population at 30 days after transplanting

Treatments	Bacteria (10^7 CFU)	Fungi (10^4 CFU)	Actinomycetes (10^3 CFU)	N-fixers (10^3 CFU)	P-solubilizers (10^3 CFU)
Before transplanting	16	03	08	14	19
T_1: $S_1F_1P_1$	33	01	12	25	31
T_2: $S_1F_1P_0$	21	02	11	16	19
T_3: $S_1F_2P_1$	72	01	12	75	74
T_4: $S_1F_2P_0$	63	01	10	48	51
T_5: $S_2F_1P_1$	35	01	11	22	42
T_6: $S_2F_1P_0$	25	02	10	14	30
T_7: $S_2F_2P_1$	78	01	11	65	85
T_8: $S_2F_2P_0$	65	01	10	42	63
T_9: $S_3F_1P_1$	46	01	12	38	54
$T1_0$: $S_3F_1P_0$	38	01	12	24	42
T_{11}: $S_3F_2P_1$	89	01	10	89	96
T_{12}: $S_3F_2P_0$	72	02	11	57	75
T_{13}: $S_4F_1P_1$	89	01	11	74	89
T_{14}: $S_4F_1P_0$	72	01	10	52	72
T_{15}: $S_4F_2P_1$	136	01	10	124	120
T_{16}: $S_4F_2P_0$	118	01	11	87	94
T_{17}: $S_5F_1P_1$	67	01	12	51	66
T_{18}: $S_5F_1P_0$	59	01	12	36	53
T_{19}: $S_5F_2P_1$	103	01	11	101	108
T_{20}: $S_5F_2P_0$	98	01	11	69	87
After harvest	46	05	10	36	59

Discussion

Higher microbial population was recoreded with panchagavya under Palekar and organic system of cultivation and it was followed by application of liquid biofertilizers. This might be due to the fact that panchagavya is a good source of beneficial microorganisms besides it contains growth promoting substances. Panchagavya contains naturally occurring beneficial, effective microorganisms, lactic and bacteria, yeast, actinomycets, photosynthetic bacteria and certain fungi have improved population in the soil. This might have served as addition of inoculums to the soil and the growth promoting substances present in panchagavya had also helped in further multiplications in the soil. This is in conformity with Natarajan (2002), Devakumar et al. (2008) Srinivas et al. (2009), besides under organic system of cultivation more organic matter was available for better growth and development of beneficial microbes than Palekar method. Higher grain (45.90 q / ha) and straw (49.4 q / ha) yield

were recorded under organic system and it was (39.90 and 42.0 q / ha) in Palekar method. This might be due to better and continuous availability of nutrients to crop through compost application under organic farming than without compost application under Palekar method. Grain and straw yield were further increased due to application of panchagavya (3%) and liquid biofertilizers. Similar results were also obtained by Ramya et al. (2016) and Sarkar et al.(2014) with organic biofertilizers, panchagavya, amrithpani, sanjibani, jeevamrutha and kunapajola in paddy.

Conclusion

Panchagavya application recorded higher beneficial microorganisms *viz*., bacteria, fungi, N-fixers, P-Solubilizers and actinomycetes. Significantly higher grain and straw yields were recorded in organic farming system and lower was recorded in Palekar method and in both methods application of panchagavya resulted in further increase in grain and straw yields. Use of these formulations in organic farming would help farmers to get higher yield and returns. These formulations can be prepared locally by resource poor farmers and improve soil health, besides obtaining higher returns to the farmers in rural areas.

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Isolation and screening of Phosphate solubilizing bacteria from rhizospheric soil of Mung bean

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Key words: Phosphate solubilizing bacteria, Rhizosphere, PGPR

Abstract

Phosphate solubilizing microbes (PSMs) are isolated from the rhizospheric soil of Mung bean grown in organic field of Amity Institute of Organic Agriculture, Noida. Four bacterial isolates IP1, IP2, IP3 and IP4 belonging to different species of genera Bacillus revealed solubilisation of rock phosphate to 50µg/ml, 40µg/ml, 55µg/ml and 60µg/ml of PO4- respectively. These isolates indicated secretion of siderophore in significant amount. The mechanism of solubilization of rock phosphate to phosphates was due to excretion of chelating agent in the medium. Siderophore is an important chelating agent, extracting Iron or Calcium from the complexes of Ca and Fe with phosphates. The bacterial isolates found in this study could be used as potential phosphate solubilizing microbes, which could be a cheap and ecofriendly alternative to expensive and polluting phosphatic fertilizers. PSBs could be applied along with rock phosphates as efficient phosphatic fertilizers in organic agriculture.

Acknowledgments

The authors are thankful to the Amity University, Noida and Indian Agricultural Research Institute, New Delhi for providing financial assistance to conduct this research.

Introduction

The content of phosphorous in soil ranges from 400-1200 mg/kg, but most of this Phosphorous remain bounded in the soil as insoluble complexes. So a very small fraction of Phosphorous is available for plant intake and growth. The deficiency of Phosphorous in soil have been observed in many agricultural soils across the globe. To compensate this deficiency of Phosphorous in soil, expensive chemical phosphatic fertilizers are used to improve nutrient balance of the soil. However, major problem with application of phosphatic fertilizer is that they get fixed in acidic soil in the form of metallic complexes of Iron and Aluminium or with Calcium in alkaline soil. Finally, this applied phosphorous doesn't become available to plants. Apart from this, chemical fertilizer industry is extremely polluting and applied phosphorous leads to eutrophication and pollutes ground water used for drinking. The development of sustainable or organic agriculture requires drastic reduction in agrochemical inputs and their replacement with more ecological, efficient and cheap natural products. Rock phosphate (RP, a hydroxyapatite) is a natural, slow phosphorous releasing phosphatic fertilizer. This insoluble form of rock phosphate could be make available rapidly by simultaneous application of both rock phosphate and phosphate solubilizing microbes. The present manuscript describes the isolation of phosphate solubilizing microbes, evaluating the mechanisms of their solubilisation and their effects in cultivation of peas under field conditions.

Material and methods

Collection of soil samples

Soil samples were collected randomly from rhizospheric soil of Mungbean grown in organic farm of Amity Institute of Organic Agriculture, Noida, Uttar Pradesh, India and transported to the laboratory for further processing. The soils adhering to the roots and around the space occupied by roots are considered as rhizospheric soil (Pascual et al., 2016). The living plant material and coarse roots were removed from the soil sample and it was stored at 4ºC for further analysis.

Isolation of PGPR

10 gm of rhizospheric soil was dissolved in 95ml of sterilized water by shaking it for 10 minutes. Then 1ml of this suspension was transferred into a 9ml blank (10-2) and this serial dilution was made up to 10-10. The pour plating of this dilution was done on Tryptone Soy Agar (TSA), Nutrient Agar (NA), basal medium amended with glucose, mannitol, sorbitol, inositol and sucrose. The plates were incubated at 28ºC for 2-3 days. The most suitable dilution was selected for estimating the population of rhizobacteria and expressed as number of CFU (Colony Forming Units) g−1 soil. A total of 50 bacterial isolates were studied for cell form and size, Gram staining, spore formation, motility and colony pigmentation. The biochemical traits studied were indole test, methyl red test, Voges-Proskauer (VP) test, citrate test, presence of oxidase and catalase, succinic acid, carbohydrate utilization pattern (Table 1).

Phosphate solubilization by test bacteria

All isolates were first screened on Pikovskaya's agar plates for phosphate solubilization as described by Rodriguez and Raja (Rodríguez and Fraga, 1999). Quantitative analysis of solubilization of tricalcium phosphate in liquid medium was made as described by Ahmad (Ahmad et al., 2008).

Siderophore production

Bacterial isolates were assayed for siderophores production on the Chrome azurol S agar medium (Sigma, Ltd.) described by Schwyn and Neilands (Schwyn and Neilands, 1987). Chrome azurol S agar plates were prepared and divided into equal sectors and spot inoculated with test organism (10 ml of 106 CFU/ml) and incubated at 28ºC for 48–72 h. Development of yellow–orange halo around the growth was considered as positive for siderophore production. Observations of Siderophore production was observed on a 0-4 rating scale.

Results

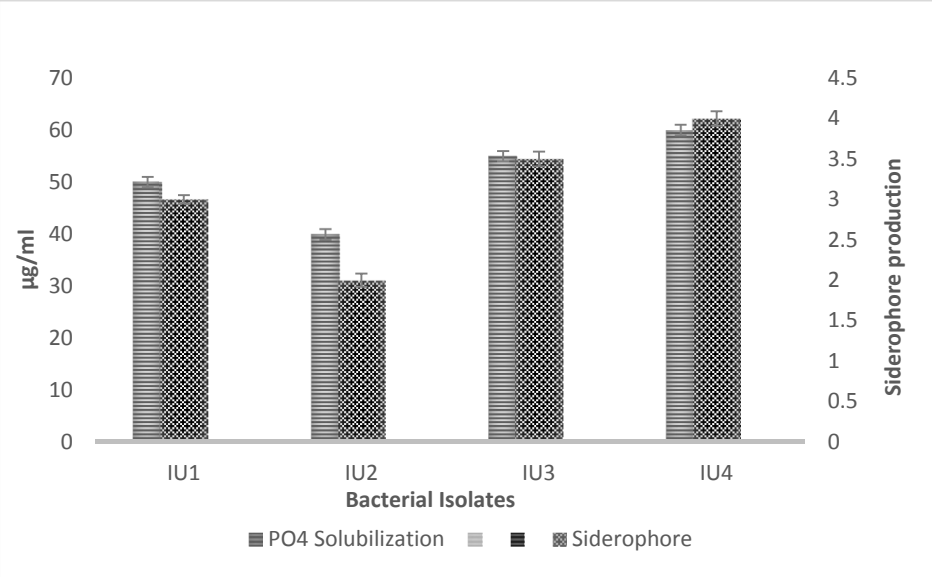
A total of 15 morphotypes were isolated from the rhizospheric soil of Mungbean and screened for their phosphate solubilizing ability under in vitro conditions. Out of the 15 morphotypes, four isolates were selected. The biochemical characterization of these isolates revealed that they belonged to different species of genus Bacillus (Table 1). The four isolates IP1, IP2, IP3 and IP4 were evaluated for their ability to produce Siderophore and dissolve Rock phosphate. The release of PO4- from Rock Phosphate by IP1, IP2, IP3 and IP4 were observed to be 50µg/ml, 40µg/ml, 55µg/ml and 60µg/ml respectively (Fig.1).

Discussion

Our data suggests that all four isolates were significant producers of Siderophore. To overcome the P deficiency in soils, there are frequent applications of Phosphatic fertilizers because a large chunk of it is converted into insoluble complexes of the soil (Khan et al., 2010). This process makes it an

expensive and environment unfriendly affair. Therefore, we need to find out the cheap, ecologically safe and environment friendly option for providing phosphorous in the soil for plant growth.

Fig 1. Production of Siderophore and release of Po_4 from Calcium Phosphate by four bacterial isolates



In this context, microbes having phosphate solubilizing ability is a viable option and eco-friendly substitute to the chemical fertilizers. Out of the various microbes inhabiting the rhizosphere, phosphate solubilizing bacteria (PSB) are considered as promising biofertilizer since they can solubilize the P and make it available to plants. In this context, microbes having phosphate solubilizing bacteria (PSB) are considered as promising biofertilizer since they can solubilize the P and make it available to plants. A wide bacterial genera like Azotobacter, Bacillus, Beijerinkia, Burkholderia, Enterobacter, Erwinia, Flavobacterium, Microbacterium, Rhizobium and Serratia are reported as the most important phosphate solubilizing bacteria (Bhattacharyya and Jha, 2012). It has been demonstrated that rock phosphate solubilizing microbes excrete chelator like Siderophore. Since the function of chelator like Siderophore is to adsorb Fe or Ca from their complexes of phosphates and make the phosphorous available to the plants. It has been reported that excretion of chelators are important mechanisms of solubilisation of phosphates by the microbes (Babana et al., 2013).

Table 1 Morphological, Cultural and Physiological characteristics of different bacteria isolated from rhizospheric soil of Mungbean.

Colony characteristics	Wrinkled, white and large (AU-1)	Circular, white and small (AU-2)	Reddish, Circular and small (AU-3)	Circular, raised white and small (AU-4)
Cell morphology	Rods	Small rods	Rods	Large rods
Gram reaction	+	+	+	+
Spore formation	+	+	+	+
Growth in 5% salt concentration	+	+	_	+
Sugar fermentation				
Glucose	+	-	+	+
Fructose	+	-	-	+
Sucrose	-	-	+	+
Maltose	+	-	+	+
Lactose	-	-	-	-
Catalase test	+	+	+	+
Oxidase test	+	+	+	+
	Bacillus species	*Bacillus* species	*Bacillus* species	*Bacillus* species

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Nutrient Management Options Through Organics in Greengram (*Vigna radiata* L.) – *Rabi* Sorghum (*Sorghum bicolor* L.) System under Rainfed Conditions

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Key words: Organic manures, Greengram, *Rabi*-sorghum, Productivity, Economics

Abstract

A field investigation was carried out from 2012-13 to 2014-15 at MARS, Raichur, India to develop organic nutrient schedule in greengarm - rabi sorghum cropping system under rainfed conditions. There were ten treatments with combinations of various organic nutrient sources equivalent to 100 per cent Recommended Dose of Nitrogen (RDN) along with foliar spray of panchagavya. The pooled results indicated that Recommended Dose of Fertilizers + Farm Yard Manure (RDF + FYM) resulted in higher yield of greengram (562 Kg/ha) and rabi sorghum (2493 Kg/ha) and showed 18.8 to 52.3 per cent and 9.1 to 37.7 per cent higher yields over organic manurial treatments in greengram and rabi sorghum respectively. The application of compost alone resulted in lower crop yields. Further, the yields realized from both the crops and net returns of the whole system with RDF were on par with Compost + Vermicompost + Panchagavya and Compost + Vermicompost + Green Leaf Manure + Panchagavya which showed promising in organic cultivation of greengarm and rabi sorghum.

Introduction

Greengram – rabi sorghum is the most profitable sequential cropping system in rainy and post rainy seasons(Kharif-Rabi) under rainfed conditions of North Eastern Dry Zone of Karnataka, India. Though both these crops alone have low nutrients demand and being cultivated on soils having low available nitrogen and phosphorus status, but are grown with feeding less than their recommended nutrient requirements with minimal use of organic manures. This has resulted in decline in crop productivity and deterioration of soil health and productivity. This necessitates the use of organic sources of nutrients for sustaining the crop productivity levels. Further, in organic production system, the first crop uses hardly around 40 per cent 'N' from organic manure applied and the rest is available to the succeeding crop. This investigation was planned to develop organic nutrient management schedule to meet the crops demand in a system approach through combination of various sources of organic manures for ensuring their better efficacy.

Material and methods

A field investigation was conducted at Main Agricultural Research Station, Raichur, Karnataka on black clayey soil during *kharif* and *rabi* seasons of 2012-13 to 2014-15. The experiment consisted of

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ten treatments with combinations of organic manures viz., compost (100% RDN), vermicompost (100% RDN), compost (50% RDN + vermicompost (50% RDN), compost (37.5% RDN) + vermicompost (37.5% RDN) + GLM-Green leaf manure (Glyricidia) (25% RDN) alone and also with fermented organic manure (3% panchagavya) and RDF + FYM and RDF. The organic manures were applied based on the equivalent to recommended dose of nitrogen for both the crops in the system three weeks before sowing as per the treatments. In rabi sorghum, RDF + FYM treatment received 3 tonne of FYM per hectare whereas recommendation for FYM was not made for greengram. The recommended dose of fertilizers (RDF) for greengram and rabi sorghum was 25:50:0 kg NPK ha-1 and 50:25:0 kg NPK ha-1 respectively. Panchagavya was sprayed at 30 and 45 days after sowing (DAS) in greengram and at 60 DAS in rabi sorghum. Jeevamrutha @ 500 l ha-1 and neem cake @ 250 kg ha-1 were applied before sowing in organic manurial treatments for both the crops. The treatments were replicated thrice in Randomised Block Design and Fisher's method of analysis of variance was applied for analysis and interpretation of the data and the level of significance used in 'F' test was at P = 0.05. Critical difference values calculated when ever ′F′ test was significant.Benefit- Cost (B:C) ratio was worked by dividing gross returns with cost of cultivation.

Results

The pooled results of three years indicated that application of RDF+FYM recorded significantly higher seed yield of greengram (562 Kg/ha) and *rabi* sorghum (2493 Kg/ha) except treatments received RDF and compost + vermicompost + Green Leaf Manure + panchagavya (C+VC+GLM+P) in greengram and compost + vermicompost + panchagavya (C+VC+P) and C+VC+GLM+P in *rabi* sorghum crop (Table 1). The yields recorded with RDF, C+VC+P and C+VC+GLM+P were on par with each other in both the crops. The extent of increase in yield with RDF +FYM over C+VC+P and C+VC+GLM+P was 23.5 and 18.8 per cent in greengram and 9.1 and 11.2 per cent in *rabi* sorghum. The net returns realized with greengram – *rabi* sorghum cropping system with RDF, C+VC+P and C+VC+GLM+P were on par at each other. B: C ratio did not follow the similar trend of net returns due to variation in cost of cultivation.In individual years also ,similar trend was seen with respect to yield and economics.

Discussion

Treatments supplemented with C+VC+P and C+VC+GLM+P resulted in on par seed yield with RDF in both greengram and *rabi* sorghum crops. Further from greengram – *rabi* sorghum system, the net returns realized with RDF showed 4.7 and 3.7 per cent higher yield over C+VC+P and C+VC+GLM+P treatments but all were statistically on par with each other. In these organic manurial treatments (C+VC+P and C+VC+GLM+P), combined application of various organic sources might have resulted in better availability of nutrients through the crop growth period. Further, these treatments combinations of various nutrient sources along with supplementation of panchagavya through foliar nutrition resulted in better growth and on par seed yield of both the crops with recommended dose of fertilizers (RDF) which inturn reflected on net returns of the whole system. This might be because of panchagavya acted as source of nutrients, micro organisms and plant growth promoters. These results are also in conformity with Patil *et. al*., (2012) and Shwetha, (2007). Use of C+VC+P or C+VC+GLM+P can be made as nutrient schedule in organic cultivation of greengram and *rabi* sorghum cropping system under rainfed conditions. This practice realizes yield and net returns as that of conventional system.

Table 1: Effect of nutrient management practice through organics on crop yield and economics in greengram – *rabi* sorghum cropping system

(2012-13 to 2014-15)

Treatments	Yield of Crops (Kg/ha)		Economics of the system		
	Greengram	Rabi sorghum	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
T_1 : RDF	526	2110	78,720	54,862	3.40
T_2 : RDF + FYM	562	2493	89,633	63,838	3.47
T_3 : Compost (C)*	369	1810	63,384	38,449	2.54
T_4 : Vermicompost* (VC)	376	2003	66,250	36,714	2.25
T_5 : C +VC**	404	2033	68,730	41,205	2.50
T_6 : C + VC ***+ GLM	401	2028	66,247	39,459	2.48
T_7 : C*+ Panchagavya	406	1960	69,238	43,176	2.66
T_8 :VC* + Panchaghavya	412	2197	74,400	43,520	2.40
T_9 : C + VC** + Panchaghavya	455	2285	80,927	52,204	2.81
T_{10} : C + VC*** + GLM + Panchaghavya	473	2240	81,073	58,882	2.88
S. Em ±	29	100	-	2,840	0.12
C.D at 5%	89	299	-	8,438	0.36

*****Compost equivalent to 100% RDN in T_3 and T_7 and Vermicompost in T_4 and T_8*
*** Compost (50%) + Vermicompost (50%) equivalent to 100% RDN in T_5 and T_9*
****Compost (37.5%) + Vermicompost (37.5%) + GLM (25%) equivalent to100% RDN in T_6 & T_{10}*

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Impacts of Organic Farming on Soil Organic Matter

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Key words: farm soil comparisons, soil organic matter sequestration, soil fulvic and humic acids contents

Abstract

Soil health is a critical component for developing Organic 3.0, which strives to place organic as a model sustainable food systems. However, the extent to which organic can contribute to maintaining and improving humic substances (HS) across the United States has not been investigated. It is especially important to take HS and its components into account when examining soil parameters, because humic substances is closely associated with soil health attributes. We measured the percent total soil organic matter (%SOM) and the percentages of sequestered SOM in the form of long-lived humic acids (%HA) and fulvic acids (%FA) in 1040 conventional farm soils from 48 United States and 683 organic farm soils from 38 United States to determine if and quantify how much organic farming leads to more SOM sequestration in comparison with conventional farming practices. The average %SOM is 7.37 for conventional and 8.33 for organic samples. %FA ranges are 0.08 to 2.20 and 0.04 to 14.8 for conventional and organic farm soils with mean values of 0.26 and 0.65, respectively. The %HA ranges are 0.17 to 23.0 (mean 2.85) for conventional and 0.25 to 48.9 (mean 4.1 for organic samples). The mean %humification (i.e. sequestration) is 45.6 for conventional soils and 57.3 for organic. Except for water retention, which is statistically better in conventional soils, all other comparisons show improved levels in organic farm soil samples. This information is critical for the development of Organic 3.0, because it provides clear information for in tracking the effects of changes in farm soil management practices over space and time, which can aid us in moving our current agricultural system toward sustainability.

Acknowledgments

We thank the V K Rasmussen Foundation and the Farmers Advocating for Organics Fund for financial support of the NSP. We express our deepest gratitude to the hundreds of soil sample donors across the nation who made this work possible.

Introduction

Over the last century, agricultural systems have increased in productivity dramatically due to the intensification of agricultural practices. However, in the face of this increased yield, there is a growing concern over the declining fertility of soils, especially reduced humic substances (HS) which is closely associated with the soil health attributes. Humic acids (HA) and fulvic acids (FA) are main components of HS in most soils. Lower than optimum levels of HA and FA depress a soil's productivity. Thus, the HS level reflects the long term ability of the soil to remain healthy and productive and, as such, HS are the baseline measure of any soil organic matter. HS, and HA in particular are better water retainers than SOM on an equal mass basis and thus help to combat drought.

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This will be especially important in the face of climate change, because higher HS will mitigate some of the environmental consequences of climactic shifts.

Soil nutrient amendments can impact SOM levels. The use of synthetic fertilizers, for example, has the potential to increase SOM, but there is still debate about the effects of synthetic fertilizer on building or degrading SOM and, synthetic fertilizers are also linked to environmental degradation and soil tradeoffs. However, few, if any studies have conducted a wide-spread, thorough comparison of organically managed soils to conventionally managed soils across the United States to determine the impacts of management system on SOM levels (Gattinger *et al* 2012).

Additionally, while total SOM measurements are frequently used in studies of soil health, global carbon cycling, the effects of landscape and climate on soil properties and the effects of land management on soil health and fertility, fewer studies have examined the levels of SOM components (HA and FA), especially in the context of organically managed soils in comparison with conventional soils. It is critical to include these measurements in analyses of SOM levels, because while fulvic acids are water soluble and fluctuate from year to year, humic acid represents the long-term storage of carbon in the soil. It also is a much more accurate measure of soil health, because it is more closely related with beneficial soil properties such as water retention, nutrient storage, and improved texture and permeability.

This study uses novel analytical methods to examine not only the total SOM content of conventional and organic soils, but also the levels of HA and FA in the soil. We examine hundreds of conventional and organic soil samples from across the United States to answer the question: How does organic management affect the levels of SOM component sequestration in soils?

Material and methods

Samples were collected from surface (0-30 cm) agricultural top soil in 50g measurements by local farmers. Leaves, sticks, rocks, pebbles and trash were removed from the samples. Samples were then air-dried and sent via USPS Parcel Post to the National Soil Project laboratory in Boston, MA. Farmers also included information about geographical location of soil collection, soil texture and classification. Samples were then stored at room temperature in sealed containers until processing.

Soil samples were requested through online, telephone, in-person, and paper communication. The goals of this study are to look at a large cross-section of organic and conventional farms to determine the average impact of organic farming as a tool for improving soil health, so we included farms with a range of crops, organic farming duration, soils and locations. Future analyses can examine specific crop types, duration of organic production, and other variables, but for this study our aim was to examine the overall impact of organic across the United States.

This study used an optimized loss-on-ignition (LOI) method to examine levels of total Soil Organic Matter (SOM) and Humic Substances (HS), including fulvic acids (FA) and humic acids (HA) in the soil (Ghabbour et al., 2014). Soil samples were also analysed for percent water retention and humicication (H) (Ghabbour et al. 2012).

All statistical data analyses were performed in R. Because the soil variables could be correlated, we used a Multivariate ANOVA (MANOVA) to determine whether there were significant differences between variable means due to organic vs. conventional soil management. We used a multifactorial model that also included the U.S. State that the sample was taken from as a cofactor, because location can have an impact on soil properties (e.g. Wardle et al., 2004). We also performed Pearson's correlation analysis on all soil variables to determine correlation coefficients. To determine which

variables contributed to significant differences between soil management, we followed the MANOVA with univariate ANOVAs on each soil variable (%FA and %HA contents, %water retention, %SOM and %H). All significance levels were corrected for multiple tests using Bonferroni corrections.

Results

Our MANOVA analysis (Table 1) showed that soil management is significant, as is the State that samples were collected from. Additionally, there was a significant management by State interaction, showing that the effects of soil management differ by the State a soil is collected from.

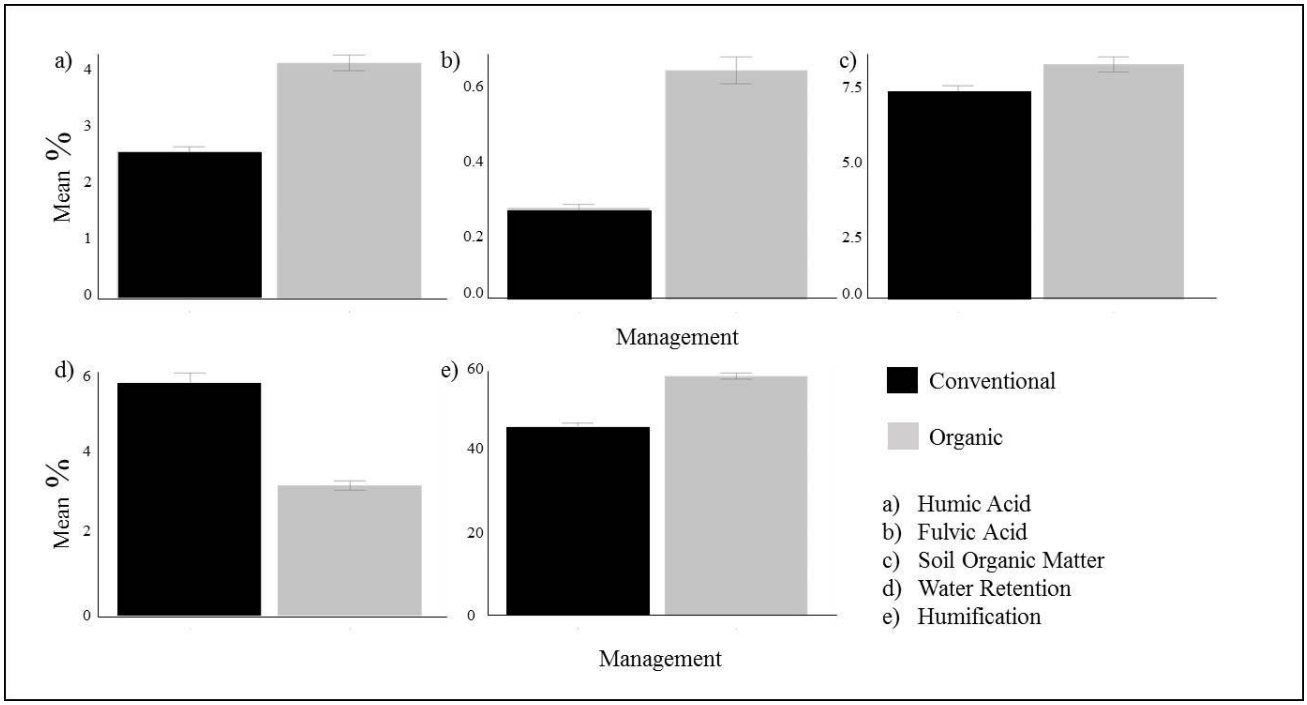
Table 1: The MANOVA Analysis showed that soil management and state were highly significant, as was the interaction between the two factors.

	DF	Pillai	F Value	Num DF	Den DF	Pr (>F)
Management	1	0.39	181.8	4	1138	<0.001 ***
State	55	1.17	8.24	220	4564	<0.001 ***
Management x State	35	0.29	2.58	140	4564	<0.001 ***
Residuals	1141					

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Because the MANOVA showed significant differences between both soil management and States, we also conducted univariate ANOVAs on each soil variable (%HA and %FA contents, %water retention, %SOM, and %H) to determine which variables contribute to these differences. All variables except % water retention showed significantly higher levels in organic as compared to conventional (Figure 1).

Figure 1: Mean levels of a) Humic Acid, b) Fulvic Acid, c) Soil Organic Matter, d) Water Retention, e) Humification



Discussion

Soil degradation is a serious threat to our ecosystems and food security. The need to optimize and foster soil health is critical for developing a future system of Organic 3.0, as it it supports nutrient retention and storage (Russell, 1973; Woomer and Ingram, 1990) and promotes soil aggregation (Oades, 1984), which leads to reduced erosion (Lal, 1956) and greater moisture infiltration (Lavelle, 1988).

The excessive use of synthetic fertilizers, and lack of recycled material soil amendments such as manure and compost have contributed to soil degradation, but many organic methods can counter these impacts. This study shows that all soil organic matter components are improved by organic management.

Further research is needed to determine specific practices used in organic contributing to these improvements. Additionally, research is needed to examine the lower levels of water retention found in organic soils as compared to conventional.

This study clearly shows that organic farming leads to more SOM sequestration, and SOM components than conventional farm management. Several studies have shown that organic soil has a healthier profile than soils that are conventionally managed, but this is the first time that research has investigated the components of SOM and done a broad analysis of samples from around the country. The findings support that not only is organic management, on average, healthier for soil health, it also suggests that organic is a critical tool for sequestering carbon in the soil, thus mitigating climate change through long-term greenhouse gas reduction.

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Farming Systems - Europe

Title	Author/s	Country
True nutrient cycles: Organic 3.0 and the use of recycling fertilizers from wastewater	Olivier Duboc, Jakob Santner, Franz Zehetner, Walter Wenzel	Austria
The role of intuition in managing Organic farm system health	Rebecca Paxton, Milena Klimek, Anja Vieweger, Thomas Döring, Ralf Bloch, Johann Bachinger, Lawrence Woodward	EU
The IFOAM principle of health – how do organic farmers apply it in practice?	Anja Vieweger, Thomas Felix Döring, Ralf Bloch, Johannes Bachinger, Milena Klimek, Rebecca Paxton, Lawrence Woodward	EU
Nutrient flows in organic field vegetable production: Survey results from Southern Germany	Verena Koch, Sabine Zikeli, Kurt Möller	Germany
The role of Biochar in biological nitrogen fixation and N2O emissions	Hans-Martin Krause, Michael Scheifele, Paul Mäder, Andreas Gattinger	Switzerland
Improving UK agro-forestry: A participatory approach to identifying, developing and field-testing innovations	Jo Smith, Anja Vieweger, Kostantinos Zaralis, Martin Wolfe	UK
Organic cropping systems tend to be more sustainable than low- input ones - A case study in Brittany, France	Alexandre Joannon, Matthieu Carof, Patrice Cotinet, Aurélien Dupont, Anne Guezengar, Djilali Heddadj, Stanislas Lubac, Christophe Naudin, Jean-Luc Giteau	France
Quantum-Based Agriculture: the Final Frontier?	Julia Wright, Henk Kieft, Saskia von Diest	UK
Why are there composition differences between organic and conventional foods? Evidence from the long term Nafferton Factorial System Comparison fields trials	Leonidas Rempelos, Marcin Barański and Carlo Leifert	UK

Organic 3.0 and the use of recycling fertilizers from wastewater

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Key words: Soil Fertility, Nitrogen, Phosphorus, Micronutrients, Struvite, Microalgae

Abstract

The depletion of fossil nutrient reserves and the intrinsic nature of farms as open entities through which nutrients flow, will require introducing more recycling fertilizers in Organic Agriculture (OA). Processes exist to safely recover nutrients from wastewater, and some products have been considered suitable for Organic 3.0. While the safety issue has the highest priority, characterization of fertilizer behaviour in soil is also an important aspect that requires appropriate testing methods. Phosphorus (P) can be recovered in forms that are compatible with the principles of OA, however, nitrogen (N) and micronutrient recovery has not received much attention and remains challenging.

Acknowledgments

Our work is supported by the Austrian Research Promotion Agency (FFG) through the Research Studio Austria FERTI-MINE [Project number: 844744].

Introduction

Organic agriculture (OA) started in the early 20th century deemed as a more sustainable alternative to conventional practices (Organic 1.0; 1900 - 1970). It is a growing sector with a set of standards that were established over the past 40 years (Organic 2.0; 1970 - 2015). Organic 3.0 (2015-) was characterized as "innovation with research" (Rahmann et al. 2016) while the objective was set to "warrant sustainable agriculture and nutrition beyond the niche" (Niggli et al. 2015).

Soil fertility management in OA focuses on the interplay of various ecosystem components through the management of soil physical, chemical and biological properties, crop rotation, biodiversity, etc. Notwithstanding the necessity to make use of ecosystem processes to enhance soil fertility (Bender et al. 2016), nutrients must be replenished if yield is declining and other management practices cannot solve the problem alone. Farms being open entities which thrive by selling products with the nutrients they contain, macro- and micronutrients are gradually transferred to urban centres even when animal manures and other farm wastes are recycled. Although N can be fixed from atmospheric N_2 by legumes, this practice has its cost in particular for stockless organic farms which may grow legumes mainly for N fixation, possibly reducing the proportion of marketable crops in the rotation. Scarcity of macro- and micronutrient fossil reserves (de Haes et al. 2012) will require that the agricultural sector increases nutrient recycling from municipal solid waste and wastewater. Municipal sewage sludge (MSS) is the major residual nutrient stream, but it is often not readily applicable as fertilizer, as it may contain a multitude of organic and inorganic contaminants.

The use of new (mainly P-) fertilizers recycled from MSS in OA is discussed in strategic documents about Organic 3.0 (Niggli et al. 2015; Rahmann et al. 2016). Precipitation products such as struvite, or calcined P from MSSash may be considered compatible with the principles of OA (European Commission 2016; Wollmann and Möller 2015). More generally "all human waste products could

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be authorized if their production processes effectively eliminate human pathogens and minimize the presence of contaminants"(European Commission 2016).

After discussing important principles and prerequisites concerning fertilizer use in OA this paper shortly presents recent developments in nutrient recovery from wastewater and discusses their potential for OA. In addition to P we also address other nutrients that may be recovered concomitantly, or separately with complementary processes.

Prerequisites for authorization of fertilizers in OA

The main criteria for the adoption of (recycling) fertilizers in OA may be categorized as follows:

1) Fossil *vs.* renewable raw materials: Renewable raw materials are prioritized over fossil products such as guano or phosphate rock. This is an important argument in favour of recycled fertilizers from wastewater.
2) Nutrient recovery efficiency: Overall, the number of recovered nutrients and their recovery rate should be as high as possible (Wollmann and Möller 2015).
3) Safety: Pathogens, trace element and organic pollutants must be avoided.
4) Solubility in water: Water-soluble fertilizers are generally avoided in OA. Beyond the risk of nutrient leaching, arguments include that a high nutrient concentration in the soil solution has a negative impact on soil ecology.
5) Use of energy and chemicals: In the context of recycling fertilizers, chemicals used for re-dissolution of P from sludge is a matter of concern (Wollmann and Möller 2015). Regarding calcined P from MSS ash, energy consumption may be acceptable because mining and transport of rock P is roughly equally energy intensive (European Commission 2016).
6) Organic *vs.* inorganic inputs: Considering the central position given to soil organic matter (SOM) managementin OA, organic resources are very important. If inorganic fertilizers such as slags and rock powders are common, organic wastes should be used directly where possible instead of their calcined products unless the thermal treatment is a means to guarantee product safety (European Commission 2016).
7) Certified organic *vs.* conventional origin: Manure from organic farms is preferred for crop fertilization although in practice nutrient transfer from conventional farms (manure, feed, straw bedding) can be substantial. Nutrients in recycling fertilizers will originate from organically managed farms proportionally to the organic market share. In this respect their use would be compatible with the principles of OA.

Overall, the principle of ecology favours nutrient recovery and recycling (1, 2), prioritizes the direct use of organic resources (6) as well as processes that require low amounts of energy and chemicals (5). Several key prerequisites (3, 4, 5) can be related to the principles of health and of care which aim at avoiding harm to / fostering health of people, animals and the environment. As evident in recent documents (European Commission 2016; Wollmann and Möller 2015) decisions will be made according to the best compromises between all those criteria.

Fertilizers from wastewater

Standard procedures in wastewater treatment plants (WWTPs) are based on N elimination by denitrification and P precipitation with iron or aluminium salts, which renders P highly insoluble in MSS. Nowadays an increasing number of processes are becoming available to produce fertilizers recovered from wastewater streams. Including struvite as a state of the art reference, examples of promising approaches are listed in Table 1 with a focus on recent developments, N recovery, and products exhibiting good nutrient availability to plants.

Table 1: Examples of technologies for nutrient recovery from wastewater

Process	Product	Nutrients recovered	Potential limitations	Reference
Struvite precipitation in (dewatered) sludge	Struvite ($MgNH_4PO_4$)	P: <5-65% of total load [a]	Needs addition of Mg Only little N recovered [b]	Wollmann and Möller (2015)
Thermo-chemical MSS ash treatment with Na and/or K additives	Contaminant depleted NaCaP bearing ash	P: ca. 90% of total load [a] Cu, Zn	Cr and Ni not removed No N recovery High energy consumption	Herzel et al. (2016)
NH_3 volatilization + acid stripping	$(NH_4)_2SO_4$	N	Soluble fertilizer Use of sulfuric acid	Evans (2007)
Microalgal nutrient recovery	Microalgal biomass	N & P: up to 100% [a, b] Likely other nutrients	Pathogens and trace elements not investigated Unsuitable for cold climate Lab-scale development stage	e.g. Vasconcelos Fernandes et al. (2015)

[a] Proportion of total P entering the wastewater treatment plant. It depends on the process, e.g. for P precipitation with or without re-dissolution from the solid phase of the sludge.

[b] The wastewater has roughly a 10 : 1 N : P mass ratio. N and P are being recovered stoichiometrically by microalgae. Struvite has a 0.5 : 1 mass ratio and as such can't be used to recover N.

The precautionary principle of care and the safe use of recycling fertilizers

The main prerequisite to adoption lies in the safe use of recycling fertilizers (European Commission 2016; Jedelhauser et al. 2015; Løes 2016). Thermo-chemical treatments of MSS ash for P and micronutrient recovery (Table 1) are possibly the most reliable in this respect. Microalgae as an emerging alternative still must be investigated in that respect (Table 1). In future, however, recycling fertilizers that are authorized under the general fertilizer regulations may already match the safety criteria for OA (see discussion in European Commission 2016).

Characterization of P availability from heterogeneous recycling fertilizers

According to Jedelhauser et al. (2015) fertilizer efficiency is the second most important criterion for adoption in OA by organic farmers. However, OA only allows the use of sparingly water-soluble fertilizers. To properly characterize such behaviour, we are proposing an approach combining (1) the assessment of water solubility and (2) an uptake-based method in which P solubilization is driven by depletion from P in solution by an infinite sink. While the first method describes the immediate solubility (which should be low in OA) the second method mimics the kinetics of P release and measures total P available in response to plant uptake (which should be high according to the plant´s demand). Our preliminary results demonstrate the suitability of this approach (Duboc et al. in preparation).

The case of N recovery and the use of soluble fertilizers

While recycling P fertilizers have received much attention, N recovery is less discussed. Struvite is not appropriate for N recovery due to an N:P stoichiometric mismatch between the wastewater and struvite. Nutrient recovery with microalgae could solve that issue but still must be developed beyond lab scale (Table 1). Although soluble fertilizers are not eligible, animal manures and slurries which are commonly used in OA have a substantial proportion of their N in solution as NH_4^+ and NO_3^-. This may leave an open door for the use of soluble fertilizer such as ammonium sulphate produced in WWTPs (Table 1) in the future as a complement to biological N fixation.

Nutrients and society –technology as a prerequisite to close the cycles

The almost unavoidable presence of pathogens and contaminants has gradually resulted in the exclusion of wastewater as a nutrient source for agriculture. Reverting this trend will require appropriate technologies in order to guarantee product safety. The envisaged implementations of P recycling schemes tend to favour centralized treatment of MSS through incineration and post-treatment of ash. On the longer term, however, small-scale decentralized processes may also fill niches with customized solutions for e.g.(1) contrasting socio-economic and geographic contexts, (2) efficient recovery of multiple nutrients or(3) tailoring of fertilizer properties and related nutrient availability for different requirements and markets. De-centralized technological approaches will also offer opportunities for more sustainable local and regional solutions that address the economic and societal needs of farmers and municipalities, e.g. by creating new employment and participation opportunities for disadvantaged population groups.

Conclusion

Among the principles of OA, the principle of care sets key prerequisites for adoption of recycling fertilizers from wastewater in OA. However, these prerequisites may already be met by the criteria for registration in general fertilizer regulations. Fertilizer efficiency and solubility are equally important aspects. Novel methods of fertiliser characterization and evaluation are considered important tools to facilitate the acceptance of new recycled fertilizer products in OA. In future, fertilizers from wastewater and other secondary raw materials should be given priority over those produced from fossil resources, thereby bringing OA closer towards its objective to foster agricultural sustainability beyond the niche.

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The Role of Intuition in Managing Organic Farm System Health

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Key words: Organic farming, Health, Intuition, Farm systems

Abstract

This article concerns the organic movement's aim to promote health across the entire farm system as outlined by the IFOAM Principle of Health (IFOAM 2005). It discusses the implementation of Health by organic farmers in Austria, Germany and the UK. Results from an international survey and a series of workshops on health promoting strategies and principles suggest that intuition is a key feature of organic farmers' management of farm health when the farm is understood as a system consisting of interdependent domains of soil, plants, animals, humans and ecosystems. Intuition is discussed with regard to the challenges of knowledge sharing and producing shared strategies for organic health promotion. It raises questions about how farmers can better reflect upon, learn from, and articulate seemingly intuitive decisions. The empirical results demonstrate the challenge and the possibilities of developing shared frameworks that support organic farmers in making decisions to promote farm health.

Acknowledgments

We are grateful for funding of this project by the Ekhaga Foundation, Sweden.

Introduction

The project 'Developing best practice networks of health in organic agricultural systems' ran a survey and a series of workshops with organic farmers from Austria, Germany and the United Kingdom (Vieweger et al. 2016). The aim of the project was to better understand how organic farmers manage the health of their farms as interconnected systems and how they learn to observe and make decisions that promote farm health. The farmers represented a range of farm types and ages, and included both male and female farmers, as well as regional differences. Despite such differences the survey and workshop discussions indicated that there were several similarities in their approaches to managing farm system health.

Chief among them was a way of observing and responding to changes on their farms that the participating farmers described as "intuition". This paper discusses how intuition plays a role in the farmers' management of farm system health and how this finding affects how farmers can share and learn health management strategies.

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Material and methods

Responses to online surveys were collected from 79 organic farmers in Austria, Germany and the UK. The survey collected farm type and demographic data about the farmers and asked why they had converted to organic, what changes in farm health they had witnessed since converting to organic, what practices were used to improve the health of their farms, and what the healthy outputs of their farms were. The surveys were analysed qualitatively, using descriptive and pattern coding techniques (Miles& Huberman, 1994; Saldana, 2013), to identify ten key statements about promoting the health of the farm. The farm was understood as a complete system made up of several interdependent domains.

These key statements were discussed in three national workshops with five invited organic farmers from each country, one international workshop with the same farmers, and one workshop with farmer and non-farmer stakeholders. The farmers were invited based on recommendations by local experts from organic associations, other farmers, and researchers. The aim of the workshops was to identify areas of agreement and disagreement about the management of farm system health, locate issues of particular importance or concern, and develop key strategies that reflect these discussions. The final workshop helped refine the strategies, but ultimately aimed to raise questions and discussion points for future research.

Intuition emerged as an important shared concept during the first international farmer workshop. Key descriptions and associated ideas were drawn from the discussions that took place at the workshop, and were retroactively used to analyse the national workshops. These ideas included: being fully emotional; being spiritually engaged; following your gut feeling; self-reflection and intuition. Additional associations were drawn from the national workshops. The analysis of intuition as a key concept for organic farmers' management of farm health has, therefore, been an iterative process.

Intuition was raised independently in the German and Austrian national workshops, and both groups decided to create a new statement encompassing these concepts. The UK farmers did not explicitly mention intuition during their national workshop. However, during the international workshop they agreed with and helped to refine the statement added by the Austrians and Germans.

All workshop discussions were recorded. The recordings as well as additional materials such as field notes, photographs, and exercise materials were analysed using qualitative data analysis software, Atlas.ti.

Results

The theme of intuition was not noticeable in the survey data. However, it was particularly present in the discussions at the German national workshop, exemplified by the following quote:

"We're always talking about things that are not actually tangible in almost every point [statement]. Today we have so many people looking for numbers and measurements, but this is something older, something that we have lost, like intuition. It is clear that this plays a role. This inner voice, intuition, awareness, a feeling. And it happens at every point […]. In my mind it should be the first point concerning the importance for health" (Farmer3_DEU, translated).

In a similar discussion at the Austrian national workshop, farmers expressed that: "It is so important to be able to observe and learn to observe the strengths and weaknesses of your farm […]" (Farmer1_AT, translated).

As a result of the Austrian and German farmers' discussions, a strategy about intuition was added to the list of key strategies to be discussed at the international organic farmers' workshop. The final set of key strategies, as it appeared at the conclusion of the international workshop, contained ten

strategies.[6] Strategy no.1, specifically concerning intuition, was considered an overarching principle that is intertwined in the other strategies. It reads:

"Farmers who aim to run healthy farming systems develop the intuition and ability for self-observation as part of the observation process of the farm; and they are aware of their own strengths and weaknesses and know their own resources and those of the farm."

Defining intuition

Participants at the international farmers' workshop described intuition as "daring to listen to your intuition/gut feeling regardless of rational explanation […] To listen to intuition is the same, but the solutions are different for every farm" (Farmer2_DEU, translated). Intuition was seen as stemming from being "fully emotionally and spiritually engaged with what you're doing, committed" (Farmer2_UK).

The workshop discussions showed that intuition is not an unproblematic concept. On the one hand intuition was seen as a deeply personal ability, such that each individual has an own intuition of how the farm should be managed. It was emphasised that organic farming means not "simply following instructions" (Farmer4_AT, translated). Management of farm health must take into account the "individuality of the farm, not just use blueprint solutions" (Farmer1_DEU, translated). On the other hand, intuition was also seen as a profound, more objective truth, which the farmer could become aware of through personal development and commitment to understanding the farm. It "relates to a higher level than gut feeling. Intuition is more right than gut feeling. It is part of something bigger" (Farmer1_DEU, translated). All farmers from all three countries could agree that the content of the intuition could vary, but that all farmers were capable of learning to be intuitive.

Daring to listen to intuition

However, learning to be intuitive meant that farmers had to dare to listen to their intuition regardless of rational explanation and, occasionally, in the face of criticism. The farmers felt they improved their capacities for managing farm health through mindful self-reflection and self-observation, meaning that farm health depends heavily upon personal development. This may be seen as running counter to the dominant scientific approaches to assessing and managing farm system health. Certainly, as expressed in the German national farmer workshop, intuition is perceived as relating to something more fundamental in managing farm health. However, the farmers were also aware of, and often participated in, scientific research related to managing the health of various domains on their farm, such as soil health, plant health and animal health. It may be only when considering these domains as interdependent parts of a complete farm system that analytical thinking is given less priority than intuition. As one farmer explained:

"You can have a great plan [...], but actually events get in the way: Huge climate fluctuation, devastating floods, all kinds of things. You have to be alive all the time to this intuition thing. You can't switch that off at any time […] and your management has to respond. […] Things do get more complicated, opportunities come and opportunities go" (Farmer1_UK).

Intuition and learning

This intuitive decision-making means that farmers have to know their strengths and weaknesses and match their capacities with the level of complexity of their farm (Farmer2_DEU, translated). The more complex the farm, the greater was the perceived level of intuition required to manage it. Experiencing the fluctuations of farm management both furthered and relied upon the application and development of intuition. As a result, both intuition for and complexity of the farm system were seen as increasing over time, allowing new farmers to develop the two hand in hand. Learning to

[6] Due to space restrictions only the most relevant will be included here. A description of the project can be found here: http://tinyurl.com/healthstatementsand the completed version of the strategies will be added early 2017.

listen to intuition was considered one of the key capacities new farmers could learn from those with more experience.

Discussion

Current approaches to improve and develop (organic) farming systems are predominantly based on concepts of the natural sciences. There is little communication in scientific and farming communities about how farmers' personal development can foster health on the farm. Our results indicate that intuition, self-observation and self-reflection are essential requirements for managing organic farms for improved health, and need to be understood in greater depth and discussed more openly.

Through cross-country farmer created strategies we make tentative strides to understand organic farmers' management of health. More specifically, we found that intuition plays an important role in implementing farm health and affects information transfer between farmers. We emphasise the importance of this topic for best practices in Organic 3.0 and suggest it requires further investigation.

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The IFOAM principle of health – how do organic farmers apply it in practice?

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Key words: health, organic, network, system, farm health

Abstract

The project 'Developing best practice networks of health in organic agricultural systems' aimed to create an international network of farmers and scientists to jointly develop new and interdisciplinary approaches to health measurement and research in ecological agriculture. The project identified personal philosophies and statements of best practice that make organic farmers successful in running healthy farming systems. Building on farmers' practical experience and findings from a former research project, we produced a working list of ten transferable strategies to increase the direct translation of organic principles into practice. The project further initiated the creation of a best practice network of health in organic agriculture, connecting farmers, advisors and scientists for future interdisciplinary research collaboration and a joint approach to increase health effects in organic agricultural food systems.

Acknowledgments

We are grateful for funding of this project by the Ekhaga Foundation, Sweden.

Introduction

The International Federation of Organic Agriculture Movements (IFOAM) has defined the following principle of health for organic agriculture:

"*Organic Agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible*." And further: "*Health is the wholeness and integrity of living systems. It is not simply the absence of illness, but the maintenance of physical, mental, social and ecological well-being*." (IFOAM 2005).

However, when asked, few farmers are familiar with the wording of these principles and the following questions arise for health research in agriculture: What do farmers understand under a 'healthy farming system', how do they individually interpret and implement this self-imposed 'principle of health' in practice, and have they developed their own principles and philosophies to manage healthy farming systems? This project has closely worked with an international group of farmers to answer some of these questions.

Material and methods

To address these questions of health in a discourse between practice and science, the Organic Research Centre (www.organicresearchcentre.com) initiated an international research project, which was conducted in England, Germany and Austria. The project included: 1) an online survey

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among farmers in each country; 2) three national farmer workshops; 3) one international farmer workshop; and 4) a final workshop with farmers, advisors and scientists.

To establish a common base for an international and interdisciplinary network, the first step of the project aimed to identify the personal strategies and philosophies of organic farmers to improve health on their farms, as well as the methods they use to implement the principle of health on their farms. An online survey (using the cloud-based software Survey Monkey) was conducted in the three countries, which was answered by a total of 79 farmers. In several open-ended questions, the participants were asked to describe how they understand, measure and improve health on their farms. From these qualitative survey answers, as well as further semi-structured interviews with consultants and other external experts familiar with the individual farmers, five farmers were identified in each country and invited to a national health workshop. Criteria for the selection of these farmers were developed by the project team; the farmers should:

- have a clear vision of the health concepts on their farm (a clear view of what makes the farm healthy, and what not).
- be particularly aware of the impact of their actions and practices on health (health effects on and of their system).
- be aware of where there are health deficiencies in the system, and be prepared to improve them continuously.
- be open to share their own philosophy with others and be interested in learning from other practitioners.

The selected female and male farmers (henceforth called 'example farmers') came from a large variety of agricultural systems (large and small scale, mixed farming, dairy or beef farms, arable and horticulture, organic and biodynamic, etc.) and as such, contributed to the project from a wide range and diversity of perspectives and experiences. With this interdisciplinary and international group of farmers as key actors, a series of national and international workshops followed, where participatory approaches were used for the next steps of the project work.

During two-day workshops with the farmers in Germany, Austria and the UK in autumn 2015, the presentation and comparison of individual health strategies of the farmers aimed to identify possible commonalities and differences in their personal visions or philosophies.

A second, international workshop was organised in February 2016, bringing all example farmers from Germany, Austria and the UK together. Here, the statements and philosophies, which had previously been developed in the national groups, were presented, discussed, and again checked for parallels and differences between the farmers, but also between countries.

And finally, in September 2016, a second international workshop was organised, this time linking the example farmers with several scientists and advisors from a wide variety of disciplines (e.g. soil science, veterinary science, cropping systems, phytopathology, social sciences etc.). The aim of this final two-day discourse was to jointly discuss the developed farmers' own health strategies, and establish the consequences and possible next steps for new and interdisciplinary approaches for health research and implementation of the health principle in (organic) agriculture.

Results

There was broad agreement among the survey participants and the finally identified example farmers that a healthy farming system does not necessarily result from the sum of individually 'healthy domains' such as animals, soil, plants or humans. As important features of a healthy farm, the survey participants mentioned for example the production of healthy food, the stability of the health of people working and living on the farm, an increase of soil fertility, an increase of

biodiversity, a low number of visits from veterinarians and generally low amounts of external inputs to the farm.

When asked in the survey about strategies or philosophies that the farmers have used to improve health on their farms over the years, most answers were related to two main topics. The majority of farmers see 1) soil health (soil fertility, soil life, etc.) as a central point of health on the farm; as well as the basis and prerequisite for healthy plants, animals and humans. And further, many farmers saw the promotion of 2) biodiversity and diversity in general on the farm as one of the most important strategies for promoting health in the agricultural system. They explained that this does not only cover the support and enhancement of wild animal and plant species, but also for example the choice of a large diversity of crop plants and varieties, a diversity of resilient livestock breeds, diversity of market channels, customers or people working on the farm.

Table 1 below summarises keywords of the ten statements for health in organic agricultural systems, which were developed and refined by the farmers during the project period, and finally discussed with advisors and scientists:

Table 1: Keywords of the ten health statements developed by the international farmer group

Statement 1	Intuition, self-observation, aware of strengths, weaknesses and resources
Statement 2	Soil health as base of health in all other areas
Statement 3	Recognising, observing changes in biodiversity, aiming to increase it
Statement 4	Awareness of working in and with nature's systems
Statement 5	Closely observing key health-related processes and reacting appropriately
Statement 6	Responsible and optimal organisation of processes and capacities
Statement 7	Away from mass production towards quality production and multiple outcomes
Statement 8	Increasingly broad and long-term perspective of the system
Statement 9	Awareness of contributing to human health through products and public goods
Statement 10	Awareness of the first and most apparent indicators of health on the farm

During the first international workshop, the farmers also defined practical methods or tools they use for implementing their individual health philosophies on the farm. The focus here was on methods that could potentially be transferred and applied to other businesses, such as choosing rare and more resilient breeds of livestock, the use of homeopathy for diseases in dairy cows, the use of hay instead of silage, or manure instead of slurry, as well as the use of effective micro-organisms. These methods are now incorporated in a working guidance document, open for input and feedback from a wide range of farmers and other stakeholders. This has laid the foundations for a guide, which will include a whole series of practical measures for the direct implementation of health principles into practice and linking up farmers, advisors and scientists for interdisciplinary collaboration in health measurement and research.

Discussion

Organic farmers have developed their own best practice strategies to improve health in their farming system. In their opinion, one of the main factors in achieving health in soils, plants, animals and humans is the awareness of strengths and weaknesses in the farming system, and particularly the knowledge and respect of available resources and system boundaries. The farmers stated that the

choice of suitable and resilient breeds and varieties for each individual farm, as well as the awareness and respect of the specific needs and nature of the animals, plants and soils, is crucial for healthy and successful farming systems. While several of these ten health statements of the farmers are relatively well known and already widely accepted and practiced strategies in organic agriculture, the farmer group also identified uncommon and rarely communicated philosophies to achieve health on the farm; such as for example the crucial importance of intuition, self-awareness and self-observation.

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Nutrient flows in organic field vegetable production: Survey results from Southern Germany

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Key words: Nutrient budgets, organic vegetable production, fertilization management, plant available phosphorus, plant available potassium

Abstract

Organic vegetable production gains more and more importance as consumer demand is growing. The main vegetable growing systems in central Europe often combined semi-intensive vegetable production with less intensive arable farming. The current study assessed nutrient budgets based on inputs via fertilisers and outputs via harvested products on field level for ten semi-intensive vegetable farms in Southern Germany. The farms showed different fertilisation strategies depending on association membership (Demeter or Bioland). Both fertilisation strategies led to annual deficits for P (-8.5 kg ha^{-1} year^{-1}) and K (-53 kg ha^{-1} yr^{-1}). Demeter farms showed nutrient deficits for all nutrients except nitrogen, sodium and chloride, while Bioland farms had surpluses for nitrogen, calcium and sulphur and almost balanced budgets for magnesium, sodium and chloride. In the longrun, the current fertilisation strategies are not sustainable due to the deficits in potassium and phosphorus and a low nitrogen use efficiency (64%-73%).

Acknowledgments

We would like to thank the farmers and advisers for their time and for the provision of data and information. The soil analyses were performed at the Core Facility of University of Hohenheim.

Introduction

Consumer demand for organic vegetables rises steadily in Europe. Therefore, many farmers include vegetables – e.g. root crops like carrots or beetroot as well as Brassica-species - in their arable rotations. These "field vegetable" systems represent semi-intensive systems with overall higher nutrient needs than the typical arable cereal/legume systems but lower demands than specialized intensive horticulture. Brassica-species need high amounts of nitrogen (N) from the beginning of the vegetation period until the harvest, root crops have a high demand for potassium (K) and all crops have a low demand for phosphorus (P). The farms therefore face several challenges: To achieve a balanced nutrient supply, to supply sufficient nutrients synchronized with the crop needs, and to avoid nutrient surpluses to prevent environmental pollution. To gain a better understanding of nutrient management strategies of semi-intensive vegetable systems we assessed nutrient budgets and soil nutrient status of tenorganically managed vegetable farms in Southern Germany. The budgets were calculated for a complete rotation, at maximum for a period of six years.

Material and methods

In 2015, ten farms (five members of the biodynamic farmers´ association Demeter e.V. and five members of the association Bioland), with different time periods since conversion to organic farming in Baden-Württemberg, Southern Germany were visited and data on nutrient inputs and

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outputs for three representative sites per farm were collected for the complete rotation in semi-structured interviews. To calculate the amounts of nutrients in the harvested product and in the applied fertiliser values from literature were used if no detailed data was available on farm. Symbiotic N_2 fixation was estimated based on the legume species, the number of cuts and the relation grass / legume. Nutrient budgets for N, P, K, magnesium (Mg), calcium (Ca), sulphur (S), sodium (Na) and chloride (Cl) were calculated on a per field basis for three fields per farm. Nitrogen use efficiency (NUE) was calculated as NUE = (Nitrogen input – Nitrogen Output)/100.

Soil samples were taken from three representative sites per farm, 10 individual top soil samples (0-0.3 m) per plot were mixed. The soil was air dried and sieved to 2 mm. The following soil analyses were done: pH ($CaCl_2$), plant available P and K (Calcium lactate extraction), plant available Mg ($CaCl_2$), total soil organic carbon and total nitrogen (combustion), $CaCO_3$ (Scheibler) and total P, K and Mg (aqua regia extraction) were analysed.

Results

The rotations of the farms differed in terms of intensity from horticulture with systems which included about 20 % arable crops (cereals, legumes, clover grass) and those with more than 20 % arable crops. Fertilisation strategies varied depending on association membership: The Demeter farms were mixed farms with animal husbandry (dairy cows, suckler cows, sheep) while four out of five Bioland farms were stockless. Therefore, the Demeter farms relied almost entirely on farmyard manure for fertilization while the Bioland farms used external fertilisers like horn grit, Bioilsa® (rape seed cake, wool, feather meal), BioAgenasol® (cereal residues from alcohol production) and Phytokorn® (residues from maize processing). Management of green manure (mostly clover grass) also differed among the farms depending on their management systems: While on stockless Bioland farms green manure was mulched and the residues remained on the field, the green manure biomass was removed on the Demeter farms for feeding ruminants.

On average, the annual nutrient budgets for the sites were characterized by high nutrient deficits for K (- 53 kg ha^{-1} yr^{-1}) and smaller deficits for P (-8.5 kg ha^{-1} $year^{-1}$) while all other nutrients where in surplus (Figure 1).

When assessing the nutrient budgets separately for the two different fertilization strategies, the differences between stockless farms and farms with animal husbandry became visible (Figure 1): Mixed farms with livestock which rely strongly on the use of farmyard manure, did not manage to provide an adequate nutrient supply and showed deficits in supply for all nutrients except N, Na and Cl; the Cl surplus was high. On the contrary, stockless farms imported nutrients via external fertilizers. On these farms nutrient budget calculations were positive for Ca, Mg and S showing surpluses of these nutrients. Both fertilization systems were not able compensate for P losses and, in particular, for K losses via exported produce. Moreover, both fertilization systems resulted in a surplus of N, which was higher on the Bioland farms. N use efficiency was higher for the Demeter farms (73%) compared to the Bioland farms (64%).

Besides the removal of nutrients via harvested goods like cereals and vegetables, the removal of N and K via cut green manure biomass contributed considerably to the nutrient imbalances on the mixed farms as the amounts of all nutrients - in particular of N and K - returned to the fields via manure were lower as the amounts removed by the cut biomass (data not shown).

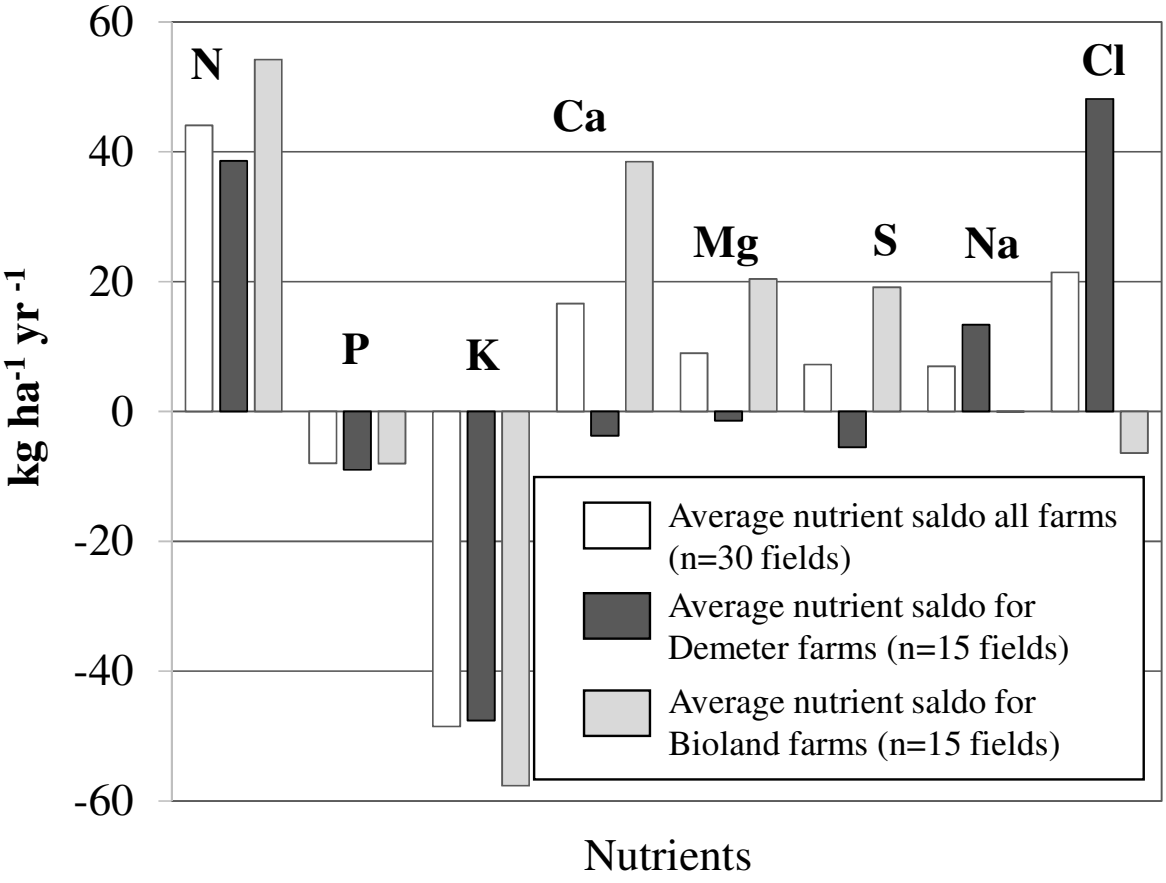

Figure 1. Average annual nutrient saldo for the different nutrients for all fields on all organic vegetable farms (n=30) as well as separated for the different organic farming associations Bioland (n=15) and Demeter (n=15).

Discussion

The Demeter farms adhered to the basic idea of biodynamic farming that emphasizes the role of animal husbandry in agriculture and relies strongly on fertilisation with animal manure in an inner-farm cycle (Demeter e.V. 2014). Contrary to these findings, the Bioland farms relied strongly on the input of external fertilisers, which is also in line with the standards of their association, which limit the overall input of N from external sources to 110 kg N for outdoor vegetable production (Bioland e.V., 2016). None of the farms exceeded this limit.

Despite this close adherence to organic standards, the farmers in our case study were not able to implement a fertilisation management that fulfilled the demands of long-term sustainability in nutrient supply. On the contrary, the adherence to current best practice fertilisation strategies led to high deficits in K and small deficits for P. Especially for K this was already reflected in the concentrations of plant available K in the soil as 72 % of the plots showed K concentrations between 7.5 and 17 mg kg^{-1} (data not shown) which is classified as low to medium according to the local fertiliser recommendations (LTZ, 2011). This confirms the findings of Gosling and Shepherd (2005) for arable farms with long term organic management in the United Kingdom. At the same time, other nutrients either were supplied in excess or were mined, depending on the fertilisation strategy.

One option to reduce the deficits in K in both systems is the application of K_2SO_4 which is possible according to the EU-regulation No. 889/2008 on Organic Food and Faming (2008) and to the standards of the different associations. Nevertheless, this would result in an even higher surplus of S for the Bioland farms compared to the current situation. Our case study illustrates that nutrient supply in organic farming systems cannot be based entirely on internal farm cycles. New fertilisation strategies (new definition of urban-rural cycles accompanied by improved management practices) as well as new fertilisers (e.g. biogas residues, fertilisers from food industry and from urban sources) have to be developed to maintain long-term soil fertility in organic farming systems.

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The role of Biochar in biological nitrogen fixation and N_2O emissions

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Key words: Key words: biochar, nitrogen cycle, nitrogen fixation, N_2O emissions, N_2O reduction, microbial communities

Abstract

Since N often is the limiting factor for plant growth managing soils N cycle is a crucial challenge for organic agricultural systems. Biochar as a soil amendment is widely discussed due it`s beneficial effects on the soil quality and the C cycle. Yet, amendment of biochar to agricultural soils also has the potential to affect N cycling. Two major processes of nitrogen cycling, biological nitrogen fixation (BNF) and denitrification, govern the transition of N in and out of the atmospheric N_2 pool. This also addresses the challenge of developing climate smart agricultural practice since nitrous oxide (N_2O), an obligatory intermediate of denitrification, also is known as potent greenhouse gas. In a pot experiment we observed biochar in increase nodulation and BNF by a factor of up to 7.8 and 2.3, respectively. In a field trial we showed biochar to decrease N_2O emission by 52% in the course of a vegetation period. The decrease of N_2O emissions was accompanied by a shift in microbial community composition of microbes specialized on N_2O reduction. In this paper we discuss biochar as valuable tool to manage nitrogen cycling in organic agricultural soils and its contribution to climate smart agricultural practice.

Introduction

The amendment of Biochar to arable soil is widely discussed due to it reported beneficial effects on crop yield, soil quality and greenhouse gas emissions. Incorporation of stable and carbon rich biochar in agriculturally managed soils not only affects the carbon cycle but also nitrogen cycling and N_2O emissions. Two major pathways determine the amount of available N in natural agricultural systems. Biological nitrogen fixation (BNF) is the only biological pathway transforming atmospheric N_2 to organic nitrogen. On the other hand the process of denitrification leads to a loss of nitrogen form agricultural system by subsequent reduction of nitrate to N_2. In the course of this process the highly potent greenhouse gas N_2O is formed. In this paper we want to give an overview of how biochar amendment affects these two processes. We performed an incubation trial assessing the impact of biochar on BNF and a field trial monitoring N_2O emissions and composition of bacteria capable of N_2O reduction after biochar addition.

Material and methods

Impact of biochar on biological nitrogen fixation

Glycine max L. was grown in four arable soils amended with 20t/ha biochar for 8 weeks at constant 22°C and 60% water holding capacity. Two soils (BIODYN and CONMIN) were taken from the DOK long-term trial in Therwil, Switzerland comparing organic and conventional agricultural systems since 1978. The two other soils, the acidic Caron soil and the alkaline ToMa soil, where selected to introduce a broad range of soil pH into the study. Biochars included wood and maize processed by pyrolysis and (pyrochar) or hydrothermal carbonization (hydrochar). After incubation soil and plant sample were analysed for N,P,K and S contents in order to assess nutrient uptake.

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Soybean biological nitrogen fixation (BNF) was assessed by determination of ^{15}N isotopic signature using natural abundance technique. *Bradyrhizobium* nodulation and plant growth were determined by quantifying dry matter of nodules plant roots and plant shoots. Obtained data was investigated by means of a three way ANOVA on the factors soil, carbonization, technique and feedstock.

Impact of biochar on N_2O emissions and N_2O reducing microbial communities

N_2O emissions were measured in a field trial with a 20 t ha^{-1} biochar, 5 t ha^{-1} lime and control treatment under the cultivation of *Zea mays*. Biochar and lime were worked in the topsoil having a similar effect on soil pH.N_2O emissions were quantified using an automated closed chamber system measuring in each chamber in a 1.5 hour interval and cumulated for the whole vegetation period. Soil samples for molecular analyses were taken after harrowing in spring, two weeks after fertilization in summer and after harvest in autumn. Community size of typical and specialized N_2O reducing bacteria was assessed via qPCR approach for which *nosZ* and *nosZ-II* served as target genes. Community composition was investigated by next generation sequencing using an Illumina platform. Obtained sequenced were then quality filtered and matched against NCBI Refseq data base in order to find closest related taxa. For statistical analysis of treatment and sampling time effects on community composition of N_2O reducers "vegan" and "indicspecies" packages of the statistical software R were used.

Results

Impact of biochar on biological nitrogen fixation

Generally pyrochars increased soil pH and available K and P. In turn hydrochars decreased mineral soil N but increased available soil S. Effects were weaker for biochars from wood feedstock compared to maize feedstock. S availability increased by 179% in the soil amended with hydrochar derived from maize. Although pyrochars and hyrdochars increased plant nutrient uptake, plant dry matter as well as root and shoot dry matter were mainly driven by soil and soil amendments had a minor effect. Nodule dry matter increased after addition of hydrochar and pyrochar, while the effect was much more pronounced for hydrochar. Nodule dry matter correlated with BNF across all soils and amendments. Across all soils and soil amendments BNF was positively correlated with availably S while a negative correlation was found to mineral N contents. Again hydrochar had the greater effect on BNF compared to pyrochar. Across soil BNF increased by a factor of 2.3 and 1.2, respectively.

Impact of biochar on N_2O emissions and N_2O reducing microbial communities

Across a whole vegetation period biochar amendment decreased N_2O emission by 52 % compared to the control. The pH effect of biochar on N_2O emissions could not be fully resolved since spatial variability in N_2O emissions in the lime was extremely high. Most N_2O emissions occurred in the 6 weeks after fertilization. After harrowing the community size of typical and atypical N_2O reducers did not differ in between the treatments. Yet, after fertilization increased abundance of atypical and especially typical N_2O reducers was detected in the biochar treatment. After harvest, however, the difference faded and no significant treatment effect of biochar on community size of typical and atypical N_2O reducers could be observed. For community composition of N_2O reducers sampling time greatly affected relative abundance of identified taxa. After fertilization community composition of atypical N_2O reducers showed a differentiation in between biochar, lime and control treatment. This effect was still visible at harvest but lost statistical significance. Main taxa driving treatment effects included *Melioribacter roseus* and *Flavobacteriaceae bacterium 1519-10*. The specialized N_2O reducer *Melioribacter roseus,* which metabolism relies on external N_2O, was associated with the biochar treatment, while *Flavobacteriaceae bacterium 1519-10*, which can perform all denitrification steps, showed increased relative abundance in lime and control treatment.

Discussion

Increased BNF after pyrochar addition were already observed in recent studies and mainly explained by decreased N availability (Rondon *et al.*, 2007) or interference with the nodulation pathway (Quilliam *et al.*, 2013). Increased nodulation after hydrochar addition has been previously described but analysis of possible mechanisms is still lacking (George *et al.*, 2012). The fact that nodulation and BNF correlated positively across all soil samples and soil amendments suggests mature and active nodules. This is also supported by negative correlation of BNF with soil mineral N contents. Furthermore, positive correlation of BNF with S suggests this element to play a crucial role of increased nodulation and BNF. In soybean fertilization with S is typically applied to increase yields (Scherer and Lange, 1996). S availability is known to have a strong influence on BNF, as it shows a more sensitive response to S deficiency compared to other plant physiological processes like e.g. photosynthesis (Scherer *et al.*, 2008). The fact that the functionality of the nitrogenase, the enzyme responsible for nitrogen fixation, relies on Fe-S or Mo-Fe-S complexes as reactive centre underpins the importance of S availability for nitrogen fixation (Fisher and Newton, 2002). Increased S availability after pyrochar addition was already reported by Uchimiya *et al.* (2010).and might be explained by enrichment of S during pyrolysis. Since production of hydrochars requires an acidification step with sulfuric acid which explains even further increased S contents in this biochar-type. Although detailed mechanisms still need to be elucidated, we hypothesize increased S availability after biochar addition to be a major driver for enhanced BNF.

Biochar`s potential to decrease N_2O emissions has been regularly reported in field an incubation trials (Cayuela *et al.*, 2013b). Although several mechanisms were proposed to explain the impact of biochar on N_2O emissions still a clear picture is lacking. While increased pH decreasing N_2O emissions and sorption of nitrate reducing denitrification rates were the most recent theories discussed in the scientific community also other hypothesis gained attention (Cayuela *et al.*, 2013a). The fact that biochar can act as a catalyst for microbial metabolism (Kappler *et al.*, 2014) and increased abundance of N_2O reducing bacteria were repeatedly observed (Harter *et al.*, 2014; Van Zwieten *et al.*, 2014) lead to the theory that increased bacterial activity around the biochar particle lead to local anoxia forming microsites in which complete denitrification (complete reduction of N_2O to N_2) can decrease N_2O emissions (Hagemann *et al.*, 2016). Additionally it was shown that biochar has the potential to absorb N_2O (Cornelissen *et al.*, 2013), which might lead to longer retention times and increased in situ reduction of N_2O. In accordance with this a recent incubation study showed that community composition of N_2O reducers after biochar addition shifted in favour of specialized N_2O reducing bacteria (Harter *et al.*, 2016). Our data suggest that this hypothesis which was developed under artificial conditions also holds true under field conditions. Nevertheless, we have seen the effect of biochar on community composition fading at the end of the vegetation period and it remains unclear whether long term mitigation due to biochar amendment can be expected. Given the hypothesis of N_2O retained by biochar in the soil also hold true under field conditions we would expect large N_2O pulse emissions during soil tillage. Before biochar can be recommended as mitigation option for N_2O both questions need to be assessed by future research.

By discussing potential mechanisms we contribute to a detailed understanding of how biochar as soil amendments affects two key processes in N cycling. For organic farmers this knowledge is of special interest, because crop yield in organically managed soils strongly depends on soils ability to provide N without additional mineral N inputs. Furthermore, decreased emission of climate relevant N_2O due to the use of biochar as soil amendment could further improve climate friendly performance of organically managed systems.

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Improving UK agroforestry: A participatory approach to identifying, developing and field-testing innovations

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Key words: silvoarable, silvopoultry

Abstract

As complex systems, agroforestry systems are more knowledge-intensive than other agricultural systems; site-specific adaptations of practices are crucial to success. Farmer education and experimentation leading to system modification plays an important role in agroforestry development. Working with silvoarable and silvopoultry farmers in the UK, we aimed to identify key challenges and potential innovations to improve their systems. Increased complexity of the systems was identified as having both positive (e.g. safety through diversity) and negative (e.g. need for more planning and labour) implications for production and management. Managing the interactions among trees, crops, pasture and livestock was also identified as a key challenge by both groups. Innovations in design and management of the systems included trialling of agroforestry-adapted cereals and grass swards on research farms while two silvoarable farmers instigated their own trials of new tree understorey crops. This research contributes to the Organic 3.0 aim of enabling widespread uptake of truly sustainable farming systems by involving producers in innovation processes to make their systems better.

Acknowledgments

We acknowledge the support of the European Commission through the AGFORWARD FP7 research project (contract 613520). Many thanks to the stakeholders for their participation in the workshops and for sharing their ideas and enthusiasm.

Introduction

The integration of trees and shrubs with crops and/or livestock, agroforestry, has been identified as a 'win–win' multifunctional land-use approach that integrates the production of commodities (food, feed, fuel, fibre, etc.) with non-commodity outputs such as environmental protection and cultural and landscape amenities (IAASTD 2008). Following the increasing evidence that agroforestry in temperate, developed countries is a sustainable approach to balancing productivity with environmental protection (Smith *et al.* 2012, Toralbo *et al*. 2016), the European Union is promoting wider adoption of agroforestry by enabling member states to provide financial support for the establishment and management of new systems. As with organic systems, the complexity of the ecological and economic interactions among, in this case, trees, crops and livestock (Lundgren 1982), implies that such systems are highly knowledge-intensive, which means that site-specific adaptations of novel practices are crucial to success. Farmer education and experimentation leading to system modification should play an important role in agroforestry development (Scherr 1991). Within Europe, the AGFORWARD project (www.agforward.eu) has adopted a participatory research approach to utilise the knowledge and experience of farmers of their own multifunctional systems to identify key challenges and potential innovations to improve their systems. In the UK, we have been working with organic arable and vegetable producers, and organic and non-organic poultry producers. This paper reports on the process followed from initial workshops to field-testing innovations, and also addresses the question "How does this research contribute to Organic 3.0?"

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Material and methods

In 2014, 42 stakeholder groups were established, involving about 820 stakeholders across 13 European countries, to develop and field-test innovations in (i) high nature and cultural value systems, (ii) high value tree systems, (iii) silvoarable systems (crops and trees) and (iv) silvopastoral systems (livestock and trees) (Burgess et al. 2016). Workshops were organised with the stakeholder groups and a participatory research and development protocol was developed to ensure a common framework for the workshops (Bestman et al. 2014). Within the workshops, participants were asked to identify which production, management, environmental and socio-economic aspects they perceived as the most positive or negative features of agroforestry. As a group, the key challenges were discussed and possible solutions identified. Where solutions didn't exist, potential innovations were suggested, and as a final step, participants were asked to rank the innovations in order of importance for trialling, and to indicate their willingness to be involved with trials.

In the UK, the Organic Research Centre worked with two groups – silvoarable and silvopoultry stakeholders. Silvoarable stakeholders included organic arable farmers who had an interest in establishing agroforestry on their farms, as well as those with existing silvoarable systems, and staff from the Woodland Trust, a UK-based charity that supports woodland establishment. The workshop was held at Wakelyns Agroforestry, an organic silvoarable farm in East Anglia on 18th November 2014, and was attended by 18 participants. The silvopoultry group were organic and non-organic meat bird and egg producers who were part of the Sainsbury's Woodland Chicken Development Group. All the Woodland brand farms must be planted with trees that cover at least 20% of the range area. Also involved were representatives from the food company supplying poultry to Sainsbury's, the agriculture manager for Sainsbury's and two people from animal welfare organisations. Two workshops were held in collaboration with Sainsbury's and the Woodland Trust. The first on 6th May 2014 on a meat bird farm in south-west England attended by 28 stakeholders, the second was on 10th June at an egg producer in eastern England attended by 17 stakeholders.

Results and Discussion

Table 1 summarises the most prominent issues and challenges to the sector identified by the two stakeholder groups. As with other stakeholder groups in the project (Burgess et al. 2016), several production, environmental and societal benefits of agroforestry were recognised. The increased complexity of the systems had several implications for production and management, such as the need for more labour (more jobs=positive; increased labour costs=negative), and the diversification of crops (risk spreading=positive; complexity of planning and management=negative). Managing the interactions among the trees, crops, pasture and livestock was also identified as a key challenge by both groups.

Innovations in design and management of the systems were identified by both groups. The silvoarable group proposed trialling new tree species, including nitrogen-fixers, the development of agroforestry-adapted cereal populations, the establishment of new crops in the tree understorey, and investigating effective combinations of components in terms of productivity, market value and labour needs. The silvopoultry group proposed the development of better range design, with trees planted directly outside the henhouses to encourage ranging, the development of grass mixtures that can tolerate shade and poultry foraging, as well as methods of grass restoration, multipurpose use of the range by integrating cattle and sheep, and the use of woodchip from the trees for energy supply and mulch.

Table 1: Benefits and challenges identified by silvoarable and silvopoultry stakeholders.

Aspect	Key Issues	
Silvoarable stakeholder group		
Production and management	Benefit	Multi-crop approach reduces risk, diversifies income, higher overall productivity, reduced evapotranspiration, lower disease/pest pressure
	Challenge	Lower crop yield; tree product quality and productivity; weed migration from tree rows; needs agroforestry adapted crops; higher labour costs; coordinating harvesting and marketing; managing trees in open system; tree pests and diseases; mechanical challenges during harvest; complexity and time for planning and management (over-diversification)
Environmental	Benefit	Carbon storage, increased biodiversity, habitat creation, microclimate regulation, nutrient recycling
	Challenge	Impact of climate change on crops and trees unknown
Socio-economic	Benefit	More jobs, community involvement, human health: mental and physical, opportunity for new farmers
	Challenge	Farmer attitudes, lack of evidence/information, land tenure, lack of policy support
Woodland Chicken Development Group		
Production and management	Benefit	Increased activity and ranging of chickens, cover from predators, environmental credentials good for marketing
	Challenge	Fruit from trees compromises chicken feed intake with impact on egg production; reduced light and ventilation; management cost and increased labour for trees; increased weeds; build-up of disease; no grass growth under tree canopy; getting birds in at night; tree roots damage drains and leaves block gutters.
Environmental	Benefit	Increased insect populations (possible benefit for production as additional feed for chickens)
	Challenge	Soil erosion
Socio-economic	Benefit	Meeting consumer pressure for environmental credentials; higher animal welfare; aesthetics
	Challenge	Tree planting impact on land value; land locked up in trees affects future use of land

Knowledge gaps and information sharing, particularly regarding tree management, was also identified by both the silvoarable and silvopoultry groups as a need. Environmental impacts were highlighted by the silvoarable group, with innovations that targeted maximising carbon sequestration over the system lifespan (and investigating the potential for carbon rewards), maximising biodiversity and reducing pesticide use. Developing marketing and branding for 'agroforestry cereals' was also proposed by the arable group; the silvopoultry groups already benefit from a price premium for their 'Woodland' eggs or meat.

Stakeholders were asked to rank the proposed innovations. Not all proposed innovations were suitable for two to three year on-farm research trials, however, therefore stakeholder preferences were reviewed for feasibility. It was decided to focus on two innovations within the silvoarable group – the development of agroforestry-adapted wheat populations, and establishing new crops in the tree understorey; and one innovation in the silvopoultry group – the development of shade-tolerant swards. Trials of agroforestry wheat populations and silvopoultry swards are currently being performed in two replicated trials on research farms. In addition, two silvoarable farmers have instigated their own trials of new tree understorey crops, and have planted rhubarb and daffodils; these systems will be monitored for production and impacts on biodiversity, economics and labour. The final outcomes of the trials will be developed into technical notes and reviewed at follow-up workshops in 2017.

This research contributes to the Organic 3.0 aim of enabling widespread uptake of truly sustainable farming systems by involving producers in innovation processes to improve their systems. It is helping to support a culture of innovation and progressive improvement towards best practice, and is building up evidence to promote organic agroforestry as a sustainable and holistic system for temperate farming systems.

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Organic cropping systems tend to be more sustainable than low-input ones - A case study in Brittany, France

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Key words: profitability; work; nitrate leaching; long-term experiment;

Abstract

Organic cropping systems are often identified as a solution to reduce environmental issues resulting from over-simplified cropping systems relying on a high amount of external inputs. Since in organic cropping systems legume crops are often included to provide nitrogen to the cropping system, they also provide more local proteins in dense animal production areas. We set up a cropping system experiment, located in Brittany, France, to evaluate the following hypothesis: organic cropping systems reduce environmental impacts of agriculture while ensuring an acceptable profit to farmers. It consists in a comparison of three cropping systems, an organic and two low-input ones. Main results of the first three years show that the absence of pesticide use is compatible with a higher profitability for farmers (of 17% to 25%), as well as not much more fieldwork (0.7 more h.ha-1). However yields are reduced (by 18% to 54%) and nitrogen losses during winter are not significantly different than those of low-input cropping systems.

Acknowledgments

This research has been funded by 4 French organisms: Compte d'Affectation Spéciale pour le Développement Agricole et Rural; Conseil Régional de Bretagne; Agence de l'eau Loire-Bretagne; l'ONEMA

Introduction

Nowadays, there are major environmental threats due to 1) an intensive use of external inputs (chemical fertilizers and pesticides) in cropping systems 2) a simplification of cropping systems by decreasing the diversity of crops and 3) a concentration of animal production in certain parts of the world. This is locally the case in Brittany, an intensive animal production region of France where there is a concentration of dairy, pig, and poultry farms as well as short and over-simplified cropping systems. When no temporary grassland is included in the rotation, then for a majority of farmers, a two years maize – wheat rotation is dominant. This contributes to surface water pollution by pesticides and algae blooms are frequent (Cellier et al, 2014). There is also locally a challenge to increase plant protein production to feed animals instead of relying on soybean importations. Organic cropping systems with diversified crops (cereal and legume crops) appear to be an answer to these environmental and production issues (Pimental et al, 2005). To test this hypothesis, in Brittany, we set up a cropping system experiment to compare the sustainability of an organic cropping system and two low-input ones.

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Material and methods

The experiments are located in Brittany, Western France, on two sites: Kerguehennec (47°52'59.4"N, 2°43'50.4"W) where both low input (K-LI) and organic (K-O) cropping systems are present; Crecom (48°19'08.1"N, 3°12'25.1"W) with a second low input cropping system (C-LI). Table 1 gives the main environmental characteristics of the two sites.

Table 1: Environmental characteristics of the two experimental sites

	Kerguehennec	Crecom
Soil	Loamy sandy clay	
Mean rainfall (1993-2013)	1 000 mm	1 150 mm
Mean temperature	11.6°C (1993-2013)	11.2°C (1999-2010)
Average fiels size	1 ha	1.8 ha

Table 2 summarizes the main agronomic characteristics of the three cropping systems tested. On each site, each crop of the rotation is cultivated each year and we present in this paper data collected during three cropping years from fall 2012 to summer 2015.

Table 2: Agronomic characteristics of the three experiments (S for spring crops and W for winter crops or intercroping)

Experiment	C-LI (low-input)	K-LI (low-input)	K-O (organic)
Rotation	Grain maize (S) Wheat (W) Rapeseed (W) Triticale (W)	Grain corn (S) Wheat (W) Fava beans (S) Wheat (W) Rapeseed (W) Triticale (W)	Fava beans (S) Triticale (W) Grain maize (S) Wheat/Fava beans intercrop (W) Buckwheat (S) Peas/Triticale intercrop (W)
Plowing	Every year	2 / 6 years	Every year
Mechanical weeding	3 / 4 years	Every year	Every year
Cover Crop	Only long fallow period - Oat	Long and short fallow period – species mix	Long and short fallow period - species mix
Intercropping	No	No	Yes
Mean N fertilization	141 kg $N.y^{-1}$ organic and mineral	139 kg $N.y^{-1}$ organic and mineral	15 kg $N.y^{-1}$ organic and mineral

In order to evaluate the sustainability of the three cropping systems we calculated indicators related to the the three dimensions of the sustainability (table 3): 1) economic dimension (GP, OC, MC, Ma), 2) environmental dimension (TFI, WNL) and 3) social dimension through on farm labor (WD, NFO). We also measured the yield (t ha-1).

Results

We could not compare yield (table 4) for the three cropping systems in their totality since different crops are cultivated in each one. However, maize and triticale are present in the three experiments and fava bean in two of them. 3 years yield average differences between the organic and low-input sites vary from 18% less to 54% less. In the organic experiment, cereal-legume intercrops increase the yield compared to sole crops (4.4 t ha-1a-1 versus 3.1 and 2.9 for triticale and fava bean).

Table 3: Indicators used to assess cropping systems' sustainability

Variables	Description
GP	Gross product (€.ha^{-1}): based on mean local selling price 2012-2015
OC	Operating cost (€.ha^{-1}): based on input prices of experimental station
MC	Machinery cost (€.ha^{-1}): French references (APCA, 2015); it includes depreciation, maintenance and machinery operating expenses but no workforce wages
Ma	Margin (€.ha^{-1}): [GP minus (OC and MC)]
TFI	Treatment frequency index: ratio of pesticide standard concentration to pesticide concentration actually sprayed[6]
WNL	Winter N-NO3 and N-NH4 losses (kgN.ha^{-1}): based on N-soil content over a 90-cm depth at the beginning (October / November) and the end of the leaching period (February, March)
WD	In field work duration (h.ha^{-1}): based on French references (APCA, 2015)
NFO	Number of field operations per year

Table 4: Average yield (2012-2015) in t ha-1a-1

Experiment	Maize	Wheat	Rapeseed	Triticale	Fava beans	Buckwheat	Cereal/Legume intercrop
C-LI	7.4	6.8	3.2	7.1	-	-	-
K-LI	7.7	6.9	2.1	6.3	3.7	-	-
K-O	6.1	-	-	3.1	2.9	0.8	4.4

Average margin over the 3 years shows a profitability of the organic cropping system 17% to 25% higher than profitability of the two low-input cropping systems, linked with a higher gross product and lower operating and machinery costs. Regarding the environment, no pesticides are sprayed for the organic cropping system and nitrogen winter losses are in between those of the two low-input cropping systems. Concerning on-farm work, the organic cropping system requires 0.7 hours more per hectare and per year but 1.5 to 2.5 fewer field operations.

Table 5: Indicators calculated over the three year experiment (3 years average except WNL calculated for 2 years)

Experiment	GP (€.ha^{-1})	OC (€.ha^{-1})	MC (€.ha^{-1})	Ma (€.ha^{-1})	TFI	WNL (kgN.ha^{-1})	WD (h.ha^{-1})	NFO
C-LI	1 125	396	303	426	1.8	25	5.4	10.9
K-LI	1 183	308	260	571	1.8	18	5.4	9.9
K-O	1 201	260	253	688	0	23	6.1	8.4

Discussion

The experimental organic cropping system improved by at least 17% the margin per hectare compared to two low-input cropping systems. This confirms results obtained in other environmental conditions (eg. Mahoney et al, 2004 in Minnesota, US). This is the consequence of a higher market

[6] Detailed explanation of TFI: each pesticide has a standard concentration (SC) above which it can not be sprayed, but it can be sprayed to smaller concentration (FC for field concentration). So for each pesticide applied to a field we can calculate the ratio SC/FC. Then for a field we sum all the ratios for each pesticide sprayed.

price for organic crops. Required field work is not significantly higher; moreover, spraying pesticides in low-input cropping systems required additional time, not included in our indicator, to prepare and wash the sprayer. These results are very relevant since fear of additional work and of reduced income are two reasons mentioned by farmers for not applying organic standards (Schneeberger et al 2002). However, reducing pesticides use or no using them required more fields monitoring which increases equally work in the three cropping systems experiments. Regarding the impact on the environment, by using no pesticides at all, the organic cropping system is healthier. But, despite a low use of organic fertilizer (15 kg N.y-1 versus 140 kg N.y-1), it does not show any benefit regarding winter nitrogen losses. This is due to a very high mineral N-soil content in fall after harvesting legume crops, which has not been efficiently caught by the following cover crop. Particularly, between fava beans and triticale in 2015, 118 kg of nitrogen have been lost. Lastly, the yield of the organic cropping system was lower, especially for pure small grain cereals (e.g. Triticale) which questions the ability of such organic cropping systems to provide enough food if they are scale up. However, cereal-legume intercrop is a possibility to increase yield of organically grown crops (Bedoussac et al, 2015) which still has to be confirmed by our experiment. Lower yield can also be partially offset by reducing food losses which vary from 20% to 45% (FAO, 2016).

Conclusion

Organic cropping systems appear to be an opportunity for the future of Brittany to produce cash crops in a sustainable way. They are a good option for farmers regarding profitability and work, and also for the environment by not using pesticides. However, nitrogen needs to be better managed which may also improve yields. Our results, by proving the benefits of organic cropping systems and identifying points to pay attention to, will contribute to helping farmers adopt such practices on a wider scale, which is in-line with Organic 3.0. Benefits of organic cropping system is related to a diversified rotation with cereal/legume intercrop, long and short fallow period and no pesticide spraying.

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Quantum-Based Agriculture: the Final Frontier?

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Key words: quantum, innovation, indigenous, biodynamics, transdisciplinarity

Abstract

Organic farming already meets multiple sustainability goals, and factors limiting its mainstreaming are social rather than technical. What is the next step for organic farming? To date, both organic and industrial agriculture have been based on the particle-matter approach within the disciplines of chemistry and biology. This review paper argues that the logical next step is to embrace Quantum-Based Agriculture (QBA) that draws from the theories and concepts of quantum physics and biology and takes a wave-based approach. The paper outlines how modern medicine, and many of our communication technologies, already apply quantum science, it explains the nature of QBA, its potential, and how commercial agricultural projects in the EU are already integrating quantum theories. Finally the paper notes that QBA is not new; it also may explain the mechanisms by which indigenous and Biodynamic farming practices work.

Introduction

Organic farming, done well, already meets multiple sustainability goals, and factors limiting its mainstreaming are arguably social rather than technical. So whilst on the one hand, IFOAM's Organic 3.0 rightly attempts to take organic to the mainstream, let us not forget – nor lose - the pioneering nature of the organic movement. What is the next step for organic farming, to boldly go where few people have gone before? To date, both organic and industrial agriculture have been based on the particle-matter approach within the disciplines of chemistry and biology. This approach focuses on the nature of individual components of physical systems, be they atoms, plant genes, soil-borne diseases or water pollutants. In contrast, Quantum-Based Agriculture (QBA) draws from the theories and concepts of quantum physics and biology that take a particle-wave-based approach. Only features of biodynamic agriculture, along with more indigenous farming approaches, could claim to be synonymous with QBA.

Rationale

Recent years have seen an unprecedented increase in knowledge and understanding of quantum theories. Quantum theory (aka quantum physics or quantum mechanics) is one of the two main branches of modern physics. While general relativity provides a picture of the macro (space-time and gravity), quantum theory addresses the micro, including subatomic particles. Today, quantum theory is used in a huge variety of applications in everyday life, including lasers, CDs, fibre-optics, digital cameras, bar-code readers, fluorescent lights, computer screens, transistors, super-conductors, spectroscopy, MRI scanners, and so on.

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Most recently, 2014 saw the publication of the first book on quantum biology, which concerns the applications of quantum mechanics and theoretical chemistry to biological objects and problems (Al-Khalili and McFadden, 2014). However, the integration of quantum principles in agricultural science has, to date, been negligible. Yet one practitioner-based farming book (Lovel, 2015) suggests that the application of quantum principles in farming techniques increases input efficiency and animal welfare, while reducing the negative environmental side-effects of farming. This situation suggests that any positive developments in this area hold high potential for an early impact, and the urgent challenge for research is to deal with a growing set of questions for farm practice about emerging new technologies based on wave-principles and information techniques.

Results

Review of the literature

Aside from the seminal and inspirational work of Peter Tomkins and Christopher Bird in the 1980s (the Secret Life of Plants, and The Secrets of the Soil, both 1989), and some early articles in the journal Biological Agriculture and Horticulture[4], research into QBA has been relatively sparse, and much of what exists has been undertaken in Soviet countries that has not yet been accessed or translated. Some research has been undertaken on the general relationship between quantum theory and agriculture, including wavelengths and agriculture (Callahan, 1994), effects of sound in agriculture (Doorne, 2002), crop sciences and quantum theory (Fernandez, 2009), quantum physics and biology (Cannenpasse-Riffard, 2011) and photons in biology (van Wijk, 2014). In terms of crop and livestock health, studies have looked at the response of bacterial cells to sound (Matsuhashi *et al.*, 1988), the relationship between infrared light and insect control (Callahan, 2001), effects of magnetised water on pot plants (Kamminga, 2004), and the effects of electromagnetic stimuli on livestock and fish (Cuppen *et al.*, 2007). Studies on food nutritional quality have focused on the nutritional quality of apples (Bloksma *et al.*, 2001), general nutrition and soil health (Sait, 2003), and the energetic quality of milk (Woestenburg *et al.*, 2005).Crop and livestock productivity research has looked at the effects of sound and electromagnetic frequencies on wheat (Katsenios *et al.*, 2015; Measures & Weinberger, 1970), on plants' stomata (Oliver 2002) and on dairy herds (Kieft *et al.*, 2008). In particular, a study by Souza *et al.* (2006) on the effects of magnetic treatment of tomato seeds is one of the few review papers and identifies a wide range of physiological effects in response to magnetic fields, including positive impacts on plant growth and development, enzyme activity, protein synthesis, auxin content, water uptake, seed germination, fruit ripening, crop yield and plant nutrient element composition. This paper also identifies difficulties in performing controlled experiments with reproducible results and proposes possible mechanisms behind the influence yet notes that no single hypothesis could explain these effects.

The quantum concept of entanglement offers explanation for the emerging field of research into intuitive farming, in which two of the authors of this article are involved. Intuitive farming incorporates the use of telepathic interspecies communication and/or the intuitive capacity, with cognitive abilities and experience, in making practical management decisions on farms. William J. Long first described telepathic interspecies communication in an academic context in 1919 and there have been numerous studies that provide evidence for this phenomenon since then, as reviewed by Erickson (2011).

[4] http://www.tandfonline.com/toc/tbah20/currentSee for example: Knorr D (1982) Use of a Circular Chromatographic Method for the Distinction of Collard Plants Grown under Different Fertilizing Conditions. Vol. 1 , Iss. 1
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Whereas telepathy occurs when a message is received from another organism, intuition arises within the human body, particularly the heart (McCraty *et al*., 2004), arising as a 'knowing' without knowing how one knows (Erickson, 2011). As part of an ongoing study initiated by Kieft (2006), surveys and interviews with intuitive farmers who communicate directly with the animals and plants show that they report higher outputs in terms of yield, crop quality, shelf life and calf survival, while inputs such as nutritive ameliorants, irrigation, measures taken against pathogens and pests, and veterinary costs are decreased. Numerous organisations have been founded on the ability of humans to integrate their interspecies communication with everyday decisions, including Findhorn Foundation (Scotland), Tamera (Portugal), Perelandra Garden (USA), Damanhur (Italy) and Cooperative Biobalance (USA). Nuthall (2012) describes how the most successful New Zealand stock cattle farmers have developed a personalised expert system, with intuition being the primary driver, and rely less on the formal technological tools that were designed to aid their practical decision-making. According to Nuthall, the development of this ability is a practical approach for helping farmers make customised decisions for increasing efficiency. However, despite the growing body of empirical and anecdotal evidence that intuitive farming is effective in improving the production and resilience of agroecological systems, the understanding of the mechanism in terms of its scientific basis, the effects and the transfer of the skills required for intuitive farming are still in its infancy and require far more research.

The potential and current application of QBA

Overall, QBA holds the potential to address specific challenges in the agricultural sector. This is not all conjecture; a number of existing innovation and technology projects in Europe are already underway although they have not yet been fully documented. These include the use of ultrasound to control blue-green algae (funded by the EU 7th Framework Programme), the use of music based on wine protein and played to vines with beneficial effects, the disinfection of potato and onion from bacteria through ultraviolet light, the use of biophoton techniques to test product quality through shelf life of fruit, eggs and flowers, the creation of a horse health treatment center based on electromagnetism, the application of low frequency electro magnetic fields on dairy cow to lower mastitis rates, and treating water with electromagnetic frequencies.

Discussion

The need for alternative methodologies and methods

Multi- and trans-disciplinary approaches will be required to take this forward, bringing on board a range of disciplines through which quantum physics cross-cuts, including mathematics, music, ethnobotany, philosophy, psychology and sociology. Key knowledge holders of traditional and biodynamic agriculture that have affinity with the science of quantum physics and biology will need to take centre stage, such as indigenous farming cultures sharing their experiences with researchers and vice versa. For example, modern sound techniques mimic tacit knowledge in many older cultures that used sound in crop and animal husbandry. In the words of Eve Balfour, a founder of the organic movement: "*It is the unscientific mind—possessed, alas, by too many selfstyled scientists!—that instantly dismisses as superstition, magic, or even as non-existent, happenings brought about through the operation of some natural law which we do not yet understand.…We should examine again the beliefs of our forebears and study the observations on which they were based, and we should use our new scientific knowledge to interpret those observations and to sift those beliefs.*" (Pfeiffer, 1947). This in turn implies the need for development of a new set of methods that are better able to explore the phenomena involved in QBA. In fact, several of the 'fathers' of modern reductionist science, such as Boyle and Newton, also pursued alchemical study with its corresponding non-standard methods (Principe, 2011).

If we want to forge further steps along the trajectory of an authentic and expansive alternative to industrial agriculture, then this is arguably the direction of choice. Following the agroecologist Miguel Altieri's postulation that "*if the scientific basis for industrial agriculture is chemistry, then the basis for sustainable agriculture is agroecology*" (Altieri, 1995), we propose that an agriculture for the future may be based on, or at least be aided by, the science of quantum theory.

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Why are there composition differences between organic and conventional foods? Evidence from the long term Nafferton Factorial System Comparison fields trials

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Keywords: organic, food quality, pesticide residues, mineral fertiliser, phenolic compounds

Abstract

Recent systematic literature reviews and meta-analyses have demonstrated that there are substantial and nutritionally relevant composition differences between conventional and organic crops. This included higher antioxidant/(poly) phenolic, but lower cadmium, protein, nitrate and nitrite concentrations and a 4 time lower frequency of pesticide residues in organic crops. However, there is a more limited understanding on the agronomic parameters responsible for these composition differences. The Nafferton Factorial Systems Comparison (NFSC) trials were established in 2001 to identify and quantify the effects and interactions between rotation design, fertilisation, crop protection, tillage and variety choice impact with respect to yield and the nutritional quality parameters in arable and vegetable crops.

Similar to recent systematic literature reviews/meta-analyses results from the first fifteen years of the NFSC trials also show that organic crops contain higher levels of antioxidants/poly/phenolics, certain minerals such as Zink and lower levels of many nutritionally undesirable compounds (heavy metals, pesticides, glycoalkaloids and Fusarium mycotoxins). Differences in crop composition were linked primarily to differences in fertilisation (e.g. cadmium, protein, nitrate/nitrite and antioxidant concentrations) and crop protection (e.g. pesticide residues and glycoalkaloid concentrations) regimes between organic and conventional systems, but variety choice and rotation design were also shown to have significant effects in some crops.

Introduction

A series of recent systematic reviews and meta-analyses have shown that there are significant differences in the concentrations of nutritionally relevant compounds between organically and conventionally foods (Baranski et al. 2014, Srednicka Tober et al 2016a, Srednicka Tober et al 2016b). Specifically, these studies demonstrated that: organic crops were estimated to have 17% higher antioxidant activity and between 18% and 69% higher concentrations of a range of individual antioxidants, while conventional crops were estimated to have 15%, 10%, 30%, and 87% higher concentrations of protein, nitrogen, nitrate, nitrite, respectively, and 48% higher levels of the toxic metal cadmium, and were 4-times more likely to contain detectable pesticide residues. Pesticide residues are found in approximately 50% of conventional, but only 10% of organic crops. Also, studies which compared pesticide concentrations in positive samples, found that pesticide levels in organic crops were 10-100 times lower than in conventional crops, suggesting that residues in organic crops were mainly due to cross-contamination from neighbouring farms (Baranski et al. 2014).

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However, there is amore limited information on which of the agronomic parameters (rotation design, fertilisation, crop protection, tillage and variety choice) that might differ between organic and conventional crop production systems are responsible for these composition differences. This is mainly because very few of the published studies that have reported composition differences between organic and conventional crops provide sufficient detail on the agronomic methods/protocols use in either system to allow the effects of specific agronomic drivers to be identified by redundancy analyses (RDA). Also there are very few factorial field experiments that allow interactions between agronomic drivers to be identified/quantified.

The aim of this study was therefore to use a series of factorial field experiments to identify and quantify the effect of, and interactions between, the main agronomic factors (that differ between organic and conventional systems) with respect to crop yield and the nutritional quality parameters. This is an important step towards identifying the yield and quality limiting factors and the design of organic crop production with increased yields and/or further enhanced nutritional quality.

Nafferton Factorial Systems Comparison (NFSC) trials

To achieve this, the Nafferton Factorial Systems Comparison (NFSC) trials were established in 2001 at the Newcastle University's Nafferton Experimental Farm, near Stocksfield, Northumberland. In the NFSC experiments the effects of crop rotation, crop protection and fertility management were studied using a split-split-split plot design. Crop rotation is the main plot with two levels, organic (diverse, rich in leguminous crops) and conventional (arable crop-dominated rotation typical for conventional systems). Each main plot is divided into two crop protection subplots (6 x 48 m) in which crop protection is carried out according to conventional farming practice (FAB – British Farm Assured; CON CP) or to organic crop protection standards (Soil Association organic farming standards (Soil Association 2016); ORG CP). Each of these subplots is divided into two fertility management sub-subplots (6 x 24 m) in which fertilization is either carried out according to conventional farming practice (CON FM) or organic farming standards (ORG FM). The arrangement of crop protection subplots and fertilization sub-subplots within sub-blocks is randomised. 10 m unplanted separation strips were established between crop protection subplots and 5 m unplanted separation strips between fertilization sub-subplots. There are four experiments following this design within the NFSC experiments, each starting at a different stage in the crop rotation, so that a diversity of crops can be studied in the trial each year. A diversity of crops including grass/clover, pure rye grass, wheat, potatoes, barley, cabbage, faba beans, onions and lettuce were included in the rotation.

Agronomic factors responsible for differences in nutritionally desirable compounds

Significantly higher levels of antioxidants, vitamins and/or other nutritionally desirable phytochemicals (e.g. glucosinolates in cabbage) were detected in a range of organic field vegetable crops (cabbage, lettuce, potato) when compared to conventionally grown crops (Rempelos et al. unpublished a, c). In most crops, the increase in phytochemical content was linked to the fertilisation regimes (composted manure instead of mineral fertilisers) used in organic production systems. Fertilisation regimes were also shown to affect gene expression, protein profiles and the concentrations of resistance compounds (e.g. phenolic acid, flavonoid and caffeic acid derivative concentrations) in crop plants, indicating that the impact of using organic matter recycling rather than mineral fertiliser based fertility management practices on crops has been underestimated (Lehesranta et al. 2007, van Dijk et al. 2012, Rempelos et al. 2013, Tetard Jones et al. 2013a, Tetard Jones et al. 2013b, Shepherd et al. 2014). For some crops (e.g. lettuce) significantly increased

vitamin levels in organic crops were also linked to the crop protection regimes (non-use of herbicides and fungicides) used in organic systems. These data indicate clearly that the non-use of chemosynthetic mineral fertilisers (and in some cases pesticides) can increase concentrations of nutritionally desirable phytochemicals in a range of crops.

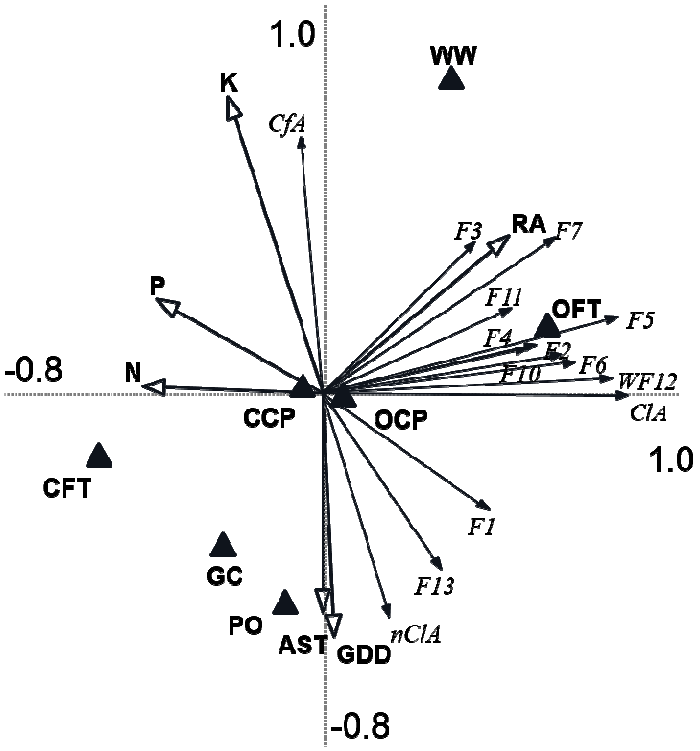

Figure 1 associations between agronomic (fertilisation and crop protection regimes), macronutrient supply (estimated based on flag leaf NPK concentrations) and climatic (radiation, air and soil temperature, and relative humidity) drivers, and phenolic compounds in flag leafs.
Most variation (64%) is explained by axis 1 and a further 5% by axis 2. Fertilisation regime (OFT: F=91; P=0.002), radiation (RA: F=48; P=0.002), P-supply (P: F=15; P=0.002); Air-temperature (GDD: F=33; P=0.002) and N-supply (F=3; P=0.064) were identified as the strongest drivers. F1 to F13: individual flavonoids; CfA: cafeic acid ClA, nClA: chlorogenic acid derivatives (Rempelos et al. unpublished a).

Studies also showed that the lower nitrate and nitrite concentrations in organic crops and protein in wheat are linked primarily to the non-use of mineral N-fertilisers, but the nutritional impact of these differences is less clear, since increased protein, nitrate and nitrite intakes have been linked to both positive and negative impacts on human health (discussed in Barański et al. 2014).

Results from the NFSC trials confirm the results of previous studies which showed that (i) high N-availability was shown to reduce the production of a range of secondary metabolites with antioxidant activity including (poly) phenolics in crop plants (see Figure 1) and increase the severity of bio trophic diseases such as powdery mildew and yellow rust (Sander et al. 1998, Gaszotonyi et al. 2011, Rempelos et al. unpublished a-d). (ii) differences in fertilisation practice were the primary driver for differences in gene and protein expression (including genes for nitrogen metabolism, phenolic acid, flavonoid synthesis), and metabolic profiles between organic and conventional crops like wheat and potato (Shepherd et al 2014, Rempelos et al. unpublished a-b). For potato and wheat significant effects of variety choice and fertiliser input level on phytochemical concentrations were also detected in supplementary short-term factorial field experiments, in which variety choice and fertiliser input levels were introduced as additional factors (Rempelos et al. unpublished c).

Agronomic factors responsible for differences in nutritionally undesirable compounds

In the factorial field trials confirmed results from systematic literature reviews/meta-analyses and individual studies that reported significantly higher levels of the heavy metals cadmium (Cd) and nickel (Ni) were found in conventionally managed crops) and a 4 time higher frequency of pesticide residues being present in organic crops. In addition the NFSC trials found higher glycoalkaloid levels in conventional potato crops (Rempelos et al. unpublished c) confirming similar trends identified in previous studies reported by Shepherd et al (2014). Higher Cd and Ni concentrations were associated with conventional fertilisation regimes, while crop protection did not have a major effect. This confirms previous studies which linked to the use of water-soluble, mineral phosphorus fertilisers, which contain both cadmium and nickel residues (Cooper et al. 2011, Rempelos et al. 2013). Higher glycoalkaloid concentrations were linked to conventional crop protection regimes, while fertilisation had no effect on glycoalkaloid levels. This may have been due to the regular ridging for weed control in organic potato crops, since this is likely to have reduced light exposure of tubers which is known to increase glycoalkaloid concentrations.

Table 1. Potato tubers aldicarb, metalaxyl and diquat pesticide residues content (Means± SE) depending on the crop protection and fertilisation treatment

	Aldicarb sulfone µg kg^{-1} FW				**Aldicarb sulfoxide** µg kg^{-1} FW		
	2004	**2006**	**2007**		**2004**	**2006**	**2007**
OCP OF	0±0	0±0	0±0	**OCP OF**	0±0	0±0	0±0
CCP OF	0±0	15.8±5.5	14.8±2.8	**CCP OF**	0±0	20.5±6.1	18.5±3.4
OCP CF	0±0	0±0	0±0	**OCP CF**	4.5±0.5	0±0	0±0
CCP CF	2±0.8	55.9±20.7	37.8±7.2	**CCP CF**	10.1±4	71.3±26.8	63.8±14
LOD	<1	<1	<1	**LOD**	<1	<1	<1
MRL	0.02mg kg (EU regulation 310/2011)			**MRL**	0.02mg kg (EU regulation 310/2011)		
	Metalaxyl µg kg^{-1} FW				**Diquat** µg kg^{-1} FW		
	2004	**2006**	**2007**		**2004**	**2006**	**2007**
OCP OF	0±0	0±0	0±0	**OCP OF**	0±0	0±0	0±0
CCP OF	0±0	0±0	2.9±0.3	**CCP OF**	0±0	7.4±0	0±0
OCP CF	0±0	0±0	0±0	**OCP CF**	0±0	0±0	0±0
CCP CF	0±0	0±0	3.1±0.3	**CCP CF**	0±0	9.4±0	0±0
LOD	<4	<4	<1	**LOD**	<5	<5	<5
MRL	0.05mg kg (EFSA 2015)			**MRL**	0.05mg kg (EFSA 2015)		

OCP: organic crop protection; CCP: Conventional Crop Protection; OF: Organic Fertilisation; CF: Conventional Fertilisation; FW: Calculated on Fresh Weight basis; LOD: Level Of Detection; MRL: Maximum Residue Level based on UK/EU regulations

Pesticide/growth regulator residues could only be detected in crops under conventional crop protection, but the concentrations of pesticides differed significantly between fertilisation regimes. Soil applied products (e.g. the pesticide aldicarp and the herbicide dicarb) were found at significantly higher concentrations in conventionally fertilised crops, while foliar applied products (e.g. the growth regulator chlormequat) was found at significantly higher concentrations in organically fertilised wheat crops (see tables 1 and 2). The lower incidence of pesticide residues in organic crops is thought to be due to non-use of chemosynthetic pesticides in organic farming practice (Baranski et al. 2014). The reasons for the effect of fertilisation regimes on pesticide residues is unknown, but for the soil applied products may have been due to enhanced microbial breakdown associated the higher microbial activity in compost compared to mineral fertilised soils, which has been well documented in the past (Dubois et al. 1999).

Knowledge gaps and future research needs

There is an increasing demand to increase the yield of organic production, while maintaining or increasing environmental sustainability and/or crop quality levels. Results from the NFSC trials and other studies indicate that both the (a) development of "precision", recycled organic waste-based fertilisers and (b) breeding/selection of more efficient crop genotypes adapted to organic production systems may contribute to this goal. However, further studies are required to study the effects of contrasting N- availability pattern from different types of organic fertilisers (e.g. green manures, farm yard/ straw bedding-based manure, compost made from animal manure and/or organic wastes, biogas digestate) during the growing season on crop yield, health and nutritional composition.

Table 2. Wheat grain Chlormequat growth regulator residues content (Means± SE) depending on the crop protection and fertilisation treatment

	Chlormequat grain µg kg^{-1} DW			
	2004	**2005**	**2007**	**2008**
OCP OF	0±0	0±0	5.8±2.2	1.6±1.2
CCP OF	262.8±26	459.3±40.5	285.4±18.5	330.4±19.1
OCP CF	0±0	0±0	1.8±0.8	1.4±1
CCP CF	77.5±7.5	111.8±13.9	82.1±9.4	152±15.1

OCP: organic crop protection; CCP: Conventional Crop Protection; OF: Organic Fertilisation; CF: Conventional Fertilisation; DW: Calculated on Dry Weight basis

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Farming Systems - Global

Title	Author/s	Country
Profitability of cacao agro-forestry systems and monocultures under organic and conventional management	Laura Armengot, Pietro Barbieri, Christian Andres, Monika Schneider	Bolivia
The potential of organic agriculture and agro-ecology for sustainable intensification of tropical agro-ecosystems	Christian Andres, Gurbir Singh Bhullar	Global
To what extent does land use differ between organic and conventional farming? A global scale analysis	Pietro Barbieri, Sylvain Pellerin, Thomas Nesme	Global
Model for productivity improvement in default organic system and its up-scaling in drylands of India	Arun K. Sharma , D.K. Painuli and N. Patel	India
Organic rice production in irrigated agriculture using the rice intensification system (SRI)	Ehiabhi Cyril Odion, Idris Ahmadu, Uthman Arunah, Abdullazeez Shero Isah, Rilwanu Yahaya and Bashiru Babaji	Sudan
Agroforestry is more productive than monoculture, and organic agroforestry is competitive with its conventional counterpart – First result from a long-term field trial in Bolivia	Christian Andres, Monika Schneider, German Trujillo, Freddy Alcon, Patricia Amurrio, Eusebio Perez, Franco Weibel, Joachim Milz	Bolivia
Can mineral nutrients be limiting factors to organic agriculture expansion at the global scale? – A spatially explicit approach	Pietro Barbieri, Sylvain Pellerin, Thomas Nesme	Global
Conventional versus organic farming systems: decoding comparisons to improve cereals organic breeding strategies	Rolland B., Heumez E. , Oury F.-X., Le Campion A.	Global
Biodynamic Agriculture; A Boon for Small Farmers for India	Binita Shah, Sanjay Roman, Khadse, Bhale, Nilesh Teli, Sarg Vikas Samiti	India

Profitability of cacao agroforestry systems and monocultures under organic and conventional management

Laura Armengot[1], Pietro Barbieri[1,2], Christian Andres[1,3], Monika Schneider[1]

Key words: productivity, by-crops, return on labour, banana, costs, labour demand

Abstract

The demand for cacao has increased. The implementation of more sustainable agricultural practices for cacao production such as organic farming and agroforestry systems depends on the profitability of such practices for the farmers. The productivity and profitability of agroforestry and full-sun monocultures under organic and conventional farming are compared for the first five years of a newly established long-term trial in Bolivia. Cacao yields were higher in the monocultures and no differences were found between organic and conventional management in the agroforestry systems. The sales of by-crops of the agroforestry systems economically overcompensated for the difference in cacao yield between agroforestry and monoculture systems. The costs were lower in the agroforestry systems and under organic management. Organic management was not more work demanding than the conventional management. Overall, the return on labour was almost the double in the agroforestry systems.

Acknowledgments

The authors are hereby grateful to their Bolivian colleagues of the research station in Sara Ana. Thhis study was financed by the Swiss Agency for Development and Cooperation (SDC), Liechtenstein Development Service (LED), Biovision Foundation for Ecological Development, and the Coop Sustainability Fund.

Introduction

Over the last decades the global demand for cacao (*Theobroma cacao* L.) has drastically increased (Vast and Somarriba 2014). The cultivated area has been expanded in tropical forest areas and production has been intensified by replacing traditional agroforestry systems with full-sun monocultures at high-input levels. To guarantee a further extension of more sustainable agricultural practices such as agroforestry systems and organic management, such systems need to be profitable for the farmers.

In this study we compare the agronomic and economic performance of four different cacao production systems, i.e. agroforestry and full-sun monocultures under organic and conventional management during the first five years of a newly established field trial. Cacao and by-crops (plantain/banana) yields, costs, revenues, and labour demand were registered, and the return on labour, i.e. the return per working day, were estimated for each system.

Material and methods

The experimental trial was located in Sara Ana (390 m a.s.l.), Alto Beni, in the department of La Paz, Bolivia. The climate is tropical humid with dry winters; the average annual precipitation and

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temperature are approximately 1'540 mm and 26.6 °C, respectively. The soils are Luvisol and Lixisols. The natural vegetation is composed of nearly evergreen humid forests.

The establishment of the plantation finished at the beginning of 2009. From 2010 to 2014 the productivity and profitability of the 4 different production systems were assessed. Cacao tree spacing was 4 m × 4 m. In the agroforestry systems, cacao trees were complemented by timber, palm and leguminous trees. Plantain was planted in both monocultures and agroforestry systems as temporary shade for the cacao trees, but they were removed at the end of 2011 in the monocultures and replaced by banana trees in the agroforestry systems, according to local practices (Schneider et al. 2016).

The organically managed systems followed the EU regulations. A perennial legume cover crop was sown. Compost was used as fertilizer and weeding was done manually and with brushcutters. In the conventional managed systems, mineral fertilizer was applied and weeding was done by means of both herbicides and manual weeding and brushcutters.

The annual yield of cacao and banana and plantain was calculated as the sum of all of the single harvests. Revenues derived from cacao were calculated for each year using annual average sales prices of each category of beans: first-quality conventional beans (average price across years ± SE: 20.95 ± 2.75 Bs Kg^{-1}), second-quality conventional beans (11.93 ± 0.93 Bs Kg^{-1}), and organic beans (23.99 ± 2.25 Bs Kg^{-1}). The exchange rate of one US dollar and Euro to Bs is about 6.8 and 7.5, respectively.

The cost calculation included the costs of tools and materials for pruning, weeding, fertilizing and in the organically managed systems, the cost of certification. The transport costs for purchasing the materials were also considered.

The working time devoted to each single agronomic activity in the field was registered. Additionally, the working time of the activities performed outside the plots was also considered, such as the compost preparation, herbicide applications preparation, cacao and banana post-harvest process and purchasing tools and materials. The return on labour, i.e., the benefit per 8 hours' labour, was calculated by dividing the annual gross margin (revenues minus costs) by the total annual working days.

Results

The cumulative cacao yields were higher in the monocultures compared with the agroforestry systems (Figure 1). No differences were found between organic and conventional management in the agroforestry systems, but higher yields were obtained under conventional management in the monocultures. As expected, the agroforestry systems achieved higher plantain/banana yields across the years, since plantains were replaced by banana trees only in the agroforestry systems.

The sales of banana of the agroforestry systems economically compensated for the difference in cacao yield between agroforestry and monoculture systems, which highlights the role of by-crops to the contribution to farmer's income during the establishment phase of the cacao plantation (Figure 1). The costs were lower in the agroforestry systems and also under organic management.

Agroforestry systems were more work demanding than the monocultures (Figure 2). However, no differences in the total working time between organic and conventional management were detected in the monocultures. This result contrasts those of previous studies claiming that organic farming is more laborious than conventional farming (Jansen 2000). In the case of the agroforestry, conventional management was less work demanding, but only because of the lower time spent for applying synthetic fertilizer compared with the compost under organic farming.

Overall, the return on labour was almost the double in the agroforestry systems (Figure 2). This is explained by the fact that the working time was an average of 16 % higher in the agroforestry systems; on the other hand, the gross margin was, on average, 51 % higher compared with the monocultures.

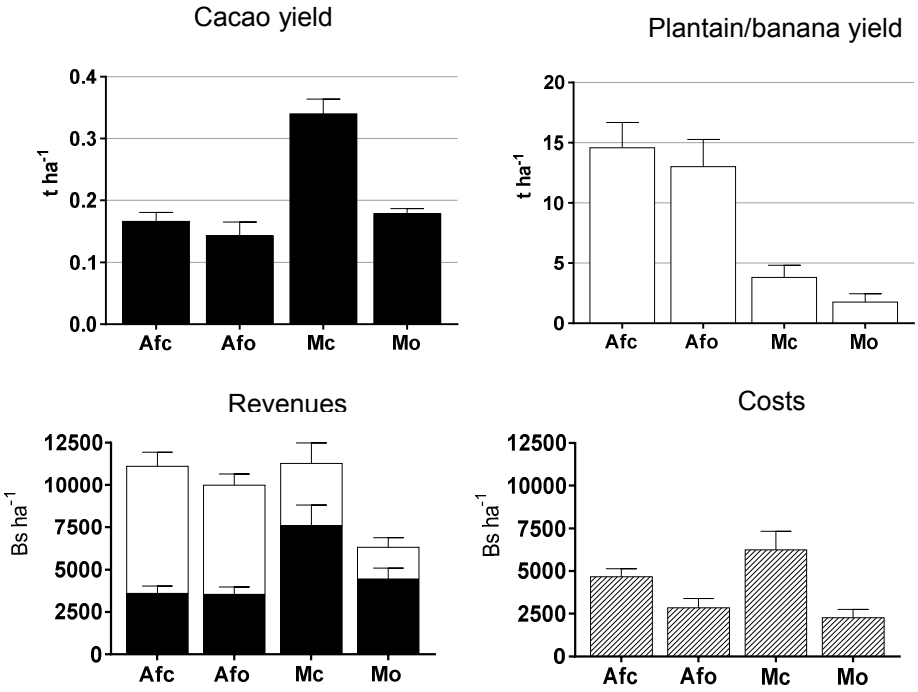

Figure 1. Mean (± SE) cacao and plantain/banana yields, revenues from cacao (in black) and plantain/banana (in white) sales and total costs per ha and year for the different production systems: Afc: agroforestry conventional, Afo: agroforestry organic, Mc: monoculture conventional and Mo: monoculture organic.

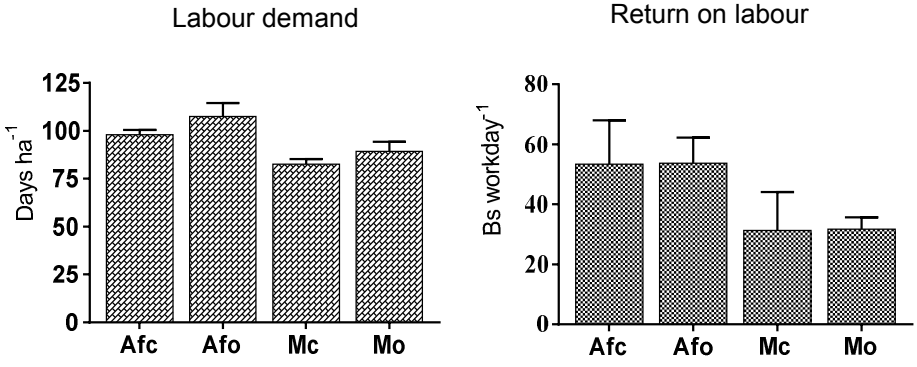

Figure 2. Mean (± SE) working days per ha and year and return on labour for the different production systems: Afc: agroforestry conventional, Afo: agroforestry organic, Mc: monoculture conventional and Mo: monoculture organic.

Discussion

Premium prices for organic cacao did not compensate for the yield gap between the organically managed monocultures compared with the conventionally managed. The premium prices obtained on organic cacao were lower than the often reported premium gain (Crowder and Reganold 2015). Even though both the yields and the revenues of cacao were higher in the monocultures, the revenues

obtained from the sales of plantain/banana in the agroforestry systems overcompensated for the lower cacao revenues. Indeed, plantains and bananas were not sold as organic products because of the lack of access to the organic market. Organic markets in rural areas in Bolivia hardly exist and the access of potential markets in big cities like La Paz is a challenge due to deficient road-transportation, and for other not so common by-crops, not being able to constantly supply the market and a low demand might difficult the sales of organic by-crops.

The lower costs in the agroforestry systems were due to the lower cost of the fertilizer and weeding, related to the lower presence of weeds in the agroforestry systems. When comparing organic and conventionally managed systems, the costs were higher under conventional management because of the higher cost of synthetic fertilizers. The lower costs in the agroforestry and organic systems may have a strong implication for smallholder farmers, as they usually hold limited savings and access to credits.

Agroforestry systems under organic farming meet the challenges of having ecological sound and economically viable systems according to new framework of Organic 3.0. However, research on how to increase cacao yields under this production systems is critical to be able to meet the growing demand of cacao in a sustainable way.

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The potential of organic agriculture and agro-ecology for sustainable intensification of tropical agro-ecosystems

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Key words: sustainable intensification, tropics, organic agriculture, agro-ecology, policy frameworks

Abstract

Sustainable agricultural intensification in the tropics is imperative, but how to achieve it is a matter of debate. Here we highlight the major knowledge gaps in agricultural research and policy that must be addressed to develop adequate governance and regulatory frameworks which can facilitate this transformation. Furthermore, we discuss the potentials and synergies of agro-ecology and organic agriculture to transform our food systems, and highlight the importance of controlling food demand through societal (behavioural) and political (structural) changes in agricultural value chains. Finally, we review sustainability standards and participatory guarantee systems in developed and developing countries, respectively, and argue that exemplars from developed countries could provide inspiration to adapt governance and regulatory frameworks in developing countries.

Sustainable intensification: a primer

How to achieve greater production of food, fibre and fuel in the near future is a matter of debate, as "conventional intensification" implies intensive use of inputs (seeds, fertilizers and pesticides) to maximize productivity, whereas "ecological intensification" refers to alternative farming systems that respect and conserve natural resources while generating acceptable farm income (SCAR, 2011; Malezieux, 2012; Bommarco et al., 2013). In recent years, the term "sustainable intensification" has been on the agenda of agricultural research and policy. However, interpretations of "sustainable intensification" differ substantially, and the discussion often focuses on production, neglecting the consumption end of value chains (Garnett and Godfray, 2012; Loos *et al*., 2014). In this paper, we adopted Pretty and Bharucha's (2014) definition of sustainable intensification as: "*a process or system where agricultural yields are increased without adverse environmental impact and without the conversion of additional non-agricultural lan*d".

The quest for the Holy Grail: sustainable intensification in the tropics

In order to address the multitude of challenges smallholders are facing in the tropics, food sufficiency at local levels is pivotal (Tittonell and Giller, 2013). Farmers need agro-ecosystems which simultaneously ensure food security, cash income and maintenance of natural resource capitals. To achieve this, alternative farming strategies such as agro-ecology and organic agriculture are becoming more popular in different parts of the world. Their objective is to minimize external inputs, enhance system-internal self-regulation and increase the net returns to society.

While agro-ecology aims at designing innovative agro-ecosystems using a landscape approach and focusing on social innovations in institutions through dialogues of wisdom (Altieri and Nicholls, 2012; Tittonell, 2013), organic agriculture focuses on a standardized framework for production and marketing which is defined by IFOAM, the International Federation of Organic Agriculture Movements (Paull, 2010).

Agro-ecology

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Despite producing lower yields of the main crop, diversified agro-ecological systems are characterized by resilience to climatic extremes (Berg, 2002) and high total productivity (Schneider *et al*., 2016), which minimizes risks associated with price fluctuations (Andres *et al*., 2016). In addition, they contribute to pest control by increasing the abundance of natural pest antagonists (Wyss and Pfiffner, 2008; Forster *et al*., 2013a).

However, the complex nature of diverse agro-ecosystems makes them more labour-intensive compared to mechanized cultivation in monocultures. In developed countries with vast acreage and relatively few people employed in agriculture, engaging enough manual labour may lead to costs that are too high to bear. Hence we argue that the feasibility of agro-ecology on larger scales in developed countries is yet to be proven. In developing countries, however, the potential of agro-ecology seems to be relatively greater, because i) there is no shortage of cheap manual labour, ii) mechanization is lacking, and iii) large acreages demanding mechanization are rare.

Organic agriculture

The main critique of organic agriculture is lower productivity; opponents claim that organic agriculture needs more land than conventional agriculture to produce the same amount of food, and thus adoption on large scales may threaten the world's forests, wetlands and grasslands (Trewavas, 2001; Avery, 2006; Pickett, 2013). Studies report the organic-conventional yield gap to range from -25% to zero or even higher yields in organic (Tuomisto *et al*., 2012; de Ponti *et al*., 2012; Seufert *et al*., 2012; Ponisio *et al*., 2015). Since organic systems typically become competitive only after the initial conversion period of three years (Panneerselvam *et al*., 2012), long-term studies showed comparable yields and higher yield stability (Lotter *et al*., 2003; Forster *et al*., 2013b; Ponisio *et al*., 2015).

A major plus of organic systems is their economic advantage; organic agriculture is significantly more profitable and has higher benefit/cost ratios than conventional agriculture when premium prices are considered (Crowder and Reganold, 2015). Besides, they exhibit many ecological advantages, e.g. long-term improvement of soil fertility (Reganold *et al*., 2001; Mader *et al*., 2002; Hepperly *et al*., 2006; Fliessbach *et al*., 2007; Teasdale *et al*., 2007; Birkhofer *et al*., 2008). Although it is generally established that organic farms show significantly higher biodiversity, the extent to which this contributes to overall conservation efforts is yet to be quantified (Birkhofer *et al*., 2014; Tuck *et al*., 2014). A meta-analysis of European studies by Tuomisto *et al*. (2012) showed that organic agriculture has positive impacts on the environment per unit area of production, but not necessarily per unit of produce, which again highlights the need to close the organic-conventional yield gap.

The majority of the research comparing organic and conventional agro-ecosystems has been carried out in temperate environments, and the number of similar studies from the tropics is limited. In order to obtain the required evidence, the Research Institute of Organic Agriculture (FiBL) established four long-term field trials in Kenya, India and Bolivia (Forster *et al*., 2013b). Initial results suggest a high potential of organic agriculture for ecological intensification of tropical agro-ecosystems (own unpublished data). However, there are major research gaps regarding organic crop production in the tropics, especially regarding pest control and soil fertility maintenance.

Agro-ecology or organic agriculture?

When comparing the two approaches, we notice that agro-ecology has a stronger focus on system-internal self-regulation and social institutions, while the main strengths of (certified) organic agriculture are channelized market access and regulatory frameworks. However, similarities among the two approaches abound: i) promotion of "closed (cyclic) systems", ii) use of multiple and diverse crops and animals, iii) capitalizing on biological processes for pest control and soil fertility maintenance, and iv) support of transition pathways towards ecological intensification of agriculture.

Both approaches combine research with practice (Bellon *et al*., 2009) and strongly advocate societal change, particularly in consumer behavior. Hence we argue that agro-ecology and organic agriculture are complementary, and should be combined to address the challenge of food insecurity in the tropics. By capitalizing on synergies, many issues of agro-ecosystems could be addressed simultaneously, be it at the research – policy interface or on the production and consumption end of value chains.

Drivers of transformation – governance and regulatory frameworks

While there is an urgent need to address the research gaps highlighted above, policy action is even more crucial for the required transformation towards higher sustainability of food systems and supply chains. To make progress towards sustainability parameters and indicators outlined in Figure 1, research and policy priorities need to be addressed together, some of which are discussed here.

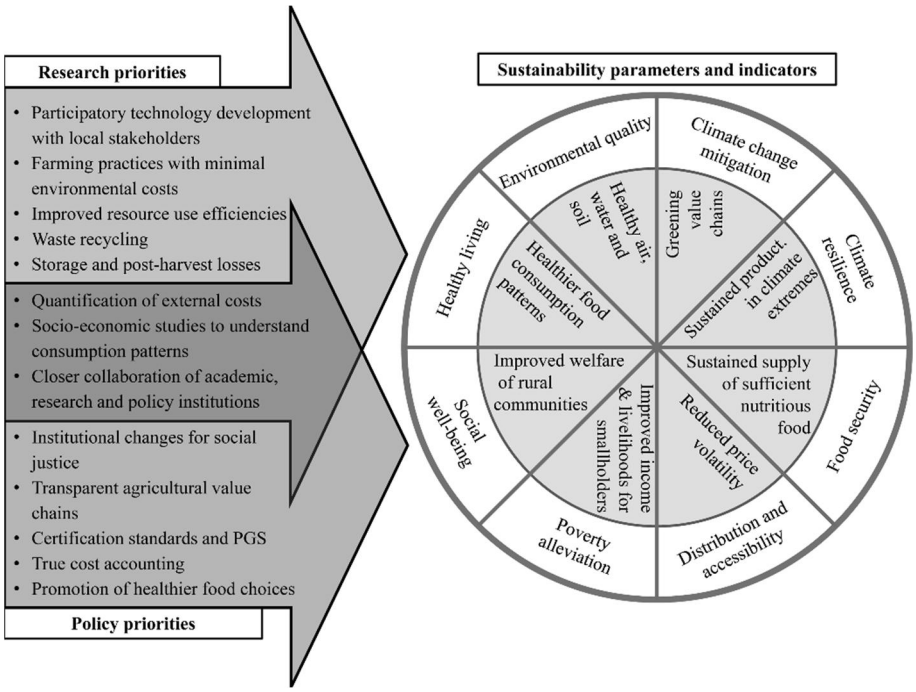

Figure 1: Research and policy priorities for sustainable intensification of agro-ecosystems and supply chains. Inner circle: sustainability indicators; outer circle: sustainability parameters.

Consumer preferences and cost internalization

The combination of higher consumption of energy dense but nutrient poor foods ("empty calories") and sedentary lifestyles has created the pandemic of obesity in developed countries, which is a major economic burden to health and social systems. (Albritton, 2009; Wang *et al*., 2011). The Standing Committee on Agricultural Research of the European Commission emphasizes that, in order to stay within the capacity of system 'Earth', increasing food demand needs to be mitigated through behavioural change and structural changes in food systems and supply chains. We need to i) educate and motivate consumers to opt for healthier and sustainably produced food, ii) implement governance structures that enhance access to, and affordability of, healthier foods, and iii) address the disruptive effect of unregulated trade which could facilitate the behavioural change on the consumer side (SCAR, 2011).

The recent boom in the consumption of sustainable/organic produce in developed countries (Niggli *et al*., 2014) provides opportunities to market niche products to prosperous consumers, but it is certainly insufficient with regard to the mainstreaming of sustainable production at larger scales. After all, the amount of subsidies to foster sustainable production to the same extent which has been

the case in some developed countries may not be available to developing countries. Therefore, we argue that developing countries should target the consumption side of value chains to create positive drivers for sustainable intensification: as consumer preferences are highly price- sensitive, making conventional produce more expensive by increasing their production costs may increase market demand for sustainable produce.

Current policies favour unsustainable production of commodities in large quantities, which are sold at distortedly low prices at the cost of the environment and ultimately humankind. Pretty (2000), for instance, reported total external costs of UK agriculture in 1996 to be 208 £ per ha of arable land/permanent pasture. Another study concluded that the non-monetarized costs of pesticide use in Switzerland amount to at least 50-100 Mio Swiss Francs per year (Zandonella *et al*., 2014). If these costs would be internalized, conventional produce would become more expensive and sustainable produce more competitive. This may translate into a shift towards higher sustainability of agricultural production (Fry and Finley, 2005; Reisch and Gwozdz, 2010). 'True cost accounting' (internalization of external costs) could help to achieve this objective (Pretty *et al*., 2001; Tegtmeier and Duffy, 2004). However, there are major research gaps in the quantification of the true environmental, social and health costs of different agricultural production systems. Furthermore, the practical implementation of such accounting systems is understandably complex and requires dedicated efforts by policy institutions based on comprehensive research findings.

Farming systems naturally involve trade-offs among competing economic and environmental goals. Therefore, it is important to create the necessary frame conditions that allow the farmer to prioritize both ecosystem services and economic benefits. Switzerland's 'multifunctional farmland' approach (adopted after the 1996 referendum) could serve as an exemplar in this regard (Baumgartner, 2000).

Sustainability standards and participatory guarantee systems

Certification standards integrate sustainable production practices with biodiversity conservation and protection of social rights. Generally, certification seems to work best when supply/demand ratios in commodity markets are low, and price premiums high. However, as the supply/demand ratios increase, sustainability standards lose their attractiveness because the prices of certified products also decrease. This puts a question mark behind the long-term sustainability of certification standards.

Consumers who are willing to share these responsibilities by paying higher prices for sustainable produce appreciate quality and truthfulness. Despite the tremendous progress sustainability standards have made across various sectors, control mechanisms remain weak in some cases, and there were media reports accusing certification schemes of being prone to fraud (Neuendorff, 2012), or even of cheating producers and consumers (Etahoben *et al*., 2012). Therefore, assuring integrity and trustworthiness of sustainability standards is of crucial importance, and research and policy should join hands to implement appropriate 'checks and balances'.

Generally, farmers profited from sustainability standards by gaining access to international markets and receiving training, which improved product quality and helped to conserve natural resources. However, the expected impact on rural livelihoods has been limited, particularly in the case of smallholders (COSA, 2013; Potts *et al*., 2014). Owing to their stronger bargaining power, processors, traders, retailers and other value chain players fetch relatively larger benefits compared to smallholders (Bjorndal *et al*., 2014; Meybeck and Redfern, 2014). Moreover, the mandatory conversion periods may discourage conventional farmers to join certification schemes. Therefore, subsidies or incentives for 'in-conversion phase' farmers could encourage the adoption of sustainable practices by larger numbers of smallholders. Furthermore, the additional costs for inspection and certification remain a serious hurdle. Often, smallholders can only benefit via group certification, for

which they need to form cooperatives. Against this backdrop, the alternative certification scheme 'Participatory Guarantee Systems (PGS)' was explored. By putting a focus on smallholders and local consumers, PGS was successful in different parts of the tropics (Zanasi *et al*., 2009; Nelson *et al*., 2010), and local governments are starting to recognize its' role.

Nonetheless, as long as viable governance and regulatory frameworks are not in place yet, case-by-case decisions about appropriate certification systems are needed, especially because their success is context-dependent (farm holdings, cropping systems, target markets and social organization of local populations have to be considered). Countries which were at the forefront of sustainability standards development (e.g. Austria and Switzerland, where 19.5 % and 12.2 % of the agricultural land is under certified organic agriculture, respectively (Willer and Lernoud, 2015)) could provide role models and assist in the development of appropriate governance and regulatory frameworks in developing countries.

In conclusion, we emphasize that in order to achieve sustainable intensification of (tropical) agro-ecosystems and transform our food systems, the major knowledge gaps outlined in this paper need to be addressed. We need i) methods to quantify the value of ecosystem services and the costs to maintain them ii) to know how to adapt alternative farming strategies to ensure their feasibility at global scale, and iii) to quantify the true costs of different types of agriculture. While this knowledge is crucial to formulate appropriate governance and regulatory frameworks to trigger the developments outlined in this paper, we must not forget that research, education, practice and policy frameworks need to be adapted to local contexts. Finally, we think that advocates of agro-ecology and organic agriculture should join hands to tackle this huge challenge.

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To what extent does land use differ between organic and conventional farming? A global scale analysis

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Key words: organic farming, conventional farming, land use, export, principal component analysis

Abstract

Agricultural land-use is a key factor that drives many services provided by agroecosystems. As such, the differences of land-use between organic and conventional farming are of critical importance. However, such differences have been poorly investigated so far. Here, we provide an analysis of land-use under organic and conventional production at the global scale. Results show that land-use differs between the two production systems and that such difference depends on global climatic regions. Organic agriculture is characterized by more export commodities (i.e. fruits) in tropical and subtropical countries and by more arable crops (e.g. pulses) in European countries. These results suggest that the differences in land-use between organic and conventional farming may result from agronomic, economic, market and trade factors. These results help to better understand organic farming expansion at the global scale and could improve future scenarios of organic production.

Acknowledgments

The authors are grateful to the FiBL colleagues Helga Willer and Julia Lernoud for providing land-use data, and to the anonymous reviewers for valuable comments on the manuscript.

Introduction

Agricultural land-use is a key driver of many services provided by agroecosystems, in particular in terms of food provisioning, carbon sequestration, nutrient supply and pest regulation. In a context of strong organic farming development at the global scale, differences of land-use between organic and conventional farming are of critical importance (De Ponti 2012, Connor 2013). However, beyond limited local studies, such differences have been poorly investigated so far in the literature. To help overcome this limitation, this paper characterises land use (in terms of share of agricultural area under the different crop species) in Organic Agriculture (OA) vs Conventional Agriculture (CA) at the global scale. In particular, we aim to i) quantify to what extent land-use differs between OA and CA, ii) estimate how such differences depend on global climatic regions, and iii) identify key drivers of such differences.

Material and methods

Statistical data on organic and conventional agriculture land-use for the years 2010-2014 were obtained from the Research Institute of Organic Agriculture (FiBL, 2015) and from FAOSTAT, respectively. Land-use data were expressed by the following crop categories: berries, cereals, citrus fruits, coconut, pulses (including soybeans), temperate fruits, tropical and subtropical fruits, grapes, nuts, oilseeds, olives, root crops, strawberries, tea/mate, textile crops, tobacco, and vegetables. The

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CA data retrieved from FAOSTAT was corrected by subtracting the respective organic surfaces. No information on temporary fodders was available.

Data was filtered by removing countries whose share of organic vs. total agricultural land was under 0.5 %. Overall, land-use of 55 countries was compared. Countries were then grouped according to i) their respective FAO global region and ii) their climatic zone (FAO et al. 2007). For large countries, the predominant climate was chosen. Climatic zones may be relevant since climate represents the main physical factor influencing crop localisation.

A descriptive analysis was computed by comparing the crop composition of the two production systems. Different global regions were compared by clustering countries belonging to each region. Shannon Index was calculated to assess crop diversity (Peet, 1975, Spellerberg and Fedor 2003). The Shannon Index provides an estimation of the land use diversity in terms of cultivated crop categories. Finally, to identify the main drivers that determine land-use differences between organic and conventional farming differ among countries, a Principal Component Analysis was performed. The PCA dataset was built including the following indicators for each country: i) the difference between organic and conventional share of the each crop categories, ii) the share of total agricultural land under organic production, iii) the domestic per capita consumption of organic products, iv) the net number of exporters, and v) the organic countries exports values standardised on the total organic agricultural land. All analysis were computed using the R 3.2.5 (R Development Core Team 2016).

Results

We found that land-use (in terms of share of the different crop categories) strongly differs between conventional and organic systems (Figure 1). At the global scale, the main differences relate to cereals, root crops, and oilseeds: these crops exhibit a lower share in organic land-use in most regions. At the regional scale, we found some big variations among regions. For instance, we found that exported commodities are over-represented in organic land-use in the Global South (especially coconut, tropical and subtropical fruits, fiber crops, and vegetables in tropical and subtropical regions). We also found that pulses were over-represented in organic vs conventional land-use in Europe but the contrary was true in Americas. Similar Shannon and equitability Indexes were found, on average, in OA compared to CA, meaning that organic farming does not necessary lead to a higher land use diversification.

The PCA helped to classify countries according to the share of total agricultural land under organic production, the internal domestic consumption of organic products, and the difference between organic and conventional share of cereals (axis 1, 25 % of the variance) and the difference between organic and conventional share of temperate fruits, root crops, and vegetables (axis 2, 15 % of the variance). In particular, three main clusters are recognisable, i) a cluster of countries in the top left quadrant, ii) a cluster in the top right quadrant and iii) a cluster in the bottom quadrants. The first group is characterised by more OA land dedicated to tropical and subtropical fruits compared to CA and high exports of Organic products. The second group by more pulses in OA, a high share of OA land, and a relative high domestic consumption of organic products. The third group is characterised by more temperate fruits, root crops, and cereals in OA compared to CA. Geographically, these three categories correspond respectively to tropical and subtropical countries, western European countries and continental/Mediterranean countries belonging to different global areas. Considering the relations between variables, a negative correlation between OA shares of tropical fruits and cereals is present. On an economic level, countries with a higher share of OA are positively correlated with a higher organic domestic consumption; and negatively correlated with countries with higher organic exports.

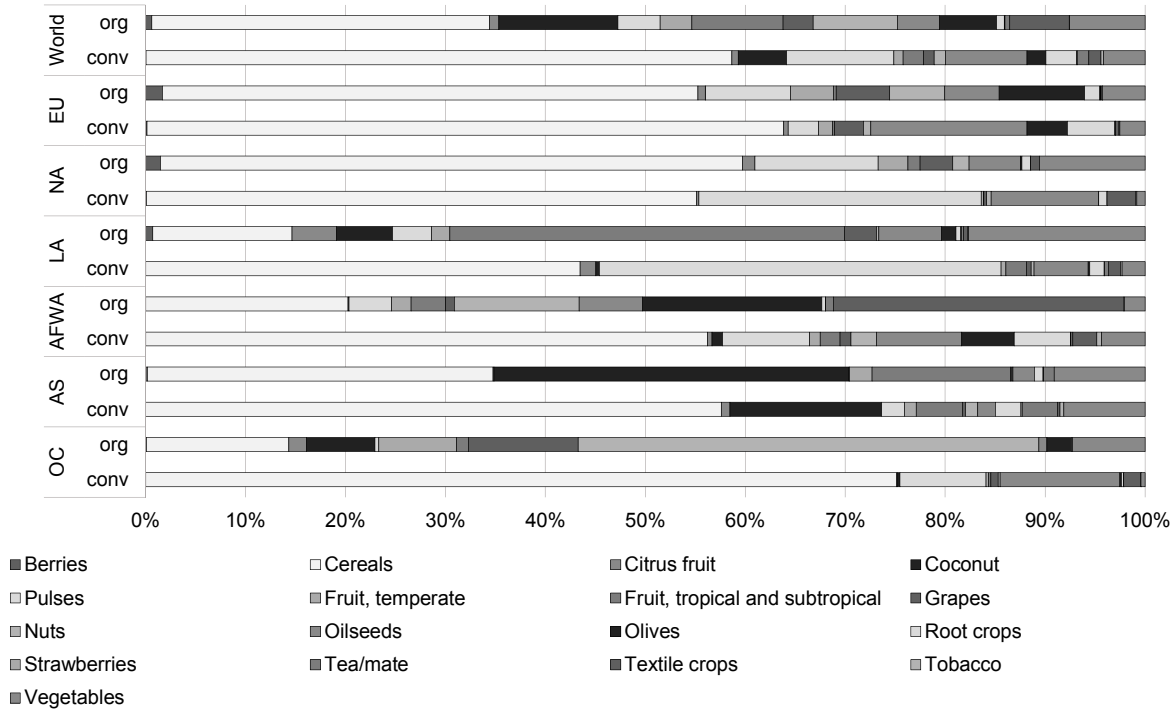

Figure 1. Conventional (conv) and organic (org) land use composition. Bars show the cumulative shares of the different crop categories (ordered according to the legend) in the different global regions: Europe (EU), North and Latin America (NA, LA), Africa and West Asia (AFWA), Asia (AS), and Oceania (OC).

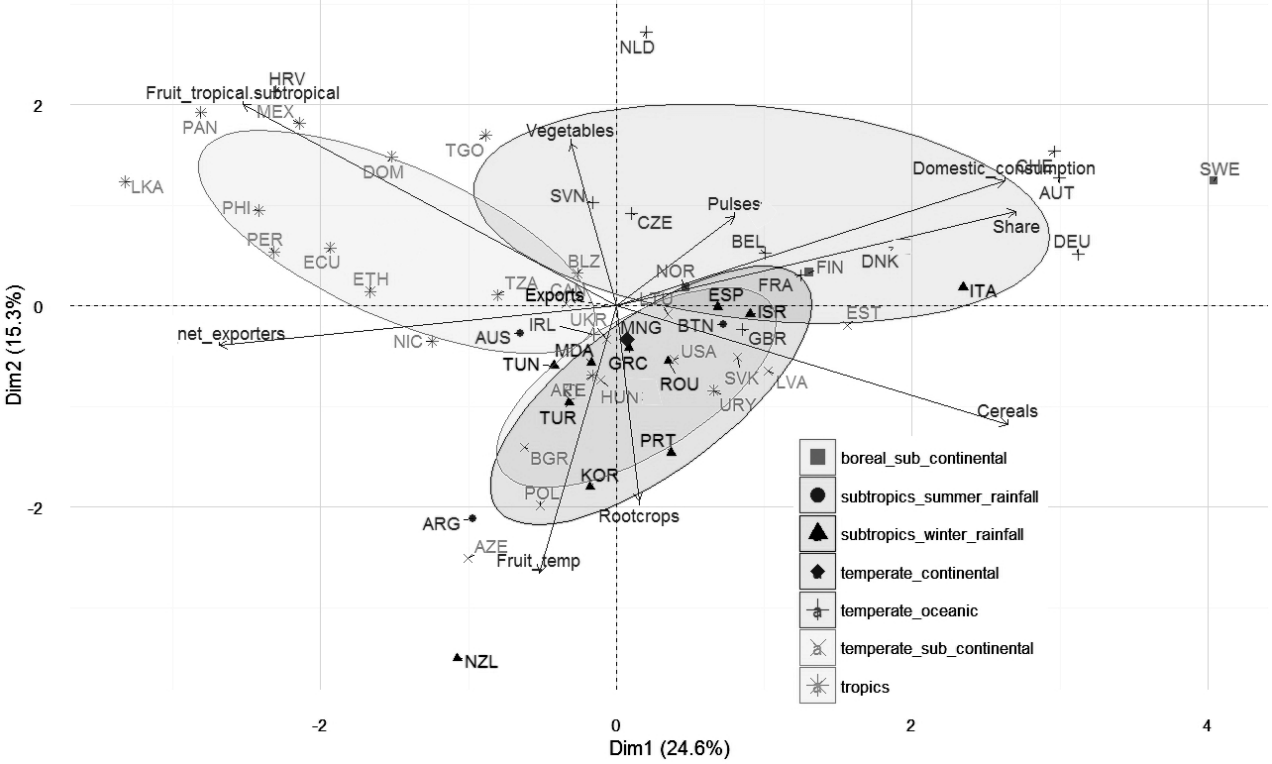

Figure 1. Results of the Principal Component Analysis. Arrows indicate the PCA variables; the variables indicating the crop categories refers to the respective difference between OA and CA, i.e. they indicates country where the land use share of the given crop is higher in OA then in CA. Symbols indicate the belonging global climatic region of each country. The ellipses (drawn according to Fox and Weisberg, 2011) group the four main climatic regions (temperate oceanic, tropics, subtropics winter rainfalls, and temperate sub-continental).

Discussion

Organic land-use is driven by a set of factors. From an agronomic point of view, organic land-use reflects the solutions that organic farmers have adopted to avoid synthetic inputs. In particular, the bigger share of pulses in Europe and the more diversified land-use in OA suggest that farmers have adapted their rotations, to harness the benefits of legumes symbiotic fixation and enhanced pest regulation by more diversified landscapes.

Although data availability represents a limitation to this assessment, especially regarding information on organic markets at the country level, our results demonstrate the key role played by economic and market forces in land-use construction. Indeed, Organic products are mostly consumed by Western countries (Agence Bio 2014). These countries, by having a strong demand for some tropical organic products, drive organic production towards exported commodities. Hence, the creation of organic local markets might help the expansion of organic arable systems in tropical areas.

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Model for productivity improvement in default organic system and its up-scaling in drylands of India

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Key words: default organic, dryland, sustainable intensification, up-scaling, agroecology, climate resilient

Abstract

About one fifth of world's agriculture area i.e. drylands is still fairly untouched from green revolution happened with the use of chemicals. These areas receives small amount of rains that restricted the use of chemicals and become a boon rather than curse, that maintained their purity of products and conserved ecosystem. These areas the hope spots for conservation of agro-biodiversty and cultural heritage of farming that otherwise know as default organic are having low productivity. A model of sustainable intensification in this system and scaling up with 'Like and Follow' approach has been developed at Central Arid Zone Research Institute (CAZRI), found very useful in improvement and up-scaling of traditional default organic system of the drylands of India.

Introduction

Traditionally, in low rainfall areas (rainfall below500mm/yr) of India multi-component default organic farming systems are prevalent which include annuals, perennials and livestock. Such systems have very low external inputs and rely heavily on recycling of local resources in order to cope up with the risk of rainfall uncertainty. Although these systems have sustained reasonable yield under the prevailing climatic uncertainties, their productivity may be improved through enhanced efficiency of resources and incorporation of modern ecofriendly technologies.

To design this default system for sustainable intensification with all possible agro-ecological approaches and incorporation of modern eco-technologies an attempt has been successfully done at CAZRI, Jodhpur. Some of the opportunities available in this region like abundance of neem tree, traditional eco-wisdom, high value monopoly native crops like cumin, psyllium, pulses and other spices have been used in development of model and up-scaling in the region.

Material and methods

For improvement in the default organic system of this tropical region with the approach of sustainable intensification a Model Organic Farm(MOF)established in 2008 in 2.0 ha area at Central Farm CAZRI(26.24º N, 72.99º E), Jodhpur and got status of certified in 2011. All the required facilities like bunding, keeping buffer zone, rainwater harvesting, preparation of inputs e.g.compost, biopesticides, etc. and use of pheromone traps and beneficial microorganism have been developed at farm. A variety of trees/shrubs for fruit and other use were planted on the farm to ensure an income from diverse sources, material for biopesticides and to increase biodiversity on the farm. Information boards are places at various places in the field so any visitor can read about and understand different aspects of the system. The entire farm has been set-up around three main branches of sustainability: rain water; waste utilization and field education. For scientific and certification purposes records are maintained about input use, farming practices, produce storage etc.

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Results

A rotation of four high-value crops, including cluster bean and sesame in the rainy and cumin and psyllium in winter season were selected for the study. Seven years after establishing the farm there has been an overall improvement in soil health and agro- diversity that is helping to make the system more resilient to climatic extremes such as drought, long dry spells or heavy rains in few hours. The population of beneficial fauna has also increased and is controlling pest incidence. More details are given below.

Improved soil properties

The use of compost (made with animal and farm waste)has led to an observable increase in soil water retention(from 8.43%to 8.92%)that has helped in better growth and crop yields. Similarly an increase in soil organic carbon content from 0.23%to 0.32% has been observed after seventh years of applying compost at a rate of 5 metric tonnes/ha/year. Biological activity, measured in terms of Dehydrogenase enzyme activity, has also improved from 1.06to 2.36(pKat g-1),showing that the soil is becoming more alive.

Crops are more resilient to climatic variability and provide a better yield

Crop resilience to climatic variability has been enhanced by the use of compost. This is observed in sustained crop growth, lesser incidence of pests and diseases and sustained yield during climatic extremes, compared to conventional farms. Yields increased significantly with an increase in the dose of compost(from 2.5to 5 tons/ha) for all the crops. Legume cultivation in the rainy season contributed an average 25-30% increase in yield in the subsequent crops of cumin and psyllium.

Disproved the widely held view that organic systems are poor yielder

There is a widely held view that organic systems give poor yields. However, the findings at the MOF show that,while during the initial developmental stage of an organic system there may be slightly lower yield than that of in a conventional one, after 2-3 years once the system is developed the yield levels are comparable to the conventional (chemical input based)system. In the sixth year (2014)yields of 917.5kg/ha for sesame,1122.2kg/ha for cluster bean, 830.9kg/ha for cumin and 856.4kg/ha for psyllium were recorded with the application of compost @ 5.0 t/ha. This is comparable to the average yield of a conventional system. Since most of the inputs are being prepared on-farm the cost of production was reduced by30-70%, depending upon the crop.

Increasing the density and diversity of farmer's friends (beneficial insects)

Round the year availability of water (harvested rainwater) and nectar and no use of chemicals led to an increase in the diversity and density of beneficial fauna, which has almost tripled in seven years. Syrphid flies, wasps of different types, honey bees, bumble bee, ground bee and geocorid bugs are major beneficial insects on *Zizyphus*. Besides insects,13 species of predatory birds have been seen including crow, prinia, babbler etc. at MOF and help in controlling insect pest.

Up-scaling with 'like and follow'approach

People or organizations present their profiles and work through the social media, and those who like them can then follow them. The same is true for organic farming, if all the possibilities are displayed and the outcomes can be seen, a famer just needs to 'like'it and prepare himself to 'follow'(adopt) it. In the second phase the farmer will need technical and to some extent, financial support for adoption, the CAZRI staff will do 'follow' up action time to time to bring it upto success level.

Farmers groups (a total of 500-600farmers/year) frequently come to visit this farm and get hands-on training. Many of them have adopted these technologies because using local resources makes it into a cost effective and affordable system for drought prone marginal farmers. Yet they often have questions and doubts about the organic approach, which we listen to carefully and give customized reply to every farmer based on his socio-economic condition and resource management skill. A

village 'Dantiwara' has been adopted to transfer the organic farming technology developed at CAZRI and organic seeds produced at MOF are being given to the farmers of this village

Policy suggestions for upscaling of organic farming in drylands

Considering the export demand and contribution in the sustainability and economy of this default organic region; it is need of the hour to do integrated efforts for quantity as well as quality organic production . These efforts are need to be done at all level i.e. policy, research, marketing etc. Integration of technologies and programmes and coordination among various agencies is the prime requirement. For example, development of package of organic production may not be much effective until and unless promotion policies and good market facilities are not available. Integrated action plan at policy and research level are required. Some of the policy suggestions are-

1. **Priority to organic farming in ongoing programs**: Organic farming need not to be promoted as a new program that may cause overburden of additional program, rather priority is given to it all the ongoing program for agriculture running by Govt.

2. **Popularization of organic farming without compulsion of certification:** In dryland areas farmers are very poor and unable to afford the cost of certification. Instead, at initial stage organic farming should be promoted for improving soil fertility, reducing cost of production,production resilience and other environmental advantages.

3. **Dissemination of organic farming in holistic manner**: Most of the agencies promoting organic farming in piecemeal approach e.g. .only vermi-compost, only Integrated Pest Management, only Integrated Nutrient Management etc. this makes confusion among the farmers. While organic farming is an integrated approach for nutrient recycling, conservation of natural resources, water conservation, crop rotation / diversification etc. Therefore, it must be inclusion of all these aspects which can make a sustainable organic farming in real term.

4. **Adoption of improved methods of composting:** Majority of the farmers in the rainfed areas apply animal and crop waste in sundried un-decomposed form to the soil, as a result the availability of nutrients to the plants decreases and also invites several pests. It would be better to apply these materials after composting them with any of the suitable methods. These methods can be popularized and financially. supported under the "Clean Village Scheme" of the central governments or by increasing technical and financial support for biogas plants that gives both energy and compost.

5. **Development of organic clusters of villages**: Available clusters of villages of watershed programs (mainly running in drylands)may be converted into organic cluster of villages by providing technical support. This will be cost effective and make easier the group certification process of organic produce.

Future of organic farming in drylands

Water scarcity and light soils in India's drylands mean that an organic approach is highly suitable and applicable in these low rainfall areas. These regions have a monopoly on high value crops, such as oilseeds and spices, which are in great demand internationally, especially if produced organically. In this way, organic production in low rainfall areas not only boosts the economy but also sustain the productivity of natural resources. The management system developed at the MOF may also be useful for drylands in other parts of the world. Further research is needed to economical and ecological quantification of the contribution that this system makes and a team of devoted trainers is required in order to up-scale(extend)this system to the interested farmers.

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Organic Rice Production in Irrigated Agriculture System Using the Rice Intensification System (SRI)

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Key words: Cowpea/soyabean green-manure, poultry manure, rice intensification

Abstract

*A trial carried out in 2015 at the Irrigation Research farm Kadawa, in the Sudan savannah, investigated system of rice intensification as it influences rice production at three spacings, using organic fertilizers only. Soyabean **(SB)** and cowpea **(CP)** fodder either incorporated with poultry manure **(PM)** or used alone were compared with **PM** alone and no fertilizer application. Rice production was best at the **PM** alone application and exceeded the **SB+PM** (7.6%) and **CP+PM** (11.4%) in grain production, SB alone (14.5%), **CP** alone (40%) and the control (60.5%). Improved grain production was predicated on improved number of tillers and plant dry weight produced at PM alone application. The spacings used were similar in yield and growth attributes though they improved at the wider spacings. Improvement in the productivity of rice is therefore possible under effective water and crop management and the use of organic fertilizers for optimal soil's physical, chemical and biological processes.*

Introduction

Irrigated rice is produced either twice in a year or after a dry season tomatoes crop in the raining season. This continuous cultivation with high doses of chemical fertilization and protection lead to soil and water pollution as well as soil salinity (WWF, Germany, 2013). The unsustainable practices, contribute to land degradation and are perhaps responsible for the low rice yields often recorded among farmers. The system of rice intensification has recorded highly improved yields of rice crops among farmers by managing soil water usage, improvement of the soil's organic matter and the proper care for the seedling. Although not fully understood yet, root development is implicated in this improved production (Kumar, et al., 2004). Seedlings are transplanted immediately after uprooting and the field is not continously flooded; this together with improved OM results in healthier root systems and more vigorous crop growth, leading to improved yield.

Material and methods

A field trial, conducted in the 2015 cropping season at the Irrigation Research farm Kadawa ($11^0$11'N, $07^0$38'E, 686m above sea level), in the Sudan savannah of Nigeria; investigated early transplanting of rice seedlings at wider spacing and no flooding of the basin on the performance of Faro 44 rice crop. Treatments included two types of green manure (GM) - cowpea (CP) and soyabean (SB) incorporated at maturity and the application of poultry manure (PM). The treatment combinations were GM alone, CP or SB with PM, PM alone and a control – where no manure was applied. Where PM was applied alone 9.6kg was used while where PM was added to plots with GM 4.8kg was used. The rice seedlings were transplanted at three (3) spacings – 20cm, 25cm and 30cm; giving a total of 18 treatment combinations in four replications. The plot size was 4m by 4m, while a

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quadrant 1m by 1m was harvested for the determination of the grain yield. Faro 44 (Sippi 692033) takes 100 – 120 days to maturity.
The nursery was prepared and planted on July 13, 2015 and PM applied to the field on July 14 and 15, before land preparation. Seedlings were transplanted from August 3 to 10, using the spacings stated above. Data taken on the rice plant included stand count, plant height, tillers per plant, plant dry weight and grain weight at harvest. The crop was harvested on December, 02, threshed and winnowed to obtain the grain yields.

Results

Tillers per plant:

The application of poultry manure alone had the highest number of tillers per plant, and was similar to both the application of CP+PM and SB+PM but significantly higher than the application of CP alone and the control (Table 1). Application of fodder and PM were also better than the application of CP alone and the control. The 30 cm spacing had more tillers than the other spacings and was significantly higher than at 20cm.

Dry matter:

Application of poultry manure alone resulted in the heaviest dry matter produced and was similar to the SB+PM application but significantly higher than other treatments (Table 2). Application of SB+PM was similar in dry matter produced to the CP+PM and CP alone but significantly higher than the SB alone and the control; while but the control and application of SB alone were similar in dry matter produced. The spacing used had no significant effect on dry matter produced, though it was highest at 30cm.

Grain yield:

The grain yield was highest with the application of poultry manure alone and was similar to the application of CP+PM and SB+PM but significantly different from manure applications (Table 3). The application of CP+PM and SB+PM had similar grain yield with the application SB alone but was significantly higher than the application of CP alone and the control; while both the application of CP alone and the control were similar in grain production. The 25cm spacing had the highest grain weight among the spacing used but they were all similar.

Table 1: Effect of the application of poultry and green manure rates and plant spacing on number of tillers/plant of rice, using the system of rice intensification

Treatments	Spacing (cm)			
	20	**25**	**30**	**Mean**
No fertilizer	10^{c}	14^{b}	16^{b}	14^{c}
CP + PM	18^{a}	17^{ab}	19^{a}	19^{ab}
CP alone	14^{b}	14^{b}	16^{b}	15^{c}
PM	20^{a}	20^{a}	20^{a}	20^{a}
SB + PM	19^{a}	17^{ab}	16^{b}	18^{b}
SB alone	14^{b}	17^{ab}	19^{a}	17^{b}
SE ± 1.25				
Mean / (SE ±) 0.51	16^{c}	17^{b}	18^{c}	

Means followed by the same letter(s) in a column are not significantly different at P = 0.05 using DMRT

Table 2: Effect of the application of poultry and green manure rates and plant spacing on dry matter per plant of rice, using the system of rice intensification

Treatments	Spacing (cm)			
Fertilizers	**20**	**25**	**30**	**mean**
No fertilizer	67.8^{f}	71.4^{f}	74.2^{f}	71.1^{c}
CP + PM	145.3^{c}	142.0^{c}	147.0^{c}	144.7^{b}
CP alone	138.0^{c}	122.0^{d}	141.4^{c}	134.2^{b}
PM alone	177.0^{b}	149.6^{c}	195.7^{a}	174.1^{a}
SB + PM	134.3^{cd}	197.2^{a}	144.9^{c}	158.8^{a}
SB alone	81.4^{f}	102.9^{e}	104.9^{e}	96.4^{c}
SE ± 15.58				
Mean / (SE ±) 6.52	123.9	130.9	134.7	

Means followed by the same letter(s) in a column are not significantly different at P = 0.05 using DMRT

Table 3: Effect of the application of poultry and green manure rates and plant spacing on grain yield (gm^{-2}) of rice, using the system of rice intensification (SRI)

Treatments	Spacing (cm)			Mean
	20	**25**	**30**	
No fertilizer	437^{cd}	400^{cd}	383^{d}	407^{c}
CP + PM	547^{abc}	660^{a}	612^{ab}	607^{a}
CP alone	459^{bcd}	473b^{cd}	467^{bcd}	467^{c}
PM alone	624^{a}	668^{a}	667^{a}	653^{a}
SB + PM	586^{ab}	591^{ab}	581^{abc}	586^{ab}
SB alone	566^{abc}	578^{abc}	566^{abc}	570^{b}
SE ± 44.49				
Mean / (SE ±) 18.16	536.8	562.1	546.4	

Means followed by the same letter(s) in a column are not significantly different at P = 0.05 using DMRT

Discussion

Crop performance:

Crops that had additional nutrients from either green manure, poultry manure or the combination of green manure and poultry manure performed better than those that did not receive additional nutrients. This is shown by a 6 – 45% increase in the number of tiller produced, 35 – 145% increase in plant dry weight and a 9 – 60% increase in the weight of grains produced. This is not surprising as added manure would have boosted the soil's organic matter (SOM), and thus nutrients and retained moisture for a longer time. The plant spacings employed did not have as much influence on the crop performance but the little increases could be enough to justify spacing crops at more than 20cm.

Effect of manure application:

The application of manure improved the number of tiller per plant by about 6 – 45%, dry matter by about 35 – 145% and grain yield by about 9 – 60% over the control (where no fertilizer was added). Of the three manures used the application of poultry manure alone was the most efficient in improving crop performance; which is not surprising since nutrients from it was more readily available than from the green manure that would need to be decomposed first before the release of the nutrients contained in it. The variation in the contributions by the legume crops can be attributed to both the biomass produced by the legumes and thus nutrient content of the plant, the amount of nitrogen fixed

into the soil as well as the ease of decomposition. While the amount of nitrogen fixed per hectare for cowpea is estimated to be 198kg that fixed by soyabean is 88kg (Schroder, 1992). This may have been responsible for the higher dry matter produced the cowpea alone over soyabean alone among the green manure alone application. It is also possible that the incorporated soyabean crop decomposed quicker than the cowpea and that this was responsible for the better grain yield and the higher number of tillers recorded with soyabean GM alone.

System of Rice Intensification (SRI):

It would seem that the system for rice intensification used in this trial improved the performance of the rice crop as yields obtained were within the yield range {80 – 106 (75kg) bags ha^{-1}} for the variety used – **Faro 44**. Some attributes of the system that could have made this possible include the management of the seedlings, use of organic matter and the intermittent supply of water instead of continuous flooding. The intermittent flooding of the rice crop in the system mimics the deficit irrigation (FAO, 2002), in which water supply is less than the crop's full requirement. Like deficit irrigation, the intermittent flooding could have favoured root development (Barison, 2002); contributing to more effective water use, and thus nutrient uptake, from deeper soil horizons. The improved root development and nutrient uptake gave rise to the improved number of tillers and plant dry weight which translated to the improved yield obtained as the photosynthetic surface was improved (improved source and sink). In addition, the improved soil environment meant soil moisture was retained for a longer time thus prolonging the period for photosynthate production and accumulation and thus yield.

Conclusion:

Given the increasing demand for food with the high rate of land degradation being experienced, sustainable and viable agricultural systems is critical to food security and poverty alleviation. The production of rice using organic agriculture methods together with the system of rice intensification is a win-win situation. Not only are the soil, water and the environment not degraded in this practice, the farmer's yield is improved tremendously. Also the technique of intermittent flooding in SRI means that, like in deficit irrigation, even if rice is to be produced using irrigation alone, less water will be required, allowing more area to be opened up for irrigated farming and/or more crops to be planted (Oweis, et al. 1999).

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Agroforestry is more productive than monoculture, and organic agroforestry is competitive with its conventional counterpart

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Key words: cocoa, Bolivia, agroforestry, organic agriculture, long-term experiment

Abstract

Cocoa (Theobroma cacao L.) is produced in monocultures (MONO) or agroforests (AF). Famers have to decide between two strategies: short-term (rapid incomes by maximizing cocoa yields in MONO) or long-term (diversified, sustainable production and ecosystem services in AF). More long-term data on the ecological, economic and social performance of such systems under different management regimes is needed to make sound recommendations to farmers. Here we describe the only long-term field trial worldwide comparing MONO and AF under conventional (CONV) and organic (ORG) management (full-factorial, randomized complete block design with four replications). First results show significantly faster development of trunk circumferences in MONO compared to AF (+21 %). In MONO, cocoa yields were 47 % lower in the ORG compared to the CONV system. In the AF, however, the ORG – CONV yield gap was smaller (-16 %) and statistically insignificant. The cumulative yields of all harvested products were significantly higher in AF compared to MONO (+161 %). The productivity of cocoa by-crops in AF may contribute to local food security and risk distribution in smallholder contexts.

Introduction

Assuming you are a smallholder in the tropics and you want to produce cocoa (*Theobroma cacao* L.), you are confronted with the following question: "Should I go for agroforestry (AF) or for a monoculture (MONO), for conventional (CONV) or organic (ORG)?" Regardless of ORG or not, MONO means maximizing income from cocoa in the first two to three decades after setting up your plantation, which happens to often go together with crop protection using synthetic inputs. In contrast, AF means maintenance of soil fertility, less problems with pests and diseases, and a continuous supply of a range of products over long periods of time of up to a century. Or in other words, higher sustainability in ecological and economic dimensions. Sounds perfect, so where is the problem?

Given that the vast majority of global cocoa production happens in MONO, there must be at least one problem. There are many in fact, and going into detail about all of them would go beyond the scope of this paper. Only so much: there is virtually no long-term data on the performance of MONO and AF under CONV and ORG management. If we are to put the ideological debate around cocoa production on a solid evidence base, and if we want to make sound recommendations to farmers, we have to address this.

Material and methods

It would be beyond the scope of this paper to explain everything we did in order to enable somebody to repeat our work. For the purpose of this paper, we only provide a general description of the trial. However, a very detailed description of the whole experimental setup and management practices can be found in Schneider *et al*. (2016). The five different cocoa production systems under comparison include two MONO and two AF, one under CONV and one under certified ORG management, as well as a dynamic agroforestry with zero external input under certified organic management (SFAS). The experiment is set up as a full-factorial, randomized complete block design with four replications. The factors tested are: i) crop diversity (MONO vs.

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AF), and ii) management practice (CONV vs. ORG). The combination of the two factors make up the system effect. Figure 1 shows example plots of a MONO CONV and a SAFS four years after planting the cocoa trees.

Figure 1: Left panel: young MONO in Bolivia. Right panel: young SAFS after shade tree pruning in Bolivia. Pictures were taken four years after cocoa tree planting. Source: own research.

Results

Productivity of cocoa trees (2011 – 2013)

Mean cocoa dry bean yields in 2013 (5th year after planting) ranged from 587 kg ha^{-1} in MONO CONV to 105 kg ha^{-1} in SAFS (Figure 2, data refer to marketable beans only). MONO CONV showed significantly higher yields than all the other systems (+153 %), followed by MONO ORG which, in turn, achieved significantly higher yields than the two agroforestry systems (+33 %). The two agroforestry systems showed no significant difference between each other, yet they attained significantly higher yields compared to SAFS (+136 %). The percentage of diseased fruits in the total amount of harvested fruits was low, ranging from 0 to 6 %, and did not significantly differ between the systems (data not shown).

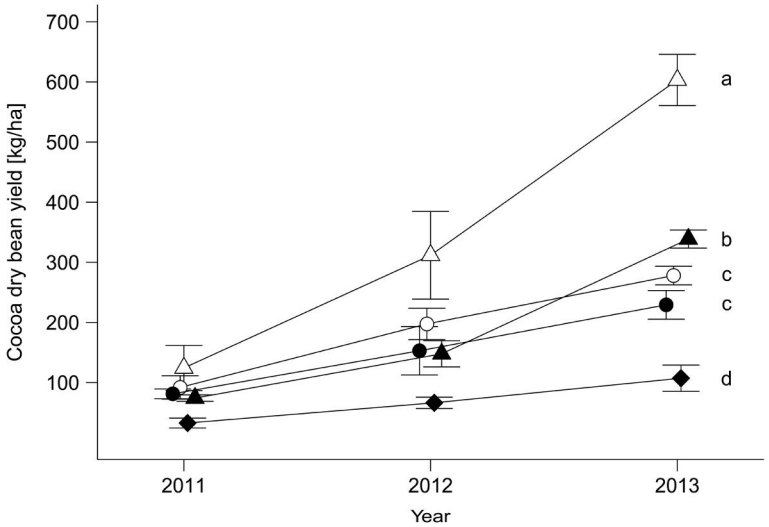

Figure 2: Development of cocoa dry bean yields 2011 – 2013 [kg ha^{-1}]. Production systems: (Δ) full-sun monoculture under conventional management (MONO CONV), (▲) full-sun monoculture under organic management (MONO ORG), (○) agroforestry system under conventional management (AF CONV), (●) agroforestry system under organic management (AF ORG), (♦) successional agroforestry system under organic management (SAFS, dynamic multi-strata, zero external input system.

Table 1: Cumulative dry matter yields [kg ha^{-1}] of marketable products harvested in five different cocoa production systems from 2009 to 2013.

Factor	Cocoa beans full stock yields[1] (2011 – 2013)				Cocoa beans current stock yields[2] (2011 – 2013)				Plantain bunches (2009 – 2011)				Banana bunches (2012 – 2013)				Diversified grains[3] (2009 – 2013)		Diversified fruits and tubers[4] (2009 – 2013)		Total (current stock yields 2009 – 2013)			
Post-hoc comparison of Crop diversity and Management practice analysis	Mean			sem	Mean			sem	Mean			sem	Mean			sem	Mean	sem	Mean	sem	Mean			sem
AF	598 [b]			48	498 [b]			45	3'568 [a]			902	8'036 [a]			841	-	-	-	-	12'101 [a]			1'720
MONO	1'012 [a]			155	756 [a]			110	3'874 [a]			921	0 [b]			0	-	-	-	-	4'630 [b]			1'002
CONV	1'009 [A]			157	767 [A]			109	4'469 [A]			930	4'478 [A]			1'738	-	-	-	-	9'714 [A]			1'914
ORG	601 [B]			45	487 [B]			38	2'972 [A]			802	3'558 [A]			1'496	-	-	-	-	7'017 [A]			1'940
ANOVA of Crop diversity and Management practice analysis																								
Source of variation	numDf	denDf	F value	*p* value	numDf	denDf	F value	*p* value	numDf	denDf	F value	*p* value	numDf	denDf	F value	*p* value	-	-	-	-	numDf	denDf	F value	*p* value
Crop diversity (D)	1	9	26.209	0.001	1	9	20.778	0.001	1	9	0.151	0.706	1	9	91.440	< 0.001	-	-	-	-	1	9	24.430	0.001
Management practice (M)	1	9	27.516	0.001	1	9	24.376	0.001	1	9	3.618	0.090	1	9	1.200	0.302	-	-	-	-	1	9	2.591	0.142
D × M	1	9	11.373	0.008	1	9	11.347	0.008	1	9	0.320	0.585	1	9	1.200	0.302	-	-	-	-	1	9	0.076	0.789
Land preparation	1	2	5.467	0.144	1	2	4.000	0.184	1	2	17.835	0.052	1	2	0.610	0.517	-	-	-	-	1	2	7.870	0.107
Post-hoc comparison of System analysis	Mean			sem	Mean			sem	Mean			sem	Mean			sem	Mean	sem	Mean	sem	Mean			
AF CONV	658 [b]			53	542 [b]			53	4'093 [a]			1'410	8'957 [a]			853	-	-	-	-	13'592 [a]			2'183
AF ORG	538 [b]			74	453 [b]			73	3'042 [b]			1'275	7'115 [a]			1'416	-	-	-	-	10'610 [ab]			2'749
MONO CONV	1'360 [a]			173	991 [a]			139	4'845 [a]			1'398	-			-	-	-	-	-	5'837 [c]			1'521
MONO ORG	665 [b]			35	521 [b]			26	2'903 [b]			1'172	-			-	-	-	-	-	3'424 [c]			1'183
SAFS	239 [c]			30	195 [c]			34	1'230 [b]			795	99 [b]			99	1'750	104	5'118	562	8'392 [b]			796
ANOVA of System analysis																								
Source of variation	numDf	denDf	F value	*p* value	numDf	denDf	F value	*p* value	numDf	denDf	F value	*p* value	numDf	denDf	F value	*p* value	-	-	-	-	numDf	denDf	F value	*p* value
System	4	12	34.969	< 0.001	4	12	30.905	< 0.001	4	12	3.551	0.039	4	12	35.115	< 0.001	-	-	-	-	4	12	8.617	0.002
Land preparation	1	2	5.079	0.153	1	2	3.978	0.184	1	2	14.645	0.062	1	2	0.713	0.487	-	-	-	-	1	2	7.663	0.101

[1]Cocoa dry bean yields after fermentation and drying (water content: 8 %), full stock yield = current stock yield standardized with number of trees > three years; sem: standard error of the mean; [2]current stock yield = actual surface yield; [3]diversified grains included maize, rice, pigeon pea and achiote (for details see Schneider *et al*. (2016)); [4]diversified fruits and tubers included cassava, hibiscus, pineapple, tannia, ginger and turmeric (for details see Schneider *et al*. (2016)); MONO CONV: Monoculture under conventional management, MONO ORG: Monoculture under organic management, AF CONV: Agroforestry system under conventional management, AF ORG: Agroforestry system under organic management, SAFS: Successional agroforestry system under organic management (dynamic multi-strata, zero external input system); different superscript letters indicate significant difference between mean values (multilevel modelling approach according to Gelman *et al*. (2012), $P(\text{Diff}>0) < 0.05$ *p* value and degrees of freedom (numDf: nominator Df, denDf: denominator Df) of fixed effects in linear mixed effect models, random factors in the model: Block (n=4).

Total system yields (2009 – 2013) and ecological benefits

In the AFs, substantial amounts of banana were harvested in 2012 and 2013 (8'036 kg ha^{-1}). In SAFS, considerable amounts of diversified fruits and tubers were harvested between 2009 and 2013 (5'118 kg ha^{-1}, Table 1). SAFS was the only system in which these crops were cultivated. The MONOs achieved both the highest cocoa dry bean yields, and MONO CONV additionally exhibited the highest plantain yields (4'845 kg ha^{-1}, harvested from 2009 to 2011) compared to all the other systems (+72 %). Despite this, the cumulative yields of all marketable products in MONO CONV and MONO ORG could not reach the level of the three agroforestry systems (Table 1).

Total system yields ranged from 13'618 kg dry matter ha^{-1} in AF CONV to 3'464 kg dry matter ha^{-1} in MONO ORG (Table 1). The AF CONV showed significantly higher values than SAFS and the MONOs (+131 %), followed by AF ORG and SAFS which were significantly higher than the MONOs (+105 %) but did not differ significantly from each other. The MONOs ranged lowest (-57 % compared to the other three systems) and were not significantly different from each other.

Discussion

Did we succeed in providing long-term data on the performance of MONO and AF under CONV and ORG management? Partly. One would not typically call results from the establishment phase of a cocoa plantation "long-term". So we have a way to go. But the fact that we dispose of this unique long-term trial described in this paper makes us optimistic that we will be able to do so in the future. The results we showed in this paper underline the reported potential of AF to contribute to local food security and risk distribution in smallholder contexts, and call for the elaboration of sound management recommendations in ORG cocoa production. Given the projected price increases for cocoa on the global market in the coming decades, the economic evaluation of our findings (addressed in a separate publication) is of utmost importance. Future research on trade-offs in ecological, economic and social dimensions may eventually allow for a holistic assessment of the different cocoa production systems.

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Can mineral nutrients be limiting factors to organic agriculture expansion at the global scale? – A spatially explicit approach

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Key words: global scale, organic agriculture, spatial-explicit modeling, budgets, fertilisers

Abstract

The potential contribution of Organic Agriculture to feed the world in the next decades is a controversial question. In this context, it is of critical importance to assess the factors that may limit organic farming expansion. In particular, due to the ban of chemical sources, nutrient availability for organic farming may fall short if organic farming strongly expands at the global scale. This study makes a first step into exploring the consequences of organic farming expansion on nitrogen (N) and phosphorus (P) balances. To do so, we tested the feasibility of organic farming expansion by calculating N and P budgets under a set of production assumptions, using a spatially explicit approach. A conversion to organic agriculture of 30 % and 100 % of the global crop and livestock production was simulated. Results in the 30 % organic world scenario showed a predominance of areas with a positive nutrient budget. Contrastingly, in the 100 % organic world scenario budgets in areas of intensive crop production became negative.

Acknowledgments

The authors are grateful to the Nathaniel D. Mueller and to Verena Seufert for providing part of the dataset, and to the anonymous reviewers for valuable comments on the manuscript.

Introduction

The potential contribution of Organic Agriculture (OA) to feed the world in the coming decades is a highly controversial question. Answering this question requires exploring scenarios of OA expansion at the global scale. One of the central issues is whether nutrient resources in compliance with OA requirements can support organic crop demand if organic production strongly expands. An eventual decrease in nutrients availability would create a vicious circle, leading to a decrease of crop yields, livestock numbers and, consequently, available organic fertilisers. Interactions in terms of nutrient exchanges between OA and Conventional Agriculture (CA) exist through material exchanges and might play a substantial role in supporting this expansion. To address this question, we developed a spatially explicit modeling approach to calculate N and P budgets for both CA and OA agricultural area under different scenarios of organic farming expansion.

Material and methods

Overall, we calculated spatially explicit soil N and P budgets for both CA and OA at the grid cell scale (5 min resolution, equivalent to 10 x 10 km at the equator) for the whole planet. Budgets were calculated as the difference between soil nutrients inputs (livestock manure, N fixed by legumes, N atmospheric depositions, and CA synthetized fertilisers) and outputs (crops exports) for each grid cell. Hence, soil was not part of the system considered, i.e. land quality differences were not taken into account. Nutrients flows from CA to OA have been reported (Nowak et al. 2013). Our scenarios will take into account these interactions. As a matter of fact, we firstly computed CA budgets, and we estimated the eventual animal

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manure surplus available in conventional manure. This manure surplus was considered to be potentially available as a nutrients source for OA.

Global spatially-explicit datasets on crop production (Monfreda et al. 2008), inorganic fertilisers application (Mueller et al. 2012), livestock numbers distribution (Robinson et al. 2014), and deposition of atmospheric nitrogen (Dentener et al. 2006) were collected. In total 164 countries, 46 crops and 5 livestock species were considered.

Budgets were calculated according to the following base equation:

$$[\sum_{i,k=1}^{5,164}(L_i \times e_{ik}) + \sum_{j=1}^{42} F_j + \sum_{w=1}^{10}(A_w \times f_w) + N_{dep}] - [\sum_{j=1}^{42} A_j \times Y_j \times n_j]$$

where:

- L_i is the livestock heads in each grid cell for the *i* animal species (cattle, pigs, sheep, goats, and poultry) and e_{ik} is the excreta coefficient for each animal species *i* and each country *k*;
- F_j is the amount of inorganic fertilisers applied in CA to each grid cell for each crop species *j*;
- A_w is area cultivated under each *w* legume species and f_w is the coefficient of N fixation computed according to Høgh-Jensen et al. (2004);
- N_{dep} is the N total atmospheric deposition;
- A_j, Y_j, and n_j are the area cultivated under each crop species *j,* their correspond yield and nutrients contents, respectively.

Crops' nitrogen and phosphorus content was collected from literature (Food Standards Agency 2002; INRA 2007; INRA et al. 2016) while country-specific livestock excreta coefficients were calculated as proposed by Sheldrick et al. (2003). Crop yields were taken from (Monfreda et al. 2008) for conventional farming and were then applied a ~ 20 % yield-gap for organic farming (Seufert, 2012, De Ponti 2012, Ponisio, 2014). In order to account for the respective leakages, inorganic fertilisers as well as the manure available to fertilise croplands was corrected according to the IPCC guidelines on nutrient losses (IPCC, 2006).

Two scenarios of organic farming expansion (30 % and 100 % of global cropland and livestock production) were tested. Conventional budgets were calculated under the hypothesis that, where possible, farmers use organic manure to balance crop nutrient requirements. The resulting surplus of animal manure, if any, was considered to be available for organic farmers within the same grid cell. Results of the OA budget allow identifying areas where N and P availability may currently represent a limitation (areas with negative budgets). All calculations were performed using the R 3.1.10 (R Development Core Team 2015).

Results

The calculations under the 30 % organic farming expansion scenario showed that N budgets in OA were null or positive in 86 % of the global grid cells. N surplus is especially present in areas characterised by a high livestock density. For P, the global budgets had a much smaller range and were generally more negative (Table 1), showing that organic systems might be more susceptible to phosphorus deficiencies.

On the contrary, in the 100 % organic farming expansion scenario most grid cells exhibited negative N budget, especially in areas of intensive cropland production (Fig. 1). The percentage of positive cells dropped to 71 %, which represents a huge difference if we consider that most of the new negative area in this scenarios are located in areas of intensive production, and, therefore, might have huge impacts on crop yields and finally on food/feed production.

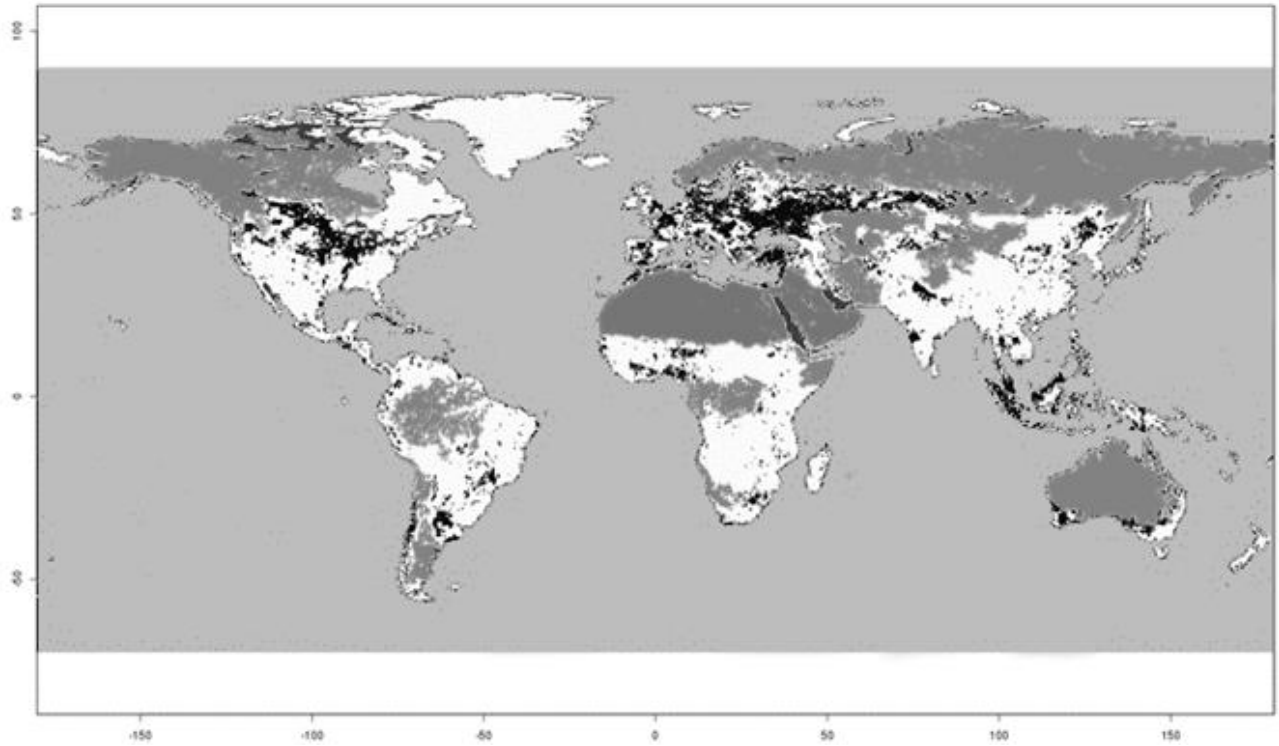

Figure 1. Global map of nitrogen budgets in the 100 % organic production scenario. The areas in black have negative N budget, areas in white have null or positive N budget, while areas in gray represent grid cells with no agriculture production.

Table 1. Average statistics for different tested scenarios of expansion of organic agriculture at the global scale.

Variable	Nitrogen, 100 % production conversion	Nitrogen, 30 % production conversion	Phosphorus, 30% production conversion
Budget (average)	0.52 t ha^{-1}	0.90 t ha^{-1}	0.16 t ha^{-1}
SD	3.02 t ha^{-1}	6.25 t ha^{-1}	1.24 t ha^{-1}
Range	-1.9 t ha^{-1}; 556 t ha^{-1}	-0.53 t ha^{-1}; 713 t ha^{-1}	-0.04 t ha^{-1}; 144 t ha^{-1}
Positive grid -cells	71 %	86 %	74 %
Negative grid-cells	29 %	14 %	26 %

The distribution of cells with positive budgets differed in the two scenarios. Positive grid cells had between 0 to 713 t N grid $cell^{-1}$ in the 30 % organic farming scenario, while they ranged between 0 and 556 t N grid $cell^{-1}$ in the 100 % organic farming scenario. This difference is partially due to CA manure surplus as an additional nutrient source in the 30 % organic farming scenarios. Therefore, such results show the significant contribution that conventional manure surplus may play as a nutrient source in OA systems.

Discussion

This preliminary analysis shows the potential of a spatially explicit approach to assess production scenarios, as a consequence of organic farming expansion. On one hand, such approach allows to geographically identify areas with unbalanced budgets and to suggest local solutions which can be tested in further scenarios. On the other hand, it allows to model nutrients source availability geographical constraints (e.g. to account for a confined manure transportability). However, our calculations rely on strong assumptions because we did not account for i) change in livestock distribution and density, ii) change in land use, and iii) transportability of manure among grid cells. Moreover, our calculations are based on the assumption that manure surpluses of CA may be used for OA, which is questionable. Despite these limitations, these preliminary results suggest that nutrient availability is not likely to limit OA performances in the 30 % expansion scenario whereas is it likely to be the case in the 100 % expansion scenario.

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Conventional versus organic farming systems: dissecting comparisons to improve cereals organic breeding strategies

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Key words: small grain cereals, yield, plant breeding strategy, conventional farming, organic farming, low-input managements.

Abstract

"Conventional" and "organic" farming systems are compared in many studies. However the lack of concern about the diversity of both conventional and organic farming systems can be imputed to the oft-quoted methodological difficulties of comparing conventional and organic systems. Indeed, the analysis of articles on genotype performance of small grain cereals under conventional and organic management strategies revealed that there are significant variations in input levels within the two systems. In addition, this could lead to conflicting results when attempting to identify the best breeding strategies for organic management systems. So our proposal is to discuss of an international classification of agroecosystem managements based on recognized agro-climatic and management indicators, proposed for both conventional and organic management strategies. This work would facilitate the sharing of new results among agronomists and breeders for designing more adapted and efficient strategies.

Introduction

Numerous studies have compared the performance of "organic" and "conventional" agriculture in terms of yield, environmental and economic impacts. "Conventional farming" is generally associated with high-chemical-input agriculture. However, this term, which is commonly used in the scientific and agricultural literature, is devoid of technical content. To draw a general definition, conventional farming qualifies the predominant agricultural practices applied in one region.

Conventional farming is contrasted to organic farming which prohibits the use of synthetic fertilizers and pesticides and relies on healthy living systems, taking advantage of biodiversity and recycling. Approved certification bodies certify farms based on a set of production standards.

After a lack of breeding effort dedicated to organic farming, plant breeding became one field concerned. But to reach this goal was the "conventional" versus "organic" comparison really relevant? Indeed, what crop managements were compared concretely?

Material and methods

In the continuum of non-organic crop management, several management strategies for crop cultivation can be distinguished from Intensive High Input (HI) characterized by heavy use of pesticides and chemical fertilizers to Extensive farming. Integrated Pest Management (IPM) significantly reduces pesticides. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms, with the use of pesticides as a last resort.

The qualifications "low-input" (LI) and "extensive" farming systems (EXT) are sometimes used interchangeably (Nemecek et al., 2011). However, in this communication, we distinguish the Swiss "Extenso" management from extensive farming. The low-input management is a breeding strategy management equivalent to "Extenso", in which weeds are controlled by herbicides associated with mechanical weeding, nitrogen fertilization is reduced and the use of fungicides and growth regulators

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prohibited (Le Campion et al., 2014; Loyce et al., 2008). Extensive farming is here considered as a very low input management system that uses very small amounts of inputs relative to the low yield potential of the land area. Besides, this latter management can be followed to respond to specific environmental constraints (water quality recovery plans in catchment basin).

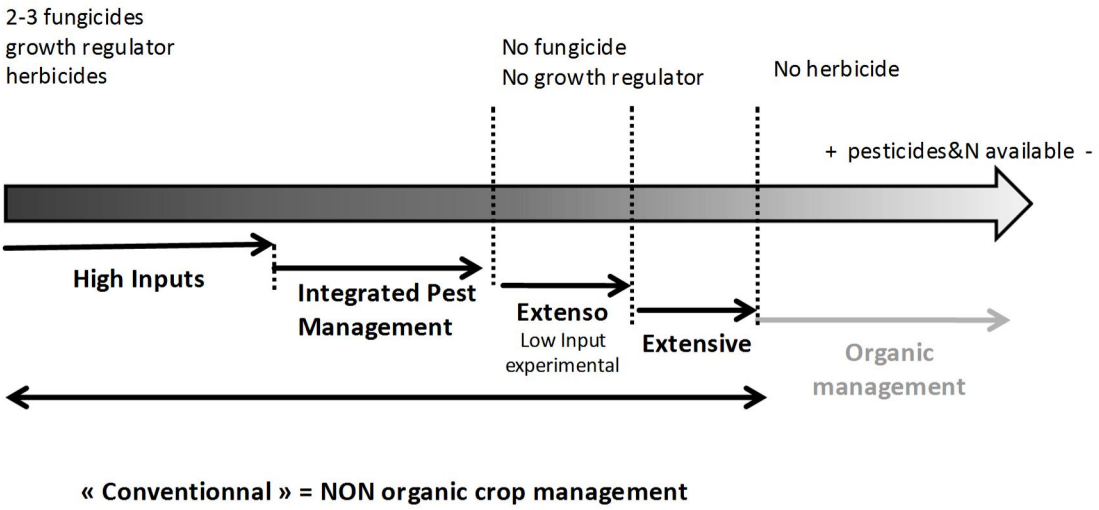

Figure 1. Schematic representation of winter wheat management continuum across the world

As underlined by Lammerts van Bueren (2011), it is estimated that more than 95% of organic production is still based on crop varieties that were bred for the conventional sector and consequently lack important traits required under organic and low-input production conditions. Indeed, quantifying genotype × environment × management interactions is a good method for establishing efficient breeding strategies.

Small grain cereals is one of the most relevant crop type in global food security, and as such, the move toward resilient and more sustainable small grain cereals production, in particular winter bread wheat, by reducing levels of chemical inputs is a major challenge. We carried out a comparative analysis of the scientific literature on the comparison of genotype performances of small grain cereals under organic and conventional managements in a plant breeding context. Our goal was to identify studies comparing small grain cereals performance under "conventional" and "organic" management systems in a breeding context. A full literature search on our issue was carried out using the ISI Web of Science. When sufficiently detailed (detailed number of treatment, detailed fertilization) crop management sequences were provided then the conventional and organic managements were inventoried. This analysis on 21 experiments aimed at identifying gaps and bottlenecks in the development of a comprehensive breeding strategy for organic farming.

Results

Based on the analysis of the selected articles, we illustrated a continuum in farming practices from high input to organic crop managements, based on two major criteria: N supply and the number of treatments (pesticides) applied to winter bread wheat (figure 2). One treatment is equivalent to one application of one commercial product. Within each management system some differences in terms of input levels can be assessed. Figure 2 does not take into account the residual amount of N available because only a few papers supplied this information. However of note is the gap between Australian and English managements both qualified as "conventional" by the authors. Thus as mentioned above, the term "conventional" while referring to the most widespread farming practices in one region is misleading at a world or country scale.

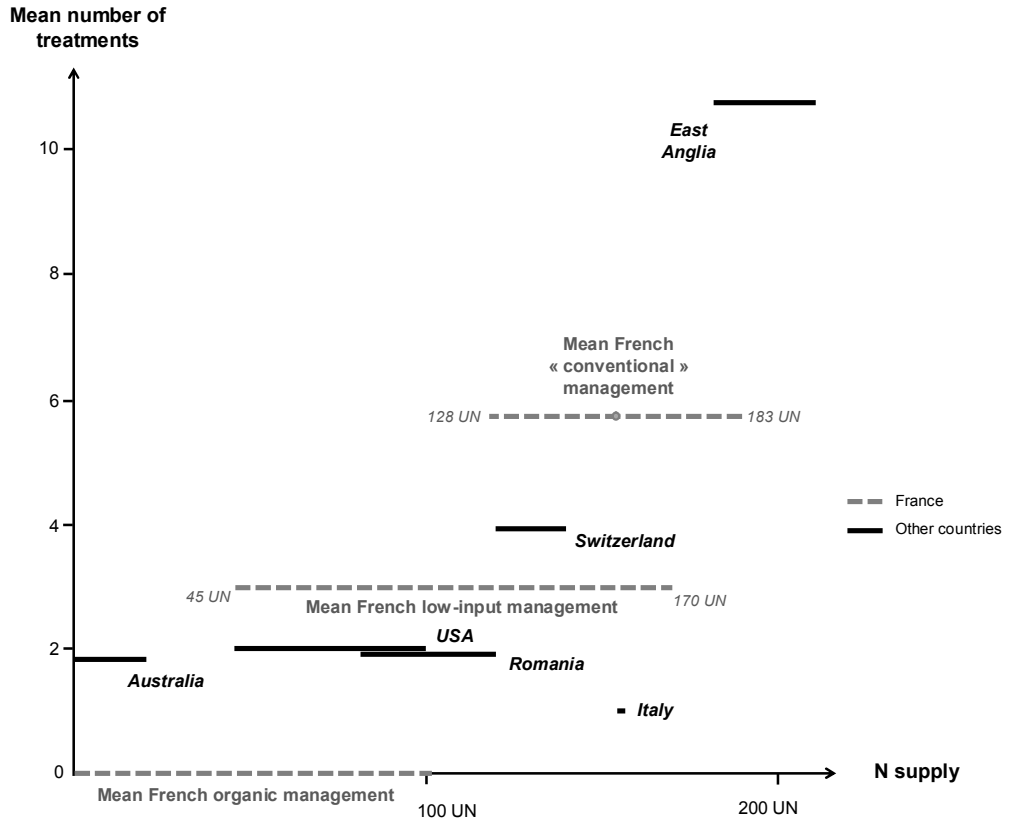

Figure 2. Diversity in farming practices for "conventional" management systems in worldwide, and of mean French "low-input" and "organic" managements.

Discussion

The yield gap between the two managements is highly variable among studies (from 44% to 96%). The yield reduction is very contextual and depends on the intensity of the conventional crop management plan, local yield potential and year effect. In plant breeding, to characterize the most suitable selection environment for one target environment it is necessary to deal with genotype × environment × management interactions. Also, the correlation between genotype performance under conventional and organic conditions was studied in several trials worldwide. However there is no general agreement among studies to identify the best selection environment for organic farming systems. According to authors direct or indirect selection for yield (in conventional farming) is more efficient for organic farming.

These contradictory reports can partly be explained by the lack of comparability within conventional and organic systems. As demonstrated above, the intensity of "conventional" farming varies considerably among countries and sometimes, as in France, between regions of one country. The same comment can be made for the experimental conditions of organic farming which can strongly differ, particularly in terms of nitrogen availability.

As a result, each management comparison trial is specific and determined by interactions between varieties, management and environment, in which the latter depends on agro-climatic limiting factors. Thus, to permit management comparisons in a breeding context, it is necessary to precisely define managements and environments and to add standardized labels. Such an international classification would facilitate to the breeders the sharing of new results and the exchange of lines in a multi-environmental screening purpose. For both managements, a climatic or agro-environmental indicator (temperature, rainfall) would be informative to identify main limiting factors. Yield potential assessed by the mean yield obtained under mainstream management conditions is a synthetic result of climatic and agro-environmental conditions. This mean yield indicates the fertility status of the land. We divided yield potential for cereal cultivation in three classes: P++ for high yielding lands, P+ for intermediate yield potential and P- for stressful environmental conditions. "TFI" and "nitrogen supply" are also useful to characterize the "conventional" managements.

To boost breeding activities to the organic sector our proposal is the establishment of an international classification of agroecosystem managements based on recognized agro-climatic and management indicators.

Acknowledgments

The authors gratefully acknowledge L. Saur, A. Gravot, A-M. Chèvre, S. Guyot, L. Guichard, R. Euvrard, J.P. Deguine, I. Felix and C. Kerbrat for their direct or indirect involvement in the preparation of this communication. We would like to thank MM. Chevalier, Ingrande, Mogis and Pinelli, organic farmers who received INRA on-farm trials in Brittany, Poitou and Ile-de-France regions for 16 years, and for sharing their knowledge and perspectives on agricultural practices.

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Biodynamic Agriculture; A Boon for Small Farmers of India, Comparative Field Trial on Soybean and Wheat Cropping Systems

Binita Shah, Sanjay Roman, Dr Khadse, Dr Bhale, Dr Nilesh Teli, SARG Vikas Samiti , Uttarakhand , India

Key words**: biodynamic, carbon, biodynamic preparations, cow pat pit, BD compost, small farmer**

Abstract

Importance of carbon in soil health is well known. Its falling availability in Indian soils is a major challenge today. All Organic Agriculture systems and techniques bring about a positive change in soil health but due to poor knowledge and understanding of different organic agriculture techniques, package of practice and production issues, not many farmers are able to follow the organic systems in a successful manner.

SARG , India is working towards the promotion of Biodynamic Agriculture (BD) for the last 20 years. A comparative study was done by PDKVY, Akola, India for two consecutive years 2013- 14 & 2014 – 15 with soybean and wheat cycle in the University Organic Farming Research Centre. In the two year study it was revealed that Biodynamic package of practice gave rise to percent increase in available nutrients like N,P,K, pH & C which was more than other comparative practices like control (farmer practice) , conventional (agro – chemical) . At the same time the Cost benefit ratio in the input costs and total production also showed an upward trend in the BD plot. While in 2014-15 trial soybean (khariff) was produced with BD practice with cost of INR3 750, Farmer Practice with INR3250 and Conventional with INR11,000 and wheat trial in 2014 rabi crop was produced in the cost of INR5875 in BD , INR5250 in control (farmers practice) and conventional by Rs11,750. Thereby depicting the double advantage of BD systems of both higher nutrient availability in soil as after 4 crops cycles as well as in cost benefit.

On the basis of the study which were conducted in partnership of SARG Vikas Samiti , India in Akola, Maharshtra , author's of the paper argue the case of biodynamic agriculture being one of the most cost beneficial and rejuvenating systems for agriculture for small farmers in India.

Acknowledgement

The authors duly acknowledge the kind cooperation and partnership of PDKVY, Akola, Maharashtra, VC Dr Ravi Prakash Dani PD, CAIM project supported by IFAD, Amravati, Maharashtra, Dr Nilesh Teli , Naturally Yours , Jalgaon , NRTT ,Mumbai, RA Ram, CISH (ICAR), Lucknow, State Training & Research Centre Machkhali , Almora , Dehradun

Introduction : Problem identification

Agriculture in India is moving towards a deepening crisis. Seventy five percent farmers of the country want to opt out of agriculture today. (Down to Earth , CSE march'14) This will lead to an all time low of people engaged in this very traditional occupation over 5000 years of agriculture history. Farmers have also been driven to sucides , according to the "National Crime Records Bureau" of **India** reported in its **2012 annual report**, that 13,755 **farmers committed sucide in India**. Of these, 5 out of 29 states accounted for 10,486 **farmers suicides** (76%) – Maharashtra, Andhra Pradesh, Karnataka, Madhya Pradesh and Kerala. A situation such as this is a result of a complex situation riddled by dispropotionate cost benefit ratio in agriculture . The prominant causes of the situation are unjudicious use of agro chemcials (on loans) followed by poor production due to irratic weather conditions . Debt based agriculture and paradox of loan default has led to this grave delimma where the youth are no longer in terested have a farming career. Looking closely at the soil health scenario of Indian soils we find that this gigantic repository of soil minerals and elements is rapidly loosing its bounty over the last few decades. As per the Indian Soil and Water Conversation Institute , Dehradun India is losing 5,334 million tons of soil every year due to soil erosion because of indiscreet and excess use of fertilizers, insecticides and pesticides over the years. About one millimetre of top soil is being lost each year with a total loss of 5,334 million tons annually due to soil erosion. The rate of loss is 16.4 tons per hectare every year. Experiments conducted by Indian Council of Agricultural Research (ICAR) indicated that non-judicious and imbalanced use of inorganic fertilizers (NPK) over years may result in deterioration of soil fertility/nutrient deficiencies. (**Hindu , Nov 26 2010**)

Modern agriculture technology is largely externalized and input based. The present practices do not address the soil health and on the contrary increase biotic pressure on the agro –ecosystem thereby marginalizing risk taking capacity by the farmer leading him to either opt out of the occupation or give up his life. The extension and technology transfer interventions most crucial for the farmer are carried out largely by commercial companies and are sales oriented.

Solution s to the problem (Methodology)

Biodynamic Agriculture principals are based on aligning with energies preponderant in the universe which are responsible for the creation and preservation of all life. While practicing biodynamic agriculture the more physical evidences of impact are observed in the evident improvement of soil structure, increased carbon content, balanced pH , availability of trace elements , increased production cycle of the crops , suppressed disease and pest incidence, high nutrition content in the

food products through the methodology of chromatography etc. Biodynamics Agriculture is a systems knowledge and reccomends use of specific inputs called as Biodynamic Preperations (BD 500 – 507) globally. The theory of biodynamic agriculture is based on the cosmic rythyms of universe. Biodynamic Agriculture also promotes the use of the planting calendar which is based on the lunar and the solar rythms.

Center for Organic Agriculture Research and Training (COART) , Department of Agronomy , Dr PanjabRao deshmukh Krishi Vidyapeeth Akola has conducted In situ Experiments over two years 2013-14 & 2014-15 to demonstrate sustainable Agriculture systems for the destressed districts of Vidharbha region, Mahatashtra. PI Dr VM Bhale and Co PI were Dr VK Khadse to find out the comparative results of the following treatments:

Salient Features of Experiment

Associated Agency	SARG Vikas Samiti (Supa Agricultural Research Group) Akola , HO Uttarakhand India
Year	2013-14/ 2014-15
Season	Kharif & rabi
Crop	Soybean, Wheat
Variety	Js 335, AKW 9305
Layout	Non Replicated Demonstration plot
Treatments	1) Biodynamic Agricultural Practices 2) Farmers Organic Agricultural Practices ()Control plot) 3) Conventional Agricultural Practices (Chemical)

Table No -1 Nutrient status of soil (2013-14)

Soil Properties	Biodynamic practices 2013-14				Farmers practices 2013-14				Conventional practices 2013-14			
	Soybean		Wheat		Soybean		Wheat		Soybean		Wheat	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
pH	7.8	7.74	7.74	7.70	7.8	7.79	7.79	7.72	7.8	7.80	7.80	7.79
EC	0.33	0.31	0.31	0.28	0.33	0.30	0.30	0.29	0.33	0.32	0.32	0.31
Available N (kg/ha)	215	221	221	230	215	219	219	225	215	219	219	222
Available P (kg/ha)	20.8	21.8	21.8	24.2	20.8	21.6	21.6	22.6	20.8	22.0	22.0	24.6
Available K (kg/ha)	330	332	332	340	330	331	333	333	330	331	331	334
Organic Carbon %	0.42	0.44	0.44	0.46	0.42	0.42	0.42	0.44	0.42	0.40	0.40	0.41

Table 1A Nutrient status of soil (2014-15)

Soil Properties	Biodynamic practices 2014-15				Farmers practices 2014-15				Conventional practices 2014-15			
	Soybean		Wheat		Soybean		Wheat		Soybean		Wheat	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
pH	7.70	7.60	7.60	7.60	7.72	7.70	7.70	7.70	7.79	7.80	7.80	7.82
EC	0.28	0.27	0.27	0.27	0.29	0.29	0.29	0.29	0.31	0.31	0.31	0.32
Available N (kg/ha)	230	235	235	239	225	225	225	227	222	220	220	219
Available P (kg/ha)	16.0	16.8	17.8	18.9	14.8	15.0	15.2	15.9	14.6	14.0	14.2	14.6
Available K (kg/ha)	340	342	342	345	333	334	334	336	334	332	332	333
Organic Carbon %	0.46	0.49	0.49	0.51	0.44	0.45	0.45	0.45	0.41	0.40	0.40	0.40

Table – 2 Production Status (q/ha)

Year	Biodynamic practices		Farmers practices		Conventional practices	
	Soybean	Wheat	Soybean	Wheat	Soybean	Wheat
	Prod. (Q/Ha)	Prod. (Q/Ha)	Prod. (Q/Ha)	Prod. (Q/Ha)	Prod. (Q/Ha)	Prod. (Q/Ha)
2013	21.75	41.9	16.5	36.6	22.5	42.8
2014	22.25	42.10	16.6	36.0	22.13	41.9

Table -3 Cost of Production (in Rs.)

Year	Biodynamic practices		Farmers practices		Conventional practices	
	Soybean	Wheat	Soybean	Wheat	Soybean	Wheat
2013	3750	5875	3250	5250	10500	11250
2014	3750	5875	3250	5250	11000	11750

Conclusion:

The Biometric observations viz. plant height numbers of tillers were comparatively higher in biodynamic plot over control plot (farmer practice). The Wheat grain yield under biodynamic treatment was increased by 14.5 % over control treatment, Where as it is at par with the yield of conventional practices. The cost of cultivation in biodynamic and farmers organic practices found much low as compared with conventional package of practices due to low input cost.

Maximum number of soil samples was found in low to medium range of organic carbon. However overall 10.81% increase in organic carbon was found in Biodynamic farming practice over conventional farming practice. Soil pH was lightly improved whereas negligible change in EC was observed. Available nitrogen wsa increased upto 10.84% in biodynamic farming practice over coneventional practice. In respect of phosphorous availibility , low range category moved to medium and medium forwarded to moderate range with overall increase of 11.45% in Biodynamic farming practice over conventional farming practice.

In a nutshell it could be inferred that biodynamic farming practice has: 1. relative benefit in crop economics , 2.compatibility with farmers 3. ecological benefit

Material and methods

Materials:

Biodynamic Agriculture system entails the use of the Biodynamic preparations called preparation 500, 501, 502, 503, 504, 505, 506, 507 & 508 globally by BD practitioners. Of these the preparations 500 & 501 are called the field preparations and 502 – 507 are called and used as compost & CPP making preparations. Preparation 500 is used @30grams in 13 liters of water as broadcast ,on an acre before sowing and once in two leaf stage, 501 is to be sprayed 1 gms in 13 liters of water in mist spray at two leaf stage. The compost preparations are used @ 1gms each in 100 cu meter. The preparations are made under the guidelines laid by the Biodynamic Association of India(BDAI) which is a member of Demeter International (DI) (Germany) . DI governs the methodology of preparation making associations and agencies. In this case the preparations were made by SUPA Biotech an agency making preparations in the Himalayan region for the last 20 years and certified by IMO Bangalore and monitored by BDAI. The BD compost , CPP and the liquid bio-pesticides were made at the COART, Akola under the supervision of the PI's and partner agency SARG Vikas Samiti. Material s used in BD compost was 30% cow dung, 50% agriculture waste, 2% lime, 8% green matter and 10% water . The compost was inoculated with CPP @ 2kgs per 300 cu feet . The materials were put together in layer system windrow with aerobic decomposition , compost was ready in 60 days. CPP was made with 60 kgs fresh dung from a lactating cow, 200 gram crushed egg shells & 200 grams basalt powder. The CPP is inoculated with 2 sets of (2 gms) of BD preparations 502 – 507 in a 3 sq feet earthen pit underground . The CPP is ready in 60 days and is used for compost inoculation, seed treatment as well as foliar spray. The bio-pesticide was made by using locally available botanicals like neem, dhatura leaves as well as nettles (urtica dioca) in equal parts which was 20% and mixed with water . Cow urine @5% was added to this mixture and left to ferment for 5 days to be used as a prophylactic spray in the crops.

Details of Biodynamic cultural treatments for Soybean (2013, 14)

Variety	Js 335

Layout	Non Replicated Demonstration plot
Treatments	1) Biodynamic Agricultural Practices 2) Farmers Organic Agricultural Practices ()Control plot) 3) Conventional Agricultural Practices (Chemical)
Details of Treatments	1- Biodynamic Agricultural Practices **(a)** Biodynamic Compost (3 ton/ha), **(b)** Seed treatment (BD CPP), **(c)** BD 500 (Soil conditioner) & 501 (Fungal resistant), **(d)** Biodynamic liquid Manure, **(e)** Sowing according to Biodynamic Planting Calendar
	1) Farmers Organic Agricultural Practices (Control plot) **(a)** Seed treatment (Rhizobium), **(b)** FYM ()5 ton/ha), **(c)** Dashaparni Spray, (d) Neemicide spray
	1- Conventional Agricultural Practices (Chemical) **(a)** Seed treatment (Rhizobium), **(b)** FYM (5 ton/ha), **(c)** 30:75 Np Kg/ha, **(d)** Chloripyriphos one spray
Plot Size	50x30 Sq.Mt
Spacing	45x5 cm
Date of sowing	24.06.2013 & 25.06.14
Intercultural operation	Hoeing – One Weeding – Two
Date of Harvesting	18.10.2013 & 18/10/14

Cultural treatmens for wheat (2014, 15)

Variety	AKW 9305
Layout	Non Replicated Demonstration plot
Treatments	4) Biodynamic Agricultural practices 5) Farmers Organic Agricultural Practices 6) Conventional Agricultural Practices (Chemical)
Details of Treatments	4) Biodynamic Agricultural practices: **(f)** Biodynamic compost (7 ton/ha), **(g)** Seed Treatment (BD CPP), **(h)** BD 500 (soil conditioner) & 501 (Fungal resistant), **(i)** Biodynamic Liquid Manure **(j)** Sowing according to Biodynamic Planting Calendar
	5) Farmers Organic Agricultural Practices (control plot): **(e)** Seed treatment (Rhizobium), **(f)** FYM (5 ton/ha), **(g)** Dashaparni spray **(h)** Neemicide spray
	6) Conventional Agricultural Practices (Chemical) **(e)** Seed treatment (Rhizobium), **(f)** FYM (5 ton/ha), **(g)** 100:50:50 NP Kg/ha **(h)** Two spray (insecticide, fungicide)
Plot size	50 x 30 Sq. Mt
Spacing	23 x 5 cm
Date of Sowing	26.11.2013 & 25.11.14
Intercultural operation	Hoeing - One Weeding – One
No. of Irrigation	Four
Date of Harvesting	16.03.2014 & 18/3/15

Method of Analysis :
Partical size distribution – by Bouyucous hydrometer method using sodium metaphosphate (100 ml) as dispencing agent.
P^H (1:2.5 Soil : Water suspension) - P^H Meter (Jackson 1967)
Electrical Conductivity (1:2.5 Soil: Water suspension) - Jackson 1967
Organic Carbon – by Walkely and Black wet oxidation method
Available N – by Subbiah and Asija (1956)
Available Ph – by Olsen's method
Available K – by using flame photometer (Jackson 1967)

Method of Plant Analysis:

Total N – by Kjeldahl's method (Jackson 1967)
Total P – by Vanadomolybdate yellow colour method (Jackson 1967)
Total K - by using flame photometer (Jackson 1967)

Quality Studies:

Protein content – calculated by multiplying nitrogen content % inseed with factor 6.25
Test Weight (g) – Randomly 1000 seeds for each plot were taken and weighed in gm.
Statistical Analysis – by using the method of analysis of varience and means were tested for significance. Critical difference at 5% level of significance. (Panse and Sukhatme 1967)
Location Experoments – Investigation was carried out at the Western Block Central Research Station, Dr. Panjabrao Deshmukh Krushi Vidhyapeeth (PDKV) Akola.

Results & Discussion

The results clearly revealed in Table 1 , Table 2 & Table – 3 where the BD practice shows a superior result over control and the conventional . The percent increase in carbon , Nitrogen, phosphate as well as potassium is more than that of the control and the conventional system which is based on agro – chemicals. In the conventional system the organic carbon has gone down at the end of the first season of soybean and wheat by 01% i.e from base line data 0.42 % it went down to 0.41% and further in the next season of 2014 at the end of the wheat season it has further gone down to 0.40 % further whereas in BD systems its has risen from base line 0.42% to 0.51 % at the end of the two year trial.

Similar is the case of nitrogen where the base line data was found to be 215 kg/ha (intial soybean 2013)and found to be 239 kg/ha at the end of the 2014 wheat whereas in conventional it was found to be 219 kg/ha in the end of the wheat season of 2014. The cost benefit analysis most interestingly shows that the BD systems can deliver the maximum with the least cost. The Cost benefit ratio in the input costs and total production also showed an upward trend in the BD plot. While in 2014-15 trial soybean (khriff) was produced with BD practice with cost of INR 3750, Farmer Practice with INR 3250 and Conventional with INR 11,000 and wheat trial in 2014 rabi crop was produced in the cost of INR 5875 in farmers practice INR 5250 and conventional by Rs11,750.

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Journal article

ISSN2229, RNI No , UPENG /2006/22736 , Journal of Eco-friendly Agriculture: Impact of organic manure and Bioagencts /Botanicals on major crops in Uttarakhand Hills , J *Aswal , DS Negi , Shah Binita*

RNI No.UPENG/2006/22736 ISSN2229-628X , Journal of eco Friendly Agriculture Vol 8,No1 , 2013 ,Integrated Organic Management of powdery mildew in vegetable peas caused by *Erisphye polygoni , Devendra singh Negi,,J Kumar, Rajan Kumar Gupta and Binita Shah.*

Book

Proctor Peter Grasp The Nettle, Quantum Agriculture , Hugh Lowell, Manual on Biodynamic Agriculture RK Pathak, RA Ram

Dissertation

Shah Binita , Organic Agriculture in Uttarakhand , Msc Ecology & Environment , Sikkm Manipal University 2007 ,

Abbreviations:

CAIM : Convergence Agriculture Initiative and Marketing

COART : Center for Organic Agriculture Research and Training

SARG : SUPA Agriculure Research Group

SUPA : Steiner Universal Philosophy Agrica

BD **:** Biodynamic

CPP : Cow Pat Pit ,

PDKVY **:** Panjabrao Deshmukh Krushi Vidhyapeeth

IFAD : Internation Fund ofor Agriculture Development

NRTT : NavajBhai Ratan Tata Trust,Mumbai

CISH : Center Institute of Sub Horticulture, Luckhnow

ICAR : Indian Council of Agricultural Research

BDAI **:** Biodynmaic Association of Indis

DI : Demeter International

Ecology

Title	Author/s	Country
A complex monitoring of biodiversity of organic apple orchards could uncover the impact of agro-management strategies	Vladislav Haralampiev Popov, Evgenia Kostadinova, Emilia Rancheva, Hristina Yancheva	Bulgaria
A place based development of organic farming to tackle water pollution problems	Audrey Vincent, Philippe Fleury	France
Nature conservation achievements on organic farms with suckler cows in north-eastern Germany	Frank Gottwald, Karin Stein-Bachinger	Germany
Effective and economically viable organic agriculture under Inhana Rational Farming (IRF) Technology towards mitigation of climate change impact.	A. Seal, R. Bera, A. Datta, S. Saha, R. Roy Chaudhury, A. Chatterjee and A.K. Barik	India
A Comparison of the impacts of organic and conventional dairying on the aquatic environment	Alan Thatcher, David Horne, Ian Brookes	New Zealand
Equal yield-scaled and lower area-scaled nitrous oxide emissions in organically managed soils	Gattinger Andreas, Colin Skinner, Maike Krauss, Paul Mäder	Switzerland
Contribution of organic farming to public goods in Denmark - a knowledge synthesis	Lizzie Melby Jespersen, Niels Halberg	Denmark
Energy efficiency and greenhouse gases emissions in organic, integrated and conventional olive orchards in Greece.	Vasileios D. Gkisakis, Nikolaos G. Volakakis, and Emmanouil M. Kabourakis	Greece
Agro-biodiversity adaptation for resilience to climate change: paradigm for sustainability in perpetuity	Thomas Abraham	India
Agroecological service crops as a tool to manage the agrobiodiversity in organic orange orchards: a case study	Corrado Ciaccia, Anna la Torre, Elena Testani, Francesco Riva, Valerio Battaglia, Filippo Ferlito, and Giancarlo Roccuzzo	Italy
Carbon sequestration in long term on farm studies in Organic and Biodynamic Agriculture, Sweden	Artur Granstedt, Lars Kjellenberg	Sweden
The role of organic in controlling nitrogen pollution	Laura Cattell Noll, Allison M. Leach, Verena Seufert, Jim Galloway, Brooke Atwell, Jan Willem Erisman, Jessica Shade	USA
Organic farming increases soil C sequestration via changes in crop litter quality	Pablo García-Palacios, Rubén Milla, Andreas Gattinger	Spain

A complex monitoring of biodiversity of organic apple orchards could uncover the impactof agro-management strategies

Vladislav Haralampiev Popov[1], Evgenia Kostadinova[2], Emilia Rancheva[3], Hristina Yancheva[4]

Keywords: apple, agrobiodiversity, ecosystem, intensification, organic farming

Abstract

This complex study investigates causal relationships between biodiversity of insect indicator-insects in soil, on land surface and on trees, and agro-management practices in organic apple orchard in the region of Plovdiv, Bulgaria. In 2013-2015, indicator-insects density and biodiversity were higher in organic than in conventional orchard which was attributed to practices facilitating improved activity of beneficial insects in keeping pest population below threshold levels. Regression analysis showed a positive but mild correlation (at polynomial model) between agricultural intensification (AI)index and biodiversity indices (of Shannon and Simpson) of soil insects and land-surface insects, and a strong correlation (at linear model) between the indices on the organic trees. The AI index should however reflect other important factors impacting biodiversity, i.e. climate and soil conditions or agro-management (e.g. time of mowing, irrigation regime or time of pesticide applications).

Introduction

The modern organic fruit production in Europe strives to establish ecologically-balanced and productive agro-ecosystems. In the last decade, the concept of "ecofunctional intensification", based on efficient use of renewable resources, recycling of organic matter and use of enhanced biodiversity, is taking increasing importance (Niggli, 2010). The central place of functional biodiversity in the concept is determined by important ecosystem services it provides at farm level, e.g. integrated pest management, recycled soil organic matter and better water-holding capacity, etc. However, at the level of EU-28, there are no unified standards for monitoring and assessment of biodiversity of organic agro-ecosystems or the level of their eco-functionality. Therefore, the study investigated applicability of a complex monitoring of biodiversity of organic apple orchard and causal relationships between complex organic agro-management strategies and biodiversity in a local agro-ecological conditions context.

Material and methods

The three-year study was performed in 2013 to 2015 in an organic and a conventional apple orchards of approximately 0,5 ha each. The organic orchard is maintained at premises of the organic demonstration farm of the Agro-ecological Centre of Agricultural University of Plovdiv, and the conventional near the village of Kalekovetz situated at few kilometers from the town of Plovdiv. Climatic data (i.e. average rainfall, humidity and temperature) were taken from the local meteorological station of Plovdiv. Two apple varieties i.e. Florina and Melodie relatively tolerant to major apple diseases powder mildew and apple-scab were monitored. The intra-rows of organic orchard were maintained with a grass-clover mixture since April 2010, while the intra-rows of

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conventional orchard were partly grassed after spring of 2014. Major soil parameters of alluvial soils, typical for the studied region, i.e. digestible forms of nitrogen (N-NH_4 and N-NO_3, mg/100 g), phosphorus (P_2O_5 mg/100 g), potassium (K_2O mg/100 g), pH in water extract 1:5, humus content (%) were analysed by soil sampling from two layers, i.e. 0-20-cm and 20-50-cm, from eight experimental plots randomly placed in the intra-rows of the two apple varieties in the beginning of each vegetation season. Monitoring of biodiversity considered major factors in the apple growing (i.e. Scheme 1 below).

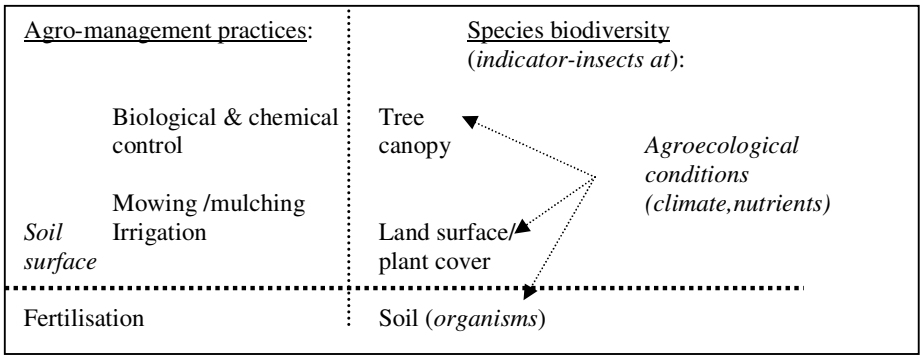

Figure 1. Factors impacting apple growing dynamics.

Agro-management practices

In organic orchard these included between 3 and 8 irrigations per month, 3-7 grass mowings per season, maintaining soil fertility with composted manure (13.33 t ha^{-1} in 2014) and Hemozim Bio-5 and use of pheromone (mating disruption) dispensers, Trifolio S Forte, Pirethrum, Madex, Nimazal. In conventional these included ~21-24 irrigations per month, ~3 mowings plus Roundup per season, and use of 4-5 applications of mineral fertilisers and 18-25 applications of chemical pesticides (i.e. Fungoran, Quore Christal, Chorus, Thiram, Karate, Score, Calipso, Vuksal macro-mix, Flint Max, Vucsal Bor, Delan, Decis, Dursban, Punch, Reldan, etc.).

Biodiversity monitoring

Biodiversity of soil organisms in soil depth was monitored by single sampling (using methodology of Guilyarov (1987)) at spring, summer and autumn in both orchards. Two plots of 0,50 m^3 each were placed in four apple orchards' intra-row. Soil was sampled in depth of 40 cm in each plot and then normalised per 1 m^3. Density and diversity of harmful and beneficial insects was calculated. Using a pitfall-trap method (Greenslade 1964), indicator-insects living on land-surface was counted once every month. For determining biodiversity of indicator-insects on apple trees, a 'shaking branches' method was used in both contrasting orchards, i.e. shaking at about 100 branches from the 4 sides of a tree, taking at least 10 trees per unit of land. Individuals caught in a hand-sack, were then collected, counted and their density was normalised per 100 tree-branches. It was done from March to November in each of the study years, three times a month aimed to consider the impact of climate and soil conditions. Species diversity and abundance were determined down to taxa (family) (Fauna Europea 2013), by employing following ecological parameters:

a) Density: total number of individuals of a taxa relative to 1 m^3 of soil (Magurran 1988) or on 1 m^2 land surface.
b) Shannon index (entropy): A diversity index, considering the number of individuals and number of taxa. Varies from 0 for communities with only a single taxa to high values for communities with many taxa, each with few individuals.
   $Hi = - \sum (ni / n) \ln (ni / n)$
c) Simpson index 1-D: The value ranges between 0 and 1. The greater the value, the greater the sample diversity. The index represents the probability that two individuals randomly selected

from a sample will belong to different species.

Simpson's Diversity Index = 1 - D = $\sum$ (n / N)2

The two indices of biodiversity are calculated by softwear PAST (Hammer et al. 2001) and data processed by STATISTICA 9.0 (StatSoft, Inc. 2004). The AI index (Herzog et al. 2006; Flohre et al. 2011) for both contrasting orchards was calculated on the basis of agro-practices aplied on the contrasting orchards, i.e. pesticides (number of treatments/season), applied fertilisers (kg N/year/da) and number of mechanical tillage (number of operations/season including mowing):

$$\mathrm{AI} = \frac{\sum_{i=1}^{n} (y_i - y_{i\min}) / (y_{i\max} - y_{i\min})}{n} \times 100$$

where AI is the agricultural intensification index, y_i is theobserved value (number of pesticide applications,amount of applied fertiliser and number of tillageoperations), y_{min} is the minimum observed value in allregions, y_{max} is the maximum observed value in allregions, n is the number of individual indicators, and i isthe identifier for the three indicators. Using regression analysis, the study investigated possible correlations between AI index and biodiversity at three levels, i.e. in soil, on land surface and on apple trees in both orchards.

Results

The low level of N and P in the soil of organic apple orchard was compensated by addition of composted animal manure and liquid fertlisers. Selection of species and group of insects, indicators of changes of biodiversity in response to changes in agro-ecological and management conditions, was crucial. Above the norm average rainfall and temperatures in 2014 and 2015, added by application of organic fertilisers, lead to higher density of soil indicator-insects, i.e. taxa *Lumbricidae* and *Porcelioidae*in organic orchard compared to conventional thus confirm Popov et al. (2014). The higher biodiversity indices (i.e. of Shannon and Simpson) for soil indicator-insects in conventional orchard indicated uniformiity of representativeness of species in soil, i.e. not only from taxa *Lumbricidae*, but also taxa *Geophilidae* and *Limacidae,* attributed to more frequent irrigation in intra-rows and grassing.ANOVA showed a significant impact (P<0.05) of interaction of main factors landuse, season andinsect taxa on the indicator-insects living on the land-surface in the two contrastingorchards. In the organic, the

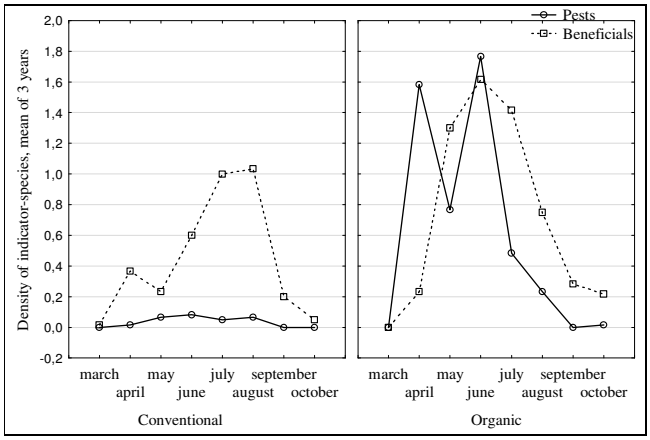

Figure 1. Impact of interaction of factors i.e. landuse and month (climate) (F(14, 1822)=17,796, P<0.05) on population dynamics of beneficial and pest insects on trees of organic and conventional orchard, mean of 2013, 2014 and 2015

impact was more profound in summer as shown by dynamics ofpest indicator-insects i.e. taxa *Grylidae* and the *Carabidae*, while in the conventional in autumn as shown by the taxa

Carabidae.The higher density of pest-insects on organic land-surface might be attrributed to organic fertilisation, maintenance of turf-mulching system and avoidance of herbicides. The impact was also significant (ANOVA, $P<0.05$) on the density of beneficial indicator-insects (i.e. *Coccinelidae, Chrysopidae* and *Cantharidae)* on organic trees (Fig. 1), where it was higher than conventional as well as the indices of biodiversity of Shannon and Simpson. Population dynamics of beneficial insects followed the dynamics of pest insects (because of food availability), but higher biodiversity reported on organic trees does not necessarily provided for a sustainable control of pest population density of *Tortricidae* (apple codling moth) and *Chrysomelidae* (leaf beetle). The polynomial and linear regression models and the mild to strong correlation (i.e between 0,632 and 0,801) between the AI index and the biodiversity indices (i.e. of Shannon and Simpson) of indicator-insects on organic soil, land-surface and trees indicated that ecological intensification lead to a higher biodiversity. However, only between 39% and 64% of the changes in the response variable biodiversity can be explained with changes in the factorial variable AI index. Almost 2/3 to 1/2 of these changes may be attributed to e.g. agroecological (e.g. climate and soil conditions) or agro-management (e.g. time of mowing, irrigation regime or time of pesticide applications) factors and the AI index should reflect these.

Discussion

The study contributes to global attempts to find a balance between ecological intensification of organic orchards and achieving sustainable production. Only a complex research of complex agroecological and agro-management relationships in various organic orchards may uncover the keys to achieve such balance. The study suggested that medium-term strategy for organic apple productionmust continue to employ biodiversity-friendly practices (e.g. turf-mulching, organic fertilisation)combined with pheromone mating disruption dispensers and bio-pesticides such as Madex and Nimazal to support beneficial insects in keeping pests below the damage threshold level. As shown by regression analysis, ecological intensification lead to a higher biodiversity, but it also signified that important agroecological (e.g. climate and soil conditions) or agro-management (e.g. time of mowing, irrigation regime or time of pesticide applications) factors must be considered when design organic pest-management strategies.

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A place based development of organic farming to tackle water pollution problems

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Key words: water pollution, place based development of organic farming, local action plan

Abstract

Organic farming (OF) appears as a potential solution to water pollutions problems because its regulations forbids the use of chemical fertilisers and pesticides. Developing OF to protect water quality requires having a place-based development of OF and it is a new challenge. In France, various projects therefore aim at targeting OF development in sensitive water catchment areas. In this paper, we carried out a case study analysis of such projects, analysing their design, the policy tools implemented and the stakeholders involved in their governance. Water managers appears as playing an active role in the promotion and the development of OF at local level. The implementation of local projects, in which OF is considered as a solution to local problems and challenges, appear as being a new feature of OF development. It brings organic stakeholders to interact with non agricultural stakeholders and this is one of the challenges to be dealt with for Organic 3.0.without the rest of the paper.

Acknowledgments

The authors gratefully acknowledge financial support from the Water Agency "Rhône-Méditerranée-Corse".

Introduction

Many countries face water pollution by nitrates and pesticides used in agriculture. In this context, organic farming (OF) appears as a potential solution to tackle water pollution problems (Benoit et al., 2014; Thieu et al., 2011) as its regulation forbids the use of chemical fertilisers and pesticides. In France, an environmental law, published in 2009, stipulates that OF should be developed in sensitive water catchments areas. Thus, various projects associating OF development and water quality protection have emerged (Vincent and Fleury, 2015). Their aim is to foster and target the development of OF in sensitive water catchment areas. To have a visible impact on water quality, it is necessary to have a substantial development of OF in these areas. In other words, developing OF to tackle water pollution problems requires to have a place-based development of organic farming. This is a new challenge because, so far, OF development was mainly based on the individual motivations of farmers to convert. Our hypothesis is that the objective of developing OF in order to protect water resources changes the OF development pattern. The following research questions will be addressed in the paper: Can local pollution problems be seen as a mean to foster OF development? How are these projects associating OF and water quality preservation being designed and implemented ?

Material and methods

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An inventory aiming at identifying projects associating OF development and water quality protection was carried out at national level. More than 30 projects were identified. Based on this inventory, we selected four projects, located in different regions of France, for a case study analysis. These four projects have been chosen to illustrate the diversity of types of projects associating OF and water quality.

For the case study, we first did a documentary analysis to better understand the goals and the organisation of each project. This analysis was based on different types of documents: project websites, newspaper articles, project proposal (for projects that have applied for financial supports), internal project reports, local action plans.

We also carried out semi-structured interviews with stakeholders involved in the project: water managers, local elected officials (from municipalities or rural districts), advisors working in extension services, farmers, cooperatives collecting and processing agricultural products, as well as with policy makers dealing with water management issues or with organic farming. In total, 42 interviews were carried out. The interviews aimed at understanding: the history of each project, its objectives, its organisation, the actions being implemented and those being planned for the future, and the stakeholders' motivations for participating in the project as well as their specific role in it.

Results

Water stakeholders: new key actors for the development of organic farming

The national inventory and the case study analysis showed that numerous projects aiming at developing organic farming to protect water quality have emerged in France since 2009. Various stakeholders took the lead in setting up such projects: agricultural stakeholders (such as farmers and agricultural advisors, cooperatives involved in the processing and marketing of organic products…) but also non-agricultural stakeholders such as local authorities (municipalities, rural district or metropolis) in charge of water management (table 1). In two of the analysed projects, local water managers have initiated the projects and are the project leaders. In the other two, the project leaders are agricultural stakeholders but they have received financial and institutional supports from one of the French Water Agency[7]. Water stakeholders therefore appear as key players in the governance of these local projects aiming at developing OF.

Place-based development of organic farming: a new feature in the history of organic farming

The main challenge in the analysed projects is to develop organic farming in the local water sensitive areas. In order to foster this place-based development of OF, local action plans have been set up and implemented in each project. They rely on adapted policy tools. Some of them aim at supporting the development of the organic surfaces (for example via extra financial support for conversion, given only to farmers whose fields are located in water sensitive areas). Others are rather market-oriented and aim at creating local processing units and supply chains to facilitate conversions of farmers and to create added value for organic products originating from these specific water sensitive areas. The national objective to develop OF in water sensitive areas has therefore a clear impact on the design and the features of new OF development projects in France.

This objective to foster a place-based development of OF is new in France. A few other cases of place based-development of OF to tackle water pollution problems exist in other countries, such as the well-known example of Munich, Germany (Barataud *et al.,* 2014). In the case of Munich, a successful program for OF development was carried out since the nineties and OF nowadays covers more than 80% of the agricultural area. But this case is very particular as 60% of the water catchment area is covered by forest and farming systems present there are extensive mixed systems (Barataud *et al.,* 2014). The cases we have studied are very different as they are located in quite

[7] There are 6 water agency in France. Water agencies are in charge of coordinating and implementing the water policy actions in France.

intensive agricultural areas, where there were no conversion dynamics before the projects started. Our analysis show that the use of new policy tools, coming from food policies as well as water policies and regulations enabled to create dynamics of conversion in areas that were not considered as "favourable for OF development" *a priori*.

Table 1: Overview of the four studied projects associating organic farming development and water quality protection

Projects	Main project objective	Project leader	Main policy actions implemented
Development of OF in the Vanne valley	Protection of the water catchment areas	Water manager	- Extra financial support for conversion to OF -Water manager investing in organising local organic supply chains
Promoting organic and sustainable agriculture in the water catchment of Rennes	Protection of the water catchment areas	Water manager	-Creation of a label for organic and sustainable products produced in the water catchment area -Introduction of labelled products in mass catering (through green public procurement)
Farmers' group for the "Development of sustainable agriculture" in Ardèche	Reduce pesticides use on farms to reduce their environmental impact	Group of farmers conventional farmers who actually decided to convert to organic, with the support the Water Agency	-Collective investment for purchasing of mechanical weeding machineries -Extra financial support for conversion to OF -Action towards the local dairy for setting up a system to collect organic milk
Creation of an organic mill in Côte d'Or	Creation of a unit to process the locally produced organic wheat and thus facilitate conversions to OF of local farmers	Group of agricultural cooperatives, with the support the Water Agency	-Awareness raising amongst conventional farmers -Market development

So far, research carried out to analyse the OF development did not really focus on the local level. Part of the research work focuses at the level of individual farmers, analysing farmers' motivations and attitudes towards the adoption of OF (Padel, 2001). Other researches have analysed the development of OF as a movement (Michelsen et al., 2001). Research targeted at the territorial dimension of OF development is rare. A few author have highlighted that OF development pattern are not homogenous in all areas and that spatial aggregation phenomena can be observed (Allaire *et al.*, 2015, Gabriel *et al.*, 2009). Other have concluded that OF development patterns are sometimes place-dependent, resulting from specific local contexts (Kjeldsen and Ingemann, 2009). But most of

these researches did not analyse how these local dynamics leading to aggregations phenomena have emerged and developed. Our work shows that the analysis of how local projects for the development of OF are designed and evolved over time is a necessary step to better understand ongoing changes in the history of the movement. Indeed this placed based development of OF, be it for tackling water pollution problems or for solving other local issues, appears to us as a new feature and a new step in the history of OF. In this new step, OF is considered as an holistic solution to local challenges (such as environmental problems but also territorial food sovereignty, education to healthy food and diets…) and new non-agricultural actors are involved in the design and in the governance of these local projects.

Discussion

In the vision elaborated by IFOAM-Organics international for organic 3.0, six different features have been identified as key challenges that need to be addressed to enable organic food and farming to get out of its "niche". Building alliances with other sustainability initiatives is one of them. Our study show that the upscaling of organic food farming indeed relies on the building of new alliances (but not necessarily only with sustainability initiatives). The objective of developing OF to protect water quality brought the organic stakeholders (organic farmers association, extension services for organic farming, organic processors…) to work with new actors: water managers, local public authorities etc… The success of these projects partly relied on the capacity of the organic stakeholders to work with non agricultural stakeholders. Building of alliances with non-agricultural stakeholders at local level for setting up local action plan for OF therefore appears as one of the key challenges to be addressed in the organic 3.0 era.

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Nature conservation achievements on organic farms with suckler cows in north-eastern Germany

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Key words: biodiversity, grassland management, small-scale measures, evaluation, credit points, assessment tool

Abstract

Organic agriculture has been proven to make a major contribution to biodiversity enhancement and, furthermore, optimization strategies are very effective. We developed an assessment tool based on a credit point system which can be used as an additional qualification for the promotion of biodiversity on farm level. The results from 34 suckler cow farms showed that extensive farming practices, which are likely to promote high levels of biodiversity, are widespread. Additional small-scale measures are necessary to promote certain target species like whinchats. These measures are implemented at specific locations with the help of nature conservation advisors. The new assessment tool provides a greater appreciation of nature conservation achievements by both farmers and consumers. This is a basic condition for more concerted efforts to preserve and even enhance biodiversity in organic farming, and can encourage organic farming as the preferred agricultural system in the future.

Acknowledgments

We thank the farmers for the fruitful cooperation. The research activities were supported by the World Wide Fund For Nature (WWF) Germany and the food retailer EDEKA.

Introduction

The loss of wild flora and fauna species dependent on farmland habitats has been dramatic in the EU countries in the past few decades and the trends are still negative (BfN 2015). Organic farming has been proven to be strongly advantageous for biodiversity (Tuck *et al.* 2014, Rahmann 2011). In addition, modified production measures implemented into farming practices are very effective in cases where conflicts arise (Stein-Bachinger *et al.* 2010, Stein-Bachinger and Fuchs 2012). Thus far, an assessment of the wide range of organic farming practices beneficial for biodiversity on a whole farm level is missing.

Within the 'Farming for Biodiversity' project, an assessment tool for nature conservation achievements has been developed based on credit points, which can also be used for marketing purposes (Gottwald and Stein-Bachinger 2016). Here we report the results of the evaluation of 34 suckler cow farms and give examples of the effects of modified management practices in grassland for whinchats (*Saxicola rubetra*). This ground-breeding bird is dependent on extensive agricultural land use and its population is declining strongly throughout Europe (Bastian and Feulner 2015).

We developed and tested effective measures as part of common farming operations on grassland which have low negative effects for farmers. The benefits of organic farming for biodiversity are communicated to the consumer by means of a nature conservation label, which should help to introduce organic farming as the preferred agricultural system in the future.

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Material and methods

We developed a catalogue of 50 modules (approx. 100 submodules) on a farm scale, referring to arable land and grassland as well as to landscape elements, taking the site conditions and farming practices in north-eastern Germany into account (Gottwald and Stein-Bachinger 2016). The site conditions are characterized by low annual precipitation (<600 mm) and low to medium soil quality.

For grassland, the farmer can choose between 13 nature conservation modules (approx. 33 submodules). Each module has been evaluated by a group of experts with points allocated according to its effectiveness in terms of nature conservation. A total of 120 points per 100 ha are required for the farmer to receive a nature conservation certificate (label). The modules comprise established extensive farming practices as well as particular conservation measures. Furthermore, special species and existing habitats, such as hedges and ponds, are evaluated. At least 20 points must be acquired through small-scale measures. They are particularly beneficial for target species and therefore, receive more credit points per hectare than large scale measures. The farmers are advised by consultants who identify species and reasonable measures.

The evaluation included 34 suckler cow farms in north-eastern Germany covering approx. 18,000 ha of grassland and 9,600 ha of arable land. 6 farms exclusively manage grassland, 26 farms have more than 50% of grassland. The average size of the farms is 812 ha (min. 126 ha, max. 4165 ha).

For whinchat (*Saxicola rubetra*), we registered territories, habitat requirements and breeding success annually from 2014 to 2016 on 6 farms and 485 ha of grassland (Gottwald *et al.* 2017). As conservation measure, the farmers left patches of meadows and pastures unused during the breeding season of whinchats from May to mid-July within preferred whinchat habitats.

Results

Measures and achievements

The proportion of farmers that implemented specific modules, and the percentage of grassland dedicated to those modules, show a high variation ranging from 9 to 100 % (farms) and < 1 to 92 % (area) (Table 1). Modules which have been implemented on more than 80 % of the total farm area are e.g. those involving 'reductions in use of fertilizers' and 'reduction of rolling and levelling' (Table 1). By contrast, small-scale measures altogether covered only approx. 7 % of the whole farmland area. The modules which correspond to large-scale measures accounted for 74 % of the credit points, small-scale measures accounted for 28 % (all farms combined).

Large-scale measures were already mainly practiced by farmers before the start of the project as part of their extensive farming practice (e.g. no fertilization, low cutting frequency). In contrast, small-scale measures were implemented for particular target species following the supervision of the farmland by nature conservation advisors. Ultimately, all the farms attained the necessary number of credit points required for the certificate or performed even better.

Breeding success of whinchats

The breeding success of whinchats on meadows and pastures without special measures was low (37 % of territories having fledglings, n = 52). The delayed use of small areas of grassland (< 5 % of the total area) until mid-July increased breeding success significantly (81 - 86 % of territories having fledglings, n = 23, Gottwald *et al.* 2017). The efficiency of small-scale measures was high, because the sites for these measures were selected deliberately within preferred habitats of the whinchats along the edges of fields and near fences. Within the study area, more than two third of whinchat territories with nests included fences surrounding pastures which are commonly used as perching places.

Table 1: Measures in grassland on 34 farms.

Modules for grassland	% of farms	area[1]	credit points[2]	Q_{25}[3]	Q_{75}[4]
Large-scale measures					
Organic grassland management (moderately extensive)	100	92	5	4	8
Pasture with extra low stocking rates	32	7	16	11	44
Reduction of rolling and levelling	82	53	8	5	12
Reduction in use of fertilizers	85	68	17	14	28
8-10 weeks without farming operations during the breeding period of birds	71	17	18	16	44
Mosaic management	21	9	2	4	13
Haymaking (instead of silage)	65	14	4	3	9
Higher cut of meadows	9	2	1	4	6
Renunciation of mower-conditioner	56	33	2	2	7
Conversion of arable land to grassland	15	1	1	3	11
Small-scale measures					
Delayed use of grassland	65	5	18	9	19
Leaving strips or plots temporarily unmown	79	1	7	2	10
Leaving strips unmown for more than one year[5]	50	<0.1	2	2	5
Special measures for valuable habitats	15	<1	1	4	14

[1]percentage of total grassland, [2]percentage of total credit points on grassland, [3,4]lower/upper quartile (percentage of credit points for individual farms which chose the respective module), [5]evaluated per 100m length

Discussion

The 34 farms exhibited a high variation of nature conservation measures as a consequence of the wide spectrum of farming structures, soil conditions and habitats for the target species. The credit point system developed in the project represented this variation and produced comparable values for the assessment of biodiversity benefits.

The grassland management of the organic farms involved with an average of approx. 0.6 livestock units per hectare and widespread poor soils (either dry and sandy or wet fens) indicates a moderate land use intensity which encourages high levels of biodiversity. Nevertheless, this promotes common species in particular, while specialist species require supplementary measures (Kruse *et al.* 2016). To reach the fixed sum of points required for the 'Farming for Biodiversity' nature conservation certificate, additional small-scale measures, such as the delayed use of small grassland areas, are necessary to promote certain target species such as the whinchat. These measures are also

favourable for other groups of species, especially for insects like butterflies and grasshoppers (Bruppacher *et al.* 2016).

Small-scale measures can be very effective, if these are planned and located deliberately, taking into account the specific habitat requirements of the target species as well as the specific management practice of individual farmers. Consequently, the advice of consultants is critical for the success of these measures and their acceptability on the part of the farmer. As they cover only small areas of the farmland, the economic constraints are small, but their execution on large farms requires high input with regard to communication and supervising. In order to provide an incentive for the farmers, they receive high amounts of credit points for small-scale measures.

Conclusions

On farms keeping suckler cows in north-eastern Germany, extensive farming practices likely to promote high levels of biodiversity are widespread. Benefits for particular target species can be enhanced by additional small-scale measures. The potential for increasing biodiversity even further is high in this farming system. In the 'Farming for Biodiversity' project, the nature conservation achievements are visible for consumers through the award of a specific certificate. Alongside farmers, scientists, conservationists and also a marketing company are involved. The sales volume of certified products from extensive farming systems increased and surplus income for farmers is generated. The "production" of biodiversity should be established as an equally valid goal in addition to the production of food in organic farming. The special benefits of organic farming and the effects of purchase decisions on the landscape and on the human environment call for more public awareness. This consciousness will support the goal of establishing organic farming as the preferred agricultural system in the world.

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Effective and economically viable organic agriculture under Inhana Rational Farming (IRF) Technology towards mitigation of climate change impact

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Key words: Organic plant management, self-nourishment, self- protection, C-sequestration

Abstract

Mitigation strategies against climate change impact and vulnerability of agriculture are now of high priority in India as 60 % of livelihood depend directly on it. Adoption of scientific organic farming could be the most viable option not only for crop sustainability, but also to utilize as the largest sink against GHG emission. Adoption of IRF organic technology has enabled production of sustainable, CO_2 neutral organic teas with net carbon sequestration of 76 kg C /ha. Crop sustenance (1384 vis-a-vis 1358 $kgha^{-1}$ as compared to chemical practice) has been ensured through plant energization and reconstitution of dynamic soil micro flora (in order of 10^7 c.f.u); as brought about by energy efficient composting and development of plant resilience. Crop resilience against adverse climatic conditions was also documented in field crops especially paddy and potato where up to 30 % higher yield over chemical practice was corroborated by 23 to 55 % higher energy use efficiency.

Introduction

High energy intensive farming helps to enhance crop production, but at the cost of the natural resource bases on which agriculture rests. Present climate change impact makes agriculture more vulnerable and needs mitigation strategies to ensure crop sustainability as well as efficient carbon sequestration. Inhana Rational Farming (IRF) Technology focuses on the development of 'Healthy Plants', in conformity to the Trophobiosis Theory of F. Chaboussou (Chaboussou 1985); which indicates that 'Pest starve on healthy plants'. The technology is based on the Element Energy Activation (E.E.A.) Principle and focuses on conjugative rejuvenation of soil and plant health, through infusion of the required energies. The study is a practical demonstration of economic climate change mitigation strategies in both tea and agricultural crops, through restoration of crop resilience and soil carbon sequestration.

Material and methods

IRF Technology developed by the Indian Scientist, Dr. P. Das Biswas is based on E.E.A. Principle (Chatterjee *et al*. 2014) which is inspired by the evolutionary concept of Vedic philosophy. As per the principle, there are five basic elements in all animate and inanimate objects of the universe namely: Earth, Water, Fire, Air and Space. And the elements have specific as well as individual role in the nourishmen of the plant system. Similarly there are five life sources or 'Prana Shaktis', which provide functional energies to the five basic elements (Fig. 1) and are also responsible for the Host- defense mechanism in the plants against biotic factors. IRF technology aims at developing healthy plants through :

(i) Energization of soil system i.e., enabling the soil to function naturally as an effective growth medium for plants (Barik *et al*. 2014) and
(ii) Energization of plant system i.e., enabling higher NUE alongside better bio-chemical functions that leads to activation of the plants' host defense mechanism (Barik et al. 2014).

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The Technology bears the essence of Trophobiosis theory (Chaboussou 1985) and works towards amelioration of factors that favourably signals pest/disease advances (Seal et al. 2016), thereby curtailing the root cause of pest interference.

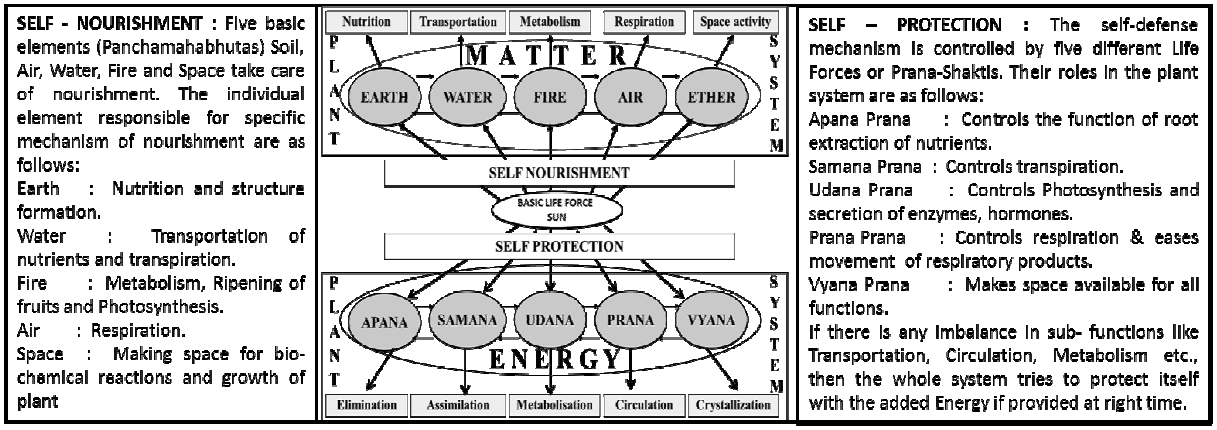

Fig. 1: Mechanism of plant energization following EEA Principle, under IRF technology

Management Practice under IRF Technology

The technology was introduced as a complete organic package of practice in 2001, in tea plantations and is being utilized for large scale organic tea production covering about 600 ha area (West Jalinga Tea Estate) in Assam (India), for the past 16 years. After successful initiation in tea (one of the difficult crops for organic), IRF technology was simultaneously introduced in field crops from 2003 onwards. In case of field crops *viz.* paddy, potato, pulses etc. same principle is followed in both research stations and farmers' field. Effectiveness of IRF Technology in terms of crop yield and soil quality development is adjudged in comparison to chemical farming; in standard experimental formats. Yield sustenance, irrespective of crop type in terms of both quantitative and qualitative components (in case of both pilot and large scale studies); as documented for over a decade; truly demonstrates the development of crop resilience under IRF technology; against climate change impacts. Organic crop management under IRF technology can be broadly divided into 6 components:

(i) *SWOT Study* : SWOT study and soil resource mapping to identify potential and problematic areas, for ju dicious application of organic soil inputs.

(ii) *Soil Management* : Application of on-farm produced Novcom compost (micro flora population in the order of 10^{16} c.f.u. per g compost) @ 3 tonha^{-1} and different on-farm concoctions *viz.* energized cow dung slurry, compost tea etc. towards soil microbial rejuvenation.

(iii) *Plant Management* : Application of different potentized and energized botanical solutions in a scheduled manner for bringing about harmonized plant growth through activation of different plant biochemical reactions *viz.* photosynthesis, respiration, transpiration etc. The solutions also provide necessary energy to sustain from biotic and abiotic stress (IRF Manual 2016).

(iv) *Pest Management* : Principally pest management is done through (i) immunity buildup of plants an d (ii) development of effective soil microbial barrier against pest and pathogen populations. Active pest population under economic threshold limits is controlled with different sulphur based (for mites) and neem oil based formulation (for sucking/ chewing insect/pest). However, cidal approach is avoided as much as possible, in order to restore natures' balance.

(v) *Disease Management* : Application of potentized and energized botanical solutions, which provide necessary energy for enhanced silicon uptake, for enhancement of structural and biochemical defense system of plants against pathogens.

(vi) *Weed Management* : Manual weeding, with leguminous and cover cropping for weed control.

Results

Organic tea cultivation under IRF Technology at W. Jalinga T.E.

Effectiveness of IRF Technology is reflected in the sustainable organic tea cultivation in the garden for the last 16 years. Considering that more than 40 % yield loss under organic conversion is common in Indian tea, comparison of 10 years average yield under conventional and thereafter organic practice (i.e., post conversion) indicated crop sustenenace, with marginal increase in productivity (Fig. 2). This has been achieved despite application of 1/3rd dose of N, as compared to the actual N harvested. Sustained crop yields even at lower dosage indicated towards an efficient soil– plant nutrient dynamics as corroborated by the 233 % increase in nutrient use efficiency (NUE) under organic management. Efficient soil functioning is reflected by the high microbial activity potential (MAP), which is an index that depicts the cumulative status of microbial population and their functional activity. About 250 times increase in MAP post adoption of organic management has contributed towards crop sustainability and soil quality rejuvenation; leading to efficient carbon sequestration. Carbon foot print estimation by Soil & More (*http://soilandmore.com/*) revealed a net CO_2 sequestration of 0.20 kg per kg made tea in W. Jalinga tea estate; as against the average Indian value of 1.80 kg per kg made tea (SMI Newsletter 2003).

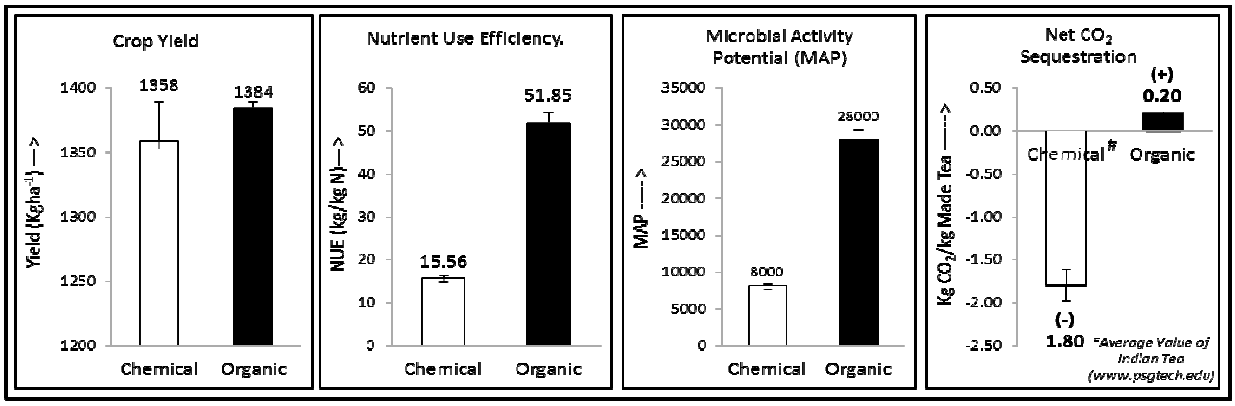

Fig. 2: Aspects of Organic Tea Cultivation under IRF Technology at W. Jalinga T.E., Assam

Organic field crop cultivation under IRF Technology

Crop yields and soil quality variation under IRF Technology has been scientifically evaluated in both research stations as well as farmers' field in the hot moist sub-humid ecological sub region; to assess its effectiveness as compared to conventional farmers' practice. The different test crops were paddy (rainfed and irrigated), baby corn, green gram, okra, potato and tomato (Table 1).

Table 1: Comparative study of crop cultivation under IRF Technology *vs*. Chemical Farming

Crop	Yield ($kgha^{-1}$)	NUE[1]	EUE[2]	Soil Health Indices		
				FI[3]	MAP[4]	SQI[5]
Experimental Stations						
Paddy (*Oryza sativa*)[#]	3194*	11.8	2.55*	24.1	15.40**	0.54*
[Variety:premium scented local rice Gobindobhog]	(2977)	(24.8**)	(2.07)	(23.6)	(11.20)	(0.47)
Baby Corn (*Zea mays*)	1700**	8.1*	1.29*	20.2	13.43*	0.46*
[Variety : HM 4]	(1333)	(6.7)	(0.80)	(20.7)	(10.12)	(0.41)
Green Gram (*Vigna radiata*)	933*	6.95	2.12*	26.5	18.12*	0.59
[Variety : PDM 84-139]	(819)	(8.19*)	(1.77)	(26.2)	(16.24)	(0.56)
Tomato (*Lycopersicon esculentum*)	35000**	129.6*	2.07**	25.9	20.13*	0.64*
[Variety : Rituraj]	(31000)	(110.7)	(0.98)	(26.3)	(17.22)	(0.58)
Farmer's Field						
Paddy (*Oryza sativa*)[##]	6098**	25.5*	3.06**	23.2*	16.04**	0.57
[Variety : IET4786]	(4707)	(19.6)	(1.98)	(21.8)	(13.21)	(0.54)
Potato (*Solanum tuberosum*)	30000*	111.1**	4.56**	28.7	22.04*	0.63
[Variety : Jyoti]	(27750)	(79.2)	(2.07)	(29.4)	(19.06)	(0.59)
Okra (*Abelmoschus esculentus*)	7793*	36.59*	2.02*	23.4	14.43*	0.51**
[Variety : hybrid Shakti (F1)]	(6860)	(27.55)	(1.72)	(23.9)	(10.27)	(0.43)
Green Gram (*Vigna radiata*)	699*	3.28*	2.05*	26.5	14.56	0.48
[Variety : PDM 84-139]	(665)	(2.67)	(1.74)	(25.8)	(12.34)	(0.45)

Note: Figure in the parenthesis represents data from chemical farming; T – test (* significant at P<0.05 and ** significant at P<0.01); #Rain fed; ##Irrigated; [1]NUE : Nutrient Use Efficiency (kg/kg produce); [2]EUE : Energy Use Efficiency; [3]FI : Fertility Index; [4]MAP : Microbial Activity Potential; [5]SQI : Soil Quality Index (Bera et al 2015).

Higher crop productivity under IRF technology was recorded from the very 1st year of intervention. Yield increase of 5.1 to 29.5 percent as documented in case of the different field crops might be due to the significantly higher nutrient use efficiency (17.07 to 40.28 %) and agronomic development; as compared to that recorded under conventional pratice. Similar trend was noted in case of energy use efficiency which was up to 120 % higher in case of organic crop production. The projects demonstrated higher energy use efficiency under organic crop management especially in case of high volume crops like potato (EUE : 120.29) and tomato (EUE : 111.11); thereby indicating better potential towards GHG mitigation. Soil health indices *viz.* soil fertility index (FI), microbial activity potential (MAP) and soil quality index (SQI) showed an overall increasing trend under organic management. Especially the index depicting microbial population and activity showed maximum response under organic soil management (24.28 % higher MAP on an average under Organic); thereby indicating the scope for effective soil microbial rejuvenation.

Discussion

Sustainable tea yields under IRF Technology corroborates better plant functioning, harmonization of pest-predator interrelationships; as well as efficient resource managment that has enabled the plantation to achieve the carbon neutral status. Higher yields in case of field crops were basically subscribed by higher number of fruits per plant as well as higher average fruit mass. The higher number of fruits per plant was mainly contributed by the longer fruit bearing stage of the organically treated plants. The finding endorsed positive influence of the potentized and energized botanical solutions (as used for plant management under IRF Technology) on the plant metabolic functions leading to efficient nutrient utilization and thereby enhancement of crop yield potentials. Also higher (average) fruit mass at harvestable stage indicated better soil-plant nutrient dynamics in the organically treated plots.

Conclusion

Ecologically and economically sustainable organic farming is pre-requisite for enabling wider adoptability, securing livelihoods and ensuring affordability at the consumer end. And these criteria which form the very objectives of Organic 3.0 is promisingly served by IRF technology, which has ensured yield sustenance irrespective of crop type, agro- ecosystem and under changing climatic patterns. The findings also testify the corresponding GHG mitigation and adaptation potential under the technology as reflected in the high carbon sequestration, soil resource regeneration, high energy use efficiency as well as development of plant resilience; but the highlight remains its cost effectiveness and assurance of time bound results.

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A Comparison of the impacts of organic and conventional dairying on the aquatic environment

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Key words: nitrogen, leaching, urine N, milk urea nitrogen

Abstract

An open grassland systems trial comparing organic and conventional dairy farming included measuring nitrogen (N) leaching from each unit. It was found that the amount leached from the organic unit was around 50% of that from the conventional. The differences in N losses can be explained with reference to differences in N ingested by cows and N excreted in urine.

Acknowledgments

The project was funded by DairyNZ. Technical assistance by Kim Fraser, Ian Furkert and the staff at DCRU is gratefully acknowledged.

Introduction

Between 2001 and 2011, Massey University set up its Dairy Cattle Research Unit (DCRU) as a system comparison between organic and conventional farming. The farm was a seasonal pastoral producer with lactation from late July until late May. It was split into two similar units. The organic unit (certified to the USDA NOP standard) covered an area of 20.4Ha and the conventional 21.3Ha, carrying typically 46 organic and 51 conventional cows respectively.

There is general acknowledgement of the impact intensive conventional dairy farming is having on the aquatic environment in New Zealand, the drive for intensification being coupled to the widespread adoption of nitrogen (N) fertilisers since the early 1990s. There are restrictions on the amount of N that can be applied only in a limited number of sensitive environments. Elsewhere, typical applications total 150 – 200 kg N/ha annually. Cow urine is the primary source of leached N. This paper reports on the relative impacts of organic and conventional farming on nitrogen leached into drainage water.

Materials and methods

The soil, Tokomaru silt loam, is a silty textured loess. An impermeable fragipan, extending from 0.8 m depth to almost 2 m, slows drainage. There is normally a large excess of soil moisture in winter, and deficit in the summer to early autumn. In order to carry cattle without serious deterioration of soil structure, it is necessary to install artificial drainage in the form of plastic pipes with mole drains ploughed above and at right angles. The farm receives approximately 1000 mm rainfall per year. N inputs consisting of urea and ammonium salts applied to the conventional unit varied from 95-180 kg N/ha/year, depending on requirements for pasture growth (Table 1). From 2007, Osflo®, a fertiliser derived from composted chicken manure, was applied to the organic unit. N inputs per annum varied from 19-77 kg N/ha (Table 1). The losses of nitrogen were measured at the outlets of drainage pipes from 2004 to 2011.To further investigate N leaching, monitoring of milk urea-N concentrations (an indirect measure of urinary-N output), cow liveweight and pasture

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crude protein (CP) on both units was carried out from September 2005 to January 2006. An annual feed-budget was constructed for the season of 2005/6 based on the data measured for the monitoring period above. Urinary-N outputs for the year were estimated using the Cornell Net Carbohydrate and Protein System model (Fox *et al*., 2004). Leaching losses of N were simulated using both the Nitrogen Leaching Estimation (NLE) model of Di & Cameron (2000) and Overseer® Nutrient Budgeting software (Wheeler *et al.* 2003).

Results

Measurements from drainage pipes allowed calculation of the total N leached per ha for each unit (Table 1)

Table 1: Annual N leached, N inputs as fertiliser and autumn rainfall (April – June)

Year ended 30 June	N lost in drainage (kg N ha^{-1})		N applied as fertiliser (kg N ha^{-1})		Autumn rainfall (mm)
	conventional	organic	conventional	organic	
2004	24	14	150	12	272
2005	11	3	155	14	209
2006	21	7	160	13	341
2007	11.4	6.4	115	33	146
2008	21.9	8.6	125	77	336
2009	10.9	8.3	100	55	314
2010	9.2	8	185	50	175
2011	16.3	10.3	95	19	288

The conventional cows ingested and urinated substantially more N than the organic cows (Table 2). The N in urine patches from conventional cows was much more concentrated than it was in urine patches on the organic unit (Table3).

Table 2: N intake, urine N output and milk urea-N for the monitoring period of September to January of 2005-2006.

	Conventional	Organic
Stocking rate (cows/ha)	2.4	2.2
Dry Matter (DM) intake (kg/cow)	2514	2179
Dietary crude protein (CP) % of DM	23.4	18.9
N intake (kg /cow)	94	66
Mean Milk Urea N (mmol/Litre)	5.1	3.6
Urine N output (kg /cow)	50	29

The annual values for N intake and urine-N output calculated with the Cornell Net Carbohydrate and Protein System model (Table 3) reflected those differences observed during the monitoring period (Table 2).

Comparisons made between measured N losses and those predicted by Overseer® and the NLE model (Table 4) resulted in reasonable agreement between the modelled and observed values particularly for the organic unit. Both models predicted the approximately 50% reduction in N loss from the organic unit relative to the conventional unit.

Table 3: N intake, urine N output for the year 2005- 2006

	Conventional	Organic
DM intake (kg/cow)	4426	4120
Dietary CP (% of DM)	22.7	18.6
N intake (kg /cow)	161	123
Urine N output (kg /cow)	90	59
Urine N output (kg /ha)	215	133
N in urine patches (kg /ha)	1123	742

Table 4: A comparison of measured and modelled values for N losses in drainage

N leached	Conventional	Organic
Measured (kg N/ha)	19	8
NLE model (kg N/ha)	15	7
Overseer® model (kg N/ha)	16	8

It has been suggested that the environmental efficiency index measured as kg N/tonne milksolids (MS) is an equitable indicator of the relative impact of a production system on the aquatic environment. This ratio was much more favorable for the organic unit than it was for the conventional (Fig. 1). Also modelled were emissions of the greenhouse gases (GHG) methane and nitrous oxide (Fig 2).

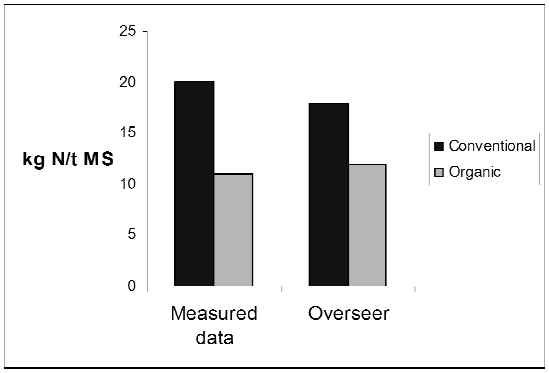

Figure 1. Environmental Efficiency Indices (kg N leached per tonne MS produced)

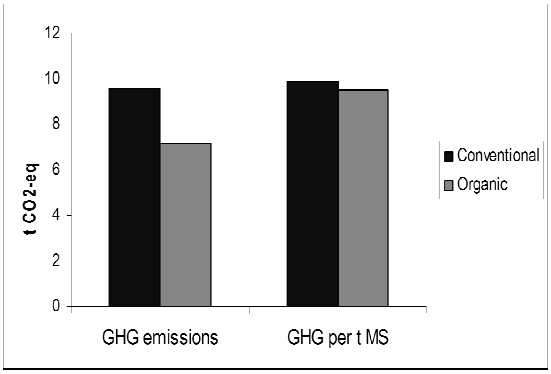

Figure 2. Modelled GHG emissions

Between 2009 and 2011, the Grow Organic Dairy Project used an updated version of Overseer® to model N leaching and conversion efficiency on a selection of commercial organic dairy farms in the North Island. N inputs included fertiliser, supplements and N fixation. This enabled calculation of the Environmental Efficiency Index of the case study farms (Table 5). The table also includes a "typical" North Island conventional farm, the values for which have been derived from DairyNZ (2012), DairyNZ (2015) and Wheeler *et al* (2011).

Discussion

The CP content of New Zealand pastures generally exceeds National Research Council protein requirements for dairy cows. Moller *et al* (1996) have established a link between N inputs and pasture CP. Urea is synthesized by the liver as a method of de-toxifying ammonia produced by ruminal organisms breaking down dietary protein and is widely distributed throughout body fluid compartments, including the rumen. Significant recycling of urea by ruminal organisms for the

synthesis of microbial protein may occur once dietary CP declines below 18-19%; urinary N excretion declines and N conversion efficiency increases.

The highest amount of leaching generally occurs in autumn/early winter, especially if a dry summer results in accumulation of mineralised N in the soil. Variations in N losses from the conventional unit generally matched variations in autumn rainfall. However, it is noteworthy that leaching from the organic unit seemed largely independent of this feature.

Table 5. Modelled N leaching from the case study organic farms and a "typical" conventional farm, N conversion efficiency as predicted by Overseer® and the Environmental Efficiency Index. (after Horne *et al* 2012)

Farm	Milk solids production (kg MS ha^{-1})	Predicted N leaching (kg N ha^{-1})	N conversion efficiency (%)	Environmental efficiency index (kg N ha^{-1} per t MS)
Means of case study farms	807	19	39	24
Conventional	1050	37	35	35

Conclusions

During the study period, the quantity of N leached from the organic unit at Massey University's systems comparison trial was approximately 50% of that lost from the conventional unit. The smaller N losses for the organic unit can be accounted for by reduced urine-N output due to lower stocking rate, DM intake per cow and dietary CP compared to the conventional unit. These results are reflected in modelled analyses of commercial organic dairy farms compared to a "typical" conventional farm. In countries where there is pressure (or mandate) to pastoralise dairy cows, the potential for reduced impact of an organic system may allow an opportunity to promote Organic 3.0.

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Equal yield-scaled and lower area-scaled nitrous oxide emissions in organically managed soils

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Key words: Nitrous oxide, farming systems, greenhouse gases

Abstract

Despite the increase in organic cropland, knowledge on the impact of organic farming on soil-derived nitrous oxide (N_2O) and methane (CH_4) emissions is rather limited. To improve the knowledge base, N_2O and CH_4 fluxes were investigated in a 571 day lasting cropping sequence in the "DOK" field trial. Two organic and two non-organic farming systems and an unfertilized control were chosen. For the whole monitoring, the two organic systems combined emitted 40% less N_2O than the two non-organic ones cumulated on area-scale. Yield-scaled cumulated N_2O emissions were nearly 10% lower for the organic systems combined, despite the yield gap of 27%. We found that besides N input, management induced soil quality properties drive differences in N_2O emissions between farming systems as well. This supports the effort to invest in soil quality by ecological intensification not only to lower the environmental burden of agriculture but also to mitigate greenhouse gases.

Acknowledgments

We gratefully acknowledge the financial support for this project provided by the Swiss Federal Offices for the Environment (FOEN) and Agriculture (FOAG).

Introduction

There is a weak knowledge basis regarding greenhouse gas (GHG) fluxes in organically managed soils. Based on the evaluation of 18 farming system studies Skinner et al. (2014) determined lower area-scaled nitrous oxide emissions and higher methane uptake in organically compared to conventionally managed soils. Related to crop yield it turned out that organically managed soils emitted more N_2O than conventional based on the evaluation of 7 comparative studies. In this study, we aim to show evidence that ecological intensification through organic farming does not necessarily lead to higher yield-scaled nitrous oxide emission in soil. Therefore we conducted GHG flux measurements in conventional and non-fertilized farming systems under the same crop rotations in the DOK long-term trial in Therwil/CH, one of the oldest and best characterized farming system trials, worldwide.

Material and methods

GHG flux measurements and accompanying soil and agronomic analyses were conducted in the DOK Farming Systems Trial established in 1978 in Therwil, CH. The GHG monitoring was performed with the closed chamber method based on weekly gas samplings over the cropping sequence: grass-clover/maize/green manure. The 571 day lasting monitoring period encompassed the four farming systems – two organic ones, bio-dynamic, BIODYN (composted manure and slurry) and bioorganic, BIOORG (rotted manure and slurry); a conventional one (with staple manure and mineral fertiliser) CONFYM - that all are cultivated in a fully (1.4 livestock units), and

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the second conventional one (exclusively mineral fertilisation) CONMIN. An unfertilised control, NOFERT, complemented the comparison.

Results

The GHG flux measurements within this monitoring campaign enabled a worldwide unique dataset over a time period of 571 days. For all investigated farming systems the lowest N_2O emissions were determined during the grass-clover phase and the highest during the maize period, when the grass-clover ley was ploughed followed by soil preparation, maize seeding and fertilization. Over the whole observation period the cumulated mean N_2O emissions ranged from 3.73 (BIODYN) to 8.21 kg N_2O-N ha^{-1} (CONFYM). We found a farming systems effect, showing that the area-scaled N_2O emissions of the two organic systems (BIODYN and BIOORG) were lower than the emissions from the two conventional systems CONFYM and CONMIN. Also during the 117 days lasting maize cropping phase, the same tendency was observed, lowest emissions from the organic systems. Unexpected high N_2O emissions were determined for the unfertilized system NOFERT. There the emissions of 4.19 kg N_2O-N ha^{-1} were as high as from the fertilized systems BIORG, CONFYM and CONMIN.

Equal yield-scaled N2O emissions between the two organic and two conventional systems were found for maize for which we have a complete data recording. There the highest values were determined in NOFERT and the by far lowest yield-scaled N_2O emissions were observed in BIODYN.

Discussion

In accordance to the meta-study by Skinner et al. (2014) we found the lowest area-scaled N_2O emissions in the two organically managed systems. This can be explained by the lower N inputs applied to grass-clover and maize. The yield-scaled N_2O emissions revealed a different picture. Skinner et al. (2014) reported a higher yield-scaled N_2O emission for organic arable systems based on the evaluation of 7 studies. Our own measurements in the DOK trial, how-ever, showed no difference in the yield-scaled emissions between organic and conventional farming systems. This might be due to the fact that the 7 studies included in the meta-study by Skinner et al. (2014) showed a larger yield gap between organic and conventional cropping systems.

Unexpected and interesting results were obtained by including the NOFERT system in the monitoring campaign. There we found relatively high area-scaled and the highest yield-scaled N_2O emission and a lack of CH_4 uptake despite of any fertiliser N inputs. The rationale behind is because of mineralisation of the grass-clover N and loss of soil organic matter. This goes along with an earlier meta-study from the US, showing that historical intensification in agriculture contributed to GHG mitigation, whereas zero fertilisation cannot be considered as a mitigation option (Burney et al., 2010). Remarkable as well are the surprisingly low N_2O emissions in the BIODYN system of the DOK. Investigation of the reasons is ongoing; the kind of applied manure, that is composted as well as the denitrifier communities are in the focus.

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Contribution of organic farming to public goods in Denmark – a knowledge synthesis.

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Key words: Organic farming, public goods, environment, animal welfare, human health, climate change.

Abstract

The contribution of organic farming to the public goods: Nature and biodiversity, environment and soil fertility, energy and climate, human and animal health and welfare, business and rural development in Denmark was evaluated in a knowledge synthesis. Overall the contribution is positive compared to conventional farming but the effects vary depending on the public good, the type of production (dairy, pigs, plant etc.), the size, location and, not the least, the management of the farm. Organic farming may not be the most effective solution to one problem, but its advantages lie in its contribution to more public goods at the same time. The organic rules give rise to synergies (e.g. ban of pesticides increase biodiversity and reduce environmental pollution) as well as dilemmas (e.g. outdoor access for animals improves animal health and welfare but increases the risk of environmental N-pollution). Improved contribution requires further organic rule development, research and education.

Acknowledgments

The Ministry of Environment and Food of Denmark is greatly acknowledged for the funding of the Knowledge Synthesis on the contribution of organic farming to public goods in Denmark.

Introduction

In Denmark, organic farming has broad political support, because it is seen as a tool to contribute to public goods like biodiversity, environment, climate change mitigation, animal welfare, human health and rural development. "Public goods" is here defined as goods or services, which society wants its citizens to have access to, and which are normally not "tradeable". At the same time the Danish consumers' demand for organic food products is soaring with a rise to 8.4 % of the retail market in 2015 (DST, 2016).

The purpose of this knowledge synthesis was

1) to review and structure the existing knowledge on positive and negative aspects as well as development potential of organic farming in relation to its contribution to the various public goods in Denmark and
2) to assess to what degree the organic regulation contributes to creating synergies or dilemmas in the contribution to different public goods.

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Material and methods

The knowledge synthesis involved 70 researchers and experts in organic production and the public goods investigated: nature and biodiversity, environment and soil fertility, energy and climate, human health and welfare, animal health and welfare, rural development. A common structure guided the synthesis for each of the public goods:

- Problem formulation in relation to the public good.
- Legislation and action plans for Danish agriculture in general in relation to the public good.
- Organic principles and requirements with relevance to the public good.
- Scientifically documented positive as well as negative contributions of organic farming in relation to the public good.
- Need for further documentation, research, development and communication to strengthen the contribution of organic farming to the public good.

Based on the scientifically documented effects of organic farming in relation to each public good the positive and negative effects were described. Afterwards an overall and cross-disciplinary synthesis was elaborated, focusing on the synergies and dilemmas that the rules and principles of organic production create in relation to the different public goods (Jespersen et al., 2015).

Results

Organic production in Denmark is governed by the EU organic regulations (EC 834/2007 and EC 889/2008) plus additional requirements on reduced nitrogen application specified in the Danish organic farming support programme. According to Council Regulation (EC) No. 834/2007, Preamble 1 the organic production method is considered to play a dual societal role, where it on the one hand provides for a specific market responding to a consumer demand for organic products, and on the other hand delivers public goods contributing to the protection of the environment and animal welfare, as well as to rural development. The aims and principles of organic production as specified in Article 3 – 7 of this regulation indicates the potential contribution of organic farming to the public goods. However, the actual (minimum) contribution of organic production to the public goods is the result of the specific rules for organic plant and animal production, which are mainly specified in Commission Regulation (EC) No. 889/2008. The type of farm (dairy, pig, poultry, plant, horticulture etc.), the farm size, the geographical location of the farm – and not the least – the management of the farm may also influence how, and how much the individual farm contributes to the public goods.

The knowledge synthesis showed that overall organic farming contributes positively to many of the public goods compared to conventional farming, but negative contributions are also observed, when looking into the details (see table 1).

The effects of organic farming on nature close to the farm and on biodiversity, including bees and other pollinators, soil fertility, animal and human health and welfare are predominantly positive. Varied crop rotation with legumes and perennial clover grass, organic fertilisers and avoidance of pesticides are the main reasons for the 30 % more plant and animal species on organic farms compared to conventional farms. Larger area per animal indoors and outdoors, access to grazing, and daily feeding of roughage are important factors for the animal health and welfare of organic animals resulting in less need for medication (including antibiotics). However, there may also be negative effects of the organic rules in the form of higher mortality rate for calves and piglets and greater risk of parasite transmission due to the outdoor access requirements. Pesticide and antibiotic

free organic food products with low input of food additives are considered positive for human health, but direct health effects (measured as absence of disease or better resilience) on humans cannot be documented because of lack of data. Organic consumers seem to have a more healthy diet composition (less meat and more vegetables and fruit) than other consumers.

Table 1: Overall contribution of organic farming in relation to public goods, organic principles and rules

PUBLIC GOOD	Predominant effects			In EU Organic Regulation	
	Positive	Effects not documented	Negative	Rules available	Principles available
Nature and biodiversity	**X**		X	**+**	**+**
Environment and soil fertility	**X**		X	**+**	**+**
Energy and climate change	x		x	**÷**	**+**
Human health and welfare	x	**X**		**+**	**(+)**
Animal health and welfare	**X**		X	**+**	**+**
Rural development	x	**X**		**÷**	**÷**

X : Dominating
x : Less distinct/particular issues
+ : Describedin detail
(+): No details
÷ : Not described at all

As regards the effects on the environment, the avoidance of pesticides is positive for nature close to organic farms, soil fertility and biodiversity as well as ground- and surface waters. However, the effect of organic farming on nitrate leaching varies depending on the type of production. Organic dairy farms have lower nitrogen losses compared to conventional dairy farms, because of lower stocking density, lower N-application and more clover-grass in the rotation. In organic cash crop production the nitrate leaching is about the same as in conventional, but in organic vegetable, chicken and pig production the nitrate leaching is generally higher than in comparable conventional production. In organic vegetable production, which requires high amounts of nitrogen (N), this is supplied in the form of manure or compost with organically bound N that has to be decomposed in the soil by the microflora, before the nitrogen is available to the plants in the form of inorganic N (ammonium or nitrate). The decomposition of the manure continues outside the growing season releasing nitrate that may leach to the ground or surface water, but due to restrictions on manure application for CAP support to organic farming (max. 100 kg utilisable N/ha) organic farmers have a high incentive for growing catch crops and improving nutrient cycling by other means. As regards pigs and poultry, the organic rules concerning access to outdoor grass covered areas for pigs and poultry reduces the possibility to collect and store the manure until its use. Instead, it gives rise to ammonia volatilisation as well as nitrate leaching from the outdoor areas, while poultry and pigs in conventional farming are generally kept indoors on less surface area per animal.

There are no rules concerning energy consumption and climate change mitigation initiatives in the EU organic regulation except principles for effective resource utilisation in general. Nor are there any organic principles or rules specifically addressing the contribution of organic agriculture to rural development. For all production types, except beef production, the CO_2 emission per hectare is lower in organic farming compared to conventional. However, for many products the opposite is the case when calculated per unit produced due to lower yields and larger space requirement per animal indoors and outdoors. Carbon sequestration in the soil is generally higher in organic farming than in conventional farming due to a more diverse crop rotation and perennial crops, especially grass

clover fields. Effects of organic production in relation to rural development is not well documented, but there seems to be positive effects as regards innovation – also as regards new cooperation models and farm ownerships, establishment of farm shops, local branding and establishment of cultural bonds between cities and rural areas.

Some of the organic rules lead mainly to synergies (positive contributions to several public goods) while others lead to dilemmas (positive contribution to some public goods and negative to others). The ban on pesticides in organic farming is an example of a rule creating synergy because, this leads to positive effects on almost all the public goods (i.e. better nature, greater biodiversity, better environment, increased soil fertility and probably also better health for humans and animals, though this is not sufficiently documented). However, the ban may have a negative effect compared to conventional farming on some public goods due to lower crop yields resulting in a negative effect on CO_2 emission measured per product unit. An example of the dilemmas is the requirement that organic sows and piglets shall live in outdoor huts with free access to a grazing area. On the one hand this rule increases the health and welfare of the sows, but on the other hand it also increases the piglet mortality rate and the risk of nitrate pollution from the concentrated manure deposition in one place of the field.

Discussion

In public regulation the focus is often on tools that improve one specific public good, e.g. the EEC Nitrate directive (EEC, 1991) for improvement of the water environment in the EU. Organic farming may not be the most effective policy tool in relation to one particular good, but its advantage is the positive contribution to several public goods. The organic rules may also create dilemmas as one rule may cause positive as well as negative effects on public goods, but the balance may vary depending on the production type (crops, dairy, pig etc.) and the farm management. Compared to conventional farming the overall contribution of organic farming to the public goods in Denmark is positive. However, more documentation, rule development, research, innovation and education is needed to obtain the full potential of the organic farming system in relation to the public goods, especially as regards resource efficiency and climate change mitigation that are subjects not yet regulated in the EU.

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Energy efficiency and greenhouse gases emissions in organic, integrated and conventional olive orchards in Greece

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Key words: Olive, management, efficiency, carbon, sustainability, performance

Abstract

The use and efficiency of energy inputs and greenhouse gases (GHG) emissions were calculated in olive orchards under organic, integrated and conventional farming systems, for two years in Crete, Greece. Energy analysis included several farming inputs, equipment and human labour use. The corresponded GHG emissions were calculated in terms CO_2-equivalents, following IPCC methodology. Less intensified farming systems, such as the organic, presented higher energy use efficiency. However, energy use was not statistically different between systems. GHG emissions were significantly higher in the conventional farming system, especially due to burning of pruning residuals. The results may contribute to the evaluation of sustainability performance of the organic olive farming systems.

Acknowledgments

This work was supported by MINERVA SA. We thank the farmers for collaborating.

Introduction

Improved energy efficiency and reduced greenhouse gases (GHG) emissions are fundamental to achieve agricultural sustainability (Dyer *et al.* 2003). Low input farming systems, like organic and integrated farming, are shown to perform better with regards to energy efficiency, GHG emissions and other aspects of the environmental impact (Gomiero *et al.* 2011). Conventional production systems, on the other, are characterized by high input use of fossil energy, directly or indirectly consumed (Pimentel *et al.* 2005). However, a general lack of information on how organic management affects energy dynamics it is recognised (Hoeppner *et al.* 2006). Therefore, detailed studies of inputs and efficiency in major cropping systems, especially for the Mediterranean, could be considered necessary to determine the importance of input use and management for the improvement of sustainability performance. The goal of the current study was defined as to calculate the energy use and efficiency and GHG emissions of the three different olive farming systems (organic, integrated and conventional), following an up-to-farm-gate approach.

Material and methods

The study took place in Messara valley, a representative olive producing area of southern Crete, Greece. Twenty four orchards, located in eight different sites, were selected following discussions with stakeholders and based on previous research (Kabourakis, 1999; Gkisakis et al. 2016). Each study site included three neighbouring orchards (organic, integrated and conventional). The orchards were monitored for two standard production years (2011-2013), in terms of climatic conditions and considering the year-to-year deviation in yield (alternate bearing). Information on

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farming practices, inputs and crop yield were collected using structured questionnaires, answered by the farmers-owners and by weekly on-site observation.

Energy analysis of each farming system included the production and application of inputs (fertilizers, pesticides and cover crop seeds), use of equipment (tractor and relative equipment, trimmers, chainsaw and sprayer) and human labour. Embodied energy of machinery was excluded in order to focus strictly on farming practices and inputs applied. Pesticides embedded energy was not included as well, due to the low amounts used. Energy inputs, crop outputs and the corresponded GHG emissions of the different farming systems were calculated. In order to determine the fossil fuel energy consumed, the total amount (litters) used by the machinery equipment, for transportation, soil management, harvest, pruning, irrigation and application of fertilizers was analysed. The embedded energy of fertilizers, synthetic and organic, and cover crop inputs was also considered (Table 1).

Table 1: Embedded energy of olive orchard inputs and human labour

	Unit	Embeded energy (Mj)	Source
Direct energy			
Petroleum (LHV)	lt	35,9	IOR (2008)
Benzin	lt	32,2	IOR (2008)
Lubricant oil	lt	40	IOR (2008)
Indirect energy			
Synthetic fertilizer:			
Nitrogen (N)	Kg	78,23	Gellings *et al.* (2004)
Phosphorus (P)	Kg	15,8	Gellings *et al.* (2004)
Calcium (K)	Kg	9,3	Gellings *et al.* (2004)
Urea (46-0-0)	Kg	27,6	Audsley *et al.* (1997)
Organic fertilizers	Kg	17,81	Alonso and Guzman (2010)
Agrobiosol	Kg	6,5	Mudahar and Hignett (1987a,b)
PatentKali	Kg	6	Mudahar and Hignett (1987a,b)
Packaged bio-fertilizer	Kg	17,81	Fluck (1992)
Boron	Kg	18,2	Mudahar and Hignett (1987a,b)
Cover crops	Kg	10,5	Wells (2001)
Manure	tn	64,4	Pimentel (1980)
Man/hours	h	2,2	Fluck (1992)

GHG emissions generated by fossil fuels, fertilizers and pruning residues management were estimated in terms CO_2-equivalents (CO_2-eq), following IPCC methodology (IPCC, 1996); carbon dioxide equivalent emissions were calculated based on the estimated global warming potential (GWP) of each greenhouse gas, expressed as the effect of one kilogram of CO_2 on global warming over a given time horizon. Non-CO_2 emissions, like N_2O generated by synthetic fertilizers use or CH_4 by compost, are multiplied by the appropriate warming potential to convert to a CO_2-equivalent basis. The GWPs for N_2O and CH_4 applied were, respectively, 21 and 310, for a 100-year time horizon.

Comparison of farming systems was performed following univariate statistical analyses, using SPSS 20.0 for Windows. Data normality was assessed by Shapiro-Wilk test ($p<0.05$) and were found to be not normally distributed, even after the application of several transformations. Therefore, a Kruskall-Wallis test was run to determine whether differences in energy use and GHG emissions occurred between farming systems. Energy use efficiency was calculated using the coefficient of Determination (R^2) of the energy use (Mj/ha), as linearly related with the olive oil production (Kg/ha); A high R^2 indicates a larger proportion of the variance in the energy use

variable that is predictable from the olive oil production variable, therefore a higher energy efficiency is assumed.

Results

Although the average energy consumption of the organic system appears lower than conventional and integrated (Figure 1), the comparison of energy use showed no statistically significant differences between farming systems (p=0,651, χ2=0,860), due to high variation of energy use among organic olive orchards.

Organic olive orchards were more efficient in terms of energy use (R^2=0,227) followed by integrated (R^2=0,197) and then conventional (R^2=0,028). GHG emissions were significantly higher in conventional orchards comparing to the organic and integrated ones (p=0,048, χ^2=6,093), especially due to burning of pruning residuals (p=0,008, χ^2=9,608).

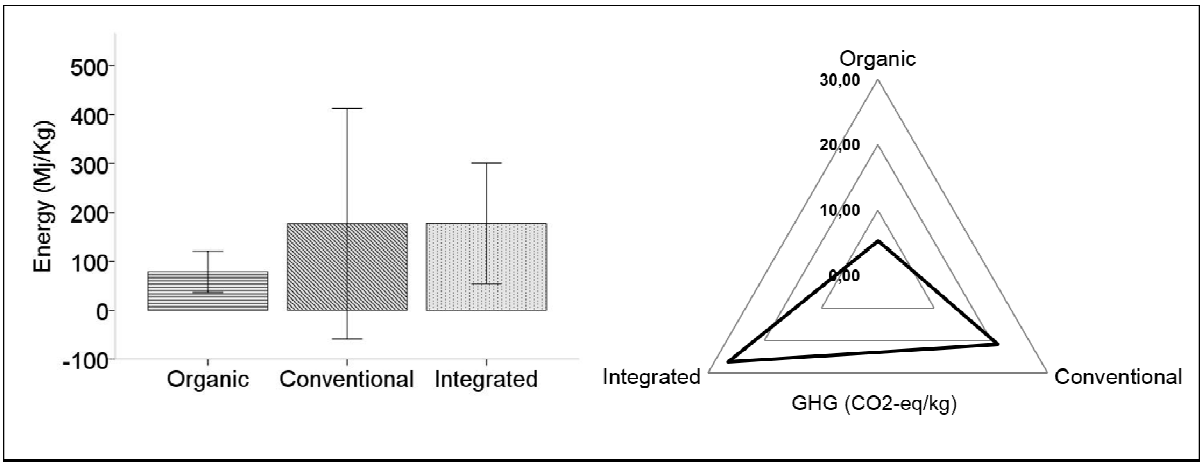

Figure 1: Energy use (Mj/Kg) and Greenhouse Gases Emissions (GHG) (CO_2-eq) per Kg of olive oil production in organic, conventional and integrated farming systems (confidence interval: 95%).

Discussion

Less intensive olive farming systems, like the organic, appeared to be more efficient in terms of energy use and GHG emissions, while certain farming practices, such as burning of pruning residues, resulted in significantly higher emissions. The non-significant differences between systems in energy use due to high variation of farming practices intensity within organic management, demonstrates the importance of farming practices, linked directly to energy use but not explicitly required by organic regulations. The above results may provide useful information for olive farmers and decision makers. It is expected as well to contribute to a holistic approach for assessing the sustainability performance of organic olive farming systems and a continuous improvement towards best practices required for truly sustainable production systems, as described within the features of organic 3.0 strategy.

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Agro-biodiversity adaptation for resilience to climate change: paradigm for sustainability in perpetuity

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Key words: Adaptation, adaptive research, biodiversity, climate change, organic, resilience

Abstract

This paper attempts to combine two different dimensions, *viz.*, nutrition potential from a certified organic farm of a station based work and 'on farm-trials' under adaptive research for resilience conducted by active participation of farmers, both of which were evaluated from the climate change perspective.

During *kharif*, *rabi* and *zaid* seasons of three consecutive years the mean organic vegetables production (kg) were 414, 4464.85, 960.33 respectively, fruits (202.33, 320.66 and 674.66 respectively) and oyster mushroom (226.66, 460.66, 103 respectively) harvested at the certified Organic Farm, which were found to meet the requirements of vitamins B, C minerals and edible fibre for over 500 families.

The 'on farm-trials' under adaptive research in Madhya Pradesh depicted desirable productivity figures under variable mean temperatures and total rainfall of the growing season in both the years and the regression analysis for correlating the productivity of rice, *viz.*, 4955 and 5220 kg ha^{-1} with these climate parameters depicted positive results.

Acknowledgments

The administration of Sam Higginbottom University of Agriculture, Technology and Sciences, which fund and extend all support for the continued certification of SHIATS Model Organic Farm (SMOF) in the successive years, is gratefully acknowledged.

Strengthening Adaptive Farming in Bangladesh, India and Nepal (SAFBIN) project of *Caritas India* implemented in the 3 districts of Madhya Pradesh, was supported by European Union Global Programme on Agricultural Research for Development and sponsored by Caritas Austria and Caritas India, which is being placed on record. The SAFBIN Project members deserve all credit for the physical and technical support, besides the cooperation extended throughout the planning and execution of the research trials in farmers' fields.

Introduction

Enhanced breakthroughs toward food and nutrition security of the burgeoning populace in the perspective of myriads of vulnerabilities and adaptation capability in the context of climate change are a dire necessity. Climate change impacts on agriculture are being witnessed all over the world, but countries like India are more vulnerable in view of the high population depending on agriculture and excessive pressure on natural resources. If temperatures rise by 4˚C in India, grain yields could collectively fall by 25 to 40 % (Rosenzweig and Parry, 1994) with rice yields decreasing by 15 to 25 % (Kumar and Parikh, 1998).

Human perspective of development has made huge breakthroughs, but concurrently has put several vital natural phenomenon into a predicament, interruption in biodiversity being one of the major.

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Thus the rejuvenation of biodiversity as an alternative paradigm towards sustainable agriculture for food production system in view of the climate change is a dire necessity.

Organic agriculture enables ecosystems to better adjust to the effects of climate change through soil fertility maintenance mainly through farm internal inputs, which are organic and biological thereby the carbon sink may become balanced at least partly (FAO, 2008).

The current paper attempts to connect three aspects, *viz*., climate change, adaptation through diversity and the organic approach.

Material and methods

The agronomic and allied evaluation were conducted during the successive years in the certified SMOF in the Faculty of Agriculture, Sam Higginbottom University of Agriculture, Technology & Sciences, Allahabad, Uttar Pradesh, India, which is currently in the 8th consecutive year [Certificate No. ORG/SC/1009/001070, valid till May 2017]. Among the range of models being continuously evaluated, the production and the converted nutrition data from 1 acre portion of the Olero-Pomo-Mushroom Culture System [OPMCS] was considered for study of the diversity, whether it accrues qualitative gains.

Further, on farm trials using Randomized Block Design were undertaken in the farmers' fields in 30 odd villages spread out in the three districts of Madhya Pradesh, *viz*., Sagar, Satna and Mandla situated in Sub-humid Tropical Hilly/Plateau AES under AEZ 5 & 6 of FAO under the SAFBIN programme by Student Researchers of M.Sc. (Ag) Agronomy with the active supervision and participation of the author and other stakeholders. Selected yield data of rice from Mandla district was subjected to statistical correlation analysis (Gomez and Gomez, 1976).

Results

One of the core principles of eco-organic farming of promoting biodiversity in general, and agro-biodiversity in particular, has been an emphasis in the SMOF with over 80 cultivated plant species, including perennials. Despite some obvious drawbacks, it seems to be potent towards addressing climate change.

Organic vegetables (Figure 1) harvested at SMOF during the three years of the current study was found to meet the requirements of not only the food needs but also was annually sufficient to supply vitamins (A, B & C) for over 5000 families with 4 members, and edible fibre for over 500 families with 4 members.Similarly, the fruits harvested from the limited plantation within boundaries of the SMOF would cater to anywhere between 80 to 800 families' nutrition requirements (Figure 2).The crops performed acceptably well and there was fair evenness between the three successive years in the production figures of mushroom (Table 1) as well as the vegetable and fruit components, despite a 53.4 and 24.6 % reduction in the mean rainfall during the *kharif* season respectively from the 1st to 2nd and 2nd to 3rd years. Similarly, the mean temperatures also increased to the tune of 2.29 and 0.64% respectively during these periods. With regard to the qualitative values of mushroom, the harvested quantity from a floor area of 384 m^2, with 4 tiers, when translated on the basis of a mean requirement of 89.68 $mgday^{1}$ $person^{1}$ observed to be sufficient to supply Vitamin B & C for 540 persons and food fibre for 250 persons (31.5 g day^{1} $person^{1}$).

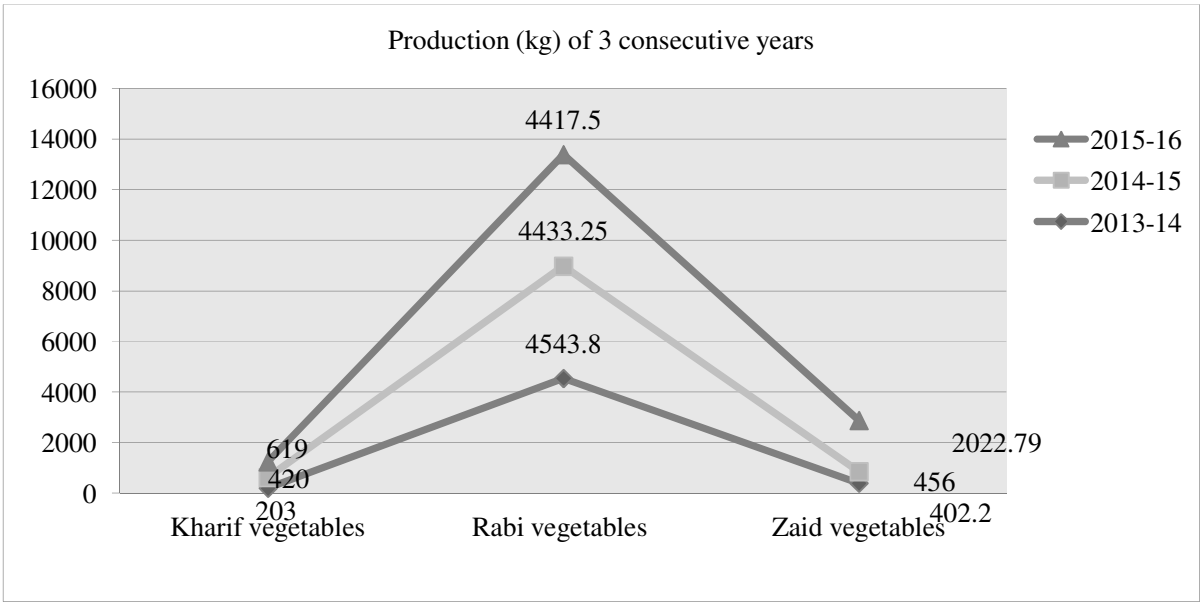

Figure 1. Production figures of vegetables harvested at SMOF during the 5th, 6th and 7th years of certification for block covering a net cultivated area of 1 acre

From their (Singh, 2013 and Jamir, 2014) 'on farm-trials' under adaptive research for two successive years in Mandla, Madhya Pradesh reported desirable productivity figures in the context of climatic parameters.

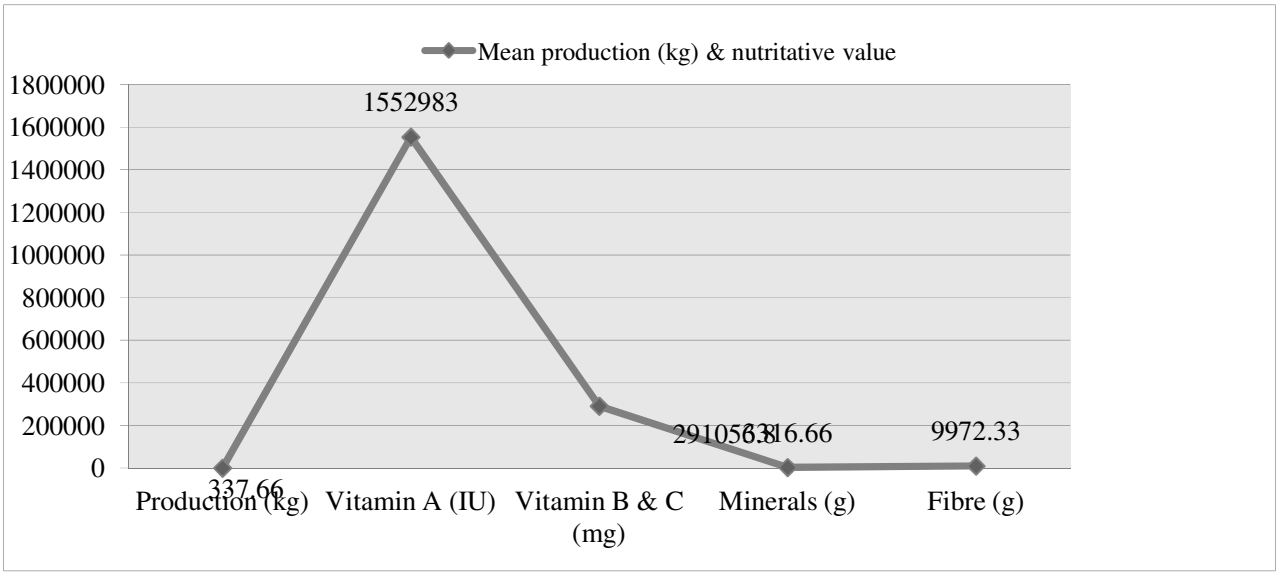

Figure 2. Production figures and qualitative values of fruits harvested during the 5th, 6th and 7th years of certification from limited plantation within boundaries of SMOF

The regression analysis, the equation Y = 265x + 4690, Y = 128.2x + 1271 and Y = 0.32x + 23.15 (Figure 3) were found to be acceptable for the grain yield (4955 and 5220 kg ha^{-1}) of rice under mean temperatures (23.47 and 23.79 ^{0}C) and total rainfall (1399.20 and 1527.40 mm) of the growing season in both the years respectively.

Table 1. Production figures and qualitative value of mushroom harvested from a net cultivated area of about 0.1 acre at SMOF during the 5th, 6th and 7th years of certification

Components	Production (fresh weight) (kg)			Qualitative Value (Mean)		
	2013-14	2014-15	2015-16	Vitamins B & C (g)	Minerals (g)	Fibre (g)
Mushroom [*Kharif* season]	200.00	230.00	250.00	13.69	4760.00	2266.66
Mushroom [*Rabi* season]	455.00	462.00	465.00	27.82	9674.00	4606.66
Mushroom [*Zaid* season]	105.00	103.00	101.00	6.91	2163.00	1030.00

Correlation between grain yield of rice with the mean seasonal temperature and total rainfall depicted the R^2 value of unity.

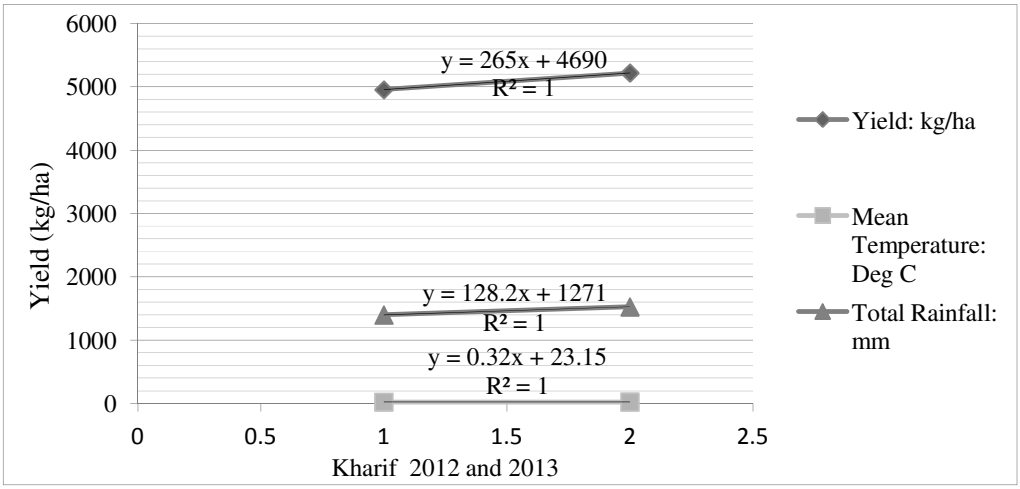

Figure 3. Correlation between grain productivity of rice with the mean seasonal temperature and total rainfall of the growing season during two successive years in Mandla district of Madhya Pradesh

Discussion

The consistency in production figures of mushroom, vegetable and fruit components between the three successive years depicts that despite the climatic variations, particularly the bad monsoon and increased temperatures of the latter 2 years during *kharif* season, there is an obvious evidence of adaptation under climate change (Niggli *et al*., 2008).

The phenomenon that organic farming practices preserve soil fertility and maintain or increase organic matter, which can reduce the negative effects of climate extremes while increasing crop productivity (ITC and FiBL, 2007 as reported by Chatterjee and Thirumdasu, 2015) may also hold true in the current scenario. Additionally, growing different assemblages of crops in time and space seeks to enhance the agro-ecosystem resilience to external shocks such as extreme weather events or price variation, which are all risks most likely to increase as the climate changes.

The eco-intensification in different dimensions, scaling up to an array of crops and building it up to system of crop intensification (SCI) have greater potential under continuance of organic production system (Abraham, 2015), which were evident in both the contexts.

Correlation analysis between grain yield of rice with the mean values of weather parameters indicates that despite some variability of climate, the grain productivity of rice did not recede. This may be taken as a positive direction towards climate resilience through better vegetative growth and optimum assimilate translocation (Jha *et al*., 2004). Both the 'on farm-trials' had either a diversity or organic component, the former being indigenous varieties and the latter used organic formulation. These factors may be given due credit for the acceptable performance of rice in the farmers' trial plots, due to the adaptability of the indigenous genotypes and the positive genotypic-environmental interaction (Jamal, 2009). Further, that the organic practices may have accrued better soil health resulting in better plant growth, yield components and yield (Yadav *et al.,* 2009).

Building strong and self-reliant smallholder farmers with maximum diversity on their farm, balanced and unpolluted natural resources and minimum reliance on external agency is inevitability. The organic production practices exhibit resilience to climate change through synergistic phenomenon. In conclusion, there is immense reason to accept, adhere and promote an intensive adoption of agro-biodiversity, which will enable nutrition security concurrently with adaptation and resilience to climate change, ultimately resulting in the indispensable perpetual sustainability.

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Agroecological Service Crops as a tool to manage the agrobiodiversity in organic orange orchards: a case study

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Key words: weed management, pest management, no tillage, system re-design, agroecology, biodiversity indices

Abstract

The ITACA project "Technical and scientific answers to new orchards converting to Organic Agriculture", a two-years project financed by the Italian Ministry of Agriculture (2014-2015) intended to verify the effect of agroecological service crops (ASC) on the agrobiodiversity in a young orange-orchard. This paper analyzes the role of ASC species and the termination strategy on weeds and fungal communities. The results show a shift of the biodiversity indices of the analyzed community in function of the compared managements.

Introduction

Ecological agriculture aims to build the strengths of natural ecosystems into agroecosystems using practices that (a) grow healthy plants able to resist to enemies, (b) stress pests, and (c) enhance populations of beneficial organisms (Magdoff, 2007). Examples of agroecological practices are the use of cover crops and reduced tillage. Cover crops contribute to optimize nutrient and water cycles, and provides ecological services such as weed and pest management by influencing the agrobiodiversity. By this, cover crops are defined Agroecological Service Crops (ASC). Moreover, reduced tillage increases biota activity in soil, reducing soil organic matter depletion and risk of erosion (Wezel et al., 2014). In order to design a resilient organic citrus system, two ASC species and two termination strategies were compared in an organic orange long-term experiment in Sicily. The work aims at evaluate the ASC effect on system biodiversity in terms of soil fungal-oomycetes and weed communities.

Material and methods

The research was carried out during 2013-2014 and 2014-2015 (hereafter reported as 2014 and 2015, respectively) in the 'Long term trial on organic Citrus' (PALAP9), within the experimental farm of the Research Centre for Olive, Citrus and Tree Fruit of the Council for Agricultural Research and Economics (CREA-ACM) in Sicily (37°17′N, 14°50′E). Orange trees [*Citrus sinensis* (L.) Osbeck] cv. "Tarocco Rosso" grafted on Carrizo citrange rootstock [*Poncirus trifoliata* (L.) Raf. × *C. sinensis* (L.) Osbeck] were planted in June 2012. The experimental design was a split-plot with two factors and three replications. The main factor was the ASC species introduction (ASC): (*i*) no ASC or control (no ASC), (*ii*) Barley, *Hordeum vulgare* L.(B), and (*iii*) Horse bean, *Vicia faba* L. var. *minor* (FB). The split-plot factor was the ASC termination strategy (T): (*i*) incorporation into the soil (GM), and (*ii*) flattening by roller crimper (RC). Each elemental plot was 72 m^2 (12 plants per plot). ASC species were sown on 25 and 24 November in 2013 and 2014, respectively, and they were terminated on 15 and 16 April in 2014 and 2015, respectively.
The evaluation of the weed and soil fungal and oomycetes communities was performed both during the cover crop cycle and after their termination in two phases: 91 and 93 DAS (Days after ASC

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Sowing) and 79 and 84 DAT (Days after ASC Termination) in 2014 and 2015, respectively. The weed density and coverage – total and at species level – was recorded by placing ten randomly-selected 0.25 x 0.25 m^2 quadrats within each plot in the row and inter-row spaces for density determination and selecting three 6.0 x 4.0 m^2 areas for coverage assessment, obtaining a representative sample per plot. The soil samples for mycological determination were collected around the rhizosphere of citrus plants (at the distance of 40 cm from each plant), to a depth of 0-40 cm. Two sub-samples were taken (in the row and between the rows) from rhizosphere soil of each plant; each sample weighed 400 grams. The two sub-samples were subsequently mixed, as to obtain a single homogeneous and representative sample on which the mycological analyses were performed. For each different ASC species and for each different termination strategy, 3 plants were considered, for a total of 48 citrus plants. The soil samples were analyzed for enumeration and identification of fungi and oomycetes, as provided by *Metodi di analisi microbiologica del suolo* (2002). Ten grams soil, wet weight, per each sample was diluted in 90 mL of sterile phosphate buffer and then serial decimal dilutions were prepared. One mL of each dilution was added to 20 mL of agar technical medium containing streptomycin sulfate (200 mgL^{-1}) in order to prevent the bacteria development. Agar plates were incubated at 25°C for 4 days. After incubation distinct colonies were counted and the number of Colony Forming Units (CFU) in a gram sample was calculated. Fungi and oomycetes were identified to genus level according to morphological features.

The weed and mycological biodiversity was evaluated by calculating diversity indices: species and genre Richness (R-weeds; R-fungi), Shannon-Weaver (SW-weeds; SW-fungi) and Dominance-Simpson (D-weeds; D-fungi) (Magurra, 2013). The obtained indices were analysed with a Correspondence Analysis (CA) by using STATISTICA software (StatSoft, Inc. 2007, version 8.0).

Results

The Correspondence Analysis (CA) summarized the variation of the weed and fungi biodiversity indices after ASC sowing (Fig. 1a) and ASC termination (Fig.1b) in the two experimental years. Starting from the 6 tested biodiversity indices, the first two components of CA (Eigenvalue 1: X-axis and Eigenvalue 2: Y-axis) explained about the 98% and 97% of the global experiment variability in the two analysed phases, respectively. The distance among the observations in the scatter chart approximates the dissimilarity of their biodiversity composition. In the first phase (93-91 DAS), this leads to observe that X-axis (85% of explained variability) completely discriminated the Barley (B) species from the other Managements (Fig. 1a). In particular, the plots belonging to barley scored in the right side of the biplot. Differences on the horizontal direction are mainly attributed to R-weeds, SW-weeds and D-fungi characterizing Faba bean (FB) and no ASC, on the negative part, and to R-fungi in the positive part of the axis. Looking to Y-axis (13% of explained variability), the FB species in the first year scored in the lower quadrants of the biplot, while B and control no ASC, scored in the upper ones. Y-axis resulted positively correlated with SW-fungi and SW weeds, and negatively correlated with R-weeds, representing I FB.

In the second phase (79-84 DAT), differences on the X-axis (86% of explained variability) are mainly attributed to R-fungi in 2014 and the II B GM, on the negative part,and to R-weeds and SE-weeds in the positive part of the axis (Fig. 1b). On the other hand, the Y-axis (11% of explained variability), resulted negatively correlated with SW-fungi and D-weeds, and positively correlated with R-fungi. The two years are discriminated with 2014 results positioned in the upper left part of the biplot and the most of 2015 ones in the bottom right side. Exceptions are RC barley in 2014 and GM barley in 2015, bottom right side, and the RC faba bean in 2015, in the upper right side, strongly associated with the R-weeds index.

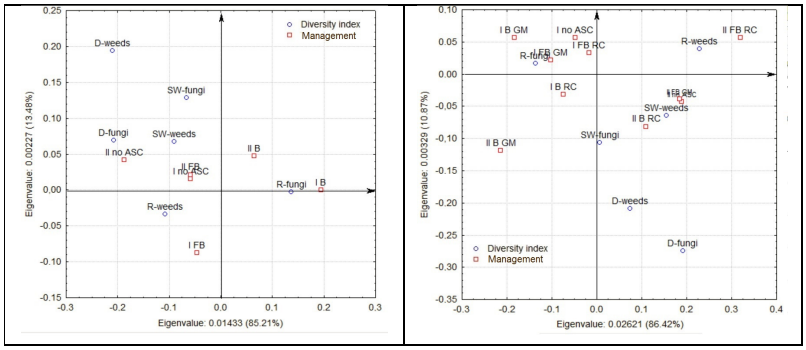

Figure 1: Field trials planning.

Biplots of the corrispondence analysis.

Figure 1a: Eigenvalue 1 (X-axis) explaining 85% and Eigenvalue 2 (Y-axis) explaining the 13% for a total of 98% of the overall variability of the experiment. Management label legend: No ASC, control; FB, faba bean; B, barley; I, 1st year (2014); II, 2nd year (2015). Parameters legend: R-weeds and R-fungi, weed species and fungi genre Richness index; SW-weeds and SW-fungi, weeds and fungi Shannon-Weaver indices; D-weeds and D-fungi, weeds and fungi Dominance-Simpson indices.

Figure 1b: Eigenvalue 1 (X-axis) explaining 86% and Eigenvalue 2 (Y-axis) explaining the 11% for a total of 97% of the overall variability of the experiment. Management label legend: No ASC, control; FB, faba bean; B, barley; I, 1st year (2014); II, 2nd year (2015); GM, ASC termination by green manure; RC, ASC termination by flattening. Parameters legend: R-weeds and R-fungi, weed species and fungi genre Richness index; SW-weeds and SW-fungi, weeds and fungi Shannon-Weaver indices; D-weeds and D-fungi, weeds and fungi Dominance-Simpson indices.

Discussion

Results put in evidence the influence of ASC introduction and termination strategies on the fungal-oomycetes and weed biodiversities in the analyzed phases of the experiment. In particular, in the first phase (93-91 DAS) the barley treatment was characterized by the highest fungal genera Richness and the lowest weed species one. Contrariwise the no ASC and FB were associated to high R-weed. Moreover, the no ASC in 2015 seemed to be also characterized by the highest dominance of few fungal genera and weed species. This result, year depending, confirms the effect of ASC introduction in promoting a lower dominance of species and genera, reducing the risk of selection of infestations, actually ensuring the increase of the system resilience.

As far as the second analysed phase was concerned, results put in evidence the effect of barley in reduce weed Richness and biodiversity and amplify fungi Richness when terminated by green manure, despite the effect of the year. On the other hand, the conservative termination (RC) of barley showed a negative trend with weed Richness (R_weeds) and a positive one with weed biodiversity (SW-weeds), whereas an opposite trend was observed for the flattened faba bean (FB RC).

These trends highlight how farmers can use the ASC and their proper management as a tool for influencing the agrobiodiversity in order to address and manage the services and disservices deriving by its components.

In this perspective, further research are needed to exploit the relationship between the ASC introduction and the plant and microbial communities, fostering the effectiveness of the ASC termination strategies in order to maximize the agroecological services to be provided by ASC species.

Acknowledgments

The authors wish to thank to Biagio Francesco Torrisi and Maria Allegra of CREA—CA for their help in plant and soil analysis. This work was funded by the ITACA research project.

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Carbon sequestration in long term on farm studies in Organic and Biodynamic Agriculture, Sweden

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Key words: carbon sequestration, biodynamic agriculture, compost, crop rotation, manure

Abstract

Beginning in 1958, three sets of long-term field trials have been conducted at the Swedish Biodynamic Research Institute in Järna, Sweden. Design of the field trial described in this paper differs from the earlier long-term experiments - it was established on an integrated biodynamic crop and livestock farm. Treatments were based on resources available on the farm; using only manure produced on-farm. The aim was to evaluate long-term effects on quality and yield in crops and quality parameters in soil, by comparing use of composted and not composted manure, with or without the full set of biodynamic preparations. Increase of carbon was calculated to a carbon sequestration averaging 400 kg carbon per ha and year in the topsoil, with the highest value (500 kg) with use of biodynamic treatments and composted manure, compared to 300 kg with use of not composted manure without biodynamic treatments.

Introduction

Long-term trials on organic farms, compared to conventional farms, have shown increased soil organic carbon (SOC) (Marriott & Wander 2006), However, uncertainty remains about SOC sequestration in organic and biodynamic agriculture (Leifeld & Fuhrer 2010).

Three sets of long-term field trials have been conducted at the Swedish Biodynamic Research Institute in Järna, Sweden, since 1958. The basic aim was to develop biodynamic farming during Nordic conditions. The experiments started as an initiative within the Scandinavian Research circle for biodynamic agriculture, founded already in 1949 with members from the all Nordic Countries.

The results from the initial K-experiment (Kjellenberg, Granstedt, & Pettersson, 2005) formed the basis for one 6- and one 9-year trial, jointly called the UJ-experiments. Results from the two trials corresponded well with each other, as well with the results from the K- experiment (Dlouhy, 1981; Kjellenberg & Granstedt, 2015; Pettersson, 1982)

The design of the field experiment reported from in this paper differs from the earlier long term experiments. It was established within an integrated biodynamic crop and animal farm. The field trial was established within an integrated biodynamic crop and livestock farm in Järna, Sweden, 59° N. Treatments were based on resources available on the farm; using only manure produced on-farm. The aim was to evaluate long-term consequences on quality and yield in crops as well as quality parameters in soil, by comparing the use of composted and not composted manure, with or without use of the full set of biodynamic preparations.

Material and methods

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The soil at the field trial site is mainly a clay loam, with an organic carbon content of between 1.9% and 2.9%. Soil under the topsoil is stratified, with glacial layered clay at the bottom. Topsoil has undergone secondary sorting of soil fractions (post-glacial clay, loam and silt) **since the last ice** age. The soil is generally high in potassium (K), low in phosphorus (P) and has a pH between 5.7 and 6.2.

Design, field trial 1991

Treatment	Plot	Block	Block	Plot	Treatment
NCM25-	25	C	A	1	CM50-
NCM25+	26			2	CM50+
CM12,5+	27			3	NCM12,5+
CM12,5-	28			4	NCM12,5-
CM25+	29			5	CM12,5+
CM25-	30			6	CM12,5-
NCM12,5-	31			7	NCM50+
NCM12,5+	32			8	NCM50-
CM50-	33			9	NCM25-
CM50+	34			10	NCM25+
NCM50+	35			11	CM25-
NCM50-	36			12	CM25+
CM50-	37	D	B	13	NCM12,5-
CM50+	38			14	NCM12,5+
NCM50+	39			15	NCM25+
NCM50-	40			16	NCM25-
CM12,5+	41			17	CM25-
CM12,5-	42			18	CM25+
NCM25+	43			19	CM12,5+
NCM25-	44			20	CM12,5-
NCM12,5-	45			21	NCM50+
NCM12,5+	46			22	NCM50-
CM25-	47			23	CM50-
CM25+	48			24	CM50+

4 m

15 m

Manure treatments

Abbreviations	Type	Tons/ha	Kg N/ha
NCM12,5-	Non-composted manure 1991	12.5	31.3
NCM12,5+			
NCM25-	Non-composted manure 1991, 1995, 2000	25	62.5
NCM25+			
NCM50-	Non-composted manure 1991, 1995, 2000	50	125
NCM50+			
CM12,5-	Composted manure 1991	12.5	31.3
CM12,5+			
CM25-	Composted manure 1991, 1995, 2000	25	62.5
CM25+			
CM50-	Composted manure 1991, 1995, 2000	50	125
CM50+			
Biodynamic preparations	- no + yes		

Figure 1. Field trial design, Skilleby Research Farm

Soil samples was taken after Ley III in the five-year crop rotation before manuring and sowing winter wheat. Samples from the upper soil layer (0–20 cm) of each of the 48 plots of the field trial were sent to Agrilab (Uppsala, Sweden), and analysed according to established standards. Total C (carbon) and N (nitrogen) content were measured with a LECO CHN 600 element analyser (SS-ISO 11464). Available P (phosphorus), K (potassium), Ca (calcium), Mg (magnesium) and Na (sodium) were analysed after extraction in ammonium lactate (AL) solution (SS 028310). Total P, K, Mg, Ca and Cu (copper) were determined according to SS 028311 after extraction in hydrochloric acid (HCl) and pH was determined according to SS-ISO 10390.

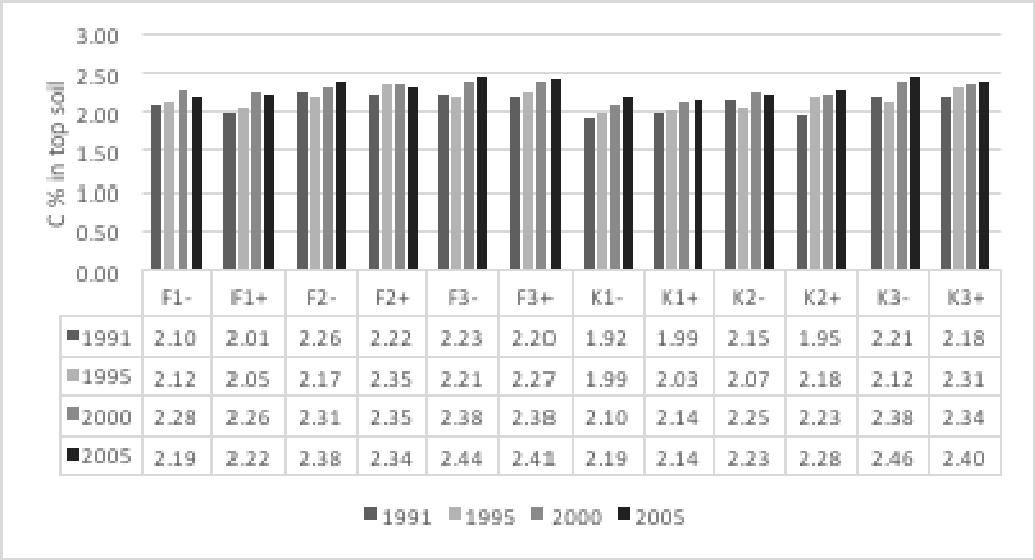
Carbon balance for each year based on total carbon yield, incorporation of crop residues in soil, harvested carbon and recirculation via manure, increase of carbon through SOM (soil organic matter), formation and decrease of organic carbon in SOM through mineralisation during the five-year crop rotation was calculated according the model developed and tested by Granstedt & L-Baeckström (2000). Values calculated in the model were compared to values obtained in trials in 1995, 2000 and 2005.

Computer program Excel 2010 (Microsoft Corp., Redmond, WA, USA) was used for calculations and statistical evaluations.

Results

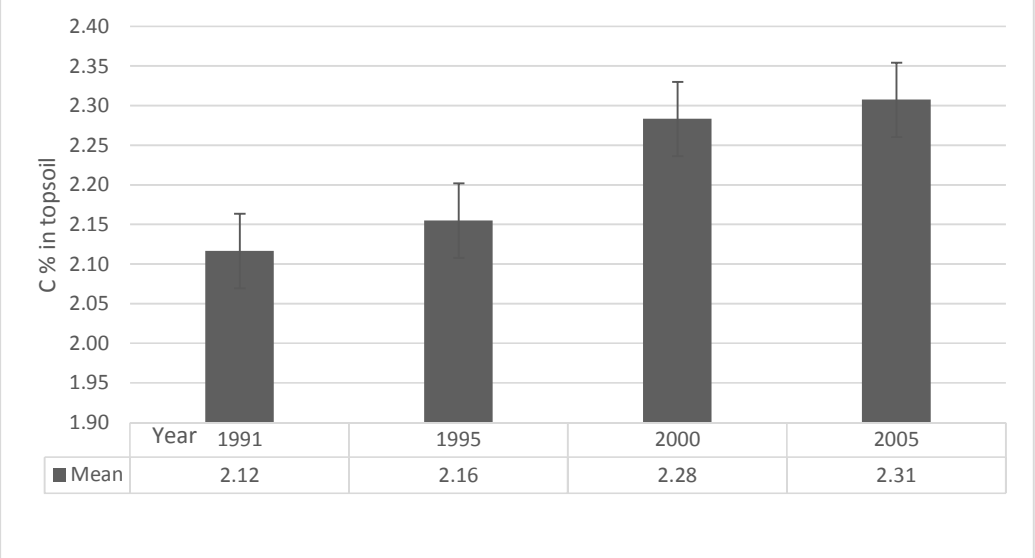
During the 15-year period 1991 to 2000 pH, P-Al, K-Al, Mg and Ca increased in all manure treatments despite of negative values for P and K in the farm gate balances. Soluble P content in the soil is very low (P class 1 to P class 2) but soluble K is at a sufficient level (K class 3).

Average total organic carbon content in topsoil increased in all treatments during the 14-year period from 1991 to 2005.



	F1-	F1+	F2-	F2+	F3-	F3+	K1-	K1+	K2-	K2+	K3-	K3+
1991	2.10	2.01	2.26	2.22	2.23	2.20	1.92	1.99	2.15	1.95	2.21	2.18
1995	2.12	2.05	2.17	2.35	2.21	2.27	1.99	2.03	2.07	2.18	2.12	2.31
2000	2.28	2.26	2.31	2.35	2.38	2.38	2.10	2.14	2.25	2.23	2.38	2.34
2005	2.19	2.22	2.38	2.34	2.44	2.41	2.19	2.14	2.23	2.28	2.46	2.40

Figure 2. Total carbon content in topsoil in the 12 different treatments 1991, 1995, 2000 and 2005.



Year	1991	1995	2000	2005
Mean	2.12	2.16	2.28	2.31

Figure 3. Average total carbon in topsoil, all treatments, in 1991, 1995, 2000 and 2005. General trend concerning total carbon content in the top soil in the 12 different treatments. Error bars indicate standard error (SE).

Discussion

Increase in soil carbon averaged 400 kg carbon per ha and year in the topsoil (0-20 cm and an average bulk density of 1.25 g/cm^3) from 1991-2005. During the first 4 years, we observed a significant increase ($p<0,05$) for composted and not composted manure with use of biodynamic treatments compared use of manure without biodynamic treatments. Additionally, we observed an average increase of 0.14 % in organic carbon in the B horizon (60-90 cm).

During the first 14 years of the field trial there was a positive correlation between the calculated total increase in soil carbon content and the measured value. There was a higher carbon sequestration in treatments with biodynamic composted manure compared to composted manure without biodynamic treatments in accordance earlier long-term studies (Mäder et al. 2002) and Bachinger (1996). With background of this results long term studies and evaluation of already obtained results are going on under Nordic conditions.

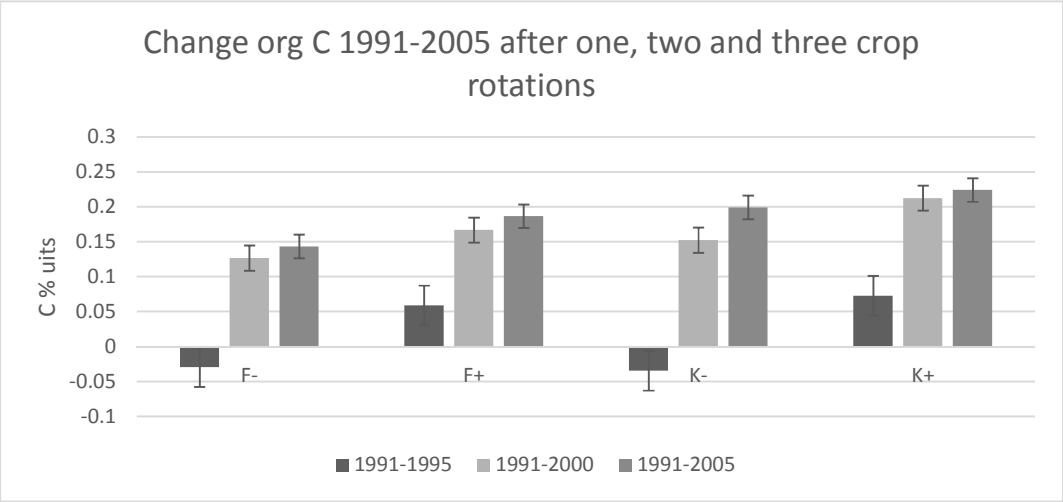


Figure 4. Average increase of total organic carbon content in topsoil in treatments with not composted manure without (NCM-) and with biodynamic (NCM+), and composted manure without (CM-) and with biodynamic (CM+) from 1991 - 1995, 1991-2000 and 1991-2000.

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The role of organic in controlling nitrogen pollution

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Key words: nitrogen, leaching, runoff, sustainability, footprints, virtual nitrogen

Abstract

This study examines whether organic agricultureis more nitrogen efficient than conventional agriculture. Using the nitrogen footprint tool, we estimated the nitrogen lost per unit nitrogen consumed for organic food production in the United States and compared it to conventional production. Additionally, we quantified the types of nitrogen inputs (new versus recycled) that are used in both production systems.Because of high variability in Nr efficiency in both systems, there is not a significant difference between Nr losses in organic versus conventional production. While nitrogen footprints were not significantly different among farming systems at the farm-scale level, significant differences were seen between organic and conventional systems in their introduction of new Nr into the environment at the global scale. Organic production creates 70-90% less new Nr per unit product than conventional production.

Introduction

Organic 3.0 strives to address current problems facing our agri-food systems, such as environmental degradation, while supporting human, economic and social health.Investigating nitrogen pollution is critical for achieving the goals of Organic 3.0, because we must develop food systems that preserves water, soil, and air quality for the well-being of this planet's inhabitants.

Many studies have compared organic and conventional agricultural practices and environmental impacts. For reactive nitrogen (Nr) pollution specifically, several meta-analyses have argued that there is no difference between organic and conventional production per unit product (Mondelaers et al. 2009; Tuomisto et al. 2012). On the other hand, Nr losses per unit land may be lower for organic farms as compared to conventional farms (Cambardella et al. 2015).

Additionally, conventional production relies heavily on new Nr sources, like synthetic fertilizer (Erisman et al. 2008). In contrast, organic production utilizes many recycled N sources, like manure (Cambardella et al. 2015). By quantifying what percentage of a food N footprint comes from new Nr sources and from recycled Nr sources, we can estimate the contribution of an individual's footprint to the global pool of Nr.

We examined the nitrogen footprint of organically produced foods in the United States and compare it to the conventional food N footprint (Cattell Noll et al. in prep). Our objectives were to: (1) quantify the virtual nitrogen factors (VNFs) of organic crop and animal production in the United States; (2) calculate the N footprint of a 100% organic diet in the United States; (3) assess how much new Nr organic agriculture contributes to the global Nr pool; and (4) compare these results to conventional VNFs, the N footprint of a 100% conventional diet in the United States and the conventional contribution of new Nr to the global pool.

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Material and methods

This analysis focused on the food production (virtual Nr) and food consumption portions of the N footprint.

A nitrogen footprint is defined 'as the total amount of Nr released to the environment as a result of an entity's resource consumption' (Leach et al. 2012). Virtual nitrogen is defined as 'nitrogen used in the food production process and is not in the food product that is consumed' (Leach et al. 2012). Virtual nitrogen losses are estimated with virtual nitrogen factors (VNF), which describe the nitrogen lost to the environment per unit nitrogen consumed (Leach et al. 2012).

Food consumption Nr is calculated based on average per capita consumption of different food groups and on the N content of those foods (%). VNFs are estimated using a mass balance approach that assumes that any N that is applied to a field and does not end up being consumed is lost to the environment (after accounting for any recycling). This includes nitrogen lost throughout the food production process, including, N in the applied fertilizer that is not taken up by the whole plant, crop residue N that is not recycled, N lost during food processing, N lost as food waste and other losses.

Primary data inputs were N applied (kg N ha-1), N in the yield (kg N ha-1) and feed conversions ratios (kg feed kg gain-1). For the organic calculation, we used data collected from a literature review. For the conventional calculation, we used data from the United States Department of Agriculture (2014). The remaining data inputs (processing waste, food waste, slaughter waste etc.) were the same for both organic and conventional production.

Data on the types of Nr applied to organic and conventional systems were collected using a literature review and analysed as a percentage of total inputs. New Nr sources include 1) synthetic fertilizer (Haber-Bosch Nr) 2) Biological Nitrogen Fixation (BNF) by the crop itself and 3) BNF by a legume green manure. Recycled Nr sources include 1) BNF by another crop in the rotation 2) animal manure 3) crop residue 4) non-legume green manure and 5) compost.

Results

Our analysis found that the results depend on the definition of system boundaries (Cattell et al. in prep). Virtual Nr losses in organic crop systems in the US are similar to virtual Nr losses in conventional crop systems (kg N lost kg N consumed^{-1}). Organic crops have similar Nr application rates (kg N ha^{-1}), but lower yields (kg N ha^{-1}); together these variables drive the Nr efficiency lower and increase the VNF. However increased crop residue recycling later in the production system increases Nr efficiency and reduces the VNF. These two impacts, nearly balance out and the result is organic crop VNFs that are similar to conventional (**Figure 1**).

Virtual Nr losses in organic animal systems are similar to virtual Nr losses in conventional animal systems (kg N lost kg N consumed^{-1}). In both systems, animal production is less efficient than crop production (Leach et al 2012). Organically raised animals consume more food (kg) to produce the same amount of weight gain (kg) compared to conventionally raised animals. This inefficiency in weight gain is balanced by greater efficiencies in organic feed production Differences in the density of organic and conventional animal production could lead to different results on a per unit land basis (Mondelaers et al. 2009).

The average total food footprint for a US consumer who only consumes organic food is similar to the average US consumer who only consumes conventional food. In contrast, the N input types (new versus recycled) are rather different, suggesting that organic agriculture contributes less new Nr to the global pool per unit N in product as compared to conventional agriculture (**Figure 2**). Across all food groups, organic production has the potential to release 70%-90% less new reactive nitrogen to the environment than conventional production (on a per unit N consumed basis).

Discussion

While differences in nitrogen footprints at the farm-scale are not significant between systems, there are important differences between organic and conventional when it comes to the global contributions to nitrogen pollution. Conventional production of crop and animal products relies heavily on newly created Nr, particularly, synthetic fertilizer created through the Haber-Bosch process. In contrast, organic production utilizes a wide variety of existing Nr sources, including manures, crop residues and composts. These data imply that organic production adds less new Nr to the global pool per unit product and therefore reduces the impact of anthropogenic Nr on the environment.

The large range around the organic crop and conventional crop estimates from our study indicates that there is a large variation in both systems, and that good management practices may be more important than the type of production system. This observation is in line with the conclusion from Kirchmann and Bergstroem (2001) who argue that there is a wider variation within systems than there is a clear difference between them.

Consuming organically produced foods has little impact on an individual's total nitrogen footprint, but it does change the percentage of newly created Nr associated with the footprint. Therefore, we conclude that, globally, organic production has the potential to introduce less new reactive nitrogen to the global pool. This can inform Organic 3.0 by providing critical information on the role of organic agriculture in preventing nitrogen pollution.

Figures

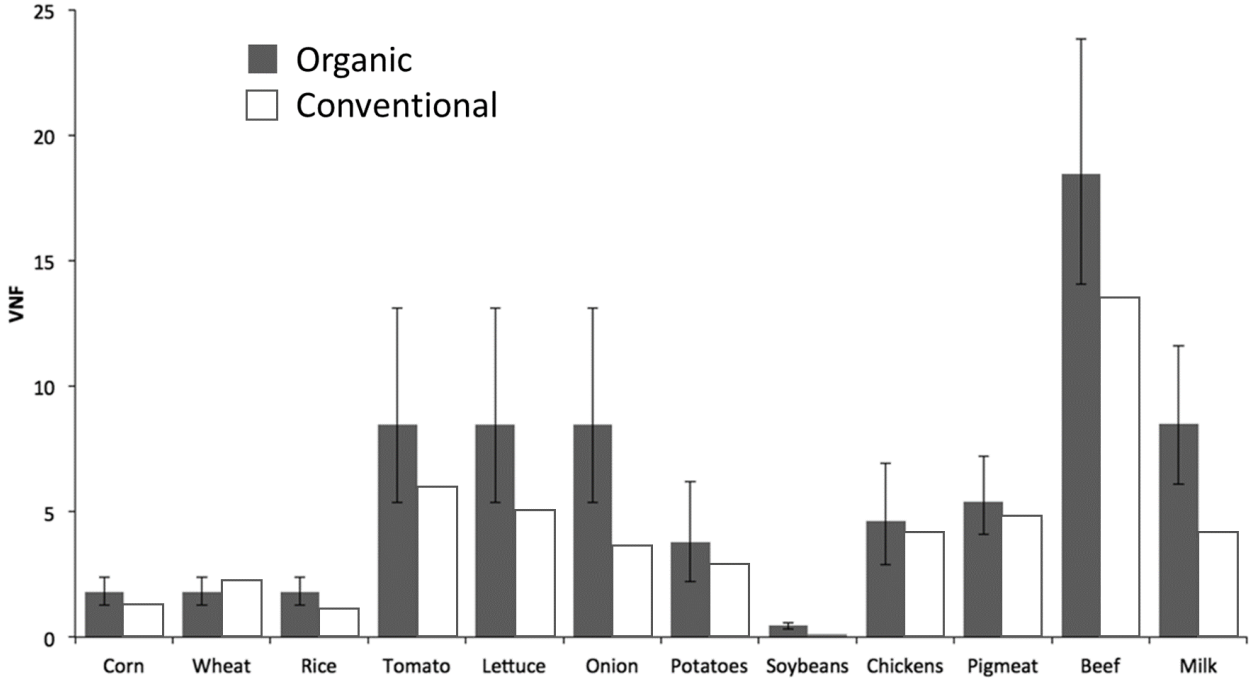

Figure 1. Virtual nitrogen factors (VNFs) for food produced organically (blue) and conventionally (orange) in the United States. The VNF for organic corn, wheat and rice has been calculated as a combined organic grain VNF. The VNF for organic tomato, lettuce and onions has been calculated as a combined organic vegetable VNF. Error bars show model output using Wald 95% confidence interval.

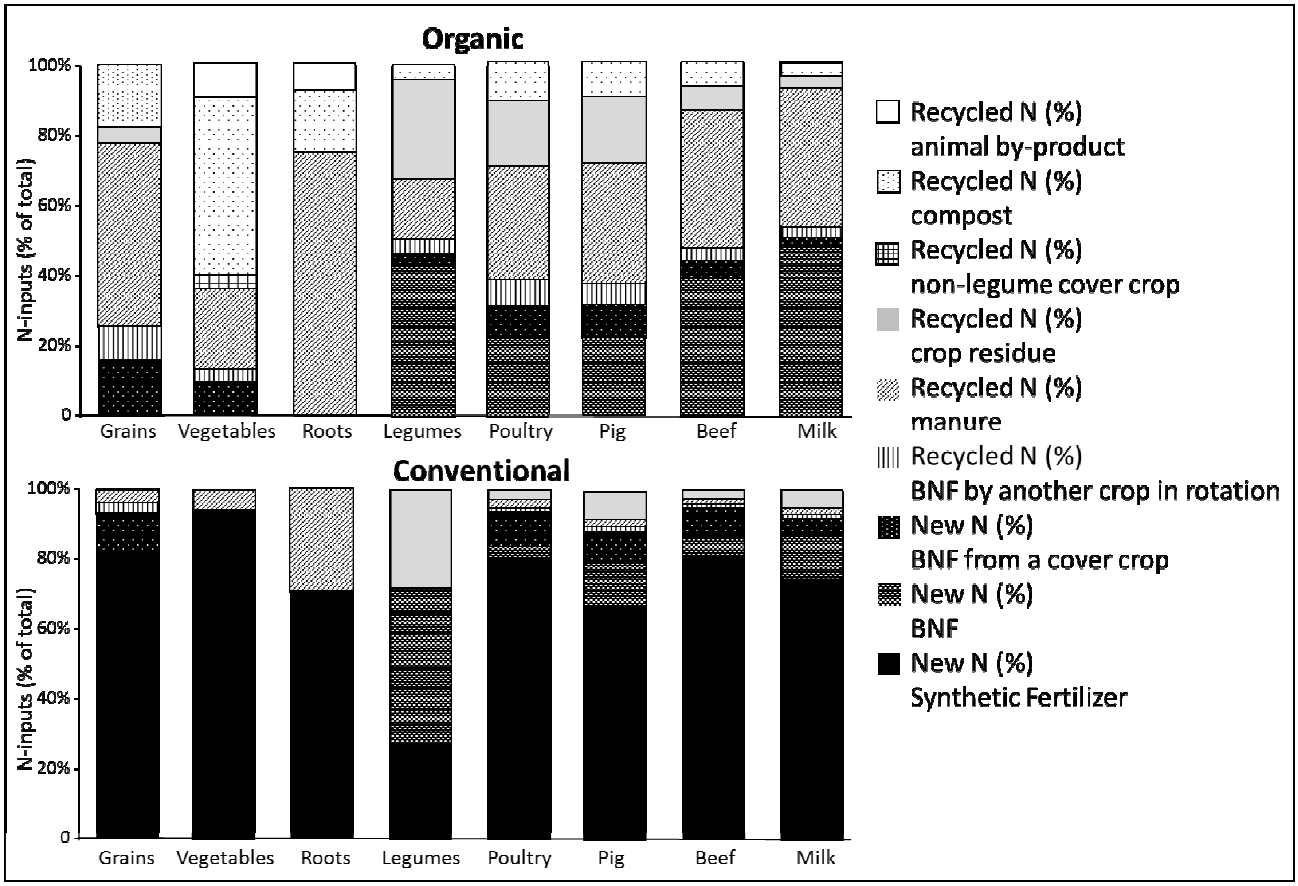

Figure 2. N input types for organic and conventional food production. New N Inputs (blue) include 1) synthetic N fertilizer, 2) biological nitrogen fixation (BNF) by the crop and 3) BNF by a cover crop or green manure immediately before the crop. Recycled N inputs (green) include 1) N from BNF by another crop in the rotation 2) manure 3) crop residue 4) a non-legume green manure 5) compost and 6) animal by-products.

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Organic farming increases soil C sequestration via changes in crop litter quality

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Key words: organic farming, soil carbon sequestration, crop traits, meta-analysis

Abstract

Nowadays, we humans face the major challenge of feeding nine billion people with sustainable agronomic practices, by relying less on external inputs and more on ecosystem services such as soil carbon (C) sequestration. While organic farming has been found to increase soil C sequestration, the mechanism behind are unknown. We reviewed the existing literature on the effects of organic farming on soil C sequestration, and used a European network of agricultural sites to address whether reduced crop litter quality with organic farming explains the soil C responses. We found that crop litter traits play a major role determining the effects of organic farming on soil C sequestration. Further mechanistic analysis may determine whether crop traits shift in accordance with soil C sequestration. This will represent a major advance in the understanding of tradeoffs between crop yield and soil C sequestration under organic farming.

Acknowledgments

We thank Gwénaëlle Flageul van Dijk, João Raimundo, Cindy Arnoldi and Karl Grigulis for help during field and laboratory work. We appreciate the use of data from the TRY initiative on plant traits (http://www.try-db.org). This work was funded by the ECO-SERVE project through the 2013–2014 BiodivERsA/FACCE-JPI joint call for research proposals, with the national funders ANR, NWO, FCT (BiodivERsA/001/2014), MINECO, FORMAS, and SNSF. P.G.P. acknowledges the Spanish MINECO for financial support via the Juan de la Cierva Program. G.B.D.D. acknowledges NWO-ALW for financial support (VIDI grant nr 864.11.003). P.M.D.S. was sponsored by a post-doc grant from FCT (SFRH/BPD/109511/2015).

Introduction

Nowadays, we humans face a major challenge of feeding nine billion people by 2050. At the same time, restrictions on the use of synthetic fertilizers and pesticides are increasing as a consequence of the global ecosystem impacts, such as declines in soil organic matter (Lal 2004). This situation requires a transition towards more sustainable strategies, such as organic farming, capable to increase crop production while enhancing soil carbon sequestration. Recent synthesis have found that soil C stocks are larger under organic than under conventional farming (Gattinger et al. 2012), but mechanisms behind such response have yet to be elucidated. Here we explored whether changes in crop traits towards increased leaf litter recalcitrance (e.g. high C:N ratio), with organic farming, may explain the responses of soil C stocks via reduced litter decomposition. We reviewed the existing literature and used a European network of agricultural sites to address this hypothesis.

Material and methods

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We synthesized studies thatevaluated the effects of organic farming on soil C stocks (Mg C ha^{-1}), soil C sequestration rates (Mg C ha^{-1} yr^{-1}), and soil respiration (mg C-CO_2 kg $soil^{-1}$ d^{-1}) using pairwise field comparisons of organic vs. conventional farming practices and meta-analytical tools. We refer to conventional when the farming system relied on the use of synthetic fertilizer and/or pesticides. To account for fertilization intensity across studies, we collected annual C and N external inputs (Kg C or N ha^{-1} yr^{-1}) in both farming systems. As the leaf economic spectrum of crops was a main aspect of our study, we obtained data on leaf P concentration, leaf N concentration and leaf dry matter content (LDMC) from the TRY database (Kattge et al. 2011) for those studies using the same crop species in both management scenarios. We also collected data on crop root: shoo (R: S) ratio. To test whether the effects of organic farming on soil C stocks were driven by responses of crop leaf litter quality to management, we selected six agricultural long-term experimental sites across different land-use types and climatic conditions in Europe. At each site, we measured soil carbon variables and leaf litter chemical traits in both farming systems.

Results

Averaged across all studies, organic farming significantly increased soil respiration, C stocks and C sequestration rates compared with conventional agriculture (Fig. 1). This positive effect was still significant even in those studies with reduced organic fertilization representing inputs that could have been produced theoretically at the respective ecological intensive farm (zero net input organic systems). Furthermore, the mean effect sizes did not differed significantly between the zero and the positive net input organic systems for soil respiration ($Q_{between}$ = 0.06, P_{random} = 0.813) and C sequestration rates ($Q_{between}$ = 2.63, P_{random} = 0.105). Such difference was significant for C stocks ($Q_{between}$ = 5.84, P_{random} = 0.016), but only in magnitude, as a positive effect size of organic farming was observed in the zero and the positive net input organic systems. Besides the major influence of climatic conditions (MAT), crop traits such as leaf N concentration were key to explain the effects of organic farming on soil C sequestration, and that influence was even larger than that of C and N external inputs.

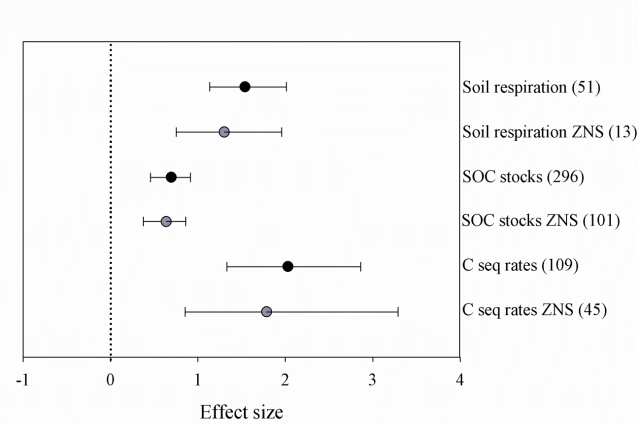

Figure 1. Mean effect size (Hedges' d) of agricultural ecological intensification on soil respiration, SOC stocks and C sequestration (seq) rates across all case studies (black circles). Significant (confidence intervals do not overlap zero) and positive mean effect sizes indicate higher value of the response variable in the ecological intensive compared with the conventional farms. The zero net input organic systems (ZNS) representing case studies where the ecological intensive treatment is ≤ 1.0 ELU (European Livestock Units) ha^{-1} are also shown (grey circles). The bars around the means are bias-corrected 95%-bootstrap confidence intervals. Number of comparisons is shown in brackets.

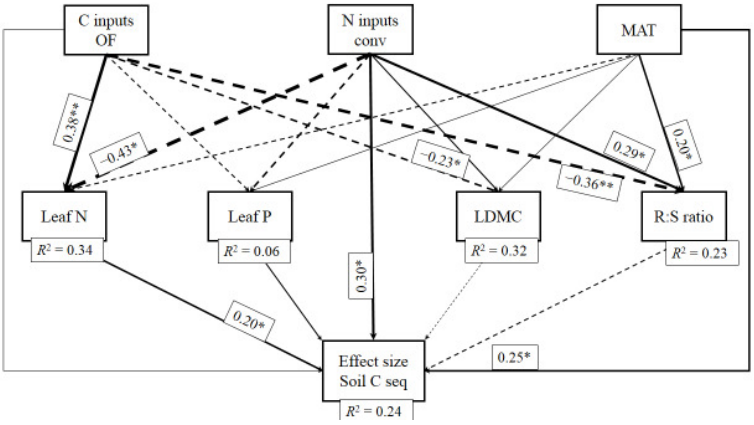

Figure 2. Structural equation model describing the influence of external annual C and N inputs, mean annual temperatures, leaf economic spectrum variables and R:S ratio on the effect size of organic farming (OF) on soil C sequestration. The widths of the arrows are proportional to the strengths of the path coefficients. Non-significant (P > 0.05) path coefficients are softened. Conv = conventional farming, continuous arrows = positive relationships, dashed arrows = negative relationships. Goodness-of-fit tests are: BootstrapP = 0.317, RMSEA = 0.079, P = 0.37, GFI = 0.990). **P < 0.01, *P < 0.05.

Discussion

Our results show that soil C sequestration is higher under organic farming at global scales, which is important for ecosystem services evaluation that can help to foster crop yield without relying on external synthetic inputs. The influence of crop leaf traits determining soil C sequestration responses to organic farming was larger than that of management issues. These results may suggest an important role for crop litter quality driving reduced soil C losses, and thus increased soil C sequestration, under organic farming. Analysing the plant and soil data from the Eco-Serve European consortium will shed some light on the mechanisms (e.g. changes in litter quality) behind the soil carbon responses. This will represent a major advance in the understanding of tradeoffs between crop yield and soil C sequestration under organic farming, which represent fundamental topics of Organic 3.0 related with our ability to sustainable feed the planet.

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Plant Production - Africa

Title	Author/s	Country
Recovery of organic tomato residues through vermicomposting for organic vegetable production	Azim Khalid, Soudi Brahim, Erraji Hassan, Roussos Sevastianos and Thami Alami Imane	Morocco
Appropriate time to apply organic fertilizer to sesame and soybean in the humid tropics	Victor Idowu Olowe, Patience Odueme, James Fadeyi, Ganiyu Adisa	Nigeria
Sustainable management of the diamondback moth, Plutella xylostella L. (Lepidoptera: Plutellidae) on cabbage	Ken Okwae Fening, Ethelyn Echep Forchibe, Kwame Afreh-Nuamah	Ghana
Towards Enhanced Kale (Brassica Oleracea) Productivity through Application of Rock Phosphate, Farm Yard Manure and (White lupin (Lupinus Albus L)) and Chickpea (Cicer arietinum L.) Integration in farming systems of Kabete Sub-County, Kenya	Richard Onwonga, Caroline Chepkoech, Quinter Genga, Raphael Wahome, Henning Jensen	Kenya
Effect of different organic substrates on reproductive biology, growth and offtake of the African night crawler earthworm (Eudrilus eugeniae)	Fred Kabi, Denis Kayima, Abasi Kigozi, Eric Zadok Mpingirika , Ronald Kayiwa and Dorothy Okello	Uganda
Impact of vetiver prunes compost application on the growth and yield of jews mallow	Adebayo Abayomi Olowoake	Nigeria
Effect of Poultry Manure and Defoliation on Organic Sesame Production in Guinea and Sudan savannahs of Nigeria	Ruth Saleh Ardzard, Ehiabhi Cyril Odion, Abdullahi Namakka, Abdulazeez Shero Isah	Nigeria
Effects of companion crops on insect pest infestation, yield, and postharvest quality of cucumber (Cucumis sativus) fruit	Oluyinka Benedicta Adewoyin	Nigeria
Effect of mycorrhizal symbiosis on the production of organic durum wheat	Khaled Sassi, Rim Bel Hadj Chedli, Ghassen Abid and Tarek Jarrahi	Tunesia
Organic farming makes cotton production the most cost effective: Case study from Benin	Silvere Tovignan, Simplice Vodouhe	Benin
Synthetic pesticide-free grain storage in Africa: Options, efficacy evidence and uptake challenges	Brighton Marimanzi Mvumi , Tanya Stathers, Alex Abraham Chigoverah	Zimbabwe

Recovery of organic tomato wastes through vermicomposting for organic vegetable production

Azim Khalid[*1], Soudi Brahim[2], Erraji Hassan[3], Roussos Sevastianos[4] and Thami Alami Imane[5]

Key words: tomato waste, compost quality, *Eisenia fetida*, UV-vis spectroscopy, humification index

Abstract

The recovery of organic wastes by composting process provides a hygienic soil organic amendment. Actually, in the context of regulation setting in Morocco, the compost should be sanitized and presents good agronomic value, beside its safety toward the environment. The objective was to assess the effect of the vermicomposting using Eisenia fetida on organic matter transformation of four composts A, B, C and D. After 36 days of incubation (vermicomposting), results showed that both C_{tot} (except vermicompost B) and N_{tot} were increased respectively in vermicomposts A, B, C and D (+27.7%,-0.19%, +10.7% and +39%), (+11.3%, +31.7%, +4.16% and +10.8%). UV-Vis spectroscopy test indicates poor humification index of vermicomposts B, C, D and commercial compost. In contrast, vermicompost A indicates high humification index. The phytotoxicity test of the four treatments has resulted in a germination index higher than of the commercial compost (GI>50%).

Acknowledgments

This study was carried out with the support of CAMPUS France within the framework of the PRAD project N °13-09 between L'Institut Méditerranéen de la Biodiversité et d'Ecologie marine et continentale (IMBE-France), Institut National de la Recherche Agronomique (Morocco) and Ibn Zohr University (Morocco).

Introduction

Vermicomposting consists in the action of epigeic earthworms on the decomposition of the organic matter (OM) through gut-associated processes, via the effects of ingestion, digestion and assimilation of the OM and microorganisms in the gut and casting (Domínguez and Gómez-Brandón 2013). Worms can consume virtually all types of organic matter and can absorb the equivalent of their own weight per day. Worm excreta are rich in nitrates, and available forms of P, K, Ca and Mg. The organic matter passage through the earthworms favors the growth of bacteria, especially actinomycetes, whose content in earthworm excrement is six times that of the soil of origin (Albrecht, 2007). The vermicompost has long been proclaimed of high agronomic value compared to traditional compost (Amic and Dalmasso 2012). In this experiment, four composts

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were characterized priori and were treated with *Eisenia fetida* in order to evaluate the impact of vermicomposting on the quality of the final organic product.

Material and methods

Four composts were produced from a previous experiment (conducted in 2013/2014) with the following combinations:

- Compost A = 100% tomato waste (axillary leaves and buds);
- Compost B = 66% tomato waste + 34% sheep manure;
- Compost C = 34% tomato waste + 66% sheep manure;
- Compost D = 100% sheep manure.

Eisenia foetida worms were introduced to compost A, B, C and D under controlled laboratory conditions temperature (25°C to 27°C) and moisture (70%). In three-level incubation boxes (two upper perforated levels for material renewal and one lower level for leachate collection), 34 earthworms were introduced to respectively 1504 g, 1335 g, 2101 g and 1361 g of composts A, B, C and D (plastic box dimension were 8.5 cm depth by 9.0 cm diameter). After 36 days of incubation, vermicomposts were collected and analysed for physical-chemical quality (pH, EC, N, C, K, Na, and C/N ratio), quality parameters (Phytotoxicity index) and humification index (UV-Vis). The last test was adapted from Zbytniewski and Buszewski (2005). One gram of compost and 50 mL of 0.5 M NaOH are stirred for 2 hours. Centrifugation (25 min, 3000 rpm) was followed by an absorption spectrum of 200 to 800 nm. Several specific spectra (SS: 280, 472 and 664 nm) are used to calculate three ratios: Q2/6 (280nm/664nm), Q4/6 (472nm/664nm) and Q2/4 (280nm/472nm). All statistical analyses were performed using IBM SPSS 21 software.

Results

Physic-chemical parameters

The results of the physic-chemical parameters show that there is an acidification effect of the vermicomposting with respect to the compost (initial situation). Indeed, acidification of nearly 5.5% was observed in treatment A. On the other hand, treatment A and B had their electrical conductivity and total nitrogen increase by 27.24% and 46.57% respectively compared to the initial situation. Concerning potassium content, significant differences were observed following vermicomposting treatment.

UV-Vis Spectroscopy

Humification ratios (Figure 1) have shown that, based on the ratio Q4/6 as humification index,

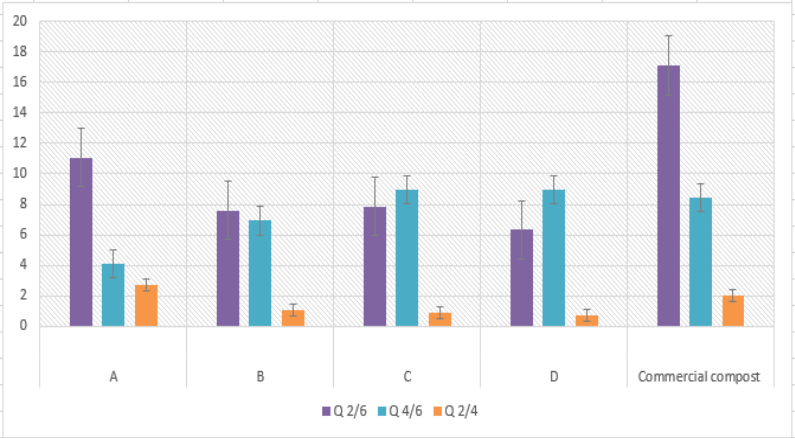

Figure 1. Humification ratio obtained by UV-Vis spectroscopy of the four treatments (A, B, C, and D) compared to a commercial compost as a control

vermicomposts B, C, D and commercial compost have a relatively high Q4/6 ratio superior than threshold 5. These vermicomposts therefore indicate a poor humification index and reveal that fulvic acids are even more abundant than humic acids. On the other hand, the vermicompost A indicates a Q4/6 inferior than threshold 5 and confirms a higher humification index.

Phytotoxicity test

The results show that the four vermicomposts indicate a higher germination index (GI) than commercial compost, with the exception of vermicompost A with the 50% concentration of the aqueous extract (Figure 2). The literature indicates that a GI > 50% suggests an organic matter without phytotoxic effect. This GI increases substantially with the increase in the concentration of 50% to 75% compost extracts, unlike commercial compost. This gives us more information about the bio stimulant effect on germination and root elongation of cress seeds.

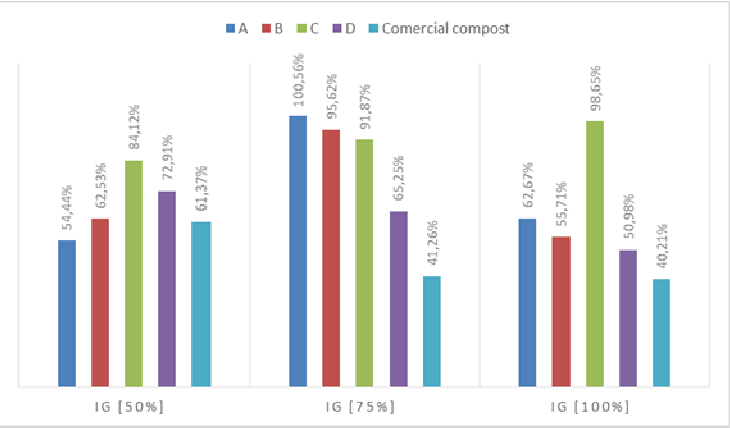

Figure 2. Effect of vermicomposting on phytotoxicity on cress seeds

Discussion

The results indicates decrease in pH after vermicomposting and it was ranged from 6.86 to and 7.61.Frederickson et *al* (2007) found that pH was significantly lower for the vermicomposted material. However, EC increased in all treatments significantly.The highest value was observed for A (7.45 mS/cm) and B (8.64 mS/cm) vermicomposts, and the lowest was recorded for C and D. This result may be explained by a higher content of tomato wastes salts content compared to the sheep manure. Total N increased respectively inA, B, C and D vermicomposts. Thismay be explained by a mineralization of organic N (Domínguez and Gómez-Brandón, 2013).The total K content had shown a significant increase. Domínguez and Gómez-Brandón (2013) had shown a higher content of total K after vermicomposting. Vermicomposts B, C, D indicate poor humification index. In the opposite, the vermicompost A indicates a Q4/Q6 ratio <5 and confirms that this is a highly humified material. This also confirmed by the lowest level phytotoxic for vermicompost A indicating the highest GI.

Conclusion

This study revealed the differential effects of vermicomposting processes on the final quality of organic matter. In general, the treatment with this method has an effect on the evolution of the physic-chemical parameters of the organic matter. The phytotoxic effect also showed a low level after treatment, which is confirmed later by the humicification index of the produced vermicomposts. Compost of tomato residues is phytotoxic, vermicomposting can improve its

quality and even more can transform it to a better organic amendment to organic vegetables production.

Suggestions to tackle with the future challenges of organic animal husbandry

The rising of consumption demand in the world have led to more and more important production of manure due to an important animal husbandry intensification. This unmanaged manure can lead to sanitary and environmental complications. Vermicomposting is a type of manure processing that has gained increasing acceptance over the years thanks to the carbon sequestration in depleted soils. Consequently, vermicomposting could be a sustainable manner of on-farm manure recycling to produce valuable organic matter, and to produce worms for organic poultry and organic fish farming.

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Appropriate time to apply organic fertilizer to sesame and soybean in the humid tropics

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Key words: application, organic fertilizer, time, sesame, soybean, tropics

Abstract

One of the major challenges in organic crop production is how to make nutrients available to plants at the time and in the quantity required by the crop. Consequently, two separate field trials were conducted during the late cropping season (June – Nov.) of 2015 to determine the appropriate time to apply an organic fertilizer (Aleshinloye Grade B, 1.05% nitrogen) to sesame and soybean for optimum productivity. On average, application of organic fertilizer to sesame at sowing resulted in significantly ($p<0.05$) higher seed yield than the control and when applied at 10 days before and 10 days after sowing. Irrespective of the time of application, organic fertilizer significantly ($p<0.05$) increased number of branches and weight of seeds per plant, and threshing percent of soybean relative to the control treatment. Lack of significant seed yield response of soybean to fertilizer application could be attributed to the relatively moderate native fertility status of the soil.

Acknowledgments

Our sincere appreciation goes to the Federal University of Agriculture, Abeokuta through the Institute of Food Security, Environmental Resources and Agricultural Research for providing the experimental plots on which the studies were carried out.

Introduction

Globally, the major drivers of organic oilseed (sunflower, soybeans, sesame etc) market are the demand for quality organic food products, increase in consumption of ethnic cuisines, and processing techniques used by manufacturers. With increasing desire for healthy lifestyle due to increase in health problems, it is now more desirable to use organic soil amendments such as organic fertilizers than chemical fertilizers in food crop production. However, availability of essential nutrients from organic fertilizers is a function of the soil type, fertility status, crop type, rate of application and weather conditions (Hadas et al., 2002). Since organic nitrogen (N) is immobile, it is therefore important that organic fertilizers be applied at such a time to make N available in required quantity for the test crop. Therefore, time of organic fertilizer application was staggered on soybean and sesame to determine the optimum time of application for optimum productivity in the humid tropics.

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Material and methods

Two field trials were carried out at the Federal University of Agriculture, Abeokuta, Nigeria during the late cropping season (July – Nov.) of 2015 at two locations. Trial 1. on sesame was at Institute of Food Security Environmental Resources and Agricultural Research (IFSERAR) Farm (7° 23′ N, 3° 39′ E, altitude 139 m above sea level). Soil of the experimental plot contained 0.12% N, 1.12% organic matter, 9.56 mg/kg available P, 0.94 cmol/kg K and a pH of 6.1. The trial was a 2 X 4 factorial arrangement laid out in randomized complete block design and replicated three times. The factors were variety: E-8 and Cameroon White and fertilizer regime: control, application at 10 days before sowing, DBS, at sowing and 10 days after sowing, DAS. Each plot measured 4m x 1.8m (7.2 m^2) and consisted of four rows. Sesame seeds were sown at a spacing of 60 cm x 5 cm giving 300,000 plants/ha. The organic fertilizer used in the two trials, Aleshinloye Grade B contained 1.05% N, 0.56% P, 2.31% K, 5.96% Ca, and 0.25% Na. Weeds were controlled manually at 3 and 6, weeks after sowing, WAS. After the first weeding at 3 WAS, five randomly selected plants were tagged in the two middle rows for plant height and yield attributes measurement at maturity. Equivalent quantity of the organic fertilizer that supplied 60 kg N (sesame) and 30 kg N (soybean) was applied at the three dates of application. Parameters measured on plot basis were on growth and development, seed yield and yield parameters for both crops. The soybean trial was conducted at the Teaching and Research Farm of the University of Agriculture, Abeokuta (7° 15′ N, 3° 25′ E, altitude 140 m above sea level). The soil contained 0.16% N, 1.60% organic matter, 44.49 mg/kg available P, 0.60 cmol/kg K and a pH of 6.7. All research protocols (land preparation, plot size, weeding, tagging of plants, spacing and organic fertilizer) stated for sesame were used in the soybean trial which was a 3 X 4 factorial arrangement laid out in randomized complete block design and replicated three times. The factors were variety: TGx 1448-2E, TGx 1440-1E and TGx 1740-2F and fertilizer regime: control, application at 15 days before sowing, DBS, at sowing and 15 days after sowing, DAS. All data collected on plot basis were analysed using MASTAC package. The treatment means of the main effects and interactions that were found significant were then separated using the least significant difference method (LSD) at 5% probability level.

Results

Data on some agronomic traits and seed yield response of sesame and soybean to time of organic fertilizer application are presented in Table 1. The two sesame test varieties were significantly ($P < 0.05$; F - test) different from each other for number of branches per plant. Seed yield was significantly (*$P < 0.05$; F - test*) affected by time of organic fertilizer (OF) application with the application of OF at sowing resulting in the highest seed yield (406.6 kg/ha). However, weight of seeds per plant was significantly ($P < 0.05$; F-test) affected by V × T interaction. Irrespective of the time of OF application to soybean plots, OF significantly (*$P < 0.05$; F – test)*) increased number of branches and weight of seeds per plant relative to the control. Soybean seed yield was higher on plots that received OF than the control plots, but the yield values though greater than 1 ton/ha were not significant.

Table 1: Seed yield and some yield attributes of sesame and soybean varieties as affected by time of organic fertilizer application

	Sesame			Soybean		
	NBR	SWT	SYD	NBR	SWT	SYD
Variety (V)						
V1	3.0	2.3	336.01	4.8	6.6	1339.75
V2	2.5	2.6	312.03	4.9	6.8	1409.79
V3	-	-	-	4.7	7.2	1310.33
LSD 5%	0.55*	Ns	ns	ns	ns	ns
Time (T) of OFA						
T1	2.3	1.9	227.35	3.7	4.1	953.17
T2	3.2	3.0	329.00	5.6	7.4	1587.33
T3	2.8	2.2	406.60	5.2	8.2	1562.67
T4	2.8	2.6	333.69	4.8	7.6	1310.00
LSD 5%	ns	Ns	72.48**	1.90*	4.06*	ns
V × T	ns	*	ns	ns	ns	ns

* significant at $P < 0.05$ and ** significant at $P < 0.01$; ns – not significant
NBR number of branches; SWT seed weight, g; SYD seed yield, kg/ha

Discussion

Sesame critically requires nitrogen during flowering (Langham et al. 2008) while soybean does so at two weeks before and two weeks after flowering (Aradashiev et al. 1981). As such, efforts must be geared towards making N available at these critical periods. Since application of OF at sowing resulted in significantly ($P < 0.05$) higher seed yield (406.60 kg/ha) than the control, other treatments and the average farmers' yield in Nigeria (300 kg/ha) and at par with world average (406 kg/ (Olowe et al. 2011), prospective sesame growers could apply OF at sowing to reduce cost of production. On average, the yield response of soybeans under the fertilized treatments (1.3 – 1.6 t/ha) was higher than what is reported on research plots (1 ton/ha) and relatively lower than the world average of 2.49 t/ha (Anon, 2011). It is suggested that OF could be applied simultaneously at sowing of sesame and soybeans.

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Sustainable management of the diamondback moth, *Plutella xylostella* L. (Lepidoptera: Plutellidae) on cabbage

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Key words: neem seed extract, diamondback moth, environmentally friendly pesticides, food safety

Abstract

Cabbage is an important cash crop to the resource-poor farmers in sub-Saharan Africa and offers a good source of vitamins and minerals. The diamondback moth (dbm), Plutella xylostella L. is a major pest causing significant losses to brassica crops worldwide. An experiment was undertaken during the major and minor seasons in 2015 to establish the effect of some products (synthetic insecticides-chlorpyrifos and lambda-cyhalothrin, botanicals - hot pepper, Capsicum futescens fruit extract, aqueous neem, Azadirachta indica seed extract, solution of local soap-alata samina and water as control) in managing dbm population on cabbage in the field. The results revealed that the highest population of dbm was recorded in the insecticides sprayed plots, with neem recording the least number of dbm. The highest yield was recorded for the neem sprayed plots, followed by alata samina and pepper for both seasons. The current finding suggest aqueous neem seed extract as the most effective option for managing dbm on cabbage.

Acknowledgments

The authors are grateful to the German Academic Exchange Service (DAAD) for the financial support to Ethelyn Echep Forchibe to undertake her studies leading to the award of Master of Philosophy in Entomology at the African Regional Postgraduate Programme in Insect Science (ARPPIS), University of Ghana.

Introduction

Cabbage cultivation is an important source of livelihood for small-scale farmers in sub-Saharan Africa due to its growing popularity for home consumption and the food industry. The diamondback moth (dbm), *Plutella xylostella* L. (Lepidoptera: Plutellidae) is a cosmopolitan pest of crucifers and causes significant yield losses of 20–100 %. Consequently, the global cost of control of dbm has recently been estimated between US$ 4 and 5 billion (Zalucki *et al.* 2012). The use of synthetic insecticides is the main control strategy, although has been ineffective due to the pest developing resistance to most of the insecticides in use today. Thus, there is the need to search for alternative sustainable pest management options for dbm. This study explores other user-friendly options for managing this devastating pest of brassica.

Material and methods

Study site

The study was carried out at the University of Ghana, Soil and Irrigation Research Centre, Kpong (00 04' E, 60 09' N), located within the lower Volta basin of the Coastal Savanna agro-ecological zone of Ghana. It has an annual rainfall between 700 and 1100 mm, an average annual temperature

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of 28 ˚C and relative humidity between 59 %-93 %. The main soil type is the Vertisols (black clay soil). Experiments were undertaken between May and August and September and December, 2015 in the major and minor rainy seasons, respectively.

Land preparation, transplanting and application of treatments

Land used was cleared of weeds, ploughed, harrowed and ridged. Seeds of certified healthy hybrid white cabbage (*B. oleracea* var. *capitata*) (cv. oxylus) were sown on raised beds in the field. The young seedlings were protected from pest attack with mosquito-proof netting (1.2 mm ×1. 2 mm of mesh size). Appropriate agronomic and cultural practices, mainly weed control and watering were employed regularly throughout the growing period. The experimental design was a randomized complete block with six treatments and three replicates. Cabbage seedlings were transplanted 30 days after germination. Spacing was 0.5 x 0.75m and each plot measured 3 m x 3 m, giving a total of 30 plants per plot. Inter-plot alley was 2m to prevent drift between adjacent plots. A well decomposed poultry manure (six months old) was incorporated into the soil (20 t/ha), a month before the cabbage was planted. Treatments used and their concentrations were as follows; neem,*Azadirachta indica*seed extract (50g/L of water), hot pepper,*Capsicum frutescens* fruit extract (20 g/L of water), local soap solution (alata samina) (7 g/L of water), Conpyrifos® (chlorpyrifos,480 g/L, applied at 2 ml/L of water), Lambda M® (lambda-cyhalothrin 25g/L, applied at 2 ml/L of water) and tap water. For the hot pepper, ripe fruits were obtained from a local market and 100g was weighed using an electronic balance to prepare 5L spray mixture. This was homogenised using an electric blender. This mixture was initially dissolved in 1L of water and later topped up with an additional 4 litres of water after it was sieved into a 15L capacity Knapsack for application. Two fifty grams (250g) of dry neem seeds were also weighed and pounded in a wooden mortar using a wooden pestle. The homogenate was dissolved in a litre of water and left overnight, and later sieved through a fine linen material. The mixture was further diluted with 4L of water for spraying. Thirty five grams (35g) of alata saminawas also weighed and dissolved in 1L volume of water. It was further diluted with 4L of water before it was applied. Applications commenced 14 days after transplanting of seedlings for both the major and minor seasons, and continued weekly thereafter until cabbage heads were fully mature, about 14 days to harvesting.

Data collection

Ten cabbage plants from the inner rows were sampled weekly and examined thoroughly for the presence of dbm larvae. Twelve cabbage heads in the inner rows were harvested and weighed for yield assessment (tonnes/hectare).

Identificationof dbm

Samples of larvae of diamondback moth were reared in the laboratory to the adult life stage to allow identification by comparison with labelled specimens in the insect museum of the Department of Animal Biology and Conservation Science, University of Ghana. Voucher specimens were also deposited in the insect museum.

Data analysis

Count data for dbm was square root transformed, and subjected to repeated measures of ANOVA. Mean cabbage head weight was analysed using ANOVA. Significant differences in means were separated using SNK test ($P \leq 0.05$).

Results

Plutella xylostella response to the treatments and yield

Plutella xylostella infestation started in the first week of sampling and increased steadily for the major and minor seasons (Figs. 1 and 2). The control (tap water) and the synthetic insecticides (lambda cyhalothrin and chlorpyrifos)-treated plots recorded the highest number of dbm for the

major season, while for the minor season, the synthetic insecticide sprayed plots recorded the highest number of dbm larvae. Neem-treated plot however, recorded the least number of dbm for both seasons, followed by alata samina and pepper-treated plots.

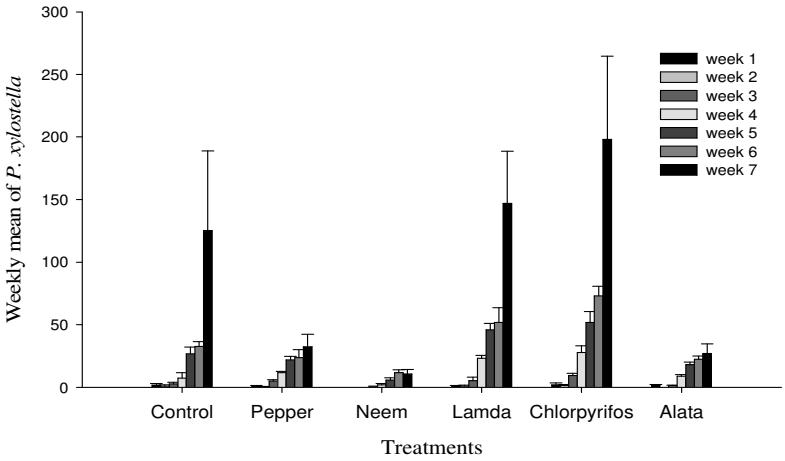

Figure1. Effects of treatments on mean (± SE) weekly counts of dbm per cabbage plant in the major season, 2015, Kpong, Ghana.

There was a significant difference among the different treatments in controlling the dbm during the major season ($F_{5,\ 125}$ = 30.49; P < 0.0010).The effect of each treatment on dbm population among the weeks of sampling was also significantly different ($F_{6,\ 125}$ = 83.45; P < 0.0010).The interaction between the sampling weeks and treatments was also significant ($F_{30,\ 125}$ =3.95; P = 0.0070).

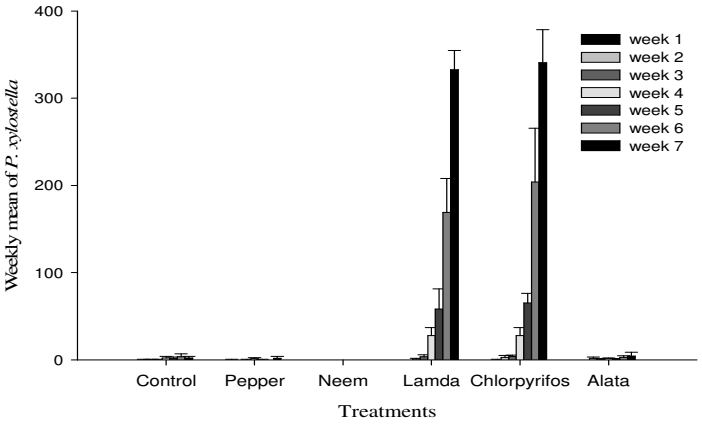

Figure 2. Effects of treatments on mean (± SE) weekly counts of dbm per cabbage plant in the minor season, 2015, Kpong, Ghana.

There was a significant difference among the different treatments in controlling the dbm during the minor ($F_{5,\ 125}$ = 99.82; P < 0.0010).The effect of each treatment on dbm population among the weeks of sampling was also significantly different ($F_{6,125}$ = 85.23; P < 0.0010).The interaction between the sampling weeks and treatments was also significant ($F_{30,\ 125}$ = 29.41; P < 0.0010).

The mean yield among the treatments was significantly different for the major and minor seasons(Table 1). The neem treated plots had significantly higher yields than lambda-cyhalothrin treated plots, but it was not significantly different from the other treatments during the major season (Table 1). However, in the minor season, the highest yield was obtained from the neem sprayed plots. A t test revealed that there were significant differences in the yield for the major and minor season for control, pepper and neem sprayed plots (Table 1).

Table 1: Mean (± SE) yield of cabbage under different treatments during the major and minor seasons of 2015, Kpong, Ghana.

Treatment	Mean yield (t/ha)		t	
	Major season	Minor season		
Control	12.37 ±1.27ab	0.59 ± 0.07c	8.94	**
Pepper	12.37 ± 1.30ab	6.50 ± 0.74c	3.93	*
Neem	17.80 ± 2.61a	28.36± 0.97a	4.08	*
Lambda	6.03 ±2.08b	5.07 ± 2.81c	0.27	ns
Alata samina	14.57 ± 2.75ab	15.05± 3.05b	0.12	ns
Chlorpyrifos	13.40 ±1.99ab	10.02± 3.70bc	0.80	ns
F	3.47	22.14		
	*	***		

Means with the same letter(s) are not significantly different ($P < 0.05$, SNK test) within columns. Means between seasons for each treatment was compared using t test ($P < 0.05$).* Significant at $P \leq 0.05$, ** significant at $P \leq 0.01$, ***significant at $P \leq 0.001$, ns = non-significant at $P > 0.05$.

Discussion

This result offers an environmentally friendly, effective and safe option to control dbm on brassica crops, especially for resource-poor smallholder farmers in Sub-Saharan Africa for enhanced livelihoods and to promote food safety. Using neem as a plant based insecticide will lead to the production of quality vegetables produced organically without the use of synthetic insecticides, thus minimising the risk of insecticides residues accumulating in harvested produce. Despite their negative effect on the consumer and the environment, the use of conventional insecticides are no more effective in controlling dbm on cabbage. This is because it has developed resistance to most of these insecticides in use today. Contrarily, neem as a botanical insecticide exhibits several modes of action (anti-feedant, causes abnormal and delayed moults, growth arrestant, increased mortality, sterility effect, etc.), thus making it difficult for the dbm to develop resistance against it.

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Towards Enhanced Soil and Kale (*Brassica Oleracea*) Productivity through Application of Organic fertilizers and legume Integration in farming systems of Kabete Sub-County, Kenya

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Key words: Chickpea; Farm Yard Manure; Minjingu Rock Phosphate;lupin; Nutrient balances

Abstract

In this study, the influence of farm yard manure (FYM) and Minjingu Rock Phosphate (MRP) application, and chickpea (*Cicer arietinum L.)* and white lupin (*Lupinus Albus L*) integration as intercrop and/or in rotation with kale on N, P and soil organic C levels and balances, and Kale yields was evaluated. The on station field experiment was conducted during the short and long rain seasons of 2014. The experimental layout was a RCBD with a split-plot arrangement replicated thrice. The treatments consisted of sole kale, kale intercropped and/or in rotation with chickpea and white lupin (as main plots). The spilt plots were; (i) FYM (ii) MRP and (iii) Control (CTRL). The soil total N and P were significantly ($P \leq 0.05$) higher in lupin/kale intercrop with application of FYM and MRP, respectively. A similar trend in total N and plant available P was registered in short rain season. There were no significant changes in soil organic C levels across cropping systems and organic fertilizers in both seasons. Positive full N balances were realized in crop rotation systems with application of FYM whereas negative partial (organic fertilizers – kale harvests) N balances were recorded across cropping systems and organic inputs except for sole kale system with application of FYM. Positive full and partial P balances were obtained across cropping systems with application of MRP. Higher kale yields were realized in lupin-kale rotation (FYM and MRP); chickpea-kale rotation (FYM and MRP) and kale monocrop (FYM). Integration of white lupin and chickpea with the application of FYM and MRP in a kale cropping system led to significant improvement in soil total N, plant available P and organic C. The improved soil nutrient status contributed to improved kale yields. Kales grown in rotation and/or intercrop with white lupin with chickpea and MRP or FYM application would therefore be a sustainable strategy for enhanced kale production in smallholder farming systems.

Acknowledgments

This study was made possible through the project – Productivity and Growth of Organic Value Chains supported by the Danish International Development Agency.

Introduction

The production potential of kale (*Brassica oleracea*), a common and important food security crop, in many Kenyan smallholder households, is limited by N and P nutrients, critical for its growth (Batiano and Mokwunye 1991). The low N and P is attributable to unsustainableagricultural and land use systems (Chase and Singh, 2014).

For many cropping systems in the tropics, application of N and P from inorganic sources is essential to maximize high crop yield potential in continuous cultivation systems (Hartemik et al., 2000). However, prolonged application of inorganic fertilizers on the other hand has resulted in negative environmental impacts such as accumulation of heavy metals in soil, crop and water (Halberg *et al*., 2006). Organic based nutrient management strategies, premised on biodegradable material is a

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sustainable alternative to high cost of fertilizer and soil nutrient depletion in SSA (Lelei et al., 2008). Among the most promising organically based soil nutrient management practices include use of organic inputs such as FYM and MRP (Place et al., 2003).
Applicationof MRP and FYM with integration of legumes; white lupin and chickpea in kale cropping systems could provide a feasible and low-cost alternative for rebuilding soil fertility (Opala *et al*., 2013; Lelei *et al*., 2014). Apart from fixing N, legumes solubilize sparingly soluble P sources through rhizosphere processes (Giller, 2001) resulting in increased N and P in soil.
Most studies on the use of MRP and FYM with integration of legumes has been biased towards cereal-based cropping systems and none has been done on kale based cropping systems. It is envisioned that integration of chickpea and white lupin, with application of organic fertilizers, into kale based cropping system will boost soil nutrient status and consequently yields.

Material and methods

Study site: The experiment was conducted at the faculty of agriculture, university of Nairobi field station, located in Kabete sub-County for two seasons (March to May 2014 – long rain season and October to December 2014 – short rain season).

Experimental design and treatments: The experimental design was a RCBD, replicated thrice, with a split plot arrangement. The main plots were; cropping systems (i) mono-cropping (sole kale), (ii) intercropping (lupin/kale; chickpea/kale) and(iii) crop rotation (lupin-kale; chickpea-kale). The spilt plots were; organic fertilizers (i)FYM (ii)MRP and (iii) Control (no fertilizer applied).

Agronomic practices: MRP was broadcasted at the rate of 60 kg P/ha and then incorporated to a depth of 0 – 0.15 m before planting. FYM was applied at a rate of 10 t/ha. Kales were planted at a spacing of 60 x 45 cm between and within rows in all treatments. Weeding was carried out twice after weed emergence. Legumes were planted and managed as described by Lelei et al. (2014). For pest and disease management, Eucalyptus tree ash and pyrethrum extracts were sprayed on the crops to control cut worms and aphids, respectively. The fields were surrounded by Mexican marigold plants to act as a pest-repellants.

Soil, Plant sampling and Analysis: Soil samples for N, P and Organic C determination were sampled at a depth of 0-15cm from every plot at the end of each cropping season and analysed according to methods by Okalebo et al. (2002).
Soil N, P and K balances were monitored and quantified using NUTMON Tool box (Vlaming et al. 2001) with slight modifications Onwonga et al. (2015). Two different balances were calculated: partial balance at farm level (organic fertilizers – Kale harvests) and full balance (ALL IN - ALL OUT) made up of a combination of partial balance and immissions (atmospheric deposition and N fixation) and emissions (leaching, gaseouslosses, erosionlosses) from and to the environment(Vlamingetal.,2001). Sampling of kales was done on three middle rows at 1, 2 and 3 months after planting and yield aggregated across seasons and extrapolated into 90kg bags/ha.

StatisticalAnalysis: Total N, P, Organic C and kale yields were subjected to analysis of variance (ANOVA)usingGenstat1.2package. The LSD ($P<0.05$) was used to separate means.

Results

Total N, available P and Organic C in soil: Total N content was significantly ($P\leq0.05$) high in lupin/kale intercrop with application of FYM and MRP in long rain season (LRS). The same trend, in total N, was observed in the short rain season (SRS). FYM treated plots registered significantly higher total N content compared to MRP across cropping systems and seasons (Table 1).

Plant available P was significantly higher in intercrops as compared to rotations and monocrops with application of FYM and MRP across cropping seasons. The Organic C levels were similarly higher in plots integrated with lupin across organic inputs. Where FYM was applied, even in a monocrop system, there was a significant increase in organic C levels (Table 1).

Table 1. Effects of cropping systems and organic inputs on total N, Organic C and P

Parameter	Cropping system	Crops	LRS 2014			SRS 2014			
			FYM	MRP	CTRL	Crop	FYM	MRP	CTRL
Total N (%)	Intercrop	lupin/ kale	0.33_{hij}	0.33_{hij}	0.340_{hijk}	lupin/ kale	0.44_{f}	0.37_{ef}	0.29_{bcd}
		chickpea/ kale	0.59_{n}	0.38_{kl}	0.405_{l}	chickpea/ kale	0.33_{cde}	0.31_{cde}	0.30_{bcd}
	Crop rotation	Lupin	0.32_{ghi}	0.24_{abc}	0.23_{ab}	kale	0.320_{cde}	0.29_{bcd}	0.26_{abc}
		Chickpea	0.49_{m}	0.37_{jkl}	0.376_{kl}	kale	0.34_{de}	0.30_{bcd}	0.24_{a}
	Monocrop	Kale	0.26_{bcd}	0.26_{bcd}	0.25_{abcd}	Kale	0.28_{bcd}	0.24_{ab}	0.22_{a}
Organic C (%)	Intercrop	lupin/ kale	3.09_{d}	3.08_{d}	2.69_{ab}	lupin/ kale	3.09_{c}	3.05_{cd}	2.98_{e}
		chickpea/ kale	2.91_{ab}	2.80_{ab}	2.74_{bcde}	chickpea/ kale	3.08_{c}	2.98_{c}	2.97_{c}
	Crop rotation	Lupin	3.05_{c}	3.04_{c}	2.71_{abcd}	kale	3.16_{e}	3.14_{de}	3.02_{cd}
		Chickpea	2.92_{ab}	2.84_{b}	2.75_{cde}	kale	3.09_{c}	3.12_{cde}	3.04_{cd}
	Monocrop	Kale	2.81_{ab}	2.78_{a}	2.77_{def}	Kale	2.78_{a}	2.82_{ab}	2.92_{abc}
Available P (ppm)	Intercrop	lupin/ kale	19.02_{e}	21.40_{e}	10.82_{bcd}	lupin/ kale	18.17_{j}	20.71_{k}	19.84_{j}
		chickpea/ kale	14.11_{d}	19.96_{e}	9.65_{ab}	chickpea/ kale	14.80_{g}	18.48_{h}	10.99_{def}
	Crop rotation	Lupin	19.05_{e}	19.54_{e}	10.24_{abc}	kale	10.41_{abc}	13.08_{f}	10.98_{bcd}
		Chickpea	12.80_{cd}	10.94_{abc}	8.67_{a}	kale	10.10_{ab}	11.24_{cd}	10.90_{bcd}
	Monocrop	Kale	9.62_{ab}	9.03_{a}	11.37_{bcde}	Kale	11.64_{de}	11.21_{cd}	9.90_{a}

Means followed by the same letters in a column are not significantly different at $P \leq 0.05$

3.1 Influence of organic fertilizers and legume integration on soil N and P balances

Nitrogen balances: Partial N balances were positive in mono-cropping system but negative in intercropping and crop rotation systems with application of FYM and MRP, respectively. The full N balances were positive (FYM and MRP) in intercrop and crop rotation systems (Figure 2A).

Phosphorous balances: Partial and full P balances were positive in all cropping system with application of MRP (Figure 2B) but nonetheless higher in legume incorporated plots.

Kale yield: Kale yield (90kg bags/ha), in the LRS was highest in monocropping system, followed by lupin/kale intercropping system with application of MRP (180 and 160) and FYM (150 and 130). This was followed by chickpea/kale cropping system with application of FYM and MRP (140 and 120). In SRS, the lupin-kale rotation system with application of FYM had the highest yield (181) followed by kale/lupin intercropping system with appliaction of MRP (177).

Discussion

N, P and Organic C levels: The higher soil total N in legume-kale rotation with FYM and MRP application is attributable to N release by FYM (Brar *et al.* 1989), and N fixed by legume component (Anyango, 2005). Increased N levels where MRP was applied can be credited to improved soil conditions and hence nitrification (see also Onwonga *et al*. 2008). Lupin-kale rotations and intercrops recorded higher N levels across treatments as compared to chickpea/kale intercrop rotation mainly because of its superior N fixation (Engedaw 2012).

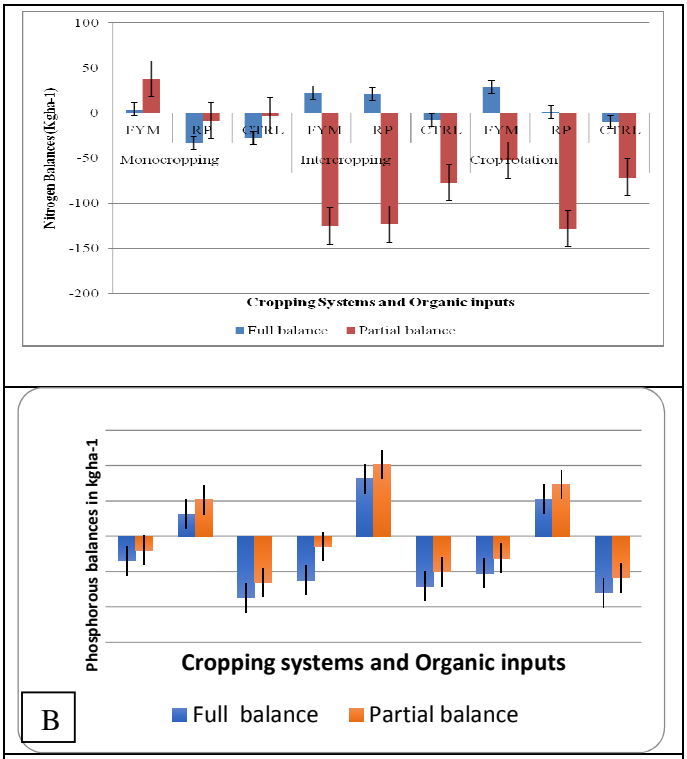

Figure 2: Effect of cropping systems and organic inputs on N (A) and P (B) balances

The high P in plots with application of FYM and MRP, was perhaps due to organic molecules, provided by FYM which bound exchangeable and hydroxyl-Al, the key fixers of P in acid soils, and production of legume exudates that dissolved MRP. The high organic C levels in plots integrated with lupin across seasons and organic inputs is as a result of its high biomass production compared to chickpea.

Nutrient balances: Positive full N balances in intercrop and crop rotation systems are to realize with application of FYM and MRP, respectively and addition of N through N fixation by legumes in cropping systems and also minimal leaching and losses through harvested products (see also Tian et al., 2000).

P balances were highest in plots with MRP, because MRP had higher P content as compared to FYM and thus the input into the soil was higher than the output through harvested produce and erosion losses. For the FYM and controls, more P was removed through harvested produce than was applied to soil. The P balances were however higher in legume incorporated plots such as intercrops and rotations. This is because legumes have been shown to increase dissolution and utilization of phosphate rock P compared to non-legumes mainly due to rhizosphere processes (Horst *et al.* (2001).

Kale yield: The high kale yields in intercropping system with application of MRP followed by FYM is mainly due to increase in N through N fixation and P through solubilization of MRP. According to Horst *et al.* (2001) and Vanlauwe *etal. (*2000), legumes increase dissolution and utilization of phosphate rock compared to non-legumes mainly due to rhizosphere processes.Chickpea and lupin residue incorporated into the soil and effects of N fixation from previous season may have also contributed to better crop nutrition and hence high kale yields in the SRS (Nyambati et al., 2006).

Conclusion

Use of organic fertilizers increased soil nutrients with FYM being superior to MRP in both cases. To enhance soil fertility, it is thus recommended that kale intercropped with lupin alongside application of FYM may be adopted as a sustainable option towards enhanced soil fertility in smallholder farming systems of Kabete Sub County and similar agro-ecological environments.

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Available on request from the first author

Effect of different organic substrates on reproductive biology, growth and offtake of the African night crawler earthworm *Eudrilus eugeniae*

Fred Kabi[1], Denis Kayima[1], Abasi Kigozi[1], Eric Zadok Mpingirika[2], Ronald Kayiwa[1], and Dorothy Okello[3]

Key words: Clitellum, Cocoon initiation, Earthworm biomass, Hatchlings, Vermibeds, Vermicomposting

Abstract

Rapid growth and high fecundity of E. eugeniae makes it a commercial vermicomposting agent. The worm is also a rich protein source (50-70%CP) in livestock diets. The major question, however, is how do we promote earthworm production as a strategy for ecological livestock intensification and integration with crops through earthworm domestication as a source of protein and vermicompost. Reproduction characteristics, growth and offtake of E. eugeniae were studied using four organic substrates including abattoir waste (AW), cattle manure (CM), soya bean crop residue (SBCR) and a mixture of cattle manure and soya bean crop residue (CM+SBCR) aged for 15 days. Organic substrate used affected reproductive biology, growth and offtake of E. eugeniae. Higher survivability, total earthworm biomass accumulation and offtake when cultured on CM and a binary combination of CM + SBCR is an indication that a strategy for sustainable crops-livestock integration can be sparked off by earthworm domestication. Earthworm domestication can be promoted using CM or a combination of (CM+SBCR) as substrate.

Acknowledgments

This work was supported by the Makerere University School of Public Health's Resilient Africa Network (RAN) and Partners. This was made possible by the generous support of the American people, through the United States Agency for International Development (USAID) - [Project ID AID-OAA-A-13-00018]. The contents of this work are solely the responsibility of the authors and do not necessarily represent the official views of the supporting organizations.

Introduction

That earthworms can reproduce parthenogenetically is not only surprising but that E. eugeniae is one of the fastest growing (280 mg/week) and productive tropical earthworm species when grown in animal organic waste is remarkable. With a sexual maturation time of 45 days, a life cycle of 60 days, a relatively high cocoon production rate (0.42 – 0.51), a short incubation time of 17 days, a high mean number of hatchlings per cocoon (2.7) and a mean body mass of 2100 mg (Viljoen and Reinecke, 1989; Lalander et al., 2015) makes E. eugeniae an ideal species for vermiculture. In order to design sustainable but intensive feeding programs based on earthworm meal as a substitute for the more expensive silver fish (*Rastrineobola argentea*) in poultry and fish diets, it is important to understand the reproductive biology, growth and offtake of the *E. eugeniae*. However, there is a paucity of information about the reproductive performance, growth and offtake of *E. eugeniae* when

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grown using different organic substrates and yet these parameters are crucial for mass production of earthworm. The objective of this study was, therefore, to assess effects of different organic substrates on reproductive biology, fecundity, longevity and offtake of *E. eugeniae* as an alternative source of livestock protein and vermicompost.

Material and methods

Study site and experimental design

Experiments to assess the effects of different organic substrates on reproductive biology, fecundity, longevity and offtake of the *E. eugeniae* earthworms were conducted at Makerere University Agricultural Research Institute Kabanyolo (MUARIK). The experiment consisted of four types of organic substrates used in three phases to culture *E. eugeniae* earthworms. Four types of test substrates namely cattle manure (CM), abattoir waste (AW) and soya-bean crop residue (SBCR) and a mixture (CM+SBCR) were used. In the first phase, a pair of clitellate worms was introduced into each of the digit and colour-coded buckets containing the respective test substrates. Ten replicates were made for each substrate making 40 experimental units. The second phase contained the same arrangements of 40 units with similar substrate replications into which the cocoons produced by worms from their respective substrate counterparts in phase one were incubated. The third phase consisted of the same arrangements of substrates as in phase one and two for raising hatchlings hatched from buckets in the second phase but with AW waste aged for 4 weeks.

Preparation of feeding material

Soya bean crop residue was obtained from the crop field at the study site; cattle manure mixed with urine was obtained from a local cattle farm at the study site while AW was obtained from a local abattoir. All the organic substrates were aged for 15 days for microbial composting and thermo-stabilization in phase 1 and 2. This was intended to expel toxic gases like ammonia and increase microbial population interaction. The moisture content of the beddings was maintained at 60 – 70 % by sprinkling with water regularly.

Source of Earthworms

Sexually mature adult earthworms (clitellate stage) of *E. eugeniae* were obtained from the earthworm production facility set up at MUARIK, which was maintained by regular feeding with aged cattle manure substrate collected from the study site. Pre-composted organic feeding material weighing 250 g were mixed with 500 g DM of soil and introduced into digit and colour-coded plastic buckets of 20 cm height, 28 cm diameter and covered with a mesh net for ventilation while excluding pests at the same time. Substrate to dark loam soil ratio of 1:2 for CM, SBCR, AW and a binary combination of (SBCR +CM) with the dark soil in the ratios of 1:1:4 on dry matter basis was used. A pair of randomly selected earthworms that were originally bred on cattle manure was then inoculated into each of the experimental buckets referred to as the vermibeds with different substrates. The earthworms in phase 1 were allowed a period of one week to acclimatize to their respective substrates into which they were initiated under dark and humid environment at room temperature.

Cocoon production data, hatchlings per cocoon, fecundity, growth rate of hatchlings, earthworm offtake were estimated according to Karmegam & Daniel (2000).

Chemical analysis

Physico-chemical composition of the substrates was determined at the soil science laboratory. The substrates were analysed for organic Carbon (C), total Nitrogen (N), total phosphorus (P), potassium (K), Carbon to Nitrogen ratio (C:N), pH and Cation exchange capacity (CEC).

Statistical analysis

Least square means for increase in biomass/worm/day, length/worm/day, cocoon production/worm/day, cocoon length, hatchling success, days to cocoon initiation, survivability, growth and offtake were analysed using a one-way ANOVA with SAS (2000). Probability of difference option of SAS was used to separate the means at $P < 0.05$.

Results

Growth rate was 17.7, 15.8, 15.6 and 14.3 mg/worm/day when earthworms were fed AW, CM+SBCR, CM and SBCR, respectively. Irrespective of the substrate, length and biomass of earthworms increased at a decreasing rate between the 1st and 11th weeks (Fig. 1). Clitellum appearance was initiated at 31.5±2.4, 32.8±3.2, 33.7±3.3 and 35.5±2.4 days for AW, CM, CM+SBCR and SBCR, respectively, while cocoon initiation was at 69.0±1.4 (AW), 54.9±2.3 (CM), 51.7±1.7 (CM+SBCR) and 60.0±2.4 (SBCR) days (Table 1). Cocoon production rate (0.41 cocoons/worm/day) was highest ($P<0.05$) in earthworms fed CM+SBCR but abnormally lowest for AW. Cocoon incubation period ranged between 9 and 16 days for CM but was 11 to 16 days for SBCR and CM+SBCR. However, no sufficient cocoons were available for incubation from AW. Hatching success was 88%, 82% and 68% in CM, CM+SBCR and SBCR, respectively. Similarly, highest mean number of hatchlings per cocoon was 3.08±0.73 from CM. Consequently; earthworm offtake in CM, CM+SBCR, AW and SBCR was 86%, 78%, 70% and 62%, respectively.

Table 1: Effect of different organic substrate on average weekly and daily cocoon production, time for cocoon initiation and cocoon average weight of *Eudrilus eugeniae* earthworms.

Variables	Treatments*				SEM	P-Value
	AW	CM	SBCR	CM:SBCR		
Average cocoon production per worm per day	0.0007[c]	0.23[a]	0.15[a]	0.41[b]	0.1696	**<0.001**
Average weekly cocoon production	0.005[c]	1.625[a]	1.045[a]	2.870[b]	0.18656	<0.001
Time for cocoon initiation	69.0[a]	54.9[c]	60.8[b]	51.7[d]	1.1085	<0.001
Cocoon Average weight (mg)	-	15.8[a]	11.6[b]	14.6[a]	0.42885	<0.001

**CM= cattle manure; AW= abattoir waste; SBCR= soya bean crop residue; CM and SCBR= a mixture of CM and SBCR in the ratio of 1:1 w/w*)

Discussion

Rate of cocoon production, cocoon initiation and cocoon weight as influenced by substrate type (Table 2) are related to cocoon production efficiencies of *E. eugeniae* as it interacts with the physco-chemical properties of the substrate. While the binary combination of CM+SBCR resulted into cocoon production rate of 0.41/earthworm /day similar to earlier values of 0.42 -0.51 cocoons/earthworm /day (Viljoen and Reinecke 1989), lower values of 0.15 and 0.23 cocoons/earthworm/day were observed in SBCR and CM manure, respectively. Increase in biomass at a rate of 17.7 mg/worm/day was highest in AW aged for four weeks, followed by CM, CM + SBCR and least in SBCR. Similar trends were also observed for increase in earthworm length. Higher rate of increase in length of earthworms in AW may mean that if well aged, the substrate

has some unidentified growth factors that favour rapid growth rate but with delayed stimulation of reproduction in *E. eugeniae*.

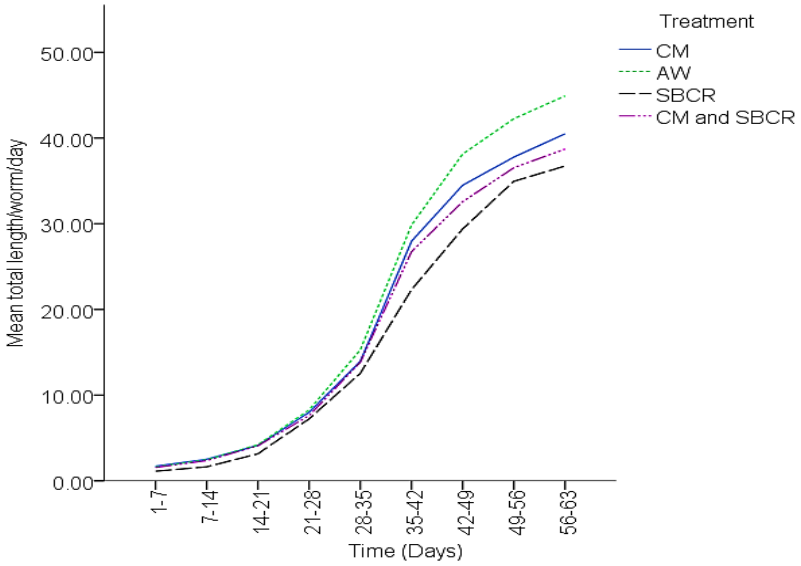

Figure 1: Growth (length) of *E. eugeniae* cultured on different organic substrates (CM= cattle manure; SBCR= soya bean crop residue; CM and SCBR= a mixture of CM and SBCR in the ratio of 1:1 w/w) for a period of 9weeks

Suggestions to tackle with the future challenges of organic farming

Attention should be given to *E. eugeniae* earthworm as a possible waste decomposer and a possible livestock protein source. The earthworm can safely dispose off organic wastes of domestic, agricultural and industrial origin to produce livestock protein, vermicompost and vermiwash as a strategy for ecological livestock intensification supported by sustainable crops-livestock integration.

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Impact of vetiver prunes compost application on the growth and yield of jews mallow

Adebayo Abayomi Olowoake[1]

Key words: Compost, Growth, Jews mallow, Vetiver, Yield

Abstract

Scarcity of chemical fertilizers has prompted the use of compost by farmers in Nigeria. Little is known about the impact of vetiver compost for increasing soil fertility needed for vegetable crop production. This study was carried out in a screenhouse of Kwara State University, Malete, Nigeria with the aim of assessing the impact of vetiver prunes compost application on the growth and yield of Jews mallow as well as its residual effect.

The potted vegetable (Jews mallow) studied were planted in a 6.5 kg soil and treated with NPK at 45 kg N/ha, vetiver compost (VC) at 2, 3, 4 and 5 t/ha including control. The treatments were laid out in a completely randomized design (CRD) with three replicates. The parameters taken on growth and yield parameters are as follows: plant height (cm), number of leaves, stem girth (mm), fresh and dry matter yield (g/pot).Result obtained from parameters studied revealed that jews mallow plant performed better (P<0.05) with the application of NPK at first planting. The fresh shoot yield value of jews mallow was 24.8g with NPK, followed by VC at 5 t/ha (14.2 g) at first planting. However, residual effect of jews mallow fresh shoot yield values obtained from VC at 5 t/ha (8.9g) was significantly (p <0.05) higher than that of NPK values (3.4 g). Based on the results obtained it is evident that vetiver prunes compost is a good source of soil amendment and it could serve as alternative for mineral fertilizer for the production of jews mallow.

Introduction

Corchorus olitorius, Jew mallow, belongs to the family, Tiliaceae. The major areas of production are in the South Western parts of Nigeria covers areas like Oyo, Ogun, Ondo, Osun, Ekiti and Lagos states. It is one of the most popular vegetables in every home. Consequently, it is grown in nearly all home gardens, market gardens near the city and truck gardens around the world (Aluko *et al*. 2014). Adequate soil fertility is essential for sustainable vegetable production. Tropical soils are beset with the problems of acidity, low nutrient contents, nutrients imbalance and soil erosion. (Ojo *et al*. 2014). In order to obtain high yield of Jews mallow, it is necessary to augment the nutrient status of the soil to meet the crop's need. One of the ways of increasing the nutrient status is by boosting the soil nutrient content either with the use of organic materials. Compost is the fertilizer made from deliberate biological and chemical decomposition and conversion of organic or plant residue (Adigun and Babalola, 2013). Oshunsanya *et al*. (2012) reported that vetiver grass strips significantly reduced soil loss and increase maize yield. Are *et al*. (2012) revealed that maize grain yield under vetiver compost was consistently and significantly higher than other treatments and mineralization of organic matter and release of associated nutrients under veticompost enhanced better soil productivity. However, the information on the composted vetiver prunes for production of jews mallowis rare. Therefore, this research was to investigate the impact of vetiver prunes compost on the growth and yield of jews mallow as well as its residual effect.

Material and methods

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Pot experiment was conducted at Kwara State University Malete, Nigeria (Latitude 80 71'N and Longitude 40 44'E) during the 2015. The university lies in the southern guinea savanna belt of Nigeria. Eighteen pots were filled with 6.5 kg of soil.

The treatments used were; composted vetiver prunes at 2, 3, 4 and 5 t/ha, mineral fertilizer (45 kgN/ha); and control. The result of analysis of the veticompost is summarized in Table 1. The treatments were arranged in a completely randomized design (CRD) with three replicates. The soils and compost were left to mineralize for two weeks before planting while the mineral fertilizer was applied two weeks after planting. Jew mallow seeds were broadcasted and thinned to two (2) seedlings. The mineral fertilizer was applied at 45 kgN/ha (Olaniyi and Ajibola, 2008). Pre-cropping chemical analysis of the experimental soil used in the screen-house was carried out before the experiment. Soil samples were collected to the depth of 0-15cm, air dried, sieved (2 mm) and analyzed for physical and chemical properties as described by Okalebo *et al*. (2002). The experiment was repeated without any fertilizer application at the second planting.

Table 1: Proximate analysis for the veticompost

Nutrient element	N (%)	P (%)	K (%)	Na (%)	OC (%)	C/N	Ca (%)	Mg (%)	Fe (mg kg^{-1})	Zn (mg kg^{-1})
Value	6.78	5.34	1.56	0.53	15.4	2.28	4.03	0.63	5915.0	172.1

Source: analyzed veticompost sample at I.A.R. & T. laboratory, Moor Plantation, Ibadan, Nigeria

The data taken include, plant height, stem girth, number of leaves, fresh shoot weight and yield. The data collected were subjected to analysis of variance (ANOVA) and treatment means were separated by Duncan Multiple Range Test.

Results

The results of the soil analysis are presented in Table 2. The soil was loamy sand and slightly acidic. However, the values of N, P and K were below the critical values of the nutrients in the soil of Guinea Savanna (Ojo *et al*. 2014) these relatively low level of major nutrients signify the need for augmentation to enhance the optimal performance of Jews mallow.

Table 3 shows the effects of composted vetiver prunes on growth and yield parameters of Jews mallow at first and second cropping. At first planting application of compost and NPK fertilizer performed better than control. Height of the Jews mallow that received VC at 5 t/ha showed the highest means of 37.3 cm, and this was significantly ($p< 0.05$) higher than other treatments. The highest stem girth (4.05 mm) recorded in Jews mallow was from NPK. This was significantly ($p< 0.05$) higher than other treatments including control. Mean number of leaves value ranged from 70.0 in NPK to 29.5 in control. The fertilizer treatments had significant effects on fresh and dry shoot weight. The values of fresh shoot weight (24.5 g) and dry shoot weight (6.6 g) respectively were significantly higher than all other fertilizer treatments including control. At second planting, Jews mallow plant height was significantly ($P< 0.05$) increased with application of compost VC 5 t/ha by 36.9 % and 57.3 % over NPK and control respectively (Table 2). There was a significant difference in the stem girth of Jews plants nourished with different compost. Similarly, application of VC 5 t/ha produced significantly number of leaves than VC at 2, 3, 4 t/ha and NPK respectively. Vetiver compost 5 t/ha gave the highest fresh shoot weight of 8.9 g when NPK fertilizer application had 3.4 g. Dry shoot weight of Jews mallow plants was at highest with application of VC 5 t/ha while the least was obtained with control.

Table 2: Physico-chemical properties of experimental soil

Parameters	Soil test value
pH	6.9
Org. C (gkg^{-1})	11.8
Total N (gkg^{-1})	2.04
P Mehlich ($mgkg^{-1}$)	10.2
Exchangeable bases (cmol kg^{-1})	
K	0.17
Mg	0.46
Ca	2.35
Na	1.86
Extractable micronutrients (cmol kg^{-1})	
Cu	1.58
Fe	67.8
Zn	3.2
Mechanical composition (cmol kg^{-1})	
Sand	872
Silt	94
Clay	34
Textural class Loamy	sand

Table 3.Effects of vetiver compost and NPK on growth parameters and shoot weight of jews mallow during first and second cropping.

Treatment	Plant height (cm)	Number of leaves	Stem girth (mm)	Fresh shoot weight (g)	Dry shoot weight (g)
First planting					
Control	22.3e	29.5e	2.22f	8.8e	1.7d
VC 2 t/ha	30.1c	39.5d	2.93c	9.1d	2.5c
VC 3t/ha	23.9d	43.5c	2.61e	9.2d	2.8c
VC 4t/ha	31.6c	38.5d	2.72d	9.8c	2.6c
VC5t/ha	37.3a	63.0b	3.69b	14.2b	4.5b
NPK	34.1b	70.0a	4.05a	24.5a	6.6a
Second planting					
Control	13.2f	22.0e	1.4d	2.7e	0.6e
VC 2 t/ha	28.1b	31.0c	2.0b	5.6b	1.3b
VC 3t/ha	23.1c	32.7b	2.0b	5.7b	1.3b
VC 4t/ha	21.5d	28.3d	1.8c	5.0c	1.2c
VC 5t/ha	30.9a	33.3a	2.9a	8.9a	2.5a
NPK	19.5e	21.3e	1.7c	3.4d	0.7d

Means having the same letter along the columns indicate no significant difference using Duncan's Multiple Range Test at 5% probability level.

Discussion

The high values of plant height and number of leaves of Amaranths grown in the pot treated with NPK 15:15:15 fertilizer over vetiver composts during the first cropping might be as a result of its quicker release of N, P and K which are the major nutrients required by crop for vegetative growth, seed and root development. This observation is in line with the findings of Olowoake (2014) that

mineral fertilizers quickly release their nutrients to the soil than organic wastes. The ($P< 0.05$) higher plant height, number of leaves, fresh and dry weight of leaf at application of VG at 5 t/ha during second planting may be attributed to vetiver compost which was a potential source of nutrients to the soils. Mahmoud *et al*,(2014) reported that organic fertilizer increased the nutrient status of the soil through gradual release of nutrients to the soil. Plant height, number of leaves and shoot fresh weight were observed to be low in the pot without any treatment. This might be as a result of low nutrients status of the soil especially N and P.

Conclusion

The use of vetiver prunes compost influenced the growth parameters of Jute mallow. From the results of the experiments, it was evident that the application of vetiver compost played a vital role in the growth and development of the crop. The application of 5 tons / ha of vetiver compost have better residual effect on Jews mallow than NPK fertilizer. The study also revealed that vetiver prunes compost can be gainfully harnessed as a fertilizer by small scale farmers because of its availability compared to inorganic fertilizer.

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Effect of poultry manure and defoliation on organic sesame production in Guinea and Sudan savannas of Nigeria.

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Key words: *Hyptis sauveolens (*Poit), effective capsule, defoliation, grain yield, shoot dry weight

Abstract

*Trials estimated productivity of sesameat various defoliation (**DF**) and poultry manure -**PM** treatments sprayed with Hyptis. 4.5tha-[1] **PM,** produced more grain yield, shoot dry weight **(SDW)** and effective pods **(EPs)** but less ineffective pods **(iEPs)**than other rates. 4WAS DFincreased **SDW** by 6.5- 30% over the control and 8 WAS DF; increased**(EPs)** by 32%, seed yield by 1.3-9.0% and reduced **(iEPs)** 22-27%;over the 8 WAS defoliation; at Samaru and Kadawa respectively. The 50% **DF** increased seed yield 1-10%; **SDW** 6-28%; **(EPs)** 3-6%; compared to the control and 100% **DF** at both locations but reduced **(iEPs)** 6-13%. Results indicated that highest individual percentage contribution was obtained from 1000 seed weight- **SW** and **SDW**; while the highest positive combine contribution to grain yield was from the number of **(EPs)** and 1000 **SW**. 4WAS and 50% defoliation of sesame with PM application; and spraying with Hyptis can enhance sesame production and reduce poverty.*

Introduction

Sesame *(Sesamum indicum* L.), is an oilseed, grown for industrial use, phytomedicine and food (Olowe *et al.,* 2009). In Nigeria, where production can be as low as about 300 kg per hectare, farmers are yet to take advantage of the robust market potential of the crop to improve their productivity (Mshelia *et al.* 2012).Factors responsible for poor yields include low soil fertility, chemical fertilization, soil degradation,as well as poor cultural management (Tepe, *et al*., 2011). Quality of soils, seed yield, and pollinators are influenced by chemicals (FAO, 2009); sesame grain yield was reduced 10-40% with synthetic pesticides sprays (Klein *et al*., 2007) Defoliation of plants activate more leaves, dormant lateral buds and branches enhancing yield of the crop. Thus, organic production methods that enhance biodiversity and improve the soil's conditions can be articulated to improve sesame production among small holders to boost productivity and eradicate poverty.

Material and methods

Trials were conducted during the cropping season in 2015, at two experimental sites of the Institute of Agricultural Research (I.A.R.) farm: - Samaru in Northern Guinea, (latitude 11^0 11'N, 07 38'E, 686m above sea level) and Kadawa in the Sudan savanna, (latitude 11^0 39'N, 08 20'E, 500m above sea level).Treatments consisted of four (4) PM rates (0, 1.5, 3, 4.5) tha^{-1},sourced from a local cockerel farm, two DF levels(50% and 100%) with a control and two DF periods- (4 and 8WAS) , arranged in a split-plot design and replicated three times. Sesame was sown at 15cm intra-row spacing, on ridges - 75cm apart; on August,10 and 17, at Samaru and Kadawa respectively; and later thinned to two plants per stand. The first DF at 4WAS; was carried out on September, 5 and September, 12; and 8WAS DF four weeks later. The crop was harvested on November, 23 at Kadawa and November 30 at Samaru; when crop had turned yellow and about 25% of bottom

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leaves had fallen. The crop was sprayed fortnightly with (African bush tea) *Hyptis sauveolens* Poitsolution at the rate of 800 g of Hyptis leaves in 15 litres of water as a prophylatic as well as control against insects.

Results

Shoot dry weight (SDW)

The 4.5 t ha^{-1} PM produced significantly heavier SDW than other rates at Samaru and Kadawa (Table 1). **DF** at 4WAS produced significantly heavier SDW than **DF** at 8WAS at all sampling periods. The no **DF** (control) produced significantly heavier SDW than the 50 and 100% **DF** at 8 and 12WAS at Kadawa and at 12WAS at Samaru; while the 50% **DF** produced heavier SDW than the other treatment at 8 WAS at Samaru.

Table 1 : Effects of poultry manure rates, defoliation time and levels on SDW of sesame plants

Treatments	SDW(g) SAMARU			SDW(g) KADAWA		
PM rate (t ha^{-1})	4WAS	8WAS	12WAS	4WAS	8WAS	12WAS
0	12.1d	26.0c	50.5b	17.5b	30.4d	55.4c
1.5	14.1c	37.7b	50.8b	16.3c	41.7c	61.4b
3.0	17.5b	37.1b	54.4b	17.9b	44.3b	64.4b
4.5	25.3a	42.9a	76.6a	26.2a	57.9a	78.7a
LSD	0.58	2.05	2.58	0.05	3.24	4.64
DF time (WAS)						
4	13.1	33.1a	63.4a	23.5	47.2a	72.2a
8	12.0	26.7b	41.7b	23.1	39.4b	44.0b
LSD	NS	1.45	8.19	NS	1.58	5.50
DF levels (%)						
Control	26.3	31.2b	69.0a	17.4	59.3a	77.5a
50	25.0	34.2a	56.0b	18.0	48.6b	63.3b
100	27.5	29.0c	40.9c	19.6	28.1c	51.5b
LSD	NS	2.79	4.24	NS	1.19	4.02

Mean within a column of treatment followed by different letter are significantly different at 5% level.

Effective pods (EPs)

EPs improved significantly with increasing rate of PM application (Table 2). Higher **EPs** were produced at 4.5 t ha-^{1} PM rate at Samaru and also at Kadawa. **DF** at 4WAS produced significantly higher **EPs** than **DF** at 8 WAS and 50% **DF** produced significantly more EPs than 100% **DF** and the control; while the control produce more **EPs** than the 100% **DF**; all at both locations.

Ineffective pods (iEPs)

iEPs only differed significantly at Samaru (Table 2); where control and 1.5 tha-^{1} PM application had more iEPs than than higher PM rates. **DF** at 8WAS had higher iEPs than **DF** at 4WAS and 100% DF more **iEPs** than the 0 and 50% **DF**.

Yield

Yield improved significantly with increase in PM rates at both sites (Table 2); the 4.5tha^{-1} producing the highest yield. DF at 4 WAS produced significantly more yield than **DF** at 8WAS, while 50% **DF** produced significantly higher yield than the 0 and 100% **DF**.

Path analysis (PA)

The PA of some growth and yield parameters showed that the highest contribution to the grain yield was obtained from the **1000SW** while the combined contribution was obtained from the **1000SW and effective pods** (Table 3).

Discussion

Poultry manure

PM improved crop performance through enhanced growth and yield as well as their attributes. 4.5tha^{-1} application rate had the most effect on the attributes as it provided the most nutrients and perhaps better improved the soil's chemical, biological and physical properties, as well as soil moisture retention capacity enabling better utilization of mineralized nutrients by the crops (Okpara *et al*., 2007).

Time of defoliation:

DF induced rejuvenation of more budsites; thus **DF** at 4WAS meant more buds and a larger photosynthetically active surface was created, than **DF** at 8WAS. Also crops recovered earlier from induced shock caused by **DF** at 4WAS while **DF** at 8WAS may have coincided with the start of pod setting, further reducing the crops's performance. These factors combined contributed to the high **EPs** and low **iEPs** observed for 4WAS **DF** compared to either the control or 8WAS **DF** and thus the improved yield.

Table 2: Effects of PM rates, defoliation time and levels on EPs, iEPs and yield (kgha-1) of sesame:

Treatments	SAMARU			KADAWA		
PM rates(t ha^{-1})	**EPs**	**iEPs**	**Yield**	**EPs**	**iEPs**	**Yield**
0	120.2d	29.7a	526.7d	141.6d	22.7	617.9d
1.5	163.6c	27.2a	611.6c	178.4c	22.3	801.1c
3.0	180.8b	19.9b	700.9b	212.3b	21.0	855.3b
4.5	190.1a	16.5c	789.9a	242.7a	20.6	960.9a
LSD	3.33	2.79	17.91	10.74	NS	29.14
DF time(WAS)						
4	201.5a	19.0b	782.0a	222.7a	20.4b	908.7a
8	121.8b	27.5a	573.1b	124.8b	28.2a	685.7b
LSD	2.36	1.97	15.49	2.65	6.31	28.89
DF levels(%)						
Control	181.9b	23.3b	703.3b	184.8b	20.6b	834.9b
50	195.9a	23.6b	744.8a	196.9a	19.4b	985.5a
100	167.2c	26.0a	601.5c	169.5c	29.4a	679.1c
LSD	10.27	2.82	23.19	3.07	2.01	20.98

Means within treatment column followed by different letters differ significantly at 5% level.

Levels of Defoliation

Excessive vegetation requiring more assimilates to maintain aswell as shading within the canopy affecting assimilate production, probably accounted for fewer EPs at the control compared to the 50% DF. Defoliation activates more leaves, buds and branches, resulting in higher EPs at 50% DF; alongside quicker recovery from DF shock and probable improved photosynthetic activites, DFresulted in higher yield at 50% compared to the 100% DF that suffered more shock and poor assimilate resulting in lower EPs, increased iEPs and thus the low yield obtained.

Defoliation time and rate interaction:

4WAS and 50% DF resulted in quicker crop's recovery, and to be more photosynthetically active to satisfy improved bud sites. This enhanced source/sink relationship; culminating in the higher EPs and yield that were observed compared to other treatment levels.

Conclusion

This study has shown that sesame can be produced using organic agriculture procedure among smallholders. The application of 4.5 tha^{-1} of PM, with 50% DF and at 4WAS gave the highest grain yield. DF reduced competition for light within the canopy, increased bud sites, photosynthetic apparatus, canopy cover, pods and yield, while spraying with aqueous Hyptis solution improved pest and pollination management.

Table 3: Percent contributions of some growth and yield components to the yield at Samaru and Kadawa in 2015

	Percent contribution (%)	
Individual Contribution	Kadawa	Samaru
Plant Height	4.47	3.24
Leaf Area	5.30	4.30
Shoot Dry Weight	10.91	8.09
Number of seed per capsule	4.02	3.02
Effective capsules	6.02	7.01
1000 grain weight	11.07	8.60
Combined Contribution		
Plant height vs Leaf Area	0.75	-9.95
Plant height vs SDW	-7.30	2.89
Plant height vs Seed per pod	-12.30	-0.01
Plant height vs EP	3.19	1.20
Plant height vs 1000grain weight	5.75	-0.46
Leaf Area vs Shoot Dry Weight	4.68	4.51
Leaf area vs Seeds per pod	3.74	0.12
Leaf Area vs EPs	11.00	10.03
Leaf Area vs 1000 grain weight	2.04	-1.18
SDW vs Seeds per pods	8.48	6.30
SDW vs EPs	-10.55	10.68
SDW vs 1000grain weight	16.56	13.53
Seeds per pods vs EPs	-7.79	-6.06
Seeds per pod vs 1000 grain	7.19	5.36
EP vs 1000 grain weight	21.00	20.77
Residual	11.77	8.01
Total	**100**	**100**

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Effects of Companion Crops on Insect Pest Infestation, Yield, and Postharvest Quality of Cucumber (*Cucumis sativus)* Fruit.

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Key word: Companion crops, insect pest, yield, Cucumber.

Abstract

Cucumber (Cucumis sativus) is susceptible to serious losses from pests which may result in 40-50% loss. Many pests have evolved resistance to some of the most commonly used pesticides, these challenges have led to increasing interest in non-chemical, ecologically ways of pest management. The research therefore investigated the effect of companion crop (Marigold, Sunflower and Mint) on pest infestation, growth, yield and postharvest quality of Cucumber (Cucumis sativus). The treatments were marigold between rows, Sunflower between rows, Mint between rows and control. Treatments were arranged in a randomized complete block design (RCBD). Data were collected on vine length, number of leaves, insect pest severity, and weight loss. Data obtained were subjected to analysis of variance (ANOVA) at $p < 0.05$. Means were separated using Duncan multiple range test (DMRT). Significant increase was observed in number of leaves among the treatments. Treatment with marigold in between rows had the highest numbers of leaves (58) followed by plots with Sunflower in between rows (45) and Mint between rows (40) and then the control (35). Cucumber with Marigold between rows had higher fruit yield while reduced weight loss and Insect pest severity were observed compared to other treatments. A similar trend was observed for the vine length and number of fruits.

Introduction

The cultivation of crops for increasing human population has resulted into various challenges such as climate change, soil degradation, and use of chemicals with residual harmful effect. Many pests have evolved resistance to some of the most commonly used pesticides, these challenges have led to increasing interest in non-chemical, ecologically ways of pest management (Denholm *et al,* 2002). Groups of plants which grow well together are called Companion plants and they can control insect pests by discouraging pest establishment or attracting natural enemies that kill the pest or trap crop that are more attractive to pests and serve as distraction from the main crop. The use of companion crop is a science-based management system simulating natural ecosystems. African marigolds (*Tagetes* spp.) produce root exudates which can be absorbed by neighboring plants and may help to reducing pest numbers, it also release thiopene, which acts as a repellent to nematodes (Matsumoto and Kotulai, 2002). Hence, the study aims at evaluation the effects of companion crops on insect pest infestation, yield, and postharvest quality of cucumber fruit.

Materials and Methods

Field experiment was conducted at the teaching and research farm of Federal University, Oye-Ekiti, Ikole Campus (7°47'N; 005°31°E). Beds of 2m by 1m were prepared for each treatment making a total of 12 beds and a distance of 1m apart. Three companion crops planted were African marigold (Tageteserecta.), sunflower (Helianthus annuuls) and peppermint (menthapiperita). The experimental design was randomised complete block design (RCBD) replicated 3 times. Treatments

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were Cucumber with marigold between rows, sunflower between rows, mint between rows and control. Seeds were planted directly on the field at spacing of 60cm by 90cm. Data collected were vine length, number of leaves, insect pest severity, and weight loss. Fruits were stored under three storage condition for 15 days: Ambient (21.9 – 33.5°C; 58 - 62 % RH), Evaporative Coolant structure (10 – 15.8°C; 70 - 75 % RH), Refrigerator (4.0°C; 40 - 45 % RH).

Weight loss: Fruits were weighed at the beginning of the experiment using an electronic balance and at three days interval during the storage period. The percentage change in weight was calculated as:

$$\frac{Loss\ in\ weight}{Original\ weight} \text{x } \frac{100}{1}\%$$

Insect severity: Observation was made at three days interval for insect damage at a score of 1 to 4: where 1= high infestation, 2 = moderate infestation, 3 = very slight infestation and 4 = No infestation. Data collected were analysed using analysis of variance (ANOVA). Means were separated using Duncan's multiple range test (DMRT) at $p < 0.05$.

Results

Significant increase ($p < 0.05$) was observed in number of leaves among the treatments (Table. 1). Treatment with marigold in between rows had highest numbers of leaves (58) followed by Sunflower between rows (45) and then Mint between rows (40) while the control had the least (35). Treatment with marigold in between rows had the longest vine length (56.0) followed by plots with Sunflower between rows (45.0), Mint between rows (40.5) and then the control 34.5cm (Table 2). Fruit number of cucumber with Marigold between rows had significantly higher fruit number compared to other treatments. A similar trend was observed on the effects of marigold on the weight loss, firmness. Insect damage was less severe on plants with marigold in between rows compared to other treatments. (Tables 4 and 5)

Table1: Mean Number of Leaf of cucumber as influenced by Marigold, Sunflower and Mint

	Weeks after planting									
TREATMENTS	3	4	5	6	7	8	9	10	11	12
Marigold + Cucumber	5a	10a	16a	19a	27a	30a	39a	43a	50a	58a
Sunflower + Cucumber	6a	9b	14b	17b	22b	28b	34b	39b	44b	45b
Mint + Cucumber	4c	5c	7c	12c	14c	18c	22c	25c	28c	40bc
Control	3c	5c	6c	10d	11d	13d	17d	20d	23d	35d

Means with the same letter in same columns are not significantly different from each other by Duncan Multiple Range Test (DMRT) at $p < 0.05$

Table 2: Vine length (cm) of cucumber as influenced by Marigold, Sunflower and Mint

TREATMENTS	3 WAP	4 WAP	5 WAP	6 WAP	7 WAP	8 WAP
Marigold+ Cucumber	26.33a	30.66a	34.76a	36.00a	38.66a	48.33a
Sunflower+Cucumber	26.00a	28.33b	30.16b	30.33b	33.46b	45.93b
Mint + Cucumber	20.33b	25.00c	25.53c	25.33c	30.66bc	44.45c
Control	20.00b	21.00d	21.03d	20.23d	25.60d	40.05d

Means with the same letter in same columns are not significantly different from each other by DMR at $p < 0.05$

Table 3: Effects of by Marigold, Sunflower and Mint on insect pest severity in Cucumber

	Weeks After Planting				
Treatments	2	4	6	8	10
Marigold + Cucumber	4.a	3a	3a	3a	3a
Sunflower + Cucumber	2b	2b	2b	2b	2b
Mint + Cucumber	2b	2b	2b	2b	1c
Control	1c	1c	1c	1c	1c

Means with the same letter in same columns are not significantly different from each other by Duncan Multiple Range Test (DMR at $p < 0.05$)

Table 4: Effects of Marigold, Sunflower and Mint on weight loss (%) of Cucumber fruit

	Days In Storage				
Treatments	3	6	9	12	15
Marigold + Cucumber	3.1a	5.0a	8.2a	12.0a	13.2a
Sunflower + Cucumber	3.5a	5.6b	9.0b	12.9b	14.7b
Mint + Cucumber	3.6b	5.7b	9.3b	12.5b	14.9b
Control	4.0b	5.9b	9.9b	13.5b	15.8b

Means with the same letter in same columns are not significantly different from each other by Duncan Multiple Range Test (DMR at $p < 0.05$)

Discussion

Increase was observed in number of leaves among the treatments. Treatment with marigold in between rows had the highest numbers of leaves, followed by Sunflower between rows, and then Mint between rows, while the control had the least. Treatment with marigold in between rows had the longest vine length, followed by plots with Sunflower between rows, Mint between rows, and

then the control. A similar trend was observed on the effects of marigold on the weight loss and firmness. Insect damage was less severe on plants with marigold in between rows compared to other treatments. Companion plant barriers may be used to reduce the spread and transmission of insect vectored viruses (Toba *et al*. 1997). Furthermore, companion plants can influence the spatial distribution of natural enemies in and around crops improving pest control (Tylianakis*et al*.2004). Peppermint (*Mentha piperita*) is a deterrent to pests such as mice, ants and other insects. Intercropping Sunflower (*Helianthusannuuls*) with other crops can help reduce pest problems such as corn borer or soybean cyst nematode can be reduced. Companion plants can directly affect adjacent plants by chemicals taken up through its roots. African marigolds (Tagetes spp.) produce root exudates which can be absorbed by neighboring plants thereby reducing pest numbers (Matsumoto *et al.,* 2002)

Conclusion

The experiment revealed that the best result in growth and yield of *Cucumis sativus* was observed for Cucumber planted with Marigold in between rows.

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Effect of mycorrhizal symbiosis on the production of organic durum wheat

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Key words: wheat, mycorrhizae, growth, yield, nitrogen assimilation

Abstract

The effects of the mycorrhizal inoculation by two commercial inoculants in the presence and absence of compost were studied on some agronomical, physiological, and genetical parameters of cultivated organic wheat. The variety Maali was used in Bir Mcherga : semi-arid of Tunisia. It was observed that the best grain yield, 1000 kernel weight, grain number per ear and number of ears/m2, is obtained in plants that received the combined mycorrhizal treatment without compost. The results showed that this treatment significantly increased biomass yield (0.9 t/ha against 0.7 t/ha in the control), chlorophyll (29.18 mg/g MF against 13.24 mg/g), dry weight (7.1 t/ha against 5.1 t/ha), plant height (76.61 cm against 66.6 cm) and the leaf area (18.93 cm2 against 12.4cm2). However in the presence of compost, these inocula showed no effect on yield components and physiological parameters.On the other hand, a genetic study has validated the effect of mycorrhizal inoculation on the mechanism of nitrogen assimilation in organic durum wheat by studying gene expression profiles: GS encoding glutamine synthetase, NR for nitrate reductase and the GSP for alpha-gliadin storage protein.

Introduction

Currently, Tunisian and foreign consumer expectations related to organic cereals quality and in particular durum wheat, are numerous and their request is increasing continuously. Indeed, the production of organic durum wheat with high quality, with sufficient quantity, is a condition for the successful development of organic cereal markets. However, the challenge of our country is to satisfy local demand whilst turning to exportation. Tunisia has so many advantages to produce and export organic products mainly to Europe.

However, the success of organic durum wheat is largely dependent on the mineral nutrition and especially nitrogen nutrition. In this regard, the use of mycorrhizal symbiosis may facilitate plant acquisition of nitrogen from sources which are otherwise not or less available to non-mycorrhizal plants. It could thus have an agricultural potential because it would act as a bio-fertilizer. In addition, this symbiosis helps to improve plant health as well as water nutrition (Smith et Read 1997). It is then appropriate to develop research to study the effect of mycorrhizal products on organic durum wheat.

Material and methods

The organic durum wheat variety "Maali" was used in the location of Bir Mcherga belonging the higher semi-arid of Tunisia (36,31°N, 9,58°E). The experimental design used during this trial, was split-split plot with three repetitions. The compost "c" (15 t.ha-1) is the main factor, the treatment with Microstar "m" (2 kg.ha-1) is the secondary factor and the treatment with Foliastim "f" (2

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kg.ha-1) is the third factor. Microstar was used in the seed coating. Foliastim was applied to early tillering and at the end of the swelling just before the exit of the cob. These two products are composed of mycorrhizal fungi (Glomus sp.). The seeding was done during the second half of December. The seed rate calculated was 400 seeds per square meter. The physiological and agronomic parameters studied are grain yield, 1000 kernel weight, grain number per ear, number of ears per square meter, ear length, plant height, chlorophyll content and dry weight.

Molecular analysis: In order to study the effect of mycorrhizal inoculation on the nitrogen assimilation mechanism in organic durum wheat plants, the analysis of gene expression GSP (Gliadin storage protein), NR (nitrate reductase) and GS (glutamine synthetase) was revealed before, during and after the grain filling stage in organic durum wheat. (Identification of specific nucleotide sequences corresponding to the genes of interest in the gene bank (NBCI) / RNA Extraction and cDNA synthesis / Reverse transcription of the mRNA to cDNA / cDNA Amplification by Polymerase Chain Reaction (PCR) / Migration on agarose gels (fragments amplified during the PCR), Ethidium Bromide Staining and Photography of gels under UV).

Results

Effect of mycorrhizal biofertilizers on grain yield

The analysis of variance for the grain yield proves that treatments "Foliastim" and "Microstar" significantly affected the wheat yield in the absence of the compost. For this parameter and the majority of other measured parameters, mycorrhizal inoculation in the presence of the compost did not produce significant results, this might be related to a competition between the microbial population of the compost and mycorrhizal fungi for nutrients.

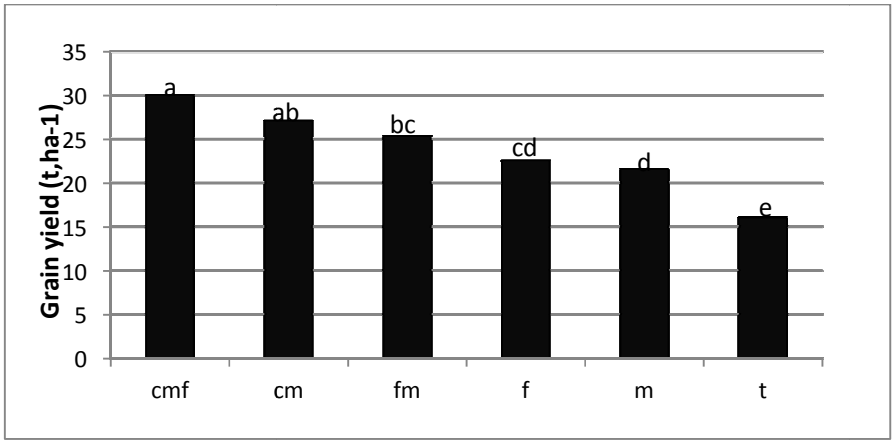
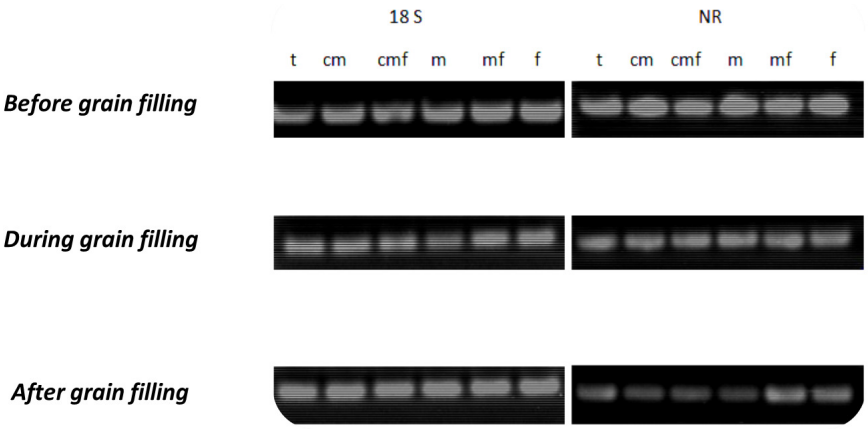


Figure 1. Effect of different treatments on grain yield (in t.ha-1)

Effect of bioinoculant mycorrhizae on the expression of nitrogen assimilation genes in durum wheat

Nitrate reductase gene (NR)

The NR gene is overexpressed before the grain filling in inoculated plants. During and after filling, the level of expression of this gene begins to decrease in all treatments, but remains a bit higher in plants that received treatment (f) and those of the combined treatment (mf). Breuninger et al. (2004) have noted that there is an expression of this gene in response to the root colonization by mycorrhizae. They reported that in conditions of water stress a positive correlation was observed between the efficiency of mycorrhizal colonization and activity of NR.

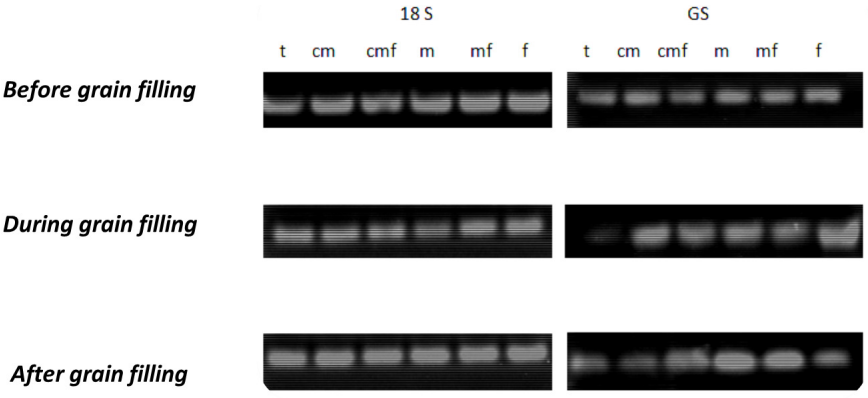


t : Control, cm : Compost+Microstar, cmf : Compost+Microstar+Foliastim, mf : Microstar+Foliastim, f : Foliastim

Figure 2. Gene expression level of NR and the reference gene (18 S) in durum wheat, before, during and after grain filling

Glutamine synthetase gene (GS)

The level of expression of this gene was low before the grain filling in all treatments. During this process the highest level of expression was marked in plants treated with "f". In addition no differences were noted between the other treatments. This gene was almost absent in the control (t). After filling, the band intensity remains high among "m" and "mf". Kichey et al. (2007) showed that there is a strong relationship between the amount of nitrogen remobilized during the grain filling stage and activity of GS and consequently a positive correlation between grain yield and activity of GS , in bread wheat (*Triticum aestivum*).



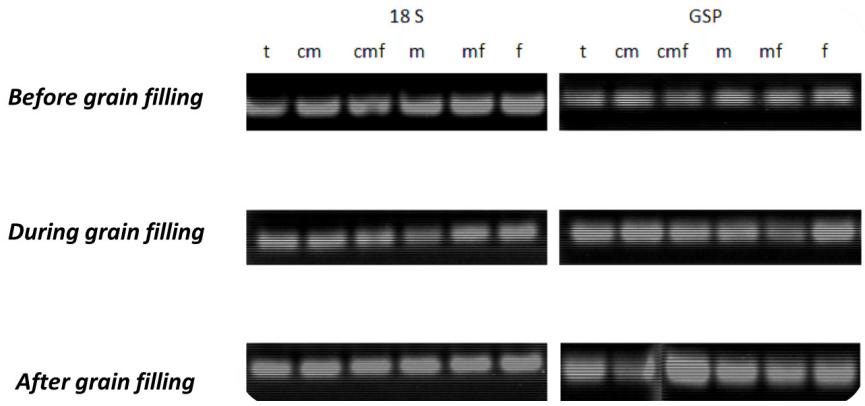
t : Control, cm : Compost+Microstar, cmf : Compost+Microstar+Foliastim, mf : Microstar+Foliastim, f : Foliastim

Figure 3. Gene expression level of GS and the reference gene (18 S) in durum wheat, before, during and after grain filling

α-gliadin storage protein (GSP)

Low expression of this gene before the filling process for all treatments and the control

In addition the level of the most important expression was noted after filling for plants that received the treatment "cmf". High levels of expression of this gene, but less important, were also reported with treatments "m", "mf" and "f". Hasanpour et al. (2012) reported an increase in the protein levels in durum wheat plants inoculated with a microorganism mixture (*Glomus fasciculatum* and *Azotobacter*). They showed the positive effect of mycorrhiza on the protein content relative to the non-inoculated wheat.



t : Control, cm : Compost+Microstar, cmf : Compost+Microstar+Foliastim, mf : Microstar+Foliastim, f : Foliastim

Figure 4. Gene expression level of GSP and the reference gene (18 S) in durum wheat, before, during and after grain filling

Discussion

The role of mycorrhizal symbiosis in the growth and plant nutrition is widely known. Numerous works have been highlighted and published on the subject. In the case of our test, in the absence of compost, mycorrhizal inoculation significantly improved the majority of measured parameters namely, plant height, leaf area, chlorophyll content, dry matter and yield components.

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Organic farming makes cotton production the most cost effective: Case study from Benin

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Key words: Relative cost, Cotton production, organic farming, cotton made in Africa, Benin.

Abstract

Despite its economic role in many West African countries, cotton sector is facing challenges that compromise its viability. To deal with this situation, many alternatives of cotton farming are promoted to sustain cotton production. In Benin, three main alternatives are observed: conventional cotton, cotton made in Africa (CmiA) and organic cotton. This paper aims at comparing the relative production cost of these alternatives by highlighting the main factors that determine the cost level. The study took place in three production zones (Banikoara, Wassa Péhunco and Kandi) in northern Benin and involved 180 cotton farmers (60 per alternative of cotton farming). Data collected were about farmers' socio-economic characteristics and inputs used for cotton production. The results show that the average relative production cost (in fcfa) of one hectare of cotton are 193,725; 227,479; and 169,242 for conventional, CmiA, and organic cotton, respectively. The ANOVA test reveals a highly significant ($P < 0.01$) cost differences among production alternatives. Accordingly, organic cotton in comparison with the conventional and CmiA, is the most cost efficient alternative for cotton farming in northern Benin. From a linear regression model, farmers' experience in cotton production, the size of cotton field, the size of maize field, and the adoption organic farming are found to be the major determinants of the relative production cost level.

1. Introduction

In many countries in West Africa, cotton represents the engine of economic development (Traoré, 2008). In Benin, the third largest cotton exporter in West Africa, after Mali and Burkina Faso, the crop is the main source of growth of national economy, representing 14% of GDP, 80% of export revenue, 45% of tax revenue, 60% of the industrial fabric (AIC, 2005). It represents the best organized agricultural supply chain and is a direct source of cash income for 325,000 farmers and more than 3,000,000 people (Matthess et al., 2005).

Despite this importance, cotton production faces economic, environmental, and social challenges. From an economic perspective, the West African cotton sector in general is subject to changes on the global market distortions, including subsidies of western countries to their cotton producers. On the environmental side, the excessive use of fertilizers and pesticides has resulted in soil degradation, pollution of groundwater, imbalance of ecosystems, destruction of living organisms, pest resistance to pesticides and lower yields (OBEPAB, 2002; Ton, 2006; Vaissayre et al., 2008). From a social point of view, the misuse of pesticides leads to cases of food poisoning, disease and death in the extreme cases (OBEPAB, 2002).

In this context of challenges which compromises the viability of cotton sector in Benin, the policy-makers have increasingly shown interest in various production alternatives towards sustainable cotton farming. As a result, for over a decade, different cotton options have been promoted. Currently, three main alternatives for cotton farming are observed in Benin: conventional cotton, cotton made "in Africa (CmiA)", and organic cotton. Considering economic viability as first

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condition, a sustainable alternative of cotton farming should minimize the inputs (i.e. fertilizers, labour, insecticides, etc.) quantities, implying minimum production costs. Later on, it should maximize the yield, so to ensure a positive balance between production and inputs. Focusing on the production costs, this study aims to compare the cost efficiency of the three alternatives of cotton production and analyze the major driving forces underlying the cost level under different alternatives.

2. Material and methods

2.1. Concepts clarification

The difference between the three alternatives of cotton farming is not related to genetic but to the farming practices and some advantages at market place (Table 1).

Table 1: Comparing the farming practices applied on the three alternatives of cotton

Criteria	Conventional	CmiA	Organic
Soil fertility management practices and ingredients	Mineral fertilizers	- Mineral fertilizers - Compost and green manure - Crops rotation	- Compost and green manure - crops rotation
Pest management practices and ingredients	Synthetic pesticides	Synthetic pesticides with exclusion ones on the 1a and 1b list of WHO	- Agro ecosystem balance - Natural pesticides based on plant extracts
Control system	No traceability No verification No certification	Traceability Verification	Traceability Certification
Advantage at market place	No Premium price	- No Premium price - Investment in education infrastructures	Premium price directly paid to farmers can reach 20% above conventional price

2.2. Study area and database

Based on the three alternatives of cotton farming, the three municipal areas were selected with the support of agricultural extension officers. As a result, Banikoara, Wassa Péhunco and Kandi were selected. Banikoara is the first municipality in term of cotton production in Benin, where the cotton farming systems mainly followed the conventional alternative. CmiA producers were located in Wassa Péhunco where the most experienced farmers of this production alternative are found. Concerning organic cotton promoted by OBEPAB[3], the municipal area of Kandi was selected.

The research units were farmers producing cotton in general. A total of 180 cotton farmers (60 per municipality, implying per alternative of cotton farming) were randomly sampled in each municipality. Data collected were about the farmers' socio-economic characteristics and the quantities and prices of inputs involved in cotton production. The study was conducted by survey methods on respondents using structured interviews based on a questionnaire. Statistical analysis was performed using the software STATA 11. ANOVA tests were used to compare cost differences among production alternatives while a linear regression model based on Ordinary Least Square (OLS) estimation was used to highlight the determinants of the cost level.

3. Results

3.1. Farmers' socio-economic characteristics

[3] Beninese Organization that Promotes Organic Agriculture

The main socio-economic characteristics of the respondents (Table 4) show that men (about 90%) are the major actors in cotton farming. There was no woman found in conventional cotton. The highest proportion of women (23%) was found in the group of organic cotton. On average, farmers applying conventional alternative of cotton farming are the oldest, more experienced in cotton production, and educated. As well, they have the biggest households, and the biggest cotton farms and maize farms. Considering the land acreage, conventional alternative is the most important form of cotton farming in the study zone. However, the CmiA alternative provides the highest yield.

Table 2: Socio-economic and demographic characteristics

Variables	Conventional	CmiA	Organic	Total
Qualitative Variables a				
Female	0 (0)	03 (5)	14 (23.3)	17 (09.44)
Male	60 (100)	57 (95)	46 (76.7)	163 (90.56)
Quantitative Variables b				
Age	43.5 (9.94)	39.31 (9.28)	41.98 (10.56)	41.6 (10.03)
Experience in cotton	18.76 (8.03)	3.73 (1.31)	5.75 (5.62)	9.41 (8.76)
Level of education	1.68 (3.38)	1.13 (1.85)	0.42 (1.64)	1.07 (2.46)
Household size	14.13 (7.18)	10.88 (4.73)	9.98 (5.93)	11.66 (6.25)
Size of land under cotton	8.20 (6.53)	2.10 (1.38)	1.27 (0.97)	3.85 (4.96)
Size of land under maize	3.9 (2.88)	1.95 (0.96)	2.29 (2.01)	2.71 (2.26)
Cotton yield	728.3 (215.7)	751.2 (318.8)	702.3 (281.8)	727.3 (274.6)

a: Values in brackets are relative frequencies; b: Values in brackets are standard deviations

3.2- Relative production cost under cotton production alternatives

Considering the different production alternatives, the average production cost of one hectare of cotton were found to be 193,725 (± 24016.72) fcfa/ha, 227,479 (± 26381.16) fcfa/ha, and 169,242 (±48787.64) fcfa/ha for conventional, CmiA, and organic cotton, respectively.

ANOVA tests reveal highly significant differences ($P < 0.01$) between types of costs and production alternatives (Table 5). Variable costs were significantly lower ($P < 0.01$) in organic and conventional farming alternatives. Fixed costs were significantly lower ($P < 0.01$) in conventional and CmiA alternatives. Household labour-related costs were significantly lower ($P < 0.01$) in organic alternative. Considering the overall production cost, organic cotton was found to be the most cost efficient alternative, followed by conventional cotton. Indeed, the production cost for 1 ha of organic cotton was significantly lower as compared to conventional and CmiA alternatives.

Table 3: Relative production costs per production alternative

Costs	Conventional	CmiA	Organic	ANOVA tests
Variables	69827.64a (16049.55)	91491.65b (30035.05)	53830.83a (49325.22)	F = 17.90 df = (2, 177) P = 0.0000
Fixed	5039.09a (3822.69)	9912.27a (12078.61)	31094.44b (29262.15)	F = 33.97 df = (2, 178) P = 0.0000
Household labour	118858.42a (26571.64)	126075.7a (35763.44)	84316.944 b (48691.04)	F = 20.59 df = (2, 178) P = 0.0000
Total	193725.16a (24016.72)	227479.63b (26381.16)	169242.22c (48787.64)	F = 42.13 df = (2, 178) P = 0.0000

Note: fcfa 1 = Euro 655; for each type of costs, values with the same letters (a, b or c) are statistically equal whereas values with different letters (a, b or c) are statistically different at 1% level ($P < 0.01$).

The main determinants of the cost level were found to be experience in cotton production, cotton land acreage, maize land acreage, and organic alternative of cotton farming.

4. Discussion

The household labour seems to play a quite significant role in cotton production as it records the highest production costs as compared to variable and fixed costs. For all the three alternatives farming of cotton, the family labour cost is above the 50 percent of the production cost. Most studies using gross margin as efficiency indicator fail in observing such prominence of household labour in cotton production. Even farmers themselves can hardly detect the value of family labour in their cotton business, they mostly rely on the global amount of money gained from selling cotton.

Organic cotton was found to be the most cost efficient alternative. Indeed, organic farming in general is acknowledged as a beneficial system for the overall health of and environment. From a global perspective, organic farming is mainly characterised by the prohibition of a majority of synthetic chemicals in both crop and livestock production (Lampkin, 2002). Therefore, cost related to variable inputs such as chemicals fertilisers and pesticides widely used in other farming alternatives are saved. Nevertheless, organic system often requires a whole farm management practices. As a result, it might result in higher fixed costs. According to Lampkin (2002), the term holistic is widely used to describe the management approach utilized in organic farming. This refers to the set of principles/regulations enshrined in organic farming that determine standards of husbandry and practice across the whole farming system, in contrast to the application of agri-environment prescriptions for example, where the intent is to target specific elements of the farming system.

Results reveal CmiA as having the highest production cost. This is due to the combination of conventional inputs and the organic ones (mainly as regard to soil fertility management) applied by CmiA farmers. Following the argument that learning from experience reduces allocative errors (Kokoye et al., 2013), the results of the regression model reveal that most experienced farmers have lower production cost. This implies that experienced reduced significantly the relative production cost per hectare. As consequence, CmiA farmers are on average the less experienced than conventional and organic farmers. They still need time to master the best combination of input to minimize production cost.

Table 4: Results of the regression model

Variables	**Coefficients**	**P>z**
Socio-economic characteristics (Z)		
Age	0.001 (0.001)	0.246
Sex (1/0)	0.010 (0.050)	0.834
Experience in cotton production	-0.006** (0.002)	0.028
Level of education	-0.004 (0.005)	0.365
Household size	-0.003 (0.002)	0.248
Cotton land acreage	-0.013*** (0.004)	0.002
Maize land acreage	0.014* (0.008)	0.098
Production alternatives (A)		
Conventional (1/0)	(omitted)	-
CmiA (1/0)	0.005 (0.048)	0.915
Organic (1/0)	-0.331*** (0.050)	0.000
Model summary		
Constant	12.305*** (0.087)	0.000
Observations (Parameters)	180 (9)	-
R-square	0.43	-

Chi2 (Probability)	138.21*** (0.0000)	-

Note: The values in bracket are the standard-errors; *, **, *** significant at 10%, 5%, and 1%, respectively.

5. Conclusion

This study reports on the cost valuation of cotton farming under three production alternatives. The results highlight that organic cotton is the most cost efficient alternative for cotton farming in northern Benin. Accordingly, organic farming appears as a production alternative in favour to the economic theory as it helps to minimize the production cost. Nevertheless, it might not support the income maximisation expectation that is not considered in the current study. Independently from farming alternative, the production cost reduces when farmers gain experience. It is therefore important to set up policies that support farmers during the early stage of the adoption of sustainable agricultural practices.

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Synthetic pesticide-free grain storage in Africa: Options, efficacy evidence and uptake challenges

Brighton Marimanzi Mvumi[1], Tanya Stathers[2], Alex Abraham Chigoverah[1]

Key words: diatomaceous earths, hermetic storage, pesticidal plants, pesticide-free grain storage

Abstract

Current grain storage methods in Africa largely rely on synthetic pesticides for pest control, but there are challenges of pest resistance development, presence of pesticide residues in food, worker pesticide exposure and environmental hazards. The current paper analyses grain storage pest management strategies that have been developed for use by smallholder in Africa to address these concerns based on non-chemical methods; diatomaceous earths and hermetic storage. The technologies were tested on stored shelled or threshed grain and found effective compared to conventional pesticides. The paper discusses hindrances to widespread and sustainable uptake of these technologies by end-users and other stakeholders, including unavailability of the technologies at affordable prices, lack of awareness of the technologies to create systemic demand, and lack of supporting policy and regulations.

Acknowledgments

The authors are grateful to the Organic World Congress Secretariat for funding participation in this Conference. The research was conducted with funding support from Department for International Development, UK and partly by the Swiss Development Cooperation.

Introduction

Sub-Saharan Africa (SSA) loses 13.5% of its cereal grains postharvest, amounting to US$4 billion annually, or the annual caloric requirement of at least 48 million people (World Bank et al. 2011). With the increasing food demand against an increasing human population and against a backdrop of climate change and variability, postharvest loss (PHL) reduction of food can complement the various production-related strategies of increasing food availability. Storage pests including insects, fungi and rodents are a major threat to food security and safety.

Residual synthetic pesticides and fumigants are used to keep stored grain free of storage pest infestation. However, the wide use (and misuse) of these pesticides has resulted in selection for resistant traits among storage insect pests. This has increased the cost of pest control, increased worker and consumer exposure to pesticides while increasing environmental pollution. In other parts of SSA, suitable pesticides are not widely available nor are farmers or traders properly trained in their use.

Natural methods such as hermetic storage (using grain bags consisting of one or two inner liners of high-density polyethylene or metal silos), diatomaceous earths (DEs) and botanicals can provide efficient, pesticide residue-free and safer alternatives to fumigants and residual pesticides for grain protection.

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Material and methods

On-station and field experiments were set-up using locally-sourced dry, clean and freshly harvested grain (maize, beans) and mixed thoroughly using shovels to ensure baseline uniformity. The grain (25 or 50 kg) was allocated to the respective treatments (hermetic bags, metals silos or DEs) compared with synthetic pesticides and untreated control. The protectants were admixed with the grain using shovels. All treatments were replicated at least three times. At farm level, the treatments were housed in farmer's stores. Grain samples were collected using clean probes at 1 or 2 month intervals for 8-10 months and analysed in the laboratory for insect numbers per species, insect damaged grain, and germination, *inter alia*, as indicators of efficacy of the technologies. Further laboratory trials were conducted using raw DEs collected from different parts of Africa against a known DE-tolerant storage insect pest, *Rhyzopertha dominica*, on wheat compared with enhanced DEs to determine if the DEs could be sourced locally or regionally instead of importing them.

Results

Sample results based on insect damaged-grain only showed that imported enhanced and some raw African DEs (Figs, 1-2) and hermetic containers (Fig 3) were as effective as the commercial synthetic pesticides under different agro-ecological conditions. Of the raw DEs tested in the laboratory, only the Zambian and Tanzanian samples caused at least 80% mortality at all concentrations against *R. dominica*. Insect progeny emergence was reduced by ≥ 78% for *R. dominica* after 7 weeks in all the African DE treatments at 2500 ppm in comparison to the untreated control (Fig. 3).

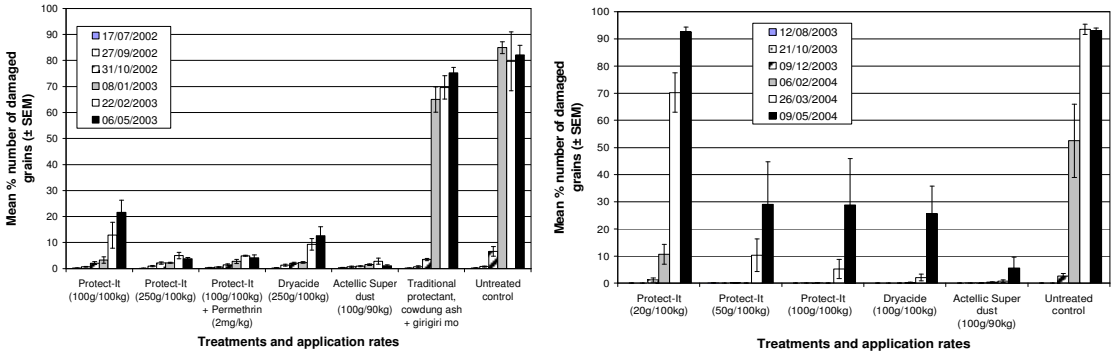

Figure 1. Mean % insect damage to dried maize (*left*) and beans (*right*) grain during the 2002/03 storage season in Babati district, Tanzania (n=4) (Stathers et al. 2008).

Discussion

Previous PHL assessment studies have mainly been quantitative yet consideration of qualitative loss could actually be greater; and include nutritional loss, mycotoxin and pesticide contamination with their serious human health implications. Both DEs and hermetic storage have the potential to reduce quantitative loss, maintain seed viability and suppress fungal activity which in turn reduces chances of mycotoxin contamination of the grain.

There is evidence that there are simple and effective chemical-free crop postharvest management technologies that can be used by smallholder farmers in Africa but the remaining challenge is having effective mechanisms for bringing the technologies to scale. In addition, there are few field studies to determine uptake and sustainability of the technologies. Technology uptake and adoption is influenced by efficacy, culture, socio-economics, cost, awareness-raising, political stability, and the way the technology is introduced (Mvumi and Stathers, 2014). Reasons why the developed

technologies are not widely adopted are summarised in Table 1.The technologies need to be developed in intended end-user's own circumstances and with participation of the various stakeholders including the end-users themselves. This increases the probability of long-term adoption and sustainability of the technologies.

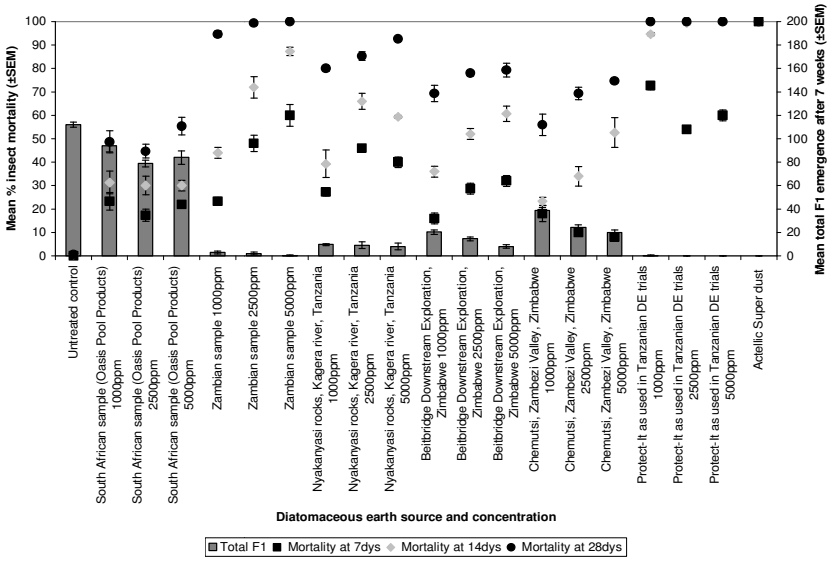

Figure 2. Effect of raw African diatomaceous earths admixed with wheat grain on adult mortality and F1 emergence of 40, 14-21 day old *Rhyzopertha dominica*, at 27°C and 55% r.h., Harare, Zimbabwe, n=4 (*Mvumi et al. 2006*)

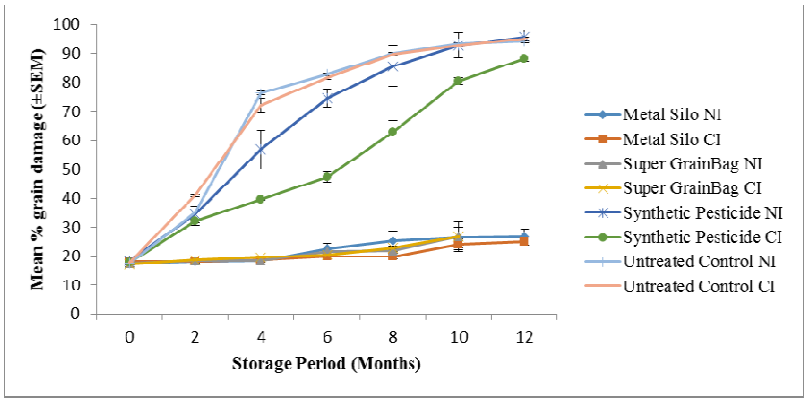

Figure 3. Mean % insect damage to maize grain during the 2013/14 storage season in Zimbabwe at Makoholi Research Station, Masvingo (n=3) (NI= natural infestation and CI= Combined infestation) (*Source: Chigoverah and Mvumi, 2016*)

Most national governments lack resources to finance PHL reduction technologies but private sector can take a lead while the governments develop and institutionalise PHM policies and implementation strategies to provide an enabling environment for private sector operations. Private-Public Partnerships and value chain approaches are key to realising meaningful and sustainable PHM interventions. For example, the impetus for research and development work on local deposits of DEs in SSA will be driven by the brewing and beverage industries, plastic and paint manufacturers, in addition to the agrochemical industries and could save African governments precious foreign currency for importing synthetic pesticides.

Use of synthetic pesticide-free technologies allows the organic food chain to be completed after production whilst reducing food and seed losses, enhancing food safety and protecting the environment from contamination with pesticides which might harm non-target organisms. However, in the trials reported in the paper, the grain was not strictly organic as most smallholder farmers are not yet practising organic production of staple grain for local consumption at scale because of limited demand. It is still a very specialised market.

Table 1. A summary of limitations of non-chemical postharvest loss (PHL) reduction technologies across Africa (Adapted from: Mvumi and Stathers, 2014)

PHL Reduction Technology	**Limitations**
Diatomaceous earths	Extremely effective and acceptable to farmers, but private sector investment required for wider scale availability
Botanicals	A lot of research and development done but very limited products on the market. Key areas requiring strengthening include cultivation, propagation and sustainable harvesting, private sector engagement and regulatory frameworks. Most of the work has been laboratory-based or on-station.
Breeding for resistance to pest attack	Good progress but farmer access to the varieties still limited. Bird attack (small grains) and storage insect pest attack (maize and small grains) still discouraging farmers from growing some otherwise improved and/or high-yielding
Hermetic storage systems	Huge potential especially in bag form; more evidence needed that they work in Larger Grain Borer- and rodent-infested areas; Metal silos effective but affordability and wider access are issues; Challenges in facilitating trained local artisans to take over manufacture and supply; Workmanship to ensure silos are airtight coupled with farmer maintenance of hermetic conditions needs further strengthening; Airtight "cocoons" have potential for commercial or local entrepreneurs provided the zipping mechanism is well-managed and multiple "re-use" still needs to be verified, plus governament tax concessions to encourage importation and/or local manufacture.
PH management training of farmers and service providers	Essential to optimise use of, adaptation of, and scaling out of PHL technologies. However, very limited funding for continuous postharvest training/capacity building exists compared to the support for tangible technologies.

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Plant Production - America

Title	Author/s	Country
Improving soil structure by using minimum-till permanent raised beds for vegetable crops	Denis La France, Maryse Leblanc, Maxime Lefebvre, Germain Moreau, Anne Weill, Serge Préfontaine, Luc Belzile, Yvon Houle	Canada
Orchard Floor Management Affecting the Growth of Young Organic 'Honeycrisp' Apple Trees	Julia Reekie and Eric Specht	Canada
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Minimum Risk Pesticides and Organic Farming Systems	Brian Paul Baker and Jennifer Ann Grant	USA
Changes in the Organic Blueberry Industry in Oregon: 2015 and 2016 Results of In-person, On-site Interviews with Growers	Javier A. Fernandez-Salvador, Bernadine Strik and Larry Lev	USA

Improving soil structure by using minimum-till permanent raised beds for vegetable

Denis La France[1], Maryse Leblanc[2], Maxime Lefebvre[2], Germain Moreau[2], Anne Weill[1], Serge Préfontaine[1], Luc Belzile[2], Yvon Houle[1]

Key words: vegetables, cropping systems, permanent beds, soil structure

Abstract

Based on the principles of Controlled Traffic Farming, applied to vegetable crops, a system was developed whereas tractor wheel tracks are permanent and not tilled deeply. The growing space under the tractor is minimum-tilled using adapted tools and bed-making implements. Results from a five-year study in Canada show an improvement of soil structure and root development, a higher density of earthworm populations, efficient weed control and crop yields equal to or greater than the conventionally rotary tilled control. An economic analysis indicates that the permanent raised bed technique might increase vegetable farm profitability due to reduced operational cost. This system has been adopted by a sizeable portion of Quebec organic market farmers.

Acknowledgments

This research was mainly supported by the Innovbio program of the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec. Appreciations are also extended to the Cégep de Victoriaville, the Organic Agriculture Innovation Platform (IRDA), Bourgault Tillage Tools and Ferme Tourmaline for their contributions and technical assistance.

Introduction

Vegetable production tends to imply a lot of tillage, often using plough and rotary implements, frequent tractor traffic, harvesting under less than ideal conditions and often leads to degradation of soil structure and compaction. During the 70's, Controlled Traffic Farming practices were evolved in field crops. By limiting machine passage to specific areas, they are one way of reducing mechanized farming's negative impacts on soils (Chamen *et al.* 1992). In the last 15-20 years efforts have been made in Germany by Wenz et Mussler (Deveyer *et al.* 2001), in Netherland (Vermeulen and Mosquera 2009) and France (Berry and Demeusy 2006) to adapt these practices to vegetable cropping systems, using minimum-till implements. This study aimed to implement such a system in Quebec and to compare it with conventionally tilled raised beds. The specific objectives were to evaluate the impact of the permanent bed system on crop yield, weed control, soil properties over time and to undertake an economic analysis.

Material and methods

The project was realized in two phases. In the first one, from 2009 to spring 2011, the CETAB$^+$ developed three pieces of tillage equipment: a disk bed hiller, a deep working cultivator, a flex-tine bedmaker. Field tests of implements were conducted on-farm and numerous modifications were made in order to improve their tillage performance. In the second phase, two separate field

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experiments were conducted from 2010 to 2014 at the Organic Agriculture Innovation Platform, Saint-Bruno-de-Montarville, QC, Canada, managed by the Research and Development Institute for the Agri-Environment (IRDA). At one of the experimental sites, the soil was a St-Urbain heavy clay with a pH of 7,4 and 4 % organic matter and at the other one, a Du Jour clay loam with a pH 6,0 and 3 % organic matter. These sites have been chosen because both had soil compaction. The experimental design was arranged in a randomized complete block design with two treatments, conventionally tilled and permanent raised beds, and 4 replications. In the conventional bed, the soil was fall ploughed at 20 cm depth and in spring a bed was made using a COMEB 1,55 m rotary bed-maker at 20 cm depth. After harvest, a disk harrow and a flex-tine cultivator were used before sowing green manure. In the minimum-tilled, permanent-raised bed treatment, the soil was not ploughed. It was tilled using a modified Bühler, 16 disk harrow, to start forming the beds and to till in crop and green manure residues. Main tillage used a "cultibutte" for 25 cm deep tillage. The machine is fitted with Wenz-Ecodyn legs and Bourgault Tillage Tools 12,7 cm tines on the three legs of the front line and 22,9 cm tines on the two back legs. Hilling and seedbed preparation was done using a flex-tine cultivator with bed-forming attachments (15 cm deep tillage). For the first two years of the project the IRDA research team used the equipment manufactured or adapted by the CETAB^{+}. In the last three years, they modified an existing equipment with chisel shanks to replace the "cultibutte". Also as the heavy soils were hard to cultivate, it was decided to do the deep tillage first, and then use the modified disk, and finish bed-making and seedbed preparation with the flex-tine bed-maker. After harvest, these tillage operations were repeated prior to sowing a fall green manure (oat/pea mixe). The experimental sites were fertilized according to soil analysis and provincial recommendation for the year's crop. Spring soil preparation was done over a few days in the second part of May. Each plot consisted of two beds 1,22 m wide and 10 m long, surface raised 12,7 cm above wheel tracks. Two rows of crops were sown or planted on each bed. Five successive crops were grown in both sites: green beans 'Strike', broccoli 'Diplomat', Spanish onion 'Vaquero', filet beans 'Tavera', and beets 'Chioggia', in 2010, 2011, 2012, 2013, and 2014, respectively. Weed control was done with a flex-tine cultivator with goose-feet in the first three years of the project, then using a K.U.L.T. DUO parallelogram with minidisk and Lelièvre blades in 2013 and 2014. The minidisk was first used in an opening mode, then in a hilling mode. In 2013 a flex-tine cultivator was used for a second mechanical weeding. This equipment was middle-mounted on a Mazzotti tool carrier tractor. Hand weeding completed mechanical weeding. Before and after mechanical weeding, weeds were counted and identified using 20 x 50 cm quadrats placed across the crop rows. Before crop harvest, they were identified, counted, cut at soil surface, dried 4 days at 70°C and weighed. Time necessary for mechanical and hand weeding was monitored. Soil samples were taken in spring, before tillage, and after harvest, before cultivating prior to sowing green manure, at the 0-10, 10-20, and 20-30 cm depth to determine the bulk density. Crop yields were measured each year. In mid to late July each year, a soil profile evaluation was effected to a depth of 60 cm deep in two neighbouring beds of each treatment. Soil structure was studied as well as root development and photographs were used to document the observations. In 2014, earthworm populations were extracted from a 30 x 30 x 30 cm cube of moist soil, measured and classified, when possible, as endogeic and anecic. Data were subjected to analyses of variance using GLM procedure in SAS 9.3 software and tested for normality and additivity. An economic analysis was also performed.

Results

There was no significant effect on bean and broccoli yield in the two first years (Table 1). In the third year, Spanish onion yield was greater in the conventional tilled raised bed. In the two last experimental years, filet bean and beet yields were higher in the permanent bed treatment and have led to a higher profit according to the economic analysis. No important effect on annual or perennial weeds was noticed during the trials. After 5 years, in the St-Urbain heavy clay, weight and number of worms were tripled compared to the conventional rotary system (Table 1). In the Du Jour clay

loam, weight of earthworms were 1,5 times higher in permanent bed system, but this difference was not significant.

Table 1. Five-year crop yields and earthworm sampling in 2014

		Yields (t ha^{-1})					Earthworms	
		2010	2011	2012	2013	2014	Density	Weight
Sites	Treatments	Green bean	Broccoli	Spanish onion	Filet bean	Beets	(nb m^{-3})	(g m^{-3})
St-Urbain	Permanent	3,2	8,7	40,7	6,9	22,2	349,5	188,8
	Conventional	3,0	9,9	42,4	5,3	17,7	113,4	54,1
		ns	ns	ns	*	*	*	**
Du Jour	Permanent	3,9	10,9	40,1	11,4	14,0	83,3	74,7
	Conventional	3,5	11,1	46,7	8,1	10,4	85,6	48,9
		ns	ns	*	***	ns	ns	ns

* significant at P≤0,05; ** significant at P≤0,01; *** significant at P≤0.001; ns non significant (P>0,05).

In the Du Jour site, soil bulk density decreased significantly in the permanent bed system indicating higher porosity and improved soil structure (Figure 1). Same tendency was observed for the St-Urbain site. In 2014, the summer was wet and soil tended to densify in both systems.

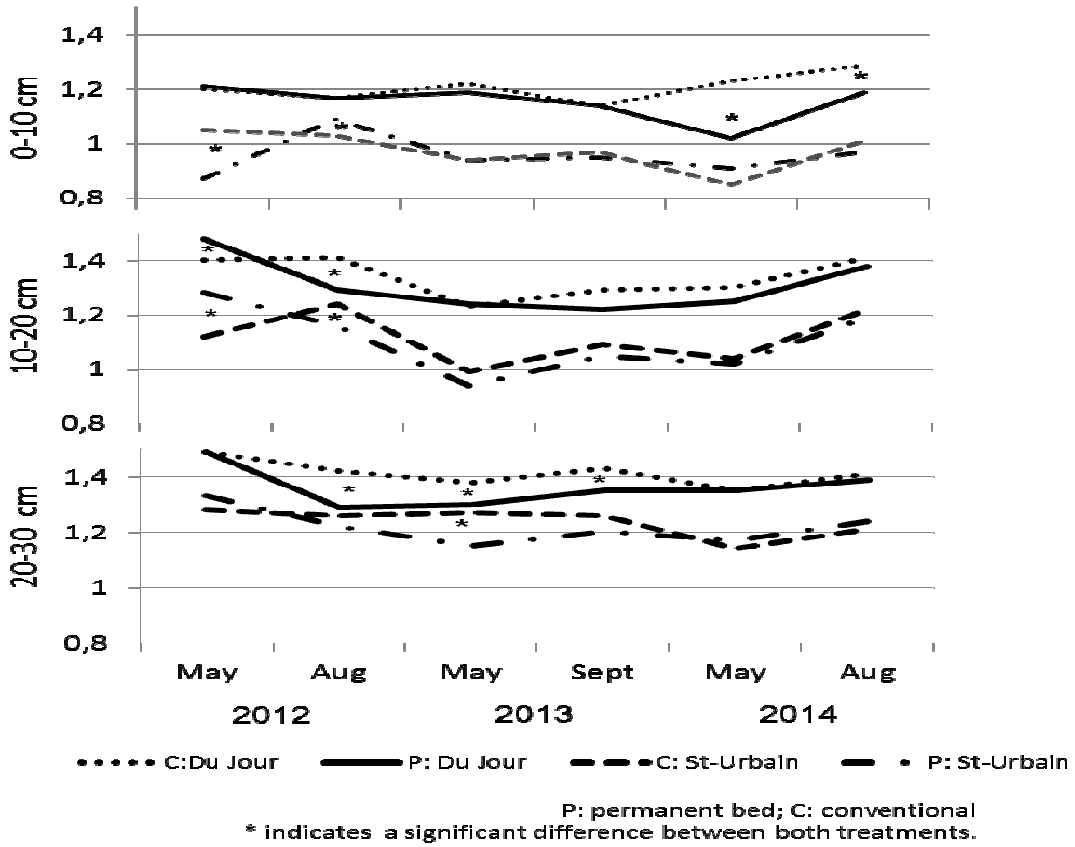

Figure 1. Evolution of soil bulk density over time

In the conventional bed system, the ploughed and rotary tilled treatment revealed compaction just below the rotary tilled area (Figure 2). This limited deeper root development. With the permanent bed system, soil structure was better throughout the whole profile and the influence of biological activity on soil aggregation was evident. Root penetration into deeper horizons was much better.

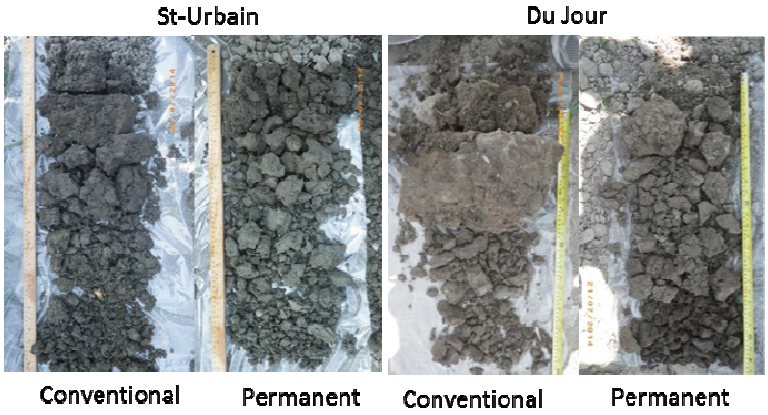

Figure 2. Soil profile.

Discussion

This new system has been shown to improve soils and plant growing conditions both in heavy and in lighter soils. It allows for elimination of ploughing and rotary tillage implements. Crop productivity tends to improve gradually. In Quebec, negligible influence was seen on weed development. One important observation realized with soil profile studies has been improvement of soil structure below lowest level of tillage. Improvements are cumulative over time. Since 2009, the permanent bed system has been experimented in Quebec with positive results (La France *et al.* 2012; Leblanc *et al.* 2015). Such innovations have been adopted by a sizeable number of market vegetable growers in France and Quebec because they have realized that improved soil conditions offered by this system are positive for crops and for economic performance. This is totally in line with the culture of innovation and continuous improvement towards best practice proposed by Organic 3.0. It is particularly important that these methods become widely known as they may help to improve poor soil structure that is frequently observed in vegetable crops worldwide.

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Orchard Floor Management Affecting the Growth of Young Organic 'Honeycrisp' Apple Trees

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Key words: reflective mulch, composted manure, companion plant, weed suppression, tree growth.

Abstract

Six orchard floor management systems (OMSs) were installed in an establishing 'Honeycrisp' apple orchard aiming to suppress weed growth. Bare ground used as control, reflective mulch, reflective mulch placed over composted manure, composted manure, green manure and bent grass as companion plant cover were set up in 2010 in replicated, randomized plots. The OMS affected weed abundance and tree growth in 2011. Reflective mulch and bent grass were effective in weed suppression. Compost and green manure plots had a high percentage of weed cover, although weed composition between these two OSMs were different. Trunk cross sectional area (TCA) was highest in trees treated with compost (25 cm^2), followed by trees growing in the reflected mulch and bare ground plots (13 cm^2); bent grass and green manure plots had the slowest growing trees with a TCA of 10 cm^2.

Introduction

In young apple orchards, weeds can out-compete trees for space, nutrients and moisture leading to cumulative decrease in tree vigour and poor productivity. Herbicides are often used to control weeds but orchard floor management has the potential to successfully replace agrichemicals in weed control. Research is needed to develop long term, non-chemical and sustainable orchard floor management practices to improve tree health, increase productivity, and control weeds without the input of chemical herbicides. Managing the orchard floor using cultivation, growth of companion plants, and organic and synthetic surface coverings (or mulches) are some non-chemical methods to control weeds. Choosing the appropriate orchard floor management system is crucial in the successful establishment of young apple orchards.

Cultivation or tillage can control weeds in the short term, but tillage degrades soil quality and disturbs ground habitat structure causing a decrease in natural populations of beneficial soil macrofauna (Wilson-Rummenie et al. 1999). Companion planting in the tree row can slightly inhibit tree growth (Hartley et al. 2000), but using a companion plant which competes with weeds but do not strongly compete with the trees for nutrients and water (Meyer et al. 1992) would prevent soil erosion and provide a stable environment for soil fauna. Reflective Mulch used as a means to control weeds and at the same time can enhance tree photosynthesis. When applied in the tree row, it can conserve soil moisture, repel insect pests and reduce the incidence of insect-vectored viral disease in several crops (Rhainds et al. 2001).

Material and methods

At the Kentville Research and Development Centre in Kentville, Nova Scotia, a young 2-acre 'Honeycrisp' orchard on MM111 rootstocks was used in this experiment. Randomized complete-block design consisting of four blocks of six orchard floor management systems (OMSs) were established for weed management practice. These OMSs are: bare ground as control (tillage to maintain weed-free), reflective mulch, reflective mulch placed over composted manure, composted

manure, organic green manure cover and bent grass as a companion plant cover. Other than the imposed treatments, all other management practices follow the organic standards.

The effect of OMS on weed abundance and tree growth was studied. Weed abundance was assessed in each of the OMS plots in 2011 (June and July); weeds in each plot were identified and their percentage coverage was quantified. By the end of the growing season, tree trunk diameter was measured in each treatment tree and the cross-sectional area (TCA) 30 cm above the scion-rootstock union was calculated.

Results and discussion

1. Weed Abundance:

Weeds in each plot were identified and their percentage coverage was quantified. Hog compost plots had abundant weeds with 61 % and 87 % coverage respectively in June and July. Green manure plots had increasingly more weeds as the season progressed, reaching 74 % weed coverage in July. Bent grass and reflective mulch were most effective in weed suppression. Weed composition differed; chickweed was predominantly found in the compost plots whereas sheep sorrel was abundant in green manure plots (Table 1).

Table 1: Weed species and their percentage coverage in 2011. Note that bare ground and reflective mulch plots had no weeds.

	Compost		Bentgrass		Green Manure	
WEEDS	June	July	June	July	June	July
Chickweed	28	41	0	0	1	0
Clover	1	1	1	1	0	1
Corn Spurry	1	1	0	0	0	0
Dandelion	6	13	2	6	1	2
Field Bindweed	5	2	0	0	0	0
Grass	2	3	0	0	8	16
Hawkweed	3	1	1	1	0	0
Lady's Thumb	1	2	0	0	0	0
Lambsquarters	3	10	0	0	0	0
Redroot Pigweed	2	4	0	0	0	0
Sheep Sorrel	4	6	11	9	15	55
Shepherd's Purse	5	2	0	0	0	0
Thistle	0	1	0	0	0	0
Wild Carrot	0	0	0	1	0	0
Total % Coverage	61%	87%	15%	18%	25%	74%

2. Tree Growth:

Trees in the compost plots had the fastest growth as shown in their trunk diameter and cross sectional area measurements (Table 2). The change in growth from the previous year also indicated that trees in the compost plots had the highest seasonal increase.

Table 2: Trunk diameter and cross-sectional area (TCA) of trees growing in the various weed management systems.

Weed Management System	Diameter (mm) 2011	TCA (cm^2) 2011	Δ Diameter (mm)	Δ TCA (cm^2)
Bare ground	39.8	12.5	10.1	5.5
Ref Mulch	38.4	11.7	9.2	5.0
Ref Mulch + Compost	53.1	22.2	11.6	8.6
Compost	54.7	23.7	12.0	9.2
Green manure	36.3	10.6	9.5	4.8
Bent grass	39.8	12.5	8.5	4.8

Conclusion

Orchard floor management system using reflective mulch in combination with composted hog manure is effective in weed control and promotes tree growth. Research is ongoing to provide all apple growers with access to new management techniques and information for organic tree fruit production.

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Participatory research about foliar fertilizers in a chili pepper crop at an organic family farm in Peru

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Key words: participatory research, smallholder, native pepper, foliar fertilizer

Abstract

Insufficient organic matter is regularly mentioned as a major limiting factor for the growth of organic farming and increased yields, and recycling of organic materials is promoted as a sustainable response to this situation. Participatory research involving a local university (UNALM) and a certified organic family farm (El Refugio), member of a farmers' association (Biofrut), was established in order to assess the effect of different foliar fertilizers in a chili pepper crop. Our results show that foliar fertilizers have a role in smallholder organic farming, that some of them produce changes in the allocation of dry matter in different plant organs and that they can also have an impact on yield and, potentially, on crop profitability.

Acknowledgments

El Refugio, a small organic farm in Peru, VLIR-UNALM Program and Vegetable Crops Research Program - UNALM.

Introduction

Participatory research (PR) is a system of knowledge production that involves researchers and community as partners to actively investigate an issue (Stringer, 2007). This type of research involves the Principle of Fairness (Luttikholt, 2007), as it allows the farmer to develop and influence research from its inception, and allows for a more horizontal exchange of experience and information between the farmer, his family and researchers and students. The challenge for development workers, researchers, and farmers is to design and use research methodologies that ensure the development and adoption of improved agricultural technologies to create sustainable production (Ponzio et al, 2013). 82% of Peru´s farms have less than 5 hectares (INEI, 2012) and poverty is difficult to overcome since they haven't received enough attention from governments, particularly with regards to public services and infrastructure (Baca & Cornejo, 2012). Insufficient organic fertilizer is often mentioned as a major limiting factor for organic farming and increased yields. The recycling of organic materials - produced on farm, purchased as commercial inputs or derived from processing industries - is promoted as a sustainable response to this situation. A field trial was designed and established with a smallholder in order to understand the potential benefits of different organic materials used as foliar fertilizers.

Material and methods

A crop of Amarillo or Escabeche chili pepper (*Capsicum baccatum* var. *pendulum*) was established in early summer at "El Refugio", a small farm managed by Pedro and José Francia, members of the certified organic group Biofrut, located in the Mala valley in the Peruvian Pacific desert, with a predominance of entisols and inceptisols and irrigated agriculture. Colectivo Ayni, a student group from UNALM, was actively collaborating with the smallholder family in order to improve

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production and outreach activities. The trial was designed through intensive discussions between students, farmers and a university researcher. Different organic materials for foliar fertilization were used (Table 1), following standard technical recommendations, in order to compare the performance of the chili pepper crop in terms of growth and development, yield and fruit quality, in a Randomized Complete Block design with 4 replications. Biol, an on-farm preparation of manure and plant materials of widespread use in the country, was compared with research and commercial formulations made of organic materials; a control sprayed with water was also included.

Table 1: Materials used for foliar fertilization, 2012

Materials	Origin	Process	Status	Dosage	Frequency
Agua de colca	marigold industry	acid lactic fermentation	research	0.5%	every two weeks
Agua de prensa	marigold industry	acid lactic fermentation	research	0.5%	every two weeks
EM	effective microorganisms	acid lactic fermentation	commercial	0.5%	every two weeks
Alopes forte	fishmeal industry	acid lactic fermentation	commercial	0.5%	weekly
FastBiol	bovine manure and molasses	anaerobic fermentation	commercial	0.5%	weekly
Biol	guinea pig manure and plant materials	anaerobic fermentation	on farm preparation	30.0%	weekly

Results and discussion

The process of dialogue and mutual learning between the farmer (and part of his extended family) and the leading author (and a university student group) allowed us to conduct this experiment, organize several on farm activities and support the gradual transformation of El Refugio into a demonstration farm for organic smallholder agriculture. This should be seen in the context of the social and economic processes in the valley of Mala and the Francia family, particularly the stagnation of the certified organic farmers` group Biofrut, the loss of farmland to urban development and the reduced interest in small-scale agriculture by the younger generation. In spite of these problems, after this experience, El Refugio increased its production, established good relationships with other potential consumers like chefs and travelers through agritourism, and become a research field were organic chili pepper agriculture is being studied with UNALM, in the framework of a project aiming at developing better value chains for Capsicum biodiversity.

Mr Francia, the leading farmer, made valuable contributions during the design of the experiment, and became heavily involved in it, with weekly evaluations of the field, suggestions on agronomic practices, joint solution to problems as well as sometimes profound discussions about the sustainability of certified organic farming and the fate of smallholder agriculture in the valley. Students, on the other side, were able to contrast knowledge gained at the university with Mr Francia´s practical experience, deriving conclusions that may explain why some practices work and how others need to be improved. Particular attention was given to the efficient use of water, pest and disease control with on farm materials and the analysis of the effect of fertilizers on chilli pepper growth and development. The Francia brothers mentioned that obtaining scientific data from their farm practices was a top gain for them. In many ways this was a remarkable experience.

Chili pepper plants sprayed with foliar fertilizers accumulated significantly more dry matter than the control (Table 2), with Biol producing the highest accumulation (248.5 g dry matter per plant). This, however, was restricted to the stems as the dry matter accumulated in roots, leaves and fruits showed no significant differences between treatments. Dry matter in stems of plants treated with Biol weighed 60% more than the control. Fruits accounted for slightly more than 50% of plant dry matter, followed by around 30% in stems; particular care was given to the extraction of roots in a sufficient number of plants, finding that they account for 7 to 10% of plant dry matter. Higher dry matter accumulation in stems was matched with the farmer´s observation that those plants appeared to have sturdier stems, able to support a higher number of fruits and a longer harvesting season. Harvesting dates were determined by the farmer according to his marketing needs and availability of labor. No significant differences were found for yield, although the treatments with foliar fertilizers produced from 1% to 30% more than the control. The highest yield of Amarillo chilli pepper was around 9 t ha-1when sprayed with Biol or Alopes forte, with an average of 7.8 t ha-1 for all treatments. Plants sprayed with Biol had the highest percentage of dry matter in stems and lowest in roots.

Table 2: Plant dry matter distribution and yield, 234 days after transplanting, 2012

Treatment	Plant dry matter distribution									Yield	
	Root		Stem		Leaf		Fruit		Total (100%)		
	g	%	g	%	g	%	g	%	g	t ha^{-1}	%
Control	14.4	8	50.1 ^{b}	28	18.4	10	95.1	53	178.0 ^{b}	6.9	100
Agua de colca	16.3	9	53.1 ^{b}	29	20.5	11	95.5	52	185.4 ^{b}	6.9	101
Agua de prensa	17.1	8	62.8 ^{ab}	29	21.2	10	112.0	53	213.1^{ab}	7.8	114
EM	21.0	9	71.0 ^{ab}	32	21.2	9	110.4	49	224.3^{ab}	7.6	112
Alopes forte	22.2	10	62.3^{ab}	27	19.6	9	124.2	54	228.2^{ab}	8.9	130
Fastbiol	16.6	9	53.0 ^{b}	28	20.7	11	100.8	53	190.4 ^{b}	7.5	109
Biol	18.1	7	81.6 ^{a}	33	25.2	10	123.6	50	248.5 ^{a}	9.1	130
Mean	17.9		62.0		20.9		108.8		210.7	7.8	
Significance	n.s.		*		n.s.		n.s.		*	n.s.	
CV (%)	22.4		24.7		34.8		20.0		25.1	19.3	

* significant at P<0.05; different letters in a column show a difference (P < 0.05) according to Duncan's Test.

The economic evaluation of the treatments was heavily influenced by the yield (although there were no significant differences among treatments) and total revenue, as well as by the price of the inputs and the quantity applied (Table 3). With Biol, the calculation was made considering this input either bought in the marketplace or produced on farm. Profitability was higher than the control for all treatments except for Biol (commercial) and Agua de colca, while with Biol (on farm) it was the highest (18% higher than the control). Price at the Saturday farmer´s market in Miraflores, an affluent district of the city of Lima, was about 6 times higher than in the conventional market. Not all chilli pepper, however, can be sold at the organic farmer´s market, so profitability would be lower due to the lower price in the conventional market for part of the total production.

Biol (on farm) and Alopes forte performed very similarly in terms of yield and profitability, a main difference being the fact that Biol can be produced on farm while Alopes forte, an input made of byproducts of the fishing industry, needs to be purchased. Nevertheless, the good results with Alopes forte point out to a potential greater role for the use of by-products from the fishing industry, in which Peru is a world leader.

Table 3: Economic analysis per hectare, 2012

Treatment	Total crop expenses S/.	Total revenue* S/.	Gross profit S/.	Profitability %
Control	10,398	41,119	30,721	295
Agua de colca	10,848	41,541	30,692	282
Agua de prensa	10,848	47,071	36,223	333
EM	10,878	46,089	35,210	323
Alopesforte	12,033	53,491	41,458	344
Fastbiol	11,248	45,163	33,915	301
Biol (market)	17,538	54,516	36,977	210
Biol (on farm)	12,088	54,516	42,427	350

* Calculated with chili pepper price at the organic farmer´s market attended by Biofruit.

Our results show that foliar fertilizers have a role in smallholder organic farming, that some of them produce changes in the allocation of dry matter in different plant organs and that they can also have an impact on yield and, potentially, on crop profitability. Best results were obtained with Biol, also confirming its widespread use among certified and non-certified organic smallholders in Peru. The role of these inputs, however, is not clearly understood and our results show that the contribution of nutrients (29 kg P/ ha-1 with Alopes forte and 23 kg K ha-1 with Biol) may have had an influence on chilli pepper growth and development and, to a lesser extent, yield; on the other hand, we cannot confirm a positive effect of lactic acid bacteria or other growth-promoting substances in these products. In any case, the yields obtained are similar to the national average for chilli peppers but less than 50% of the yield in the top producing region (generally medium-sized monocultures with very heavy use of synthetic inputs) (Ministerio de Agricultura, 2014), and this particular chilli pepper is considered a heavy feeder (Castillo, 2014). This points out to the need to improve organic management of commercial crops in smallholder systems, particularly with a better understanding of soil and plant nutrition. Finally, we were able to demonstrate that a close interaction between farmer and researcher from the inception stage is instrumental for a good understanding and mutual learning, improving the overall quality of the research and its potential to motivate better farm practices.

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Minimum Risk Pesticides and Organic Farming Systems

Brian Paul Bakerand Jennifer Ann Grant

Key words: Pesticides, Minimum Risk, Precautionary Principle, Essential Oils

Abstract

When faced with production challenges related to insect pests, diseases and weeds, organic farmers have a limited set of options. Minimum risk pesticides offer organic farmers several choices for overcoming the various challenges. By making certain active ingredients eligible for exemption from registration as minimum risk pesticides, the US Environmental Protection Agency (US EPA) created an incentive for innovation. The authors reviewed the literature regarding the effects of the substances on human health and the environment, and to explore their efficacy against specific targeted organisms. Most, but not all pesticides classified as minimum risk by US EPA comply with US organic standards and are permitted by US EPA for use on food. Exceptions are identified. The literature review revealed a substantial body of scientific studies on the efficacy of minimum risk pesticides. However, there are uses and applications that have not been rigorously investigated. The authors conclude that further research is needed to see how minimum risk pesticides can be safely and effectively used in organic and integrated farming systems.

Acknowledgments

The authors acknowledge the previous work of Raksha Kuenen, as well as comments made by Mike Helms and Dan Wixstead. Funding was provided by the New York State Department of Environmental Conservation.

Introduction

In principle, organic farmers rely on ecological balance to grow healthy crops. Plants are protected by relying on biological and cultural practices, agricultural and genetic diversity, and the design of farming systems that are resilient and sustainable. Organic farmers avoid the use of pesticides (IFOAM 2005). One reason is that pesticides may have adverse effects beyond the intended target pest species, including risks to human health and the environment. In the United States, organic food is governed by the US Department of Agriculture's National Organic Program (NOP) rule [7 CFR 205]. The regulation prohibits the use of synthetic inputs, including most pesticides, unless they appear on the National List [7 CFR 205.105(a)]. The National List can also prohibit natural (non-synthetic) inputs that pose risks to human health or the environment.

Pesticides in the US are regulated by the US Environmental Protection Agency (EPA), primarily through a system of registration. Pesticide registration requires a suite of testing on environmental and heath impacts that can be expensive and time consuming for companies bringing products to market. In the mid-1990s the EPA identified minimum risk pesticides and employed its authority to exempt them from registration, thereby lessening the burden on companies and encouraging production and adoption of lower risk pesticide products (Andersen et al. 1996). The rulemaking process invited public comment on the factors for exemption, acceptable risks posed by the proposed active ingredients, and which active ingredients and formulations should qualify for exemption. The following criteria were considered: (1) Whether the active ingredient is widely available to the general public for other uses; (2) if it is a common food or constituent of a common food; (3) if it has a nontoxic mode of action; (4) if it is Generally Recognized As Safe (GRAS) by the Food and Drug Administration (FDA) when used in food; (5) if there is no information showing significant adverse human health or environmental effects on any population; (6) if its use pattern would result in significant exposure; (7) if it is likely to persist in the environment.

Ultimately, 31 active ingredients were listed as eligible for exemption, and none have been added or subtracted since. Most are derived from plants and many are essential oils. They include substances such as cedarwood oil, garlic, and several mints. Formulated products need to meet specific requirements as well (US EPA 2016).

To clarify the eligibility and requirements for exemption, EPA proposed revisions to the regulation at the end of 2012 (US EPA 2012). These proposed revisions were amended after public notice and rulemaking, and took effect on February 26, 2016 (US EPA 2015c). The date set for full compliance is February 26, 2019. The revisions give more precise descriptions of the eligible active ingredients. They also codify the inert ingredient list to be consistent with other reforms the EPA is undertaking with formulated products that have both active and non-active substances. In the interest of transparency and accountability, manufacturers as well as vendors now need to be identified on the product labels. The revised regulations make now an ideal time to reexamine the utility of minimum risk pesticides in organic agriculture.

In a project requested by New York State's pesticide regulatory agency, the Department of Environmental Conservation, we prepared profiles of the 31 active ingredients contained in the 1996 regulation. The profiles include general background on the origins and use of the substances, physical and chemical properties, assessments of impacts on human health and the environment, summary descriptions of product performance and efficacy against specific target pests, and regulatory requirements—including whether the active ingredient is allowed under the USDA Organic standard. The profiles will be posted and publicly available in early 2017 on the New York State Integrated Pest Management Program website.

Material and methods

We prepared profiles of each of the 31 Minimum Risk Pesticide active ingredients based on a search of the scientific literature. The profiles summarize information about the pesticidal uses of the substance, such as main target pests; and uses for specific crops, food, public health, structural pests, or as antimicrobials. We compiled information gathered from various bibliographic databases, including Web of Science (Thomson-Reuters 2016), SciFinder (ACS 2016) and Google Scholar (Google 2016b). The Aggregated Computational Toxicology Online Resource (ACToR) database was searched by common name, chemical name, and CAS number; and EPA data were reported when available (US EPA 2015a). When EPA data was not available, we searched other sources such as additional toxicity data compiled in the National Institute of Health's ToxNet database contained in the HSDB (HSDB 2015), Data from the Office of Pesticide Program's Incident Data System (IDS) was also included when found in various EPA reports and work plans. One of the databases in the IDS, the National Pesticide Information Center (NPIC) database was searched for human health incidents, animal poisonings and environmental incidents that involve the active substance (NPIC 2016).

The Human Health Assessment section includes data on the acute, sub-chronic and chronic toxicity of the substance. The Environmental Assessment section summarizes the impact of the substance on non-target organisms, including acute toxicity on aquatic invertebrates, aquatic vertebrates, non-target avian species, non-target plants and non-target insects. Additional studies were sometimes included, particularly when the EPA identified data gaps. Keyword searches included 'pollinators' and 'aquatic invertebrates' combined with the substance. EPA's reports of incidents involving animals and environmental releases were searched and summarized (NPIC 2016). Reported incidents that involved neither human health nor animal effects were assumed to be environmental in nature. These may have involved abandoned pesticides, spills, misapplications, and unknown exposures. Environmental fate, ecological exposure and environmental expression were also summarized. The parameters include leaching; photodegradation in water, air, and soil; and ready biodegradability. EPA sources were given priority (US EPA 2015a; EPI 2012).

Product Performance was based first on a search of data submitted to EPA, when available (US EPA 2015a). We searched the scientific literature for efficacy data through Web of Science (Thomson-Reuters 2016), SciFinder (ACS 2016) and Google Scholar (Google 2016b). The patent literature was also searched for any patents that were granted—both in the US and internationally—claiming efficacy of formulations with active ingredients eligible for exemption from registration (US PTO 2016; Google 2016a). Efficacy for the control of specific pests or specific uses and applications were reported.

The profiles cite references involving technical grade active substances, registered pesticides with those substances declared as active ingredients, exempt formulations sold in the US, and formulations made and sold outside the US. Some of these formulations, and experimental formulations used under laboratory conditions, may not meet EPA's criteria for exemption from registration (as described above), and we reported products as non-exempt when their status was clearly presented in the literature. Furthermore, many efficacy studies involve multiple 25(b) active ingredients as well as non-active formulants, both of which may have possible synergistic effects. We have included these studies because they may be informative to those seeking information on 25(b) active ingredients, and it is sometimes difficult to determine from the reports whether the pesticide studied met 25(b) criteria. Summary information was provided to distinguish what was tested for efficacy. Thorough review of these products and formulations with multiple 25(b) active ingredients was beyond the scope of the project.

Each profile notes the substance's status under various regulations, laws and standards. Specifically, every substance has a summary of its status with respect to food tolerances and whether the FDA has declared the substance as Generally Recognized As Safe (GRAS) status as a food product [21 CFR 182, inter alia]. Food tolerances or exemptions from tolerances listed in 40 CFR 180 were cited and summarized when available.

Products used where food is grown, produced, or handled can only include active ingredients with applicable tolerances or tolerance exemptions in 40 CFR 180. Where tolerances have not been set or exemptions granted, the EPA does not have sufficient information to know whether residues on food are safe (US EPA 2015c). If a Minimum Risk Pesticide product is applied to food or animal feed, then every ingredient must have a tolerance or exemption from a tolerance. The substance's status as to whether it is allowed or prohibited by the USDA Organic standard is also reported.

Results

None of the 31 active ingredients have a food tolerance established, but many are explicitly exempt from the requirement of a tolerance. Many 25(b) substances are either a commonly consumed food or GRAS food additive. Active ingredients that are not exempt from the requirement of a food tolerance and are not considered commonly consumed foods are allowed to be used only where the use and application is not expected to result in residues in food. Therefore, dried blood, cedarwood oil, citronella and citronella oil, eugenol, geranium oil, 2-phenethyl propionate, and zinc metal strips are not considered eligible for food uses (US EPA 2015b). All 25(b) active ingredients are permitted for non-food uses. Most minimum risk pesticides are allowed for organic production under the NOP. However, lauryl sulfate, sodium lauryl sulfate, potassium sorbate, and 2-phenethyl propionate do not comply with the USDA Organic standards. Zinc metal strips used to prevent algal growth on roofs appear to be outside the scope of the organic standards.

The three eligible active ingredients that accounted for the greatest number of incidents—putrescent whole egg solids, dried blood and garlic oil—were related to their use as vertebrate pest repellents, primarily for deer. These incidents were largely related to children or pets eating the repellents, causing nausea and other symptoms. While the eligible active ingredients are non-toxic, many can cause allergic reactions in sensitive individuals.

Discussion

Minimum risk pesticides provide organic farmers options that they can use in their production systems. By allowing for exemption of these substances from pesticide registration, the EPA has opened the door to innovation by companies manufacturing exempt pesticides and by their end users—including organic farmers. The 25(b) exemption criteria effectively classify all substances as Toxicity Category IV, which is the lowest risk category. However, some health hazards exist, even though these products may pose less of a risk than most conventional and organic pesticides. Therefore, minimum risk pesticides still need to be used carefully. Also, because of their non-toxic mode of action and lack of persistence, these pesticide products may need to be applied frequently and at high rates to be effective. Our profiles project helps end users assess these hazards and which uses of minimum risk pesticides might be effective, and which should not be pursued. The authors recognize that further research is needed to encourage innovation in appropriate and safe uses and applications of 25(b) exempt pesticides.

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Changes in the Organic Blueberry Industry in Oregon: 2015 and 2016 Results of In-person, On-site Interviews with Growers

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Key words: *Vaccinium*, survey, production practices, farms, challenges.

Abstract

Organically certified blueberry production area grew nearly ten-fold from 2003 to 2011 in the U.S.A. In 2015, there were an estimated 283 ha of certified organic blueberry in Oregon. New transitional and organic blueberry fields continue to be planted by organic farmers. In 2015, a survey was developed to conduct on-site in-person interviews with certified and transitional organic growers. Quantitative and qualitative data were collected. Different farms were included in the 33 interviews. Half of the operations were small farms of 2 ha or less. Blueberry area for 70% of farms was less than 2 ha. Blueberry production systems were diverse and included: 31% using drip irrigation, 38% overhead; 44% were grown on flat ground, 41% on raised bed. Fertility and management practices varied widely among growers. Pest problems noted were weeds, Spotted Wing Drosophila (SWD), and vertebrates. Growers described a wide variety of marketing outlets and challenges to their organic blueberry production.

Acknowledgments

Funding for this project was provided by the Clackamas Extension's 2016 Innovative Fund Program. The authors would like to acknowledge the collaboration and assistance of: Oregon Tilth Certified Organic, Stellar Certification - Demeter USA, Oregon Department of Agriculture organic certification program and all the growers that participated for the valuable information provided.

Introduction

Worldwide blueberry (*Vaccinium* sp.) production and consumption have steadily increased since the 1990s (Strik, 2014), mainly due to an increase in crop profitability, high consumer demand for the crop, and successful marketing campaigns showcasing the human health benefits of consuming the fruit (Brazelton 2007). Certified organic blueberry area in the U.S.A increased from an estimated 194 ha in 2003 to 1,665 ha in 2011(Strik 2014). A great driver of the increase in production is the higher value of certified organic fruit (Strik 2014). In 2014 there were 88 ha of certified organic blueberry in production in Oregon (USDA 2015). An actual, on-site assessment has never been conducted in Oregon and is needed to determine the challenges and successes faced by growers. The objective of the study was to characterize and describe the current status of the organic blueberry industry in Oregon through conducting an on-site, in-person survey and interviews with certified and transitional growers.

Material and methods

In 2015, a survey was developed to conduct on-site in-person interviews with certified and transitional organic blueberry growers in Oregon. A list of certified growers was obtained from the USDA National Organic Program database (USDA, AMS), and accredited organic certifiers. The survey was conducted as an oral, on-site, in-person questionnaire. Quantitative and qualitative data collected included cultivars and area grown, pre-planting practices and soil amendments used, management systems, soil pH and fertility programs, pruning, irrigation and pest management, average yields, harvesting and postharvest practices, and sales and marketing information for each farm. Different farm sizes and business structures were included in the survey. Growers were located throughout Oregon. Only one interviewer conducted the survey to ensure consistency.

Data were analysed and one way tables were chosen to present most of the quantitative results. Multiple response data were analysed using separated table analysis. A rating scale was used to ask growers about their reasons for choosing to be organic in regards to their farm practices and production system; five options were provided: philosophical; environmental impact; health concerns for self, family and/or workers; market opportunity; fashionable production trend; and awareness of synthetic pesticide impacts. Weighted averages were used for applicable questions with multiple answers to determine the highest scoring responses and present a clear picture of the issue.

Results

Certifier supplied information

Based on information obtained from the USDA National Organic Program (NOP) database, there were six accredited certifiers operating in Oregon that certified blueberry growing operations: Oregon Tilth Certified Organic (OTCO; Corvallis, OR), Stellar Certification Services (Stellar; Philomath, OR), California Certified Organic Farmers (CCOF; Santa Cruz, CA), Organic Certifiers (Ventura, CA), Oregon Department of Agriculture (ODA; Salem, OR) and Washington State Department of Agriculture (WSDA; Olympia, WA). Once these were contacted to confirm the number of operations certified we determined that only the first four actively certified blueberry farms in Oregon for a total of 68 operations (as of July, 2015). In addition, one transitional operation (in the process of converting the blueberry area to certified organic) was also interviewed for a total of 69 potential survey participants.

To estimate existing and future organic area in the State, information was obtained from the certifiers and later updated and verified by the operations surveyed. Based on the certifier data, there were an estimated 355 ha of certified organic blueberries in Oregon prior to conducting the survey.

State crop area and farm characteristics

This report includes 33 growers interviewed, equating to a 48% participation rate. These growers had 442 ha of certified organic blueberry. A more accurate estimate (including growers not surveyed) would be for a total of 481 ha of certified organic area. Additionally, if area not currently certified, but planted and in transition, is included, we estimate there will be 610 ha of certified organic blueberry within the next 2 to 3 years in Oregon, based on our survey.

The majority of organic operations surveyed (52%) had a total farm area larger than 8.1 ha, followed by 33% of farms between 2.1 to 8.1 ha (Figure 1a). Additionally, most had certified blueberry area ranging from 0.1 to 2 ha (70%), followed by 24% of farms having from 2.1 to 8 ha and 6% more than 8.1 ha of blueberry (Figure 1b).

Farmers had diverse operations with a variety of crops other than blueberry being grown, including other small fruits, pome fruits, nuts, vegetables, herbs, agronomic crops, pastures, and animal production. Twelve percent of growers were exclusively producing blueberries and all were producing a variety of cultivars and types of blueberry including northern highbush (*V. corymbosum*), complex hybrids between northern and southern highbush (e.g. 'Legacy'), and rabbiteye (*V. virgatum*) cultivars (up to 46 different cultivars grown in the state). Nine percent of growers had parallel production of blueberries as organic and conventional at the same farm. All organic certified operations were located in the western side of the State with 88% of all farms surveyed in the central corridor in between the Coast and Cascade Mountain Ranges in the Willamette, Umpqua and Rogue valleys and the remaining 12% were in the Hood River and South Coast areas.

The majority of blueberry producers considered philosophy, environmental impact, health concerns, and awareness of synthetic pesticide impacts as "very important" reasons for being organic, while almost half (46%) and 40% considered a marketing opportunity as a "very important" or "important" reason for being organic, respectively. The majority of growers (68%) did not consider their organic production being a fashionable trend "an important" reason for choosing to be organic.

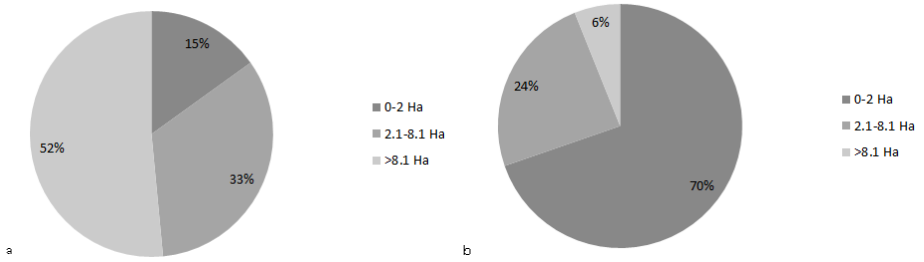

Figure 1. Percent of organic blueberry farms surveyed in Oregon (2015) by farm area category: a) total farm size and b) total blueberry area.

Production practices

Blueberry production practices varied widely among operations depending on the growers' approach. Modifying soil pH was common amongst the surveyed organic growers with 56% adjusting their soil pH prior to planting, mostly with sulfur or other approved acidifying agent for organic production (78%; coffee grounds, acidified barks or plant residues or other low pH alternatives) and 22% using lime to increase soil pH to the desired range of 4.5 to 5.5 (Hart et al. 2006). Soil testing was done by 30% of the growers once a year, 5% twice a year, 12% every other year, 18% did not test their soil at all and 37% tested at some other frequency. Half of the growers had never used leaf tissue testing, whereas the rest tested either once a year (25%), every other year (7%) or at some other frequency (18%). Of the growers doing tissue testing, 24% did it in late July to early August (as recommended; Hart et al. 2006), 29% in the spring (March–May), 12% after fruiting and 35% at different times (June or during late fall growth).

There was a wide range of organic or other soil amendments, and nitrogen and other macro- and micro-nutrient fertilizers used for fertility management varying widely amongst growers. Fertility sources used included animal meals and manure products, vegetable-based meals and mineral sources, all in liquid and solid forms (granular, pelletized or powdered).

Of all surveyed growers, 31% used drip, 38% overhead and 31% a combination of both types of irrigation systems. Forty four percent of growers had flat ground as their row management system, either when blueberries were planted by them or by the previous owner of the farm, while 41% of the remaining operations had raised beds and 5% had a combination of both systems at the same farm. The remaining operations (10%) had an alternative row management system including circular mounded plantings, containers with substrate or a grass/legume rotational or grazing system around the blueberry plants.

Most interviewed operators (96%) pruned all, or at least part, of their blueberry area annually. Hard, detailed pruning, the recommended method by Oregon State University (Strik et al. 1990; 2003) was done by 82% of the operations, by taking out big canes and non-fruitful or twiggy growth at the top of bush, thinning to the most vigorous and fruitful wood and shaping the bush to a vase for better light and air flow. The remaining 18% of growers practiced one or a combination of speed pruning (making only big cuts lower on bush; Strik et al. 2004), renovation pruning (for older bushes with large and aged wood), light pruning (quickly taking out a limited amount of wood from the top of the bush) or other alternatives such as mechanical hedging, use of ruminant animals to thin plants or fast chainsaw cuts to the base as well as combinations of all of the above.

The most important pest problems noted by growers were weeds (mentioned by 82%), Spotted Wing Drosophila (*Drosophila suzukii*; 48%), Mummy berry (*Monilina vaccinii-corymbosi*; 19%) and Blueberry Shock Virus (BlShV; 19%). Vertebrate problems were common amongst organic blueberry growers with 89% of them having issues with birds, 86% with rodents (voles, moles, squirrels or others), and 46% with deer. A wide range of additional challenges facing organic blueberry producers in Oregon were mentioned, including weed management, pest control, labor, disease, weather and climate change, plant nutrition and fertility management, financial and other farm specific problems (Figure 2).

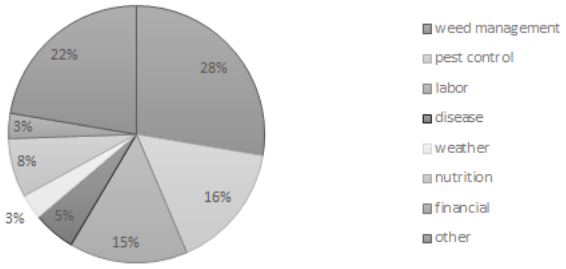

Figure 2. Greatest challenges faced by organic blueberry producers surveyed in Oregon (2015).

Harvest methods and marketing

Eighty two percent of the organic growers surveyed harvested fruit by hand only and 11% by machine harvest exclusively, while the remaining 7% harvested fruit using both techniques. A variety of methods were used when picking including field packing for fresh or processing, packing and sorting in the field or at a separate facility, and bulk harvesting all in different packages including clamshells, recycled paper hallocks, bulk cardboard or plastic containers. The largest share of the producers surveyed sold their fresh blueberries directly to the final consumer (45%), while 20% sold fresh fruit to retailers and 20% to wholesale buyers. Only 15% of the interviewed growers sold their fruit to processors.

Discussion

Planted as well as production area for organic blueberries in Oregon has continued to expand as shown by the survey data collected. A wide variety of organic production systems are used depending mostly on the grower's approach and management philosophy. It is clear that organic blueberries are a feasible option for blueberry growers in Oregon and present a direct way of bringing economic, environmental and social sustainability to small medium and large farmers contributing to moving organic out of its current niche and into the mainstream. The present study should be followed by a survey of consumer trends and changes regarding blueberry consumption in organic hotspots across the state. It is also clear that improvements are needed to convey the information from organic research to small growers effectively and determine that the best practices and education methods (extension or others) to better serve a diverse audience of changing demographics in the blueberry industry.

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Plant Production - Asia

Title	Author/s	Country
A Comparison Study on Quality of Organic and Conventional Rice and Wheat	Xi Yunguan, Jin Shu, Wang Lei,Chen Qiuhui, Tian Wei	China
A short review on applications of signal transduction and xerophytophysiology in organic crop production	Hui-Lian Xu and Qicong Xu	Japan
The effects of wood vinegar and soursop (Annona muricata L.) plant extract on soil microorganisms	Noraini Md Jaafar, Joel, Jia Le Khor and Nur Saidahtul Nadiah Harun	Malaysia
Performance Evaluation of Roselle (Hibiscus sabdariffa L.) Accessions under Organic Conditions	Rodel G. Maghirang, John Marty C. Mateo and Claudette D. Oraye	Phillipines
Validation and Documentation of Organic Production Systems for Lowland Rice in Camarines Sur, Philippines	Carmelita Nidea Cervantes, Felipe P. Laynesa, Jobelly B. Pacis	Phillipines
Effects of cultivation sites and varieties on ascorbic acid contents in organic vegetables	Siwaporn Thumdee, Benjamas Comekan , Ashariya Manenoi	Thailand
Comparing the rate of growth of organic greenhouse cucumber in different growth media fed with two humic acid levels	Amir Abbas Yousefi, Mohammadreza Rezapanah', Maryam Moarefi	Iran
Promising biological activity of Cydia pomonella granulovirus (CpGV) isolates for organic apple protection	Mohammadreza Rezapanah	Iran
Life Cycle Environmental Impact Assessment of long term organic rice production in Subtropical area China	Xueqing He, Yuhui Qiao	China
Total dry matter, nutrient uptake and yield of summer mungbean as influenced by organic management practices	Sharvan Kumar Yadav, Hanamantraya Bhimaraya Babalad[1], Shanti Kumar Sharma, Mahendra Kumar Yadav, and Roshan Choudhary	India
Organic nutrient management and intercropping for improved rainwater conservation and productivity under rain fed maize-barley rotation	Pawan Sharma, Vinod Kumar Bhatt, Sathiya, Krishnamurthy, Harish Sharma, and Lekh Chand	India
Development of a growing media for producing organic tomato (*Solanum lycopersicum L.*) in greenhouse	M. Reza Ardakani, Mehdi Sharifi	Iran

Study on The Utilization of Pig Manure in Vermicomposting Production by Earthworm (*Eisenia andrei*)	Po-Chin Chang, Yung-Song Chen	Taiwan
The Use of Neem and Pyrethrum Botanical Insecticides on Controlling Crocidolomia pavonana	Agus Kardinan	Indonesia

A Comparison Study on Quality of Organic and Conventional Rice and Wheat

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Keywords: Rice, Wheat, Organic, Quality, Comparison

Abstract

In order to compare the effects of organic and conventional cropping patterns on the quality of rice and wheat, the quality of rice in 2015 and wheat in 2016 from the field experiment in the Taihu Lake region were tested, which was under the condition of equal nitrogen input for 5 consecutive years in organic and conventional system. The results show: the content of total flavonoids in organic rice and wheat were significantly higher than those in conventional ones; while the content of amino acid and protein in organic rice and wheat were generally lower than those in the conventional; the content of Cr, As in organic rice and Cu, Cd, Zn in organic wheat were significantly lower than those in the conventional. Therefore, the safety and healthy quality of organic rice and wheat were significantly better than those of conventional ones.

Introduction

In China, there were few research reports on whether the crops grown with organic fertilizers had significant differences in nutrient quality, safety quality between crops grown with chemical fertilizers. Therefore, the quality of rice in 2015 and that of wheat in 2016 in organic and conventional way under the condition of equal nitrogen input for 5 consecutive years in the Taihu Lake region were measured and analyzed as to provide the basic datafor the quality comparison of organic and conventional rice and wheat production.

Materials and Methods

Experiment material

The experiment of rice and wheat rotation set up three treatments, (1)Blank control(CK): no fertilizer; (2)Conventional fertilization: based on the extensive survey, the average fertilization rate and fertilization mode of local farmers; (3)Organic fertilization: using pig manure compost under the condition of equal nitrogen input with conventional group. Nitrogen input of each treatment is showed in Table 1.

Table1:Nitrogen input of each treatment

	Planting patterns	Types of fertilizer	input of nitrogen (N,kg/hm^2)	input of phosphorus (P_2O_5,kg/hm^2)	input of potassium (K_2O,kg/hm^2)
rice season of 2015	conventional	C-F	298.8	39.3	74.7
	organic	O-F	298.8	54.4	339.9
wheat season of 2016	conventional	C-F	184.2	19.6	37.3
	organic	O-F	184.2	96.3	92.3

C-F: chemical fertilizer; O-F: organic fertilizer

In the experiment, the growing rice was 9998-3 and the Winter Wheat is Yangmai 11.

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Test method

The following indicators for rice and wheat were detected: proteins, amino acids, mineralelements, vitamins, flavonoids and other substances for nutritional quality, for the safety quality,mainly focusing on heavy metals.

Kjeldahl method was used to test protein, and albumin, globulin, glutelin, gliadin were tested by Coomassie brilliant blue method. Fat was detected by Soxhlet extraction and ash used burning method. The vitamins were determined by HPLC. Amino acids were analyzed by HPLC while tryptophan using ultraviolet - visible spectrophotometry. Starch used enzyme hydrolysis. The total flavonoids were determined by ultraviolet - visible spectrophotometry. Calcium, iron, sodium, magnesium, chromium and other metal elements were tested byICP-OES inductively coupled plasma spectrometry. Lead, mercury, arsenic, cadmium, copper and other heavy metal elements were analyzed by ICP-MS inductively coupled plasma mass spectrometry.

Results and analysis

Comparison between Protein and amino acid

The reasults of protein content of rice and wheat can be seen in table 2, which shew that organic rice and wheat had lower protein content.Forthe amino acids, except tryptophan, organic rice (0.06%)was higher than conventional (0.05%) and aspartate of organic wheat (0.27%) was higher than the conventional (0.19%),the remaining 15 amino acids such as lysine, threonine, leucine, isoleucine, valine, methionine and phenylalanine also followed the same regularity as the protein.

Table2:Comparison of Protein content in Rice Grains with Different Treatments

Test items	average value（rice，%）			average value（wheat，%）		
	blank	conventional	organic	blank	conventional	organic
protein	5.18[a]	7.34[b]	6.72[b]	12.62[a]	18.17[b]	11.21[a]
globulin	0.35[a]	0.84[b]	0.42[b]	0.2[a]	0.4[b]	0.32[c]
glutenin	5.28[a]	8.35[b]	6.79[c]	7.25[a]	10.44[b]	5.83[c]
albumin	0.29[a]	0.3[a]	0.34[b]	2.33[a]	1.99[b]	2.12[c]
gliadin	0.052[a]	0.085[b]	0.086[b]	0.35[a]	0.28[b]	0.09[c]

Comparison of other nutrients

The results of the detection of mineral elements, total flavonoids, vitamins and fats in rice and wheat are shown in Table 3:

1. The content of Fe and Mg in organic rice and wheat was higher than that in the conventional, and in organic wheat, Fe was twice. The content of Ca in organic rice was significantly lower than that in conventional and blank, and the content of Na in the organic wheat was higher than that in the conventional and the blank.
2. Total flavonoids in rice treatment, organic> blank>conventional, respectively as 0.247%, 0.188% and 0.153%. In wheat treatment, organic> conventional> blank, respectively as 0.151%, 0.097% and 0.082%.
3. The content of phosphorus in organic wheat grain was significantly higher than that in conventional and CK, but there was no significant difference in rice grain; the content of potassium, there was no significant difference in rice and in wheat.
4. VitaminB1 in rice treatment, conventional> organic> CK, while the treatment of wheat as organic> conventional> CK. Fat in rice treatment, organic> conventional> CK, and wheat treatment is conventional>CK> organic.

Table3: Comparison of Nutritional Quality ofRice and Wheat with Different Treatments

Test items	average value（rice）			average value（wheat）		
	blank	conventional	organic	blank	conventional	organic
Fe, mg/kg	132.15[a]	85.3[b]	101.91[c]	217[a]	139.4[b]	271.5[c]
Ca, mg/kg	339.25[a]	280.7[b]	223.85[c]	439[a]	493[b]	432.6[a]
Na, mg/kg	42.35[a]	59.86[a]	37.42[b]	118.65[a]	179.45[b]	213.3[c]
Mg, mg/kg	673.65[a]	584.6[b]	611.05[ab]	1073.5[a]	1028[a]	1163[a]
P,%	0.373[a]	0.357[a]	0.289[a]	0.205[a]	0.215[a]	0.33[b]
K,%	0.536[a]	0.578[a]	0.503[a]	0.591[a]	0.61[a]	0.629[a]
Total flavonoids%	1.88[a]	1.53[b]	2.47[c]	0.82[a]	0.97[b]	1.51[c]
VitaminB1,mg/kg	0.84[a]	1.92[b]	1.61[c]	1.97[a]	2.4[b]	2.5[c]
Fat(%)	0.072[a]	0.79[b]	0.84[b]	1.605[a]	1.895[a]	1.565[a]

Safety quality

The results of heavy metal detection showed that organic rice and wheat measured by the six kinds of heavy metals content are lower than the national standard limit. Especially, the content of Cr in organic rice was significantly lower which was 2.96mg.kg^{-1}, compared to 5.14mg. kg^{-1} in conventional. The content of Cd in organic wheat was significantly lower than that in conventional, which was 0.045 mg. kg^{-1}, compared to 0.090 mg. kg^{-1}. The As content of organic rice was significantly lower than conventional rice, which was 0.17 mg. kg^{-1} and 0.36 mg. kg^{-1} in conventional. Cu and Zn of organic wheat was significantly lower than that of conventional treatment. It can be seen that organic rice and wheat have lower content of heavy metals than those in conventional rice and wheat,. Although the use of compost in organic field has led to an increasing in the total amount of heavy metals, but the soil available state content is not high, the product content is not high neither. The results showed that the adsorption of Pb and As in rice was stronger than that of wheat, but the adsorption of wheat to Cu, Cr, Cd and Zn was stronger than that of rice.Soil heavy metal detection showed (see Table 5), although the total Cu and Zn content in the organic plots were significantly higher than those in the conventional plots due to the organic fertilizer derived from livestock and poultry, its effective state is lower than the conventional soil, so that the Cu, Zn in organic products are lower than the conventional products.

Table 4:Comparison of heavy metal content in rice and wheat grains treated with different treatments（mg/kg）

Test items	average value（rice）			average value（wheat）		
	blank	conventional	organic	blank	conventional	organic
Cr	8.23[a]	5.14[b]	2.96[c]	0.91[b]	0.44[a]	0.54[a]
Cu	ND	ND	ND	5.85[a]	5.81[a]	4.74[b]
Pb	0.7[a]	0.59[a]	0.58[a]	ND	ND	ND
Hg	ND	ND	ND	ND	ND	ND
As	0.21[a]	0.36[b]	0.17[a]	ND	ND	ND
Cd	ND	ND	ND	0.078[a]	0.09[b]	0.045[c]
Zn	-	17.8[a]	17.6[a]	-	53.06[a]	34.27[b]

Conclusion

1. Proteins and amino acids, especially the essential amino acids are the important indicator of the nutritional value of rice and wheat. The results showed that the nutritional value of organic rice and wheat were slightly lower than the conventional from the point of view of protein, but from

the view of taste, organic rice and wheat werebetter than the conventional because protein content was negatively correlated with food taste.

2. The content of total flavonoids in rice and wheat were significantly increased, which means the antioxidant capacity and health quality were significantly higher than those in conventional production.
3. Compared with the conventional cultivation methods, the content of heavy metals in organic crops was lower than those in conventional, especially the content of Cr, As in organic rice and Cu ,Cd andZn in organic wheat were significantly decreased.

Table5:Content of total and available heavy metals in soil (mg/kg)

		As	Cd	Cr	Cu	Ni	Pb	Zn
Available heavy metals in soil	blank	0.143	0.033	ND	0.967	ND	0.883	1.647
	conventional	0.135	0.173	0.303	1.56	ND	0.873	2.227
	organic	0.493	0.107	0.187	1.093	ND	1.2	0.467
Heavy metals in soil	blank	22.63	0.02	81.13	24.96	19.49	21.99	63.50
	conventional	29.50	0.43	73.27	25.22	27.04	26.46	74.55
	organic	25.24	0.36	76.15	41.22	26.48	26.81	123.70

Note: The effective state is extracted with 0.01 M calcium chloride

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A short review on applications of signal transduction and xerophytophysiology in organic crop production

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Key words: drought, gene up-regulation, osmotic adjustment, signal transduction, systemic acquired resistance, xerophytophysiology

Abstract

Because of excessive fertilizers and pesticides to crops for high yields, genes for biotic or abiotic stresses and product quality in the plants have been inactivated. Based on the hypothesis that these inactivated genes could be activated again by stimulation with natural factors instead chemicals, experiments included 1) partial root-drying for soil-based tomato, 2) stimuli to hydraulic tomato crop by modest salinity, 3) bulb-clove exposition of flowers, and 4) competition by intercropping crops into grasses. Gene expression was up-regulated. Improvements include 1) maintenance of leaf turgor and increase in symplastic water by osmotic adjustment; 2) activation of antioxidant enzymes, 3) strengthened morphology, and 4) systemic acquired resistance. In conclusion, these applications with natural factors instead chemical treatments based on signalling and xerophytophysiology are feasible in organic plant productions..

Introduction

In nature, many species of plants grow together in competition, sharing benefits of nature. Many properties or traits of a plant species, such as stress and pest resistance, fruit quality, are ultimately controlled by genes. Genes in plant are expressed only when the product is needed (Alberts et al. 2002). For example, a gene responsible for resistance to a disease is expressed only when the pathogen infects the plant. Nowadays, excessive fertilizers and pesticides are used to crops for high yields and therefore the product or the role of the disease resistant gene is not needed. Consequently, this resistance gene is inactivated because of no its turn to play a role. However, in organic crop production where no pesticides are used, this kind of inactivated gene can be activated again when the external environment (e.g. available water or nutrients, temperature and other stresses) needs it to express. Therefore, our research group tried to impose article drought or competitive factors to crops such as partial root drying to tomato crops, modest salinity to hydraulic tomato, bulb-clove exposition to flowers, and grass intercropping for tomato. The gene expression and the consequent improvement in plant physiology, yield and disease resistance were examined.

Material and methods

1. Plant materials and treatments. ***1) Partial root drying*****.** Tomato plants (*Solanum lycopersicum* cv. Myko) where grown in rainout shelters with organic fertilization and management. One month after seedlings transplanted, the root zone is irrigated while the other half is allowed to dry out, and then the previously well-watered side of the root system is allowed to dry down while the previously dried side is fully irrigated (Xu et al. 2011). ***2) Hydroponic salinity*****.** Tomato plants (cv. Capello) were sown in NFT systems in peat-bags in a greenhouse. EC of the nutrient solution was changed from 1.0 to 4.0 according to evapotranspiration demand by an automatic fertigation control

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system. The control plots were fertigated with a nutrient solution at the fixed EC of 2.5. The details of the treatment are described in the Xu et al. (1995). ***3) Bulb exposition***.*Gladiolus hybridus* L. cv. Satonoyuhi was grown in Andosol soil. The bulb and the base part of the shoot were exposed by removing away the soil around in the treatment plots. The soil was covered back to the exposed bulb after the treatment lasted for four weeks. ***4) Grass intercropping***. Seeds of 5 species of turfgrass were shown in October and the tomato seedlings were transplanted as stripes into the turfgrass.

2. Measurement and analysis. ***1) Photosynthesis*.** Photosynthetic rate (P_N) was measured by a Li-6400 systemunder different*PPF*in the fully expanded leaves. The data was analyzed as $P_N = P_C$ (1 - e^{-Ki}) - R_D ($P_C$photosynthetic capacity, K constant, $iPPF$, and R_D dark respiration,Y_Q(maxium quantum yield) = KP_C). ***2) Osmotic adjustment*.** The method of P-Vcurve ($-\Psi^{-1}$ ={ Ψ_{FT}^{-1}-π_{s+a}^{-1}[ζ_o-β(1-ζ)-ζ_{ap}]}$e^{-\alpha(1-\zeta)}$+π_{s+a}^{-1}[ζ_o-β(1-ζ)-ζ_{ap}])was used as described by Xu et al. (2011). ***2) Analysis of gene expression*.** Analysese of the stress responsive genes, such as *DREB* gene for tomato and *Gdi* 15 for flowers were conducted according to Qin (2013).

Results

Partial rootzone drying

Partial root drying (PRD) not only induced osmotic adjustment, whereby the leaf turgor potential maintained higher than usual, but also strengthened the tomato plant resistance to leaf blights. P-V curve analysis showed that osmotic potential was lower, leaf turgor potential leaf symplastic water fraction was larger in tomato leaves of PRD-treated plants.(Table 1) Experiment with potted seedlings showed that PRD treatment induced up-regulation of the gene $BREB_2$, which is an important transcription factor in the drought and salt stress signalling pathways.

EC variation improved hydroponic tomato crop

Salinity stimulation by EC variation improved hydroponic tomato crop. After plants under high EC were overwatered, leaf water potential recovered to the control level and leaf turgor became higher due to the lower osmotic potential (Table 2). At a given leaf water potential, the plants under variable EC maintained higher leaf water content.

Stimulation induced gene up-regulation

Experiments with potted tomato plants that were treated with soil salinity stimulation confirmed that this kind of salinity induced the up-regulation of the stress-responsive gene $DREB_2$. Stimulation by exposing bulbs of tulip and gladiolus flowers induced up-regulation of the *Gdi 15* gene and the consequent increase in anthocyanins of the flowers (Table 3).

Competitive stimulation by grass intercropping improved tomatocrops

Competitive stimulation by intercropping tomato plants into grasses induced up-regulation of stress-responsive gene DREB3 and consequent improvements in fruit quality and disease resistance in the tomato crop. In conclusion, the stimuli adopted in a series of experiments were based on the theory of signalling and xerophytophysiology with the same consequence of up-regulation of the stress-responsive genes.

Table 1: Effect of PRD treatment on fruit yield in tomato.

Treatment	Yield (g/plant)	P_C (μmol m^{-2} s^{-1})	P_{FT} (MPa)	ζ_{sym}	ζ_{Cosm}	*DREB3* expression
Control	2729	21.5	0.88	0.79	0.0	1.3
PRD	3686**	29.0**	0.94*	0.83*	61.5**	4.3

ζ_{sym}, symplastic water fraction; ΔC_{osm}, increase in osmplytes; * and ** mean significance at P≤0.05 and P≤0.01, respectively, and the same for tables below.

Table 2: Osmotic adjustment shown by the π decrement caused by solute accumulation (π_{SA}) and concentration effect (π_{CE}) in tomato plants grown in peat-bags under variable EC (from 1 to 4 dS m^{-1}).

Treat	----------Before overwatering----------						----------After overwatering----------					
	EC	Ψ_L	P	π	π_{SA}	π_{CE}	ζ	ζ_{FT}	Ψ_L	P	π	ζ
	(dS m^{-1})	----------(MPa)----------							----------(MPa)----------			
CK	2.5	-0.70	0.40	-1.10	--	--	0.916	0.907	-0.51	0.56	-1.07	0.941
Varied	1-4	-0.77*	0.40	-1.17*	0.08	-0.01	0.920	0.911	-0.54	0.61*	-1.15*	0.944

Table 3: Photosynthetic capacity (P_C), anthocyanins in petals, flower color and in the relative expression of the *Gdi 15* genein *Gladiolus* treated with bulbs exposition.

Plot	P_C (μmol m^{-2} s^{-1})		Anthocyanins	Flowercolor	*Gdi 15*	---------ζ_{sym}-------		------ΔC_{osm}----	
	0d	30d	(OD$_{530}$ g^{-1})		(Relative)	1d	30d	1d	30d
Control	23.4	22.1	7.4	3.6	1.04	0.68	0.71	0.00	0.00
Exposed	22.9	24.0**	8.7**	4.2**	2.37**	0.79**	0.77*	49.2**	36.9**

ζ_{sym}, symplastic water fraction; ΔC_{osm}, increase in osmplytes; 0d and 30d means immediately after and 30 days after the treatment finished.

Table 4: Tomato crop intercropped into grasses.

Treatment	Fruit yield (g/plant)		Disease index (%)	P_C(μmol m^{-2} s^{-1})	*DREB3* expression
	Early	Late			
Intercropped	2978	837	24.8	17.3	1.1
CK	3197	623	36.2	14.2	2.7

Discussion

In contrast to animals, plants cannot move away from adverse environments and heavily rely on perception and adaptation mechanisms to adverse environmental conditions, such as UV, drought, cold, heat, salinity, pests and pathogens. Molecular biological research has revealed that plants can perceive stimulations by the external environmental changes, transduce the signals to the internals, induce regulations of the related genes and activate metabolisms related with adjustments in conferring stress tolerance. In drought conditions, such as soil water deficit, salinity, low humidity and high UV irradiation, often observed changes in response to drought are osmotic adjustment and morphological strengthening, which are based on mechanisms of xerophytophysiology (Xu, 2007). In research on plant water relations and water stress or drought, many approaches in cultivation and breeding have been found and tested to increase resistance or tolerance to environmental stresses in crop plants. However, very few research cases have emphasized on the beneficial effects of soil water deficits, especially with expectation and intention to impose water deficit on the crop plants for benefits. Technological advances in plant signal transduction directly affect the application of genetic methods for crop improvement. With the advent of genomics and related new technologies, the rapid identification of potential signal transduction genes and interactive proteins and the dissection of pathways are now effective and successful (Cardinale et al., 2002). However, efforts from scientists have been mainly made on genetic engineering of resistant plants and neglected is the relatively simple way in which plants are induced to activate the conserved resistance gene by

giving the plants an environmental stimulus. In recent years, we have done the research on applications and implications of signal transduction and xerophytophysiology in plant productions. The applications include 1) regulated deficit irrigation (RDI) for soil-based crops such as partial root drying and infiltration or sub-irrigation, 2) stimuli to hydraulic tomato crops caused by substrate or root salinity with high electric conductance (EC) of nutrient solution, 3) exposition of hypocotyl (peanut), mesocotyl (sorghum), or bulb-cloves (garlic) that would not be exposed in normal cases, 4) under-canopy irradiation with LED blue light, 5) drying cut trace of potato seed tubers and drying root of wheat seedlings used for transplanting, 6) ridged bed planting of wheat and highland planting of paddy rice, and 7) hydroponic greenhouse tomato production with low air humidity. In contrary to the passive measures in purpose of increasing stress resistance and reducing damages, practices summarized in this article aim at inducing beneficial effects in the later stages by imposing modest water stresses artificially and intendedly at early growth stages. The mechanisms as occur in the xerophytes are induced in mesophytes as agricultural crops. The physiological mechanisms of the treatment effects are osmotic adjustment and leaf turgor maintenance In addition to those mentioned above, there are many other practices using xerophytophysiological ideas in crop production to obtain high yield and high quality, for example, using salt shock or high electric conductivity in the rhizosphere to increase sugar concentrations in tomato fruit (Niedziela et al., 1993), soaking seeds in salt solution to increase drought resistance and grain yield in cereal crops, and cutting roots by hoeing to increase grain yield of wheat crops grown in high nitrogen nutritional conditions. These are all based on the xerophytophysiology and signal transduction using different treatments as stimuli, which are implied to an exciting area of research because many problems are waiting to be solved and benefits are also expected.

There are a lot of research achievements from the forefront of plant biology using the model plant Arabidopsis and most of these achievements have not been used in crop production. We suggest to use these theory and technique to activate the sleeping genes to serve quality improvement and pest resistance in organic crop production. The best way to use the natural factors such as modest drought and competitive stimulations instead using chemicals or energy-costing mechanics.

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The effects of wood vinegar and soursop (*Annona muricata* L.) plant extract on soil microorganisms

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Key words: fungicide, wood vinegar, soursop leaves extracts, soil microorganisms

Abstract

The application of chemical fungicide has been reported to pose risks to the environment and human health (Wightwick et al. 2010). Therefore, farmer's dependency on chemical fungicide and its application must be reduced. Many studies on plant-based fungicide have been carried out to substitute chemical fungicide as it minimizes the environmental hazard. Wood vinegar (WV) and plant extract, such as soursop leaves extract (SE) are proven to be an effective fungicide. Wood vinegar, also known as pyroligneous acid, is the by-product of pyrolysis, while soursop is a medicinal plant in which most of its plant parts (seeds, fruits, barks, leaves) are beneficial to human. The active compounds in these plant-based fungicides were proven to kill the fungal pathogen damaging plants seeds and growth (Isman, 2006; Kartal et al. 2004). However, little is known on the effects of plant-based fungicide on the non-targeted soil microbial population in general, especially beneficial soil microorganisms. Fungicides application could affect beneficial soil fungi such as arbuscular mycorrhizal fungi (AMF) and those regulating nutrient cycles in soil. Hence, the objective of this preliminary study was to evaluate the effects of biological fungicides on soil microorganisms. This short-term laboratory experiment hypothesized that application of plant-based fungicides would influence soil microorganisms, to some extent (based on concentration and type of biological fungicide application) via direct and indirect effects on microbial component in soil. The experiment which consisted of 9 treatments was laid out as completely randomize design (CRD). The treatments comprised of T1 (control or without biological fungicide), T2 (5%WV), T3 (10%WV), T4(15%WV), T5 (20%WV), T6 (5%SE), T7 (10%SE), T8 (15%SE), and T9 (20%SE). The fungicides was applied a day before soil sampling. Soil pH, soil microbial population and carbon dioxide were determined after 24 hours. Results showed that soil applied with WV at higher concentration than 15% had lower soil microbial population compared to control, indicating suppression of both soil fungal and bacterial population as in T4 and T5. Similarly, soursop plant (leaves) extract at 10% to 15% concentrations (T7 and T8) had lower fungal growth. Amongst SE treatments, T9 (20%SE) promoted soil fungal growth and total CO_2 released. Based on this short term preliminary trial, it can be concluded that WE and SE displayed contrasting immediate effects (in terms of concentrations applied) on promotion and suppression on the growth of soil bacteria and fungi. Caution must be made when applying these plant-based fungicides as they may have some negative effects on soil microorganisms. Further studies are required for long term trial and further effects of plant-based fungicides on beneficial soil fungi such as AMF.

Acknowledgments

The authors are grateful to Universiti Putra Malaysia (UPM) and Putra Young Initiative (IPM) research grant for the financial support of this project. The authors acknowledge the assistance and involvements of Mr.Farid Azlan (University Malaya) and students of Noble Laureate's Outreach Camp 2016 in this experiments conducted at Soil Microbiology Laboratory, Department of Land Management, Faculty of Agriculture, UPM

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Introduction

Plant-based fungicides currently preferred and commercially used by modern farmers for to its eco-friendly effects to the environment, and most importantly to the human health. These biological fungicides, such as wood vinegar (WV) and plant extract, such as soursop leaves extract (SE) have high potential as an effective natural fungicide and pesticides. Wood vinegar, also known as pyroligneous acid, is produced by condensation of smoke emitted during carbonisation of wood into charcoal and has been widely used in various sectors, including agriculture, forestry, food processing, and livestock industry (Ogawa and Okimari, 2010). The main compounds found in most wood vinegar are phenolic and acetic acid, carbonyl derivatives and phenol derivatives. Phenolic components such as phenol, guaicol and cresol are considered biocidal agents in wood vinegar (Kartal *et al.* 2004). Similarly, soursop extracts have been long known for their medicinal and antimicrobial properties. Some of the important bioactive compounnd in soursop are cyclohexapeptides, acetogenins, annonaceous acetogenins, tannins, steroids and cardiac glycosides (Gajalakshmi *et al.* 2012; Badrie and Schauss, 2010). Previous studies have shown that extraction of both soursop leaves and fruits contain major bioactive compounds with fungicidal and pesticidal properties (Isman, 2006).

However, there are limited studies on the effects of these bioactive compounds in wood vinegar and soursop extracts on soil microbial community and activities.Wood vinegar showed good antifungal properties by inhibiting growth of various fungi such as white-rot fungi and brown-rot fungus (Theapparat *et al.* 2015). Wood vinegar was also shown to inhibit growths of *Alternaria* blotch of apple plants, caused by *Alternaria mali* fungus (Jung, 2007), while soursop extract was shown to inhibit growth of *Collectotrichum destructivum*, seed-borne pathogens (Akinbode and Ikotun, 2008).However, there are concerns related to the fungicide application on other non-targeted soil microorganisms in generals or in particular beneficial fungal group such as arbuscular mycorrhizal fungi (AMF).Since there are lack of study on the effects of biological fungicide on non-targeted beneficial soil microorganisms, our aim of this preliminary study was to evaluate the immediate or short term effects of biological fungicides on soil microorganisms.

Material and methods

The experiment was conducted as completely randomized design (CRD) with 9 treatments. The treatments consisted of T1 (control or without biological fungicide), T2 (5%WV), T3 (10%WV), T4 (15%WV), T5 (20%WV), T6 (5%SE), T7 (10%SE), T8 (15%SE), and T9 (20%SE). Wood vinegar was obtained from Malaysia Biomass Industries Confederation (MBIC). Different concentrations were prepared by diluting wood vinegar with distilled water. Soursop extract was extracted using ethanolic extraction method, which was modified from the method by Nagappan (2012). Two kilograms of fresh soursop leaves were rinsed with tap water and sterilized by using 96% ethanol. The sterilized leaves were blended with 96% deionized ethanol and put into conical flask. The flasks were covered with aluminium foil and were left in shaker for 24 hours with continuous agitation at 100 revolution per minute (rpm). The extract was then filtered and the solvent was then removed by using rotary evaporator with water bath at the temperature of 60˚C and 100 rpm rotation. The residue was collected and 2 litre of soursop extract was prepared by adding 96% ethanol. The extract was assumed to be 100% concentration. Similar to wood vinegar, different concentrations were prepared by diluting the soursop leaves extract with distilled water. Prior to plant-based fungicides application to soil, sterility of both fungicides was check by sampling 1 mL of each WV and SE and their concentrations and spread in petri dishes containing Potato Dextrose Agar (PDA) and Nutrient agar (NA). Data (soil pH, microbial carbon dioxide and populations) was recorded 24 hours after fungicide application. Soil microbial population was

determined using total plate count technique (Parkinson *et al.* 1971). Carbon dioxide was calculated and recorded by using titration method (Paul and Clark, 1996).

Results

The sterility test showed that T1 and T2 contained minimal bacterial contaminant, while T1 contained fungal contamination (data not shown). Results obtained showed that the microbial respiration as observed in carbon dioxide (CO_2) released by soil microorganism in T9 (SE 20%) was 110mg/100g soil, which was the highest among treatments. There was increased in microbial CO_2 with increasing WV and SE concentrations. Total CO_2 for T3, T4, T5, T6, T8 and T9 were higher than T1 (control), which could be the results of available sugar in these plant-based fungicide, thus increased the carbon sources availability for the soil microbial activities (Table 1).

Soil bacterial population in T2, T3, T6, T7, T8, and T9 were higher than T1 (control), while T5 was lower than T1. Similar bacterial population was noted between T4 and T1. The results showed that T5 which was the highest WV concentrations (20%) suppressed soil bacterial population. In other words, WV at higher concentration more than 15% (>15%WV) had lower soil microbial population compared to control, in which suppression of both soil fungal and bacterial population were found in T4 and T5. In contrast, soursop extract (SE) at 15% and 20% promoted soil bacterial growth and activities (via CO_2 released). Similarly to WV, SE at concentration 10% to 15% (T7 and T8) had lower fungal growth. Amongst SE treatment, T9 (20% SE) promoted soil fungal growth and activities (as observed in fungal population and total CO_2 released).

Table 1: Effects of fungicides on soil pH, soil microbial CO2 and population

Fungicides	Treatment concentrations	pH	Total CO_2 (mg 100 g^{-1} soil)	Microorganisms population (log cfu g^{-1} soil)	
				Bacteria	Fungi
T1	Control	5.19	52.8	4.62	4.16
T2	5% WV	5.12	46.2	4.83	3.85
T3	10% WV	5.32	57.2	4.82	4.27
T4	15% WV	5.16	69.3	4.62	3.54
T5	20% WV	5.24	74.8	3.97	3.64
T6	5% SE	5.1	62.7	4.94	4.32
T7	10% SE	5.25	70.0	4.78	4.18
T8	15% SE	5.06	92.4	4.89	4.05
T9	20% SE	5.09	110.0	4.88	4.40

WV: Wood Vinegar; SE: Soursop Extracts

Discussion

Fungicides application at some concentrations affected microbial activities and growth (indicated by microbial respiration and population) as observed in this study. Wood vinegar was applied in 5%, 10% 15% and 20% concentrations and similar concentration was applied for soursop extracts. These concentrations were chosen as wood vinegar at 25% are proven to be effective towards certain strain of fungal such as *R. solani* (Saberi *et al.* 2013). Our results were in line with their findings in which in this study, soil applied with WV at higher concentration than 15% had suppressed both soil fungi and bacteria. Similarly, soursop leaves extract at 10% to 15% concentrations (T7 and T8) had lower fungal growth. Amongst SE treatments, T9 (20%SE) promoted soil fungal growth and total CO_2 released. Soursop leaves extract (SE) can be used as effective fungicide at 15% concentration. However, the concentration used in this study was above the concentration of that in Abubacker and Deepalakshmi (2013). They found that soursop extract at 15 mg/mL was effective in antifungal activity towards *Alternaria albicans*, *Aspergillus*

erithrocephalus, and *Aspergillus albicans*. Since we did not determine the bioactive compounds in wood vinegar and soursop extracts, we only could attributed that the lower population of soil microorganism found in fungicides applied soil was due to the bioactive compound in both fungicides. Previous studies found that both WV and SE have antifungal properties, which may negatively affect soil fungi (Isman 2006; Kartal *et al.* 2004). Fungicides WE and SE displayed contrasting immediate effects on growth promotion and activities of soil bacteria and fungi as found increased microbial CO_2 which can be due to availability of simple sugar in these plant-based fungicides. Thus, further research is needed to characterise the bioactive compounds and study the short and long termeffects of individual fungicide on soil microorganisms especially growth and activities in soils and their effects on plant production.

Conclusion

In limitation of our research, soursop extract and wood vinegar were found to display contrasting effects on promotion and suppression on the growth and activities of soil bacteria and fungi. Caution must be made when applying these plant-based fungicides focusing on their effective range of concentrations for pest or disease management as they may have some negative effects on soil microorganisms.

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Performance Evaluation of Roselle (*Hibiscus sabdariffa* L.) Accessions under Organic Conditions

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Key words: organic conditions, roselle breeding, roselle evaluation, yield

Abstract

Roselle comes in varying phenotypic traits but there is no recommended variety for calyx production in the Philippines so far. It is then the objective of this study to evaluate the performance of roselle accessions under organic conditions to come up with a recommended variety in the future. Four (4) roselle accessions were evaluated from November 2015 to May 2016 based on calyx yield and other horticultural traits, acceptability and nutritional quality. At the end of the study, one (1) roselle accession was selected for calyx production. Promising accession will be recommended to roselle farmers and will be used in our roselle breeding program as well.

Acknowledgments

The authors are grateful to the Department of Agriculture – Bureau of Agricultural Research for the research fund.

Introduction

The Vegetables Section of the Crop Science Cluster- Institute of Plant Breeding, University of the Philippines Los Baños has been at the forefront in organic vegetable breeding and research. A project on indigenous vegetables was initiated and this included the observational trial of roselle, *Hibiscus sabdariffa* L. under organic conditions.

Roselle, just like the other indigenous vegetables, easily adapts to organic farming and even requires minimal management and production inputs. It has a deep root system contributing to its drought tolerance. It can compete well against weeds, though higher calyx yields can be obtained if weeding is practiced.

There are many cultivars of roselle based on phenotypic variations but there is no recommended variety for calyx production in the country. The objective of this study was to evaluate the performance of roselle under organic conditions to come up with a recommended variety for effective breeding program.

Materials and methods

Observational yield trial of four (4) roselle accessions (RI13-039, RXII13-034, RXII 13-002 and RXII 14-068) was conducted from November 2015 to May 2016. Seedlings were transplanted two weeks after emergence in 5 m x 1 m double row beds with a planting distance of 50cm x 50cm. Vermicompost served as basal fertilizer (100 g/hill). Sidedressing of 100 g/hill vermicompost was applied 30 and 60 DAT. Fermented Plant Juice (FPJ) with kakawate and malunggay as raw materials was applied 15 DAT, either by drenching or spraying at a rate or 1 Liter FPJ: 50 Liters water) which continued every other week up to flowering stage. Fermented Fruit Juice (FFJ) from various fruits was applied every other week as well with the same rate as FPJ from flowering to fruiting. Minimal weeding was practiced but weed-free area is done during the first month of crop

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growth. For pest management, hot pepper extract with soap solution was applied in the early morning as contact organic pesticide to control leaf folder, cutworms and aphids. Data on horticultural characteristics were gathered from five (5) plant samples per plot. The trial was conducted with two replicates in Randomized Complete Block Design. Mean separation was done using the LSD (Least Significant Differences) test of the SAS System at 5% probability. ANOVA and correlation analysis between growth, yield and yield components was determined using the SAS system as well.

As part of the promotion of roselle not only as a vegetable but also as a natural health drink, acceptability of roselle calyx as juice was also conducted. This aimed at comparing the calyces of the two selected accessions of roselle.; RI13-039 and RXII13-034. They were subjected to acceptability evaluation and nutrient analysis. Roselle juice was prepared (50g per L water) and 40 respondents from CSC-IPB participated in the sensory evaluation. There were 33 male and 7 female staff who participated in the said survey. Age ranges of the respondents were from 30 – 64 years old. Note that only the two accessions were used in sensory evaluation because the other two accessions (RXII 13-002 and RXII 14-068) had very small calyces. Respondents were asked to taste and compare the two accessions.

The determination of anthocyanin content method used was adapted from Lee et al (2005). The absorbance of the prepared solutions was read at 520 nm and 700 nm, respectively, using a UV-Vis spectrophotometer. Vitamin C content of roselle calyces was determined using a modified procedure from Jagota and Dani (1982). A standard curve was prepared using ascorbic acid as a standard. Vitamin C content was calculated from the standard curve using interpolation method.

Results

Observational trial and correlation analysis

Plant height was highest in RXII13-068 while stem diameter was highest in RI 13-039. RXII 13-034 and RXII 13-039 flowered earlier than the other two accessions. Although the number of branches per plant did not differ among the accessions, number of fruits per plant was highest in RXII 13-068 and fresh and dry calyx yield was highest in RXII 13-034 (Table 1). Yield of roselle ranges from 4 to 6.5 t ha^{-1} for fresh calyx, 800 to 1,200 kg ha^{-1} for dried calyx and 10 t ha^{-1} for leaves (McClintock and El Tahir, 2011; Aminul Islam et al., 2016). The data obtained from this study conforms to previous researches conducted on roselle yield trial.

Plant height is negatively correlated with stem diameter and number of branches per plant, hence, the higher plant height means smaller stem diameter and less number of branches. Days to 50% flowering is negatively correlated with the number of fruits per plant, fresh/ dry calyx weight per plant and number of seeds per capsule while it is positively correlated with number of fruits per plant. Number of fruits per plant is negatively correlated with fresh calyx weight per plant. The negative correlation between these two parameters only show that high number of fruits per plant does not necessarily mean that you will obtain higher fresh calyx yield per plant. For instance, Accession RXII13-034 had higher fresh calyx yield than the rest of the accessions although it has the lowest number of fruits per plant. Fresh calyx weight per plant is positively correlated with dry calyx weight per plant and number of seeds per capsule. Lastly, dry calyx weight per plant is positively correlated with number of seeds per capsule (Table 2).

Acceptability and Nutrient Analysis

Results from the evaluation revealed that RI 13-039 is preferred by 14 respondents while RXII 13-034 by 12 respondents. Thirteen respondents preferred both samples while only one respondent did not like any of the samples given. This just shows that roselle juice is acceptable as a health drink.

Anthocyanin content from Accession RXII 13-034 was extremely higher compared to that of RI 13-039 although the former had relatively higher Vitamin C content than the latter. Total phenolic content of roselle leaves was highest in RXII 13-068 (Table 3).

Table 1: Horticultural traits observed from four roselle accessions.

Sample	RXII 13-068	RI 13-039	RXII 13-002	RXII 13-034
Plant height (m)	2.25 a	1.32 c	1.97 ab	1.86 b
Stem diameter at base (cm)	2.90 b	3.51 a	2.87 b	2.83 b
No. of branches per plant	5.85 ns	9.00 ns	7.65 ns	6.05 ns
Days to 50% flowering	102.00 a	92.00 b	106.00 a	89.00 b
No. of fruits per plant	147.00 a	122.65 ab	137.90 ab	104.95 b
Fresh calyx weight per plant (g)	73.50 c	325.18 b	68.95 c	745.15 a
Fresh calyx weight per ha (kg)	735.00 c	3251.80 b	689.50 c	7451.50 a
Dry calyx weight/plant (g)	14.70 c	165.63 b	13.79 c	409.31 a
Dry calyx weight/ha (kg)	147.00 c	1656.30 b	137.90 c	4093.10 a
No. of seeds/capsule	15.15 c	23.10 b	12.10 c	31.20 a

Means with the same letter are not significantly different at 5% level of significance; ns= not significant

Table 2. Correlation between growth, yield and yield components of roselle accessions

Traits	Plt. Ht.	Stem	No. of branch	Days to flowering	No. fruits	Fresh calyx weight	Dry calyx weight	No. of seeds
Plant Height	1.00							
Stem diameter	-0.81*	1.00						
No. of branches	-0.73*	0.65	1.00					
Days to flowering	0.58	-0.36	-0.06	1.00				
No. of fruits	0.46	-0.14	0.16	0.74*	1.00			
Fresh calyx weight	-0.33	-0.05	-.013	-0.86**	-0.81*	1.00		
Dry calyx weight	-0.34	-0.04	-0.13	-0.86**	-0.82	0.99**	1.00	
No. of seeds	-0.52	0.11	0.06	-0.87**	-0.85	0.98**	0.98**	1.00

Discussion

Vitamin C and anthocyanin contents served as one of the criteria in selecting the best roselle accessions. Roselle calyces were known to contain high amounts of vitamin C and anthocyanins. On a separate study, anthocyanins found in roselle include delphinidin 3-sambubioside, cyanidin 3-sambubioside, delphinidin 3-glucoside and cyanidin 3-glucoside (Mgaya Kilima et al., 2014). The anthocyanin in roselle is the reason why it is known to lower bad cholesterol (LDL, low density lipoprotein) levels in cholesterol-fed rats (Hirunpanich et al., 2005), rabbits (Chen et al., 2003) and even on clinical trials in humans (Lin et al., 2007).

Results from this study identified promising roselle accessions with high calyx and/ or leaf yield. This information would be of great value to horticulturists and breeders *per se* in the development and improvement of roselle varieties in the Philippines, which would go a long way to help the farmers and the vegetable crop industry in general.

Table 3: Anthocyanin and Vitamin C content of roselle calyx

Sample	Anthocyanin pigment (mg/100g dry weight) of calyx	Vitamin C (mg/100g) of calyx	Phenolic content (mg/g dried sample) of leaves
RI 13-039	518.22	166.81	28.75
RXII 13-034	1,583.05	128.79	32.92
RXII 13-068	_	_	51.70
RXII 13-002	_	_	34.33

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Validation and Documentation of Organic Production Systems for Lowland Rice in Camarines Sur, Philippines

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Key words: organic and conventional production systems, system of rice intensification

Abstract

The promotion and adaption of organic agriculture are constrained by many challenges associated with limited science-based technologies and farmers' hesitance to break the chemical-based farming habit, especially on rice.

Hence, the study validated and compared the agronomic and economic performance, and soil status of recommended organic production practices with local farmers' current organic and conventional systems for rice in Camarines Sur, Philippines. On-station trials were conducted for 2 wet and 2 dry cropping seasons. Each trial was set-up in randomized complete block design (RCBD) with the following production systems as treatments in four replications: T1- recommended organic systems, T2- farmers' organic-systems of rice intensification (SRI), and T3-farmers' conventional chemical systems.

In all cropping seasons, T1 produced plants that generally performed best in terms of growth and yield compared with T2 and T3. Treatment 2 had lower yield performance than T1 but better than T3. The soils in T1 had improved pH and organic matter content, while phosphorus and potassium were not changed. Soil texture in this system was also improved from clay to clay loam.

In spite of high yields, T1 obtained the lowest return on investment (ROI) in all cropping seasons due to high cost of organic inputs (green manure and vermicompost) and their application, T2 was most profitable because of better yield and lower production cost. This treatment appeared to be the best option for rice production in terms yield and economic returns and better alternative for the current conventional chemical system.

Acknowledgement

We acknowledge with thanks the Department of Agriculture-Bureau of Agricultural Research for the research funds, the Project Team of University of the Philippines at Los Bańos (UPLB), Laguna, Philippines headed by Dr. Oscar B. Zamora and Dr. Blesilda Calub for the technical guidance, and the rice farmers who unselfishly shared their current production practices and allowed data gathering in their fields.

Introduction

In the Philippines, the promotion and adaption of organic agriculture is still constrained by many challenges associated with limited science-based technologies, scarcity of organic inputs, high labor cost (Cervantes 2016), and farmers' attitude of being apprehensive at any technology at the problems associated with the use of synthetic inputs, seemingly are not prepared to accept changes. At the moment, reliable information on organic agriculture practices are generally lacking

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(Reganold &Wachter, 2016). Likewise, while some organic farming technologies are being promoted, many of them are based on personal testimonies and anecdotes. They need to be subjected to validation and fine tuning through scientific evaluation process, hence this proposal.

The availability of rice as staple food is always associated with food security in the Philippines. The Bicol Region ranks 4th in terms of rice production in the country with an average yield of 3.7 tons/ha for inbred rice and 4 tons/ha for hybrid rice under intensive chemical inputs (DA 2011). With the known adverse effect of chemical farming and increasing cost of synthetic inputs, alternative systems such as organic rice farming should be in place.

R&D widens the understanding and acceptance of agricultural production systems by farmers (Brown, Dennis, & Venkatesh, 2010; Mariano, Villano, & Fleming, 2012). Hence, the study aimed to validate and document the performance of rice by comparing the agronomic and economic performance, and soil changes of recommended organic practices with local farmers' current organic and conventional practices in rice in Camarines Sur, Philippines.

Materials and Methods

The study was conducted at Central Bicol State University of Agriculture (CBSUA) experimental farm for two years in 2 dry and 2 wet cropping seasons. It was set-up in randomized complete block design (RCBD) with three rice production systems as treatments namely: Treatment 1 (T1) - recommended organic practices from University of the Philippines at Los Banos (UPLB), Laguna, Philippines, Treatment 2 (T2) – farmers' current organic practices (system of rice intensification), and Treatment 3 (T3)– farmers' current conventional chemical practices. Treatments were replicated four times. Each plot measured 5 meters by 6 meters. The trial has a total area of 500 m^2 including 2 meters alleyways and borders.

The practices for T2 and T3 were determined from the results of field interviews and focus group discussions (FGD) with farmers. The treatments differed in seedling production, planting age and distance, irrigation, and fertilizer and pest managements, but adopted common land preparation and harvesting practices. Yield data were taken from 3x4 m^2 harvest area while growth data were taken from plants outside the harvest area. Data were analysed using appropriate statistical tools.

Results and Discussions

In most growing seasons, T1 performed best among the different production practices in terms of growth and yield. The yield performance of this organic rice system can be attributed to application of organic production inputs. Various studies found the contributions to high yield of green manure (Ghosh, 2007; Selvi, Nadanassababadyl, & Rajendran, 2005) and vermicompost (García et al., 2014) Combining these materials with microbial inoculant in T1 (Butler, Purcell, & Hunter, 2007; Chen, Zheng, Wang, Xu, & Zhang, 2013; de Salamone et al., 2010; Dodd & Ruiz-Lozano, 2012) and natural liquid supplements (Pant, Radovich, Hue, Talcott, & Krenek, 2009) resulted to better performance. These inputs enhanced the quality of soil that consequently resulted to better crop performance in T1. However, the high yields in T1 did not guaranteed high profits because of high cost of production inputs and their application.

Treatment 2 employed SRI which is commonly used by local organic rice producers because of negligible loss in yield during the shifting process from conventional to organic. This treatment had plants with lower but most often statistically similar performance with plants from T1 but better than those from T3. While SRI's advantages were questioned, the better performance of organic-SRI over conventional rice production have been scientifically proven in several studies (Barison & Uphoff, 2011; Chapagain, Riseman, & Yamaji, 2011; Hameed, Jaber, Hadi, & Elewi, 2011; Thakur,

Rath, &Kumar, 2011). The good performance of plants in this system could be attributed to the combined use of organic materials, weekly application of natural liquid plant supplements, rotary weeding that controlled weeds and aerated soil, and enhanced tillering and root growth due to early planting and wider spacing.

Treatment 3 produced plants that performed least compared to other production systems. In spite of the chemical inputs applied based on soil analysis, plants in this treatment had the least tiller production and number of grains per panicle, lightest grain weight, numerically lowest grain yield and lowest percentage of filled grains. Chemical fertilizers applied in this production system may be rich in the three essential nutrients (NPK) that crops need but they were easily used up by the plants and became least available for the next cropping season (Gutser, Ebertseder, Weber, Schraml, & Schmidhalter, 2005). The use of chemical fertilizers and pesticides can result to poorer quality of soil because it increases soil acidity and produce other adverse effects on soil life and dynamics (K.Anitha Kumari, K.N.Raja Kumar, 2014; Savci, 2012; Thilagar, Bagyaraj, & Raoca, 2016). Organic fertilizers contains more diverse nutrients in smaller quantity, released slowly for plant use and contribute to improvement of the bio physico-chemical properties of soil.

Table 1: Yield and yield parameters rice plants as affected by different production systems. CBSUA. August, 2014-April, 2016.

Treatment	Year 1		Year 2	
	WS	DS	WS	DS
Number of Productive Tillers/Plant				
T1 Recommended organic practices	17.60a	20.10a	18.90	12.58b
T2 Farmer's organic practices	12.23b	14.15b	17.00	14.55a
T3 Conventional chemical practices	11.20c	10.23c	16.35	10.58c
CV (%)	3.9	4.3	15.1	6.1
Percent (%) Filled Grains/Panicle				
T1 Recommended organic practices	81.58a	86.97ab	85.60a	92.70a
T2 Farmer's organic practices	76.02b	89.77a	82.97a	93.99a
T3 Conventional chemical practices	67.54c	84.96b	73.86b	79.70b
CV (%)	4.1	2.0	5.6	3.0
Biomass Weight (t/ha^1)				
T1 Recommended organic practices	17.7	25.30	14.23	19.03a
T2 Farmer's organic practices	13.37	25.07	13.57	17.07ab
T3 Conventional chemical practices	12.65	23.27	12.60	15b
CV (%)	17.2	8.6	29.2	5.3
Grain Yield (t/ha^1)				
T1 Recommended organic practices	5.99a	8.39a	6.98a	9.77
T2 Farmer's organic practices	5.01a	6.54b	5.48b	9.83
T3 Conventional chemical practices	4.60b	5.27b	4.50c	8.71

Means with the same letter are not significantly different at 5% p-level; WS- Wet season, DS- Dry Season

Soils from different from production systems were analyzed after the 4th cropping seasons. Soil pH was 5.4 in T1 and 5.3 in both T2 and T3. Organic matter content was higher at 3.45% in T1 than the 3.26% in T2 and T3. Consequently, nitrogen content was also higher in T1 than in other treatments. Phosphorus content in soils of T1 was 2.5 ppm but other treatments had 3.5 ppm. Potassium was the same for all treatments. Soil texture of T1 was improved to loam while soils of other treatments remained clay loam.

Rice production was generally profitable in all seasons. With premium price for organically-grown rice, T2 generated highest average profits (194%) which can be attributed to better average gross income per hectare of ($2525.05) and lowest cost of production ($843.45). Treatment 1 had

lowest ROIs (58%) in spite of highest recorded gross yields ($2901.31). It has the lowest net returns ($2901.31) because of high production expenses ($1828.05) attributed to high cost of production inputs (green manure and vermicompost) and their application. Treatment 3 had lowest gross income ($1935.34) which generated an average ROI of 178% which was lower than T2 but higher tha T1. Better economic returns in T2 were observed in similar studies in Japan (Chapagain et al., 2011) and India (Haldar, Honnaiah, & Govindaraj, 2012).

The study scientifically proved that the current farmer's organic practices can be best for better yield and profits in growing lowland rice. However, when organic production inputs can be produced locally by farmers, the recommended organic practices can be the better option because of its yield performance. Both organic production systems are better alternatives for the current conventional chemical because of their yield advantage as well as immeasurable contributions to promote resiliency and sustainability of farms, as well as protection of human health and environment. To hasten the adoption organic production systems, the Department of Agriculture and the local government units of the Philippines should intensify programs and subsidies that will promote diversified farming systems and vermicomposting at the farm level for sustainable source of low-cost production inputs.

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Effects of cultivation sites and varieties on ascorbic acid contents in organic vegetables

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Key words: vitamin C, lettuce, arugula, tomato, cultivation site, variety, organic

Abstract

Ascorbic acid content is an important character determining vegetable quality. The objectives were to determine the effect of cultivation sites on ascorbic acid contents in organic cos lettuce and salad rocket, and the difference of content among organic tomato varieties. Cos lettuce had been produced in Lamphun (LP), Phetchabun (PB) and Nakhon Ratchasima (NR), Thailand. Salad rocket had been grown in NR, Thailand and Champasak (CS), Laos. The produces were delivered to NR for ascorbic acid analysis. Cos lettuce from LP had the highest content (20.4 mg/100 g FW) compared to those from PB and NR. The ascorbic acid content (23.3 mg/100 g FW) of CS's salad rocket was higher than the NR's. Six tomato varieties grown in NR showed significant difference in ascorbic acid contents. Beef and purple tomatoes had a higher content (23.3 mg/100 g FW) than red cherry, yellow, plum, and 'Sida' pink tomatoes. These results indicated significant effects of production sites and varieties on ascorbic acid in organic produces.

Introduction

Information on nutritional values of organic crops is beneficial to farmers and consumers (Siderer *et al.*, 2005). Ascorbic acid (vitamin C) content is the first priority reflecting nutritional quality of fruits and vegetables as it is essential for human. The ascorbic acid contents in fresh produces are varied by environmental factors and internal factors (Premuzic *et al.*, 1998; Gil *et al.*, 1999; Kalt *et al.*, 1999). This research aims to give information on ascorbic acid contents in organic vegetables.

The first objective of this research was to determine the effect of cultivation sites which were different in environments and cultivation practices on ascorbic acid contents in organic cos lettuce and organic salad rocket. The second objective was to determine the difference of ascorbic acid contents among tomato varieties which were grown organically at the same site. The information on ascorbic acid contents in various organic produces may help health-considering consumers to choose their best choices. The differences on ascorbic acid contents among growing sites and varieties may motivate farmers to manage their organic production to meet desirable quality.

Material and methods

There were three experiments in this research. The first experiment was study on effect of cultivation sites on ascorbic acid contents in organic cos lettuce (*Lactuca sativa* L. var. *longifolia*). The second experiment was study on effect of cultivation sites on ascorbic acid contents in organic

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salad rocket (*Eruca sativa* Mill.). The third experiment was comparison of ascorbic acid contents among six tomato (*Solanum lycopersicum*) varieties.

Cos lettuces had been produced organically at Adams Organic Farms in Lamphun, Phetchabun and Nakhon Ratchasima provinces, Thailand. Organic salad rocket had been cultivated at Adams Organic farms in Pakthongchai, Nakhon Ratchasima province, Thailand and in Pakse, Champasak province, Laos. Six tomato varieties including red cherry, yellow cherry, purple, plum, 'Sida' pink, and beef tomatoes were grown at Adams Organic farms in Pakthongchai, Nakhon Ratchasima province, Thailand. About 50-100 kg of the vegetables were harvested from each cultivation site and placed in plastic containers. Then they were delivered to the packing house of Adams Organic Farm in Pakthongchai by 6-8 °C cold truck. The distances (and times taken) from Lamphun, Phetchabun, and Champasak farms to the packing house were around 700 km (10 hrs), 650 km (9 hrs), and 350 km (5 hrs), respectively. After delivery to the packing house, all vegetables were stored at 6 °C before performing experiment.

One sample of the leafy vegetables and of the tomatoes were about 50 and 100 g, respectively. They had been randomly picked from various containers and combined. The ascorbic acid content was determined in the vegetable samples using 2, 6-dichloroindophenol titrimetric method (AOAC, 1990) with three replications. In brief, the vegetable sample was fine ground. Five grams of ground sample was adjusted to the volume of 50 ml by 0.4% oxalic acid solution. Then the solution was filtered by Whatman® No.1 paper. Ten milliliters of filtered solution was titrated with 0.04% 2,6–dichlorophenol indophenol solution to the end point. Ten milliliters of ascorbic acid standard solution was also titrated in each determination. The volumes of the 2,6–dichlorophenol indophenol solution used for titration to the end point of sample and standard, and the sample weight were calculated for the ascorbic acid content.

The data were submitted to the Analysis of Variance (ANOVA) and the mean values were compared using Least Significant Difference (LSD) test or T-Test at □ = 0.05 level.

Results

Cos lettuce cultivated at different sites had significant difference in ascorbic acid contents (Table 1). Cos lettuce from Lamphun and Phetchabun provinces (in Northern part of Thailand and higher latitudes) showed higher ascorbic acid contents than cos lettuce from Nakhon Ratchasima province (in North-eastern part of Thailand and lower latitude) (Table 1).

Table 1: Ascorbic acid contents of organic cos lettuces cultivated in three provinces of Thailand; and organic salad rockets cultivated at Adams Organic Farms in Pakthongchai, Nakhon Ratchasima province, Thailand and Pakse, Champasak province, Laos (n=3)

Cos lettuce from cultivation sites	Average ascorbic acid content* (mg/100 g FW[1])±SD[2]
Lamphun province, Thailand	20.43a ±0.70
Phetchabun province, Thailand	19.29a ±0.40
Nakhon Ratchasima province, Thailand	17.30b ±0.40
Average	19.01 ±1.20
Salad rocket from cultivation sites	**Average ascorbic acid content* (mg/100 g FW[1])±SD[2]**
Pakthongchai, Nakhon Ratchasima, Thailand	20.63 *b* ±0.54
Pakse, Champasak, Laos	23.33 *a* ±0.54
Average	22.00 ±1.33

* Average values were significantly different among cultivation sites by Analysis of Variance (ANOVA) at □ = 0.05 level. Average values followed by different letters were significantly different by Least Significant Difference (LSD) test or T-test at □ = 0.05 level.

[1] FW = fresh weight; [2] SD = standard deviation

Ascorbic acid content in salad rocket from Champasak, Laos (higher in latitude and elevation) was significantly higher than that from Nakhon Rachasima, Thailand (Table 1). The production site in Champasak is at a higher latitude and higher elevation than the production site in Nakhon Rachasima.

Purple and beef tomatoes had higher ascorbic acid contents than other four varieties. Red cherry and yellow cherry tomatoes had the lowest ascorbic acid contents compared to other varieties (Table 2).

Table 2 : Ascorbic acid contents in six organic tomato varieties cultivated on Adams Organic farm in Pakthongchai, Nakhon Ratchasima province, Thailand (n=3)

Tomato varieties	Average ascorbic acid content * (mg/100 g FW[1])±SD[2]
Red Cherry Tomato	10.22d ±0.32
Yellow Cherry Tomato	9.52d ±0.78
Purple Tomato	23.33a ±0.39
Plum Tomato	19.15c ±0.35
'Sida' Pink Tomato	21.46b ±0.24
Beef Tomato	23.34a ±0.67
Average	17.84 ±5.80

* Average values were significantly different among varieties by Analysis of Variance (ANOVA) at □ = 0.05 level. Average values followed by different letters were significantly different by Least Significant Difference (LSD) test at □ = 0.05 level.
[1] FW = fresh weight; [2]SD = standard deviation

Discussion

The result on cos lettuce and salad rocket indicated significant effect of cultivation sites. In these cases, the differences in ascorbic acid contents of cos lettuce and salad rockets among cultivation sites may be caused by different temperature during growing period. The sites that caused the produce to have the higher ascorbic acid contents (Table 1) are on the higher latitudes and elevations which have lower average temperatures. For example, the cultivation site at Pakse, Champasak, Laos locates at 1,300 meters above sea level and has average temperature about 20-25 °C. While the cultivation site at Pakthongchai, Nakhon Ratchasima, Thailand locates at 300 meters above sea level and has average temperature about 28-33 °C. Cool temperature promoting ascorbic acid production and delaying ascorbic acid degradation in fruit and vegetable have been reported in many article (Gil *et al*., 1999; Lee and Kader, 2000; Giannakourou and Taoukis, 2003).

Six tomato varieties in this research showed significant difference in ascorbic acid content (Table 2) supports the reports that genotypes influencing ascorbic acid content in tomatoes (Maclinn *et al*., 1937; George *et al*., 2004). Ascorbic acid content was often reported to have a negative correlation to fruit weight (Stevens *et al*., 2006). However, in this experiment, the highest ascorbic contents found in both purple tomato which has a small fruit size and beef tomato which had a big fruit size showed that ascorbic contents may not correlated with fruit size. This point agreed with correlation result in tomato mutant lines reported by Stevens *et al*. (2006).

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Comparing the rate of growth of organic greenhouse cucumber in different growth media fed with two humic acid levels

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Key words:greenhouse cucumber, humic acid, yield, organic, growth media.

Abstract

This study was carried out in 2015 in a greenhouse, in the Iranian Research Institute of Plant Protection to investigate the basics of organic greenhouse cucumber production in Iran. The first 2 factors consisted of 2 different organic growth media on the market called: 1) Gilda (coco peat and vermicompost) and 2) Shadgol (coco peat and peat moss). The second factor selected contains 2 humic acid concentrations (0 and 30 gr. per plant). Cucumber traits measured were plant height, stem diameter, fruit length, fruit diameter and fruit weight. The results showed that there were significant differences between the different growth media treatments on plant height and stem diameter, at probability level of 1%, fruit diameter at probability level of 5%, and that, the organic growth media, Gilda, has the highest average plant height (104.99 cm), the highest average stem diameter (94.83 mm), and the highest average fruit diameter (32.07 mm). So, in conclusion we find that different media caused an increase in some traits and that Gilda is suitable for organic cucumber production.

Acknowledgments

We would like to thank to Center of Excellence for Organic Agriculture (CEOA) and Biocontrol Dept. /IRIPP for their support and providing the green houses.

Introduction

Cucumber (Cucumis sativus L.) is one of the widely consumed cucurbits in Iran, which is used as a fruit there. Organic fertilizers can be an effective alternative to chemical fertilizers in cucumber cultivation, as they contain high levels of nutrients and organic matter. In recent years organic farming development, in spite of many potentials for growth in Iran, was very slow. But nowadays, the elimination or reduction of chemical fertilizer consumption is a requirement of sustainable agriculture development in Iran and the use of organic fertilizers is on the rise. The use of organic growth media containing compost and Vermicompost in pots could possibly be one of the most effective techniques for raising seedlings in organic production systems. This technique has the potential to be used in adverse conditions, because pots can be easily moved to safe places and ultimately facilitate the production of cucumber seedlings in due time. Also, the use of Vermicompost in greenhouse cucumber production increases crop yield and plant growth. As well as, good production conditions can be provided by using humic acid which affects the growth and development of plants by increasing vegetative growth traits and yields, and can lay the groundwork for improved organic crop production.

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Material and methods

This study was carried out in 2015 in a greenhouse under organic management in the Iranian Research Institute of Plant Protection, located in Tehran, and under supervision of Center of Excellence for Organic Agriculture, to investigate the basics of organic greenhouse cucumber production. The Factorial experiment was conducted in a completely randomized design with 3 replications and pot cultivation. The purpose of the experiment was to find a suitable medium for cultivating a cultivar of organic greenhouse cucumber seed called Negeen F1, which was tested for the first time in Iran. This cultivar is suitable for autumn and spring cultivation and has a strong root system. The first factor consisted of 2 different growth media on the market called: 1) Gilda (coco peat, perlite, vermicompost, compost, peat moss, leaf soil, sand and clay) and 2) Shadgol (coco peat, leaf soil, peat moss and sand). For the purposes of this experiment we changed these names to, growth media (1) and (2). The use of this medium is an approved and established method in organic agriculture, and is used here for the first time for greenhouse organic cucumber cultivation. The second factor selected contains 2 humic acid concentrations (0 and 30 gr. per plant) of Iranian organic brand "Geranular Pars Humic ". The traits measured were: plant height, stem diameter, fruit length, fruit diameter and fruit weight. 12 pots, sized 30X25 cm, were used for this experiment, filled with a mix of 6 kg of growth media and two levels of humic acid at the beginning of cultivation. The seeds were transplanted in special trays in a mixture of 70% coco peat and 30% perlite, and when they reached the 4-leaf stage in 2 weeks, a seedling of the above cultivar was transferred into each pot. To control pests and diseases, yellow and blue sticky cards were used in addition to permitted preventative sprays. The first plant height and stem diameter measurements were carried out weekly and continued for the 2 month growth period of the plant from seedling to placement in the main medium. Fruit length, fruit diameter and fruit weight were also measured and recorded weekly for 7 weeks from fruiting to ripening. Measuring tape, callipers and a digital scale were used to measure the length, diameter and weight of fruit, respectively. Averages were measured for the resulting data, which were then analysed using the SAS software.

Results

Table 1: The analysis of test variance for comparing the growth and yield rate

Mean Square						
fruit weight	fruit diameter	fruit length	stem diameter	Plant height	Degree of freedom	Sources of variation
72.79^{ns}	0.708^{ns}	1.37^{ns}	0.07^{ns}	69.67^{ns}	2	repetition
486.85^{ns}	22.91^{*}	0.76^{ns}	3.87^{**}	309.5^{**}	1	Medium
37.60^{ns}	7.002^{ns}	3.76^{ns}	0.099^{ns}	49.38^{ns}	1	Humic acid
156.43^{ns}	3.59^{ns}	1.63^{ns}	0.007^{ns}	2.48^{ns}	2	Medium*humic
238.56	2.81	2.36	0.018	16.04	6	Pilot error
17.43	5.46	10.41	1.34	4.009	---	C.V)

**, * and ns are Significant at 1% probability level and non-significant at 5% probability level respectively.

The results of the variance analysis table show that there is a significant difference among treatments of different growth media (utilizing numbers 1 and 2) on some traits, such as plant height and stem diameter, in greenhouse cucumber of cultivar "Negeen F1" at 1% probability level, and

fruit diameter, at 5% probability level, while there was no significant difference between treatments using different levels of humic acid, as well as interaction of medium and humic acid on all traits (Table 1).

Plant Height, Stem Diameter and Fruit Diameter

According to the mean comparison table (Table 2), there is a significant difference among different growth media, including growth media No. 1 and 2, on height, stem diameter and fruit diameter of the cucumber plant so that the growth media No. 1, with a mean factor of 104.99 cm, 10.64 mm and 32.07 mm, has the highest plant height, stem diameter and fruit diameter compared to the growth media No. 2, with a mean factor of 94.83 cm, 9.5 mm and 29.31. Based on the Duncan Test, the growth media Nos. 1 and 2 are located in groups "a" and "b" respectively.

Table 2: Comparing the mean and standard deviation of the main effects of medium and humic acid on the Negeen F1 morphological traits.

	plant height		stem diameter	
medium	**Mean**	**Std Dev**	**Mean**	**Std Dev**
A1	104.99a	5.90	10.64a	0.12
A2	94.83b	3.38	9.51b	0.19
Humic acid				
B1=0	97.88a	6.89	10.17a	0.56
B2=30	101.94a	6.48	9.98a	0.5

	Fruit Length		Fruit Diameter		Fruit Weight	
medium	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**
A1	15.00a	1.1	29.31b	0.78	82.22a	7.22
A2	14.50a	1.5	32.07b	2.04	94.96a	15.58
Humic acid						
B1=0	14.19a	0.83	31.45a	2.13	86.82a	17.00
B2=30	15.31a	1.58	29.93a	1.70	90.36a	8.99

There is no significant difference among means with common letters per column according to Duncan's multiple range test at 5% level.

Discussion

These experiments show that the yield of growth medium No. 1 has the greatest effect on plant height, stem diameter and fruit diameter with suitable ingredients such as vermicompost, peat and peat moss. In this growth medium, the greenhouse cucumber root of Negeen F1 could be developed easily and it readily absorbed the required nutrients such as nitrogen from all parts of the soil due to being light-weight and having the nutrients needed. This appropriate rooting ultimately causes an increase of plant height, stem diameter and fruit diameter in the tested medium and the results of the research correspond with those of Mirzahoseini (2014), Ghoojani (2013), Narkhed et al (2011), Zarabi et al (2010) and Almasian (2009). But, the cause of non-significance of humic acid treatment as well as its interaction with the growth medium can be seen in the further effect of the medium as the first factor in the mentioned traits. The difference between development growth and yield rate in the cultivar "Negeen F1" can be related to a difference in plant cultivation on different growth media. Having a strong main root that penetrates the soil to a depth of one meter is one of the traits the greenhouse cucumber plant. A number of secondary roots have moved to the lower depths of the soil and form a new root system in the deeper soil during plant growth, and is replaced with the

previous root system. Since the yield rate of the final period was far less than the initial period, it can be concluded that the initial root system loses its yield over time, and because there was no space to create a new root system, its growth was reduced over time.

Suggestions

Since the yield rate of the final period was far less than the initial period, in future research, the amount of space and good soil conditions must be assessed in terms of texture and nutrition. Also, according to Solgi and colleagues (2010), the cause of non-significance of some certain traits such as fruit weight and fruit length can be attributed to an insufficient space for the growth of plant root system, and as a result, larger pots should be used to apply this method. Another cause of significant failure of these traits can be because the cultivar "Negeen F1" has been imported into the country just recently and is being tested to determine the feasibility of its use in Iran's climate. But since there is a significant difference in some traits between various growth media, it is recommended that other growth media should be used in subsequent experiments to compare the growth and germination of seeds.

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Promising biological activity of *Cydia pomonella* granulovirus (CpGV) isolates for organic apple protection

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Key words:codling moth, *Cydia pomonella* granulovirus, bioassay

Abstract

One of biological control agent against main apple pest, codling moth, Cydia pomonella L. is an effective baculovirus,the Cydia pomonella granulovirus (CpGV), especially in organic apple production and protection. Biological activity parameters, such as LC_{50} and LT_{50}, of CpGV isolates were evaluated and compared with Mexican isolate on neonate larvae under laboratory conditions (26±0.2˚C, RH: 60±2%, 16:8 L: D) in this study. The rate of virus used ranged from 0 to 16000 occlusion bodies/ml of artificial diet (OBs/ml) to determine the rate of larval mortality after 6 days for the LC_{50}. The CpGV isolates show promising activity as biocontrol agent for codling moth especially in organic apple orchards.

Acknowledgments

I am thankful to Prof. Johannes Jehle, Julius Kühn-Institut (JKI), Germany, for providing CpGV-M and sharing his knowledge.

Introduction

The CpGV, a main member of Baculoviridae family, is a dsDNA virus that is highly virulent to codling moth (CM), *Cydia pomonella* L. (Lep.: Tortricidae), one of the most destructive insect pests in apple, pear and walnut orchards(Rezapanah *et al.* 1996). The CpGV is harmless to non-target animals and has no detrimental impact on the environment (Gröner 1986).The CpGV preparations are registered as biocontrol agents in at least 34 countries worldwide (Gebhardt*et al.* 2014) and they meet all the demands of a modern, sustainable and environmentally friendly insect control agent for codling moth, especially in organic gardening (Keinzle *et al.* 2003). Most of CpGV products that are commercialized and used for codling moth control are based on the so-called Mexican (M) isolate, which was isolated and identified in 1963 (Tanada 1964). Two further described isolates are a Russian (R) isolated in 1974 (Harvey and Volkman 1983) and an English (E) isolate from laboratory (Crook *et al.* 1985). Further geographic isolates of CpGV have been reported from different locations in the world since 2001 (Rezapanah 2001, Rezapanah *et al.* 2002 and 2008). Theisolates'sbiochemical variation can be distinguished by restriction fragment length polymorphisms (RFLPs), single nucleotide polymorphisms (SNPs) in highly conserved genes (Eberle *et al.* 2009) and in their phylogenetic position based on genome sequencing (Gebhardt*et al.* 2014). All known CpGV isolates are classified into five phylogenetic genome groups A – E (Gebhardt*et al.* 2014 and Eberle *et al.* 2009).

The biological activities of the CpGV isolates have been evaluated, discussed and improved under laboratory conditions on mostly neonate larvae or 5th instar larvae (Huber 1981, Rezapanah *et al.* 1996 and Lacey *et al.* 2002). The CpGV's biological activity parameters, such as LC_{50}, LD_{50} and

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LT_{50} were criticized too by Harvey and Volkman (1983) and Crook *et al.* (1985). In this study, the biological activities of some isolates have been evaluated on a recognised *C. pomonella* laboratory population via comparative bioassaies.

Material and methods

Propagation and purification of virus occlusion bodies

Fourth or early fifth instar larvae of *C. pomonella* were used to propagate the isolates separately. Infected larvae were ground in 50mM Tris-HCl buffer, filtered through tea filter including cotton tissue and centrifuged in final concentration 50% (W/W) Sucrose for 60 min at 40000g. After two times wash in the buffer, they loaded onto a 20-80% (v/v) glycerol gradient and centrifuged for 40 min at 13000g in middle of centrifuge tube. The virus band was recovered, washed twice and suspended in ultra-pure water. Counting of occlusion bodies was performed using a Helber counting chamber (0.02 mm depth) and a phase contrast light microscope (Rezapanah *et al.* 2008). 20 ml of 10^5OBs/ml concentrations were stored at refrigerator with 6˚C and diluted just before using. The CpGV isolates were biochemically characterized (Rezapanah *et al.* 2008) and biologically in this investigation. The light and electron microscopic studies reviled for the presence confirmation of granulovirus in samples by TEM electron micrograph of a partially dissolved capsule of a CpGV isolate by 0.1 N NaOH and stained with PTA 2% aqueous (Rezapanah 2001).

Rearing conditions and Cydia pomonella colony establishment:

An efficient monotonous laboratory colony of neonate larvae needed for Bioassays. The *Cydia pomonella* larvae used for bioassays derived from insect rearing at the JKI-Darmstadt, Germany. Insects and eggs were incubated at 26±0.2°C, 60±2% relative humidity and a 16/8 hours light/dark photoperiod. The larvae were reared individually in the 2.5*2.5*2.5 cm^3 plastic cubes.

Bioassay procedure:

The diet incorporation bioassay (LC_{50}) was carried out for freshly hatched *C. pomonella* larvae (11). The 50 individually held larvae were put on artificial diet containing the virus concentration (each 1*1*1 cm^3). The bioassays formed using 5 concentration of virus that produced mortality ranging from about 20 to 90%. The concentration of 10^5 OBs/ml of isolates was incorporated into the artificial diet in different amounts so that different concentrations of virus from 0 (control) to 16000 OBs was obtained each in one dish (Huber 1981). 50 neonate larvae were used for each concentration of virus control. The top of the dishes were covered by a lid preventing larvae escape. Larvae were incubated for 6 days before determination of mortality. Thelarvae which did not react to tactile stimuli were regarded as dead. The double bioassays were performed with selected isolates and CpGV-M1 isolate as positive control. Replicate tests were performed on 3 separate dates and totally about 750 larvae were examined for each isolates. The hypothesis about similarity of isolates probit lines were checked by Polo-Pc software (Copyright LeOra software, 1987 and 1994).

LT_{50} Bioassay was conducted with the LC_{50} dosage of all isolates against the neonate larvae. The 2-ml Ependorf vials filled with 1 cm of artificial diet.A 2-mm diameter hole in the cap of each vial covered with stainless steel screen eliminated condensation (Lacey *et al.* 2002). The LC_{50} dosage was performed for the experiment. Dead larvae were counted every day until they all died. Mortality data were evaluated by probit analysis using the POLO-PC software (LeOra Software,1987 cited by Rezapanah 2001) and figures were obtained using excel.

Results

Laboratory data show that codling moth was susceptible to all virus isolates. However, among the isolates tested, the greatest virulence according to its LC_{50} value was 2277 OBs/ml/diet, and the LC_{10} and LC_{90} values were 230 and 23493 OBs/ml. The LC_{50} for other isolates were 4454 and 7370 OBs/ml. Despite the acceptance of the similarity of the lines, the LC_{50} was nearly half of others and 0.6 of the Mexican isolate, however, that was not significant. The calculated LC_{50} value for the Mexican isolate in the present experiment was 2724 OBs/ml, though, the previous LC_{50} determinations for this isolate is: 2600 OBs/ml (Crook *et al.* 1985) and 5367 OBs/ml (Rezapanah 2001). The slopes of probit lines were promising and had no significant difference, but the similarity hypothesis of probit lines rejected. However, considerable differences in the virulence and biological activity of the isolates were found (Fig. 1) is hopefulness.

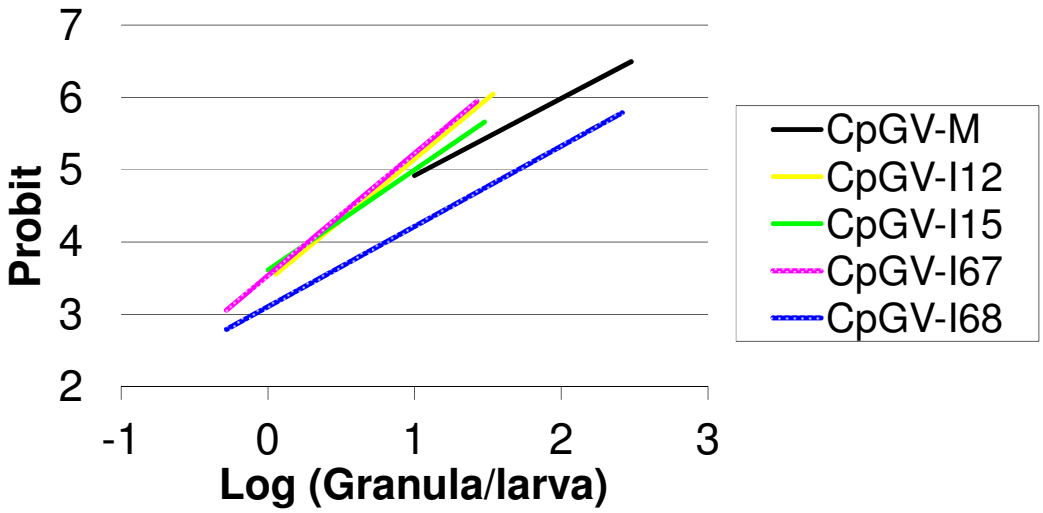

Figure 1.LC_{50} bioassay and probit lines of CpGV isolates. The probits of 3-7 indicates the mortalities of 2, 16, 50, 84 and 98 percentages.

The results of the LT_{50} bioassay which conducted to determine the rate of the mortality among the isolates and also in comparison with Mexican isolate summarized in the figure 2.

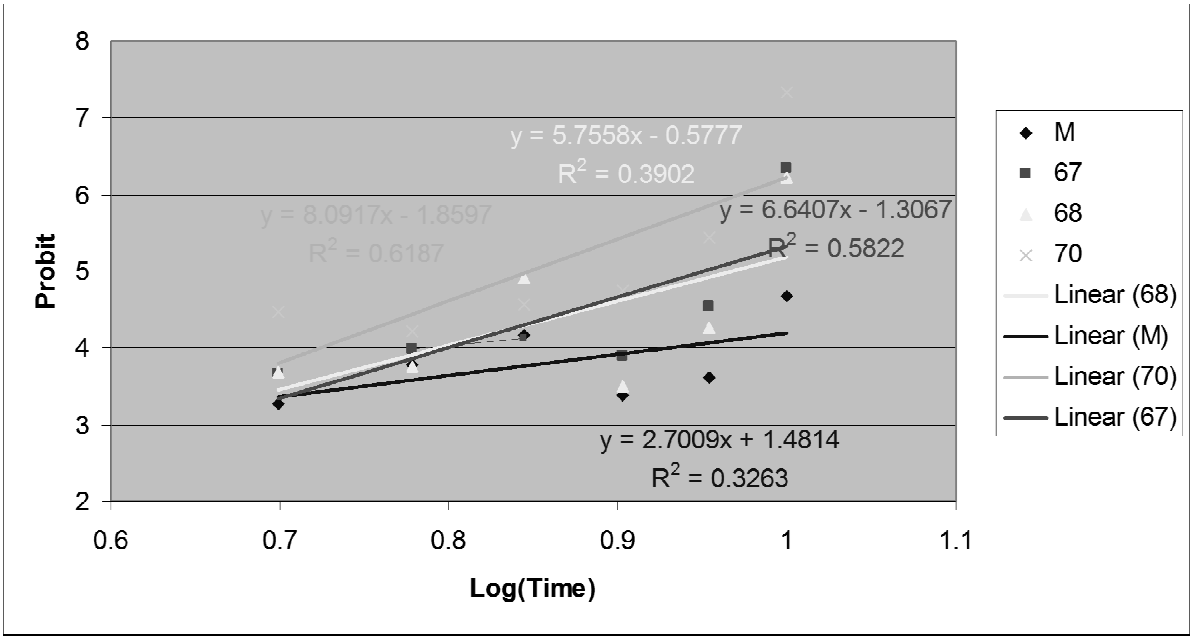

Figure 2. LT_{50} bioassay and probit lines of CpGV isolates. The probits of 3-7 indicates the mortalities of 2, 16, 50, 84 and 98 percentages.

Discussion

The control strategy of this pest in organic orchards should focus not only on prevention of damage but also on the long term reduction of the pest's population to an acceptable level (Keinzle *et al.* 2003 and Rezapanah *et al.* 1996 and 2008). So, natural occurrence investigations (Ghorany *et al.* 2017) of such biocontrol agents in hot zones, the Caucasus region as evolutionary origin of codling moth,become more important in organic agriculture researches. It is interesting that there is no naturally collected isolate from Europe even in natural outbreak of CpGV in Hungary (Rezapanah *et al.* 2008 cited from Szalay-Marzso, 1975). Experiences with other pests have shown that the best place to look for possible antagonists is in the area of origin of the pests (Rezapanah *et al.* 2008). For codling moth this seems to be Eurasia, particularly the Caucasus region (Rezapanah *et al.* 2008 cited from Barnes, 1991). It is only from this area that in the past natural occurrence of the virus has been reported (Rezapanah 2001).It seems further modification for bioassay studies, in vivo cloning and more field examinations in order to use this isolates for the new formulation of CpGV is recommended especially for organic orchards may dealing with low susceptibility to CpGV isolates (Gebhardt*et al.* 2014) even more than the yield satisfactory of codling moth control.

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Life Cycle Environmental Impact Assessment of long term organic rice production in Subtropical area China

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Key words: Life Cycle Assessment; Organic rice; operation period; subtropical area

Abstract

Organic farming is considered as a promising solution for reducing environmental burdens related to conventional agricultural practices. The purpose of this paper was to explore the environmental benefits of organic rice production system and their changes over organic operation period (OR5/OR10/OR15 organic rice for 5, 10, 15 years; CR for conventional rice) in Wanzai County, Jiangxi Province, sub-tropical area of China. Overall, Life Cycle Assessment (LCA) results show the organic operation had lower environmental impacts comparing with conventional farming; the comprehensive environmental impact indices decrease from 0.7928 (OR5), 0.7150(OR10) to 0.6781(OR15) with the year increase of organic operation. CR has higher indices of non-renewable energy depletion (NED), water depletion (WD), acidification potential (AP), eutrophication potential (EP), aquatic toxicity potential (ATP) and human toxicity potential (HTP), while OR has Higher land occupation (LO), global warming potential (GWP) and soil toxicity potential (STP) indices. The largest environmental indices is ATP for CR, and WD for OR. The arable farming subsystem contributed more than 85% to the environmental indices comparing to the agricultural materials production subsystem in all the production systems. Organic rice systems have the potential of being recommended as sustainable agricultural practices in comparison with the conventional one from environmental aspects.

Acknowledgments

This work is supported by the "Key organic Certification technology research and demonstration for Regional specialty products" (No. 2014BAK19B00), the National Key Technology R&D Program in the 12th Five-Year Plan of China.

Introduction

Environmental pollution in agriculture mainly results from the overuse of fertilizer and pesticides. In organic agricultural system, more sustainable agriculture measures, such as crop rotation, leguminous crops, covering, green manure, physical trapping etc., be taken to guarantee the supply of soil nutrients, control pests and increase productivity, causing less environmental pollution. Environmental protection is an important concept of organic agriculture, and its environmental impact has been a hot research topic. It has been well-documented that organic agriculture is more friendly than no-organic farming (Meier et al., 2015; Tuomisto et al., 2012). However, how do these environmental impacts change over time? Is that the longer the organic methods apply, the lower the environmental impact it causes?

Rice is the main cereal crops in China, with 30.3 million hectare rice sown area and occupied 26.9% of the sown area of grain crops. Rice cultivation mainly distributes in the South China, like Jiangxi Province, with 3.3 million hectare, occupied 11% of the total sown area of rice in China. Organic rice is the main organic agricultural product in China, accounting for 16.1% (0.18 million hectare) of the organic agricultural area in 2014(CNCA, 2016). Organic agriculture was initiated in

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Wanzai County, Jiangxi Province in 1999, and the area of organic rice in Jiangxi Province was 6000 hectare in 2014.

Material and methods

The organic rice production systems (OR5, OR10 and OR15 stand for organic operation for 5, 10, 15 years from very beginning) comply with the China Organic Agricultural Product Standard (GB/T 19630.1-2011). For weed control, manual tending is widely practiced by organic rice farmers in Wanzai County. Conventional rice system relies on agricultural chemicals such as pesticides and synthetic fertilizers. Rice straw is plowed into fields after the harvest in all the four farming systems. The LCA (Life Cycle Assessment) method is used to evaluate the impact of different production system on Environment.

An inventory of production data, emissions and resources used was compiled for the entire life cycle. The data of organic and conventional rice management practices were collected by questionnaire interviews with 98 farmers (OR5 with 24 farmers, OR10 with 25 farmers and OR15 with 23 farmers and CR with 26 farmers), farmers were selected randomly from three villages of each production system. While information on the amount of diesel used during the production process was derived from the interviews, data on fossil energy used for fertilizer and pesticide production were calculated from the consumption of primary energy factors in China (Liang, 2009). The study 'Environmental Impact Assessment of Circular Agriculture' was used to obtain information on emissions, such as CO, CO2, NOx, SO2, CH4 and N2O that originate from the energy consumed during agriculture material production (Liang, 2009). The energy consumption and pollutant emissions data of organic fertilizer referenced 'Comparative Evaluation of Chemical and Organic Fertilizer on the Base of Life Cycle Analysis Methods'(Ji et al, 2012).

Paddy nitrogen loss data and CH4, CO2 emissions data were derived through through DNDC9.5 model simulation. Phosphorus loss was calculated as 0.86 % of inputs from chemical/ organic phosphorus sources (Ji et al., 2006; Lu et al., 2014).

In conventional rice production, airborne pesticide residues were determined using a standard residue rate of 10 % per unit weight of pesticides, 1 % to freshwater, and 43 % to soil (Van et al., 2004). In organic rice production, different agriculture measures are used to control pests, such as hormone traps, color plate traps, etc. Sometimes farmers also use small amounts of bio-pesticides instead of chemical pesticides. The toxicity of bio-pesticides was not considered in our analysis as farmers usually apply a small amount of bio-pesticides that easily decomposes in the environment with little toxicity for human beings.

Heavy metal (Zn、Cu、Cd、Pb) residues were considered in terms of inputs of agricultural materials in the farming subsystem. Inputs of heavy metal came mainly from organic manure and fertilizers. Heavy metal content in the organic manure and fertilizers were estimated according to Kong et al.(2006).

Results

Resource Demand

The primary resources used in organic and conventional rice production included renewable (land and water) and non-renewable (e.g. fossil fuels) resources. The energy depletion for organic production was from 343.6MJ/t to 1003.9 MJ/t, and 2393.5 MJ/t for the CR. The energy depletion of CR was significantly higher than that of OR5/OR10/OR15 (p<0.05), and the energy depletion of organic rice only accounted for 14.35%-41.94% of CR. It was notable that the energy depletion of OR10 was significantly higher than that of OR15 and OR5 (p<0.05) (Table 1).

For the land occupation, the paddy land was the only one had been considered. The land occupation of OR5 was the highest because of the lowest yield. The land occupation for CR was 1401.8 m^2 per metric ton, 14.54%-25.09% less land compared to OR5/OR10/OR15. However the water depletion of CR was significantly higher than that of OR5/OR10/OR15 (p<0.05) (Table 1).

Characterization of pollutant emissions

The total global warming potential of OR5/OR10/OR15 was higher than that of CR with significant difference (p<0.05). However, the total acidification potential in CR was 7.5 kg SO2-eq/t, much higher than that of OR5/OR10/OR15. The aquatic eutrophication potential of CR was 1.9 kg PO4-eq/t, similar to the results of OR5/OR10/OR15 (Table 1).

In this study, only the residues of heavy metal and pesticide had been considered to be the sources of toxicity impacts. The human toxicity potential and aquatic eco-toxicity potential in CR were 1.1kg 1,4-DCB-eq/t and 343.4 kg 1,4-DCB-eq/t. The soil eco-toxicity impact potential of CR was 7.3kg 1,4-DCB-eq/t, similar to the results of OR5/OR10/OR15. The soil eco-toxicity impact potential of OR5 was the highest because of the lowest yield (Table 1).

Result of normalization and weighting

During the normalization step, each of the environmental impact potentials were divided by the world per-capita environmental impact normalization factor for 2000 in order to normalize environmental impacts and calculate the environmental index for organic and CR production systems. In the weighting step, each normalized indicator value was multiplied by a weighting factor, which represented the potential of the respective impact category to harm resources, natural ecosystems, and human health.The aggregate life cycle environmental impact indices of CR is 9.6555, the indices of all organic production systems from 5 year to 15 years were much lower than that of the conventional one, with significant difference (p<0.05). The indices of OR5/OR10/OR15 decrease from 0.7928 to 0.6781 with the year of organic operation. In CR system, aquatic eco-toxicity was found to be the major impact, contributing 81.11% to the environmental impact index, followed by water depletion (16.09%) and aquatic eutrophication (1.27%). For OR5/OR10/OR15, the environmental impact indices were dominated by water depletion, accounted for 64.81%- 66.61%. Soil eco-toxicity (14.39%- 15.65%) and aquatic eutrophication (11.92%- 12.76%) also contributed a large part to the indices (Fig. 1).

Table 4 The results of characterization of life cycle impact of organic/conventionalrice

Impact category	Unit	CR	OR5	OR10	OR15
NED	MJ/t	2393.5±165.6a	343.6±27.1c	1003.9±294.0b	512.6±111.4c
WD	m3/t	5138.7±259.6a	1737.0±125.2b	1532.7±136.9b	1494.0±91.5b
LO	m2/t	1401.8±33.1c	1871.3±99.1a	1673.5±131.1b	1640.4±107.2b
GWP	kg/ CO2-eq/t	1764.6±79.0b	2676.3±148.3a	2394.6±230.3a	2291.8±309.9a
AP	kg/ SO2-eq/t	7.5±2.1a	2.6±0.3b	2.5±0.3b	2.2±0.6b
EP	kg/PO4-eq/t	1.9±0.5a	1.5±0.2a	1.4±0.2a	1.3±0.4a
HTP	kg/1,4-DCB-eq/t	1.1±0.1a	0.02±0.005b	0.02±0.002b	0.02±0.001b
ATP	kg/1,4-DCB-eq/t	343.4±24.8a	5.5±1.4b	6.0±0.5b	6.7±0.4b
STP	kg/1,4-DCB-eq/t	7.3±0.6a	8.1±0.9a	7.6±0.9a	6.6±2.2a

Differentletters indicate significant differences among treatments (CR, OR5, OR10 and OR15) for each impact categories, p<0.05, Duncan's Multiple Ranger Test (DMRT) method was used.

Demand for non-renewable energy depletion (NED), water depletion (WD), land occupation (LO), global warming potential (GWP), acidification potential (AP), eutrophication potential (EP), aquatic toxicity potential (ATP), human toxicity potential (HTP), and soil toxicity potential (STP)

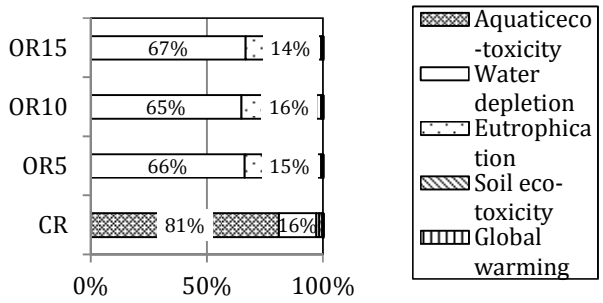

Fig. 1 The proportion of different environmental impacts on the total impact indices in CR/OR5/OR10/OR15.

Discussion and conclusion

Overall, the organic farming had lower environmental impacts comparing to conventional farming; The comprehensive environmental impact indices decrease with the year increase of organic operation mainly due to the rice yield; Higher LO, GWP and STP indices were found in the organic paddies rice production systems comparing with the conventional one. CR had higher indices of NEP, WD, AP, EP, HTP and ATP than OR. The ATP had the largest environmental impact in CR, and in OR5/OR10 and OR15 the largest index was the WD. 4) Main factors that caused the environmental impact were the application of chemical fertilizer and pesticide for CR and the large amount of manure in OR farming system in the paddy fields.

In conclusion, the OR cultivation is a promising sustainable agricultural practice comparing to conventional one from environmental perspective.

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Total dry matter, nutrient uptake and yield of summer mungbean as influenced by organic management practices

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Key words: Mung bean,Panahagavya, liquid organic manure, nodules, uptake

Abstract

The experiment was conducted at MARS, University of Agricultural Sciences, Dharwad, Karnataka state during summer season of 2013-14. Significantly higher Total dry matter Production at harvest was obtained with application of Enriched comost (1/3) + Vermicomost (1/3) + Glyricidia green leaf manure (1/3) equivalent to recommended dose P_2O_5 + FYM (24.18 g/plant) and among liquid organic manurial treatments, foliar application of panchagavya @ 5 percent (24.98 g/plant). The higher uptake of NPK by mungbean at harvest was significantly higher with application of EC (1/3) + VC (1/3) + GLM (1/3) equivalent to 50 kg P_2O_5 + FYM and with panchagavya foliar spray @ 5 % applied at flowering and 15 days after flowering. Application of EC (1/3) + VC (1/3) + GLM (1/3) equivalent to 50 kg P_2O_5 + with FYM recorded significantly higher grain yield (1368 kg/ha) as compared to EC (1/3) + VC (1/3) + GLM (1/3) equivalent to 50 kg P_2O_5 per ha alone (1258 kg/ha) and was on par with RDF + FYM (1301 kg/ha).

Acknowledgments

Heartly thankful to Dr. H. B. Babalad and Dr. S. K. Sharma who gave me support to conducting this research trial and financial support during research**.**

Introduction

India is the largest producer and consumer of pulses in the world. The crop productivity under organic production system can be enhanced through optimizing the nutrient requirement of crop at different stages. It can be achieved through integrated organic nutrition by using different sources of nutrients which have different nutrient release pattern and efficiency. Combined application of organic manures mainly Compost, VC and GLM manure produced higher yield apart from improving soil health (Babalad et al 2009). Further, the liquid organic manures correct the nutrient deficiency as and when noticed under organic production system. Keeping these points in view a field experiment entitled "Effect of nutrient management through organics on growth and yield of summer mungbean" was carried out at MARS, UAS, Dharwad (Karnataka) during summer season of 2013-14.

Material and methods

The field experiment was conducted under irrigated condition during summer season of 2013-14. The soil of experimental site was sandy loam in texture, well drained and maximum water holding capacity was 52 per cent and bulk density was 1.20 Mg /m^3.

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Eighteen treatments were laid out in split plot design with three treatments in main plot Viz, organic manures M1: EC (1/3) + VC (1/3) + GLM (1/3) equivalent 50 kg P_2O_5 + FYM, M2 : EC (1/3) + VC (1/3) + GLM (1/3) equivalent 50 kg P_2O_5 and M3 : RDF + FYM @ 5 t/ha and six treatment in sub plot Viz, liquid organic manures treatments, L1 : Cow urine @ 10 % two sprays at flowering and 15 DAF, L2 : Panchagavya @ 5 % two sprays at flowering and 15 DAF, L3 : Vermiwash @ 10 % two sprays at flowering and 15 DAF, L4 : Plant Growth Promoting Rhizobacteria two sprays at flowering and 15 DAF, L5 : Urea @ 2 % two sprays at flowering and 15 DAF and L6 : Control (water spray). GLM on fresh weight basis, FYM, enriched compost and vermicompost on dry weight basis were applied as per the treatments in M_1 and M_2 10 days before sowing. Panchagavya @ 5 %, vermiwash @ 10%, cow urine @ 10%, PGPR and urea 2% were foliar applied as per the treatments at flowering and 15 DAF.

Results

Total dry matter production

Application ofEC (1/3) + VC (1/3) + GLM (1/3) equivalent to 50 kg P_2O_5 with FYMrecorded significantly higher total dry matter production of summer mungbean (24.18 g/plant) over EC (1/3) + VC (1/3) + GLM (1/3) equivalent to 50 kg P_2O_5 alone and on par with RDF + FYM (23.48 g/plant) (Table.1). Among liquid organic manures, application of panchagavya @ 5 per cent recorded significantly higher TDMP (24.98 g/plant) and it was at par with the application of vermiwash @ 10% (24.38 g/plant) and cow urine 10% (23.93 g/plant).

Seed yield

Seed yield of summer mungbean was significantly higher (1368.3 kg/ha) with application of EC (1/3) + VC (1/3) + GLM (1/3) equivalent to 50 kg P2O5 with FYM as compared to EC (1/3) + VC (1/3) + GLM (1/3) equivalent to 50 kg P2O5 alone (1258 kg/ha) and was on par with RDF + FYM treatment (1301 kg/ha). (Table.1)Among liquid organic manures, foliar application of panchagavya @ 5% (L2) recorded significantly higher grain yield (1430 kg/ha) as compared to rest of the treatments except vermiwash @ 10 % (L3) which was found at par.

Uptake of nutrients

At harvest uptake of major nutrients N (56.19 kg/ha), P (12.63 kg/ha) and K (24.93 kg/ha) was significantly higher with the application of EC (1/3) + VC (1/3) + GLM (1/3) equivalent to P_2O_5 with FYM over EC + VC + GLM equivalent to P_2O_5 alone. Similarly, panchagavya spray has resulted in significantly higher uptake of N (60.36 kg/ha), P (12.73 kg/ha) and K (27.97 kg/ha) over other liquid organic manures. (Table.1) The interaction effect of EC (1/3) + VC (1/3) + GLM (1/3) equivalent to P_2O_5 with FYM along with panchagavya @ 5 per cent has resulted in higher uptake of NPK over other treatments.

Thus, it can be concluded that among organic manures application of EC (1/3) + VC (1/3) + GLM (1/3) equivalent to 50 kg P_2O_5 with FYM and among liquid organic manures, panchagavya @ 5 per cent were found to be optimum for mungbean crop for obtaining higher TDMP, yield and uptake of nutrients.

Table.1 Total drymatter production (TDMP), yield and uptake of nutrients in summer mungbean as influenced by organic management Practices

Liquid organic manures (L)	TDMP (gplant^{-1})				Yield (kgha^{-1})				Nitrogen uptake (kg ha^{-1})				Phosphorus uptake(kg ha^{-1})				Potassium uptake (kg ha^{-1})			
	Organic Manures (M)																			
	M1	M2	M3	Mean	M1	M2	M3	Mean	M1	M2	M3	Mean	M1	M2	M3	Mean	M1	M2	M3	Mean
L1	23.06	24.67	24.06	23.93	1284	1434	1367	1362	50.37	56.93	52.73	53.34	11.23	13.00	12.17	12.13	23.52	25.98	25.35	24.95
L2	24.02	26.11	24.80	24.98	1342	1538	1409	1430	57.23	63.83	60.00	60.36	11.73	13.47	13.00	12.73	26.65	29.45	27.82	27.97
L3	23.34	25.17	24.62	24.38	1307	1462	1379	1383	54.40	59.63	56.73	56.92	11.40	13.20	12.57	12.39	25.25	26.88	25.92	26.02
L4	21.36	23.06	22.55	22.32	1230	1261	1237	1243	45.37	52.37	48.57	48.77	10.37	12.07	11.43	11.29	18.55	21.65	20.65	20.28
L5	22.20	23.89	23.30	23.13	1250	1353	1265	1290	48.37	54.97	51.00	51.44	10.97	12.43	11.87	11.76	22.05	25.25	23.78	23.69
L6	20.50	22.17	21.55	21.40	1134	1161	1147	1147	41.97	49.43	44.73	45.38	10.07	11.63	10.83	10.84	17.35	20.35	19.05	18.92
Mean	22.41	24.18	23.48		1258	1368	1301		49.62	56.19	52.29		10.96	12.63	11.98		22.23	24.93	23.76	
For comparison	S.Em±		LSD (0.05)		S.Em±		LSD (0.05)		S.Em±		LSD (0.05)		S.Em±		LSD (0.05)		S.Em±		LSD (0.05)	
M	0.39		1.52		19.74		77.51		0.69		2.70		0.29		1.15		0.37		1.45	
L	0.44		1.26		20.71		59.80		0.90		2.61		0.19		0.56		0.39		1.13	
Interaction (M x L)	0.81		NS		5.45		NS		0.97		2.81		0.82		2.38		0.76		2.19	

Discussion

The combined application of organic manures and liquid organic manure spray provided better availability of nutrients at different stages of crop growth with higher efficiency and hence resulted in higher TDMP, growth, yield and yield attributes and uptake of nutrients. Similar results also have been observed by Sanjutha *et al.* (2008) Tolanur (2008) andSomaundram(2003).

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Organic nutrient management and intercropping for improved rainwater conservation and productivity under rain fed maize-barley rotation

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Key words: Organic versus conventional, Intercropping, soil erosion, soil moisture, maize-barley, rain-fed

Abstract

Organic, inorganic and integrated nutrient management, and intercropping practices were compared in terms of productivity, soil erosion and rain water conservation under rain fed maize-barley rotation. Four main treatments included: N0: no fertilizers added, N1: inorganic fertilizers alone, N2: organic and inorganic fertilizers in equal ratio, and N3: organic composts alone. Sub treatments with green gram intercropping under maize were: I0:no intercropping I1: green gram intercropped and mulched in soil; I2: green gram intercropped for grain production. Results showed that the grain yields of maize and barley were at par under different nutrient management, while the straw yields were lower under organic treatments. Both the intercropping treatments reduced maize yields; while improved barley straw yields. Organic nutrient management and intercropping reduced the run off % and soil loss, and improved soil profile moisture, indicating improved rainwater conservation in soil.

Introduction

The rain fed agriculture is being practiced in about 60% of cultivated area in India; however the erratic rainfall during the past few decades has resulted in decline in farm productivity (Venkatswarlu and Prasad 2012). The increased biodiversity and improved soil moisture and nutrient conservation in organic agriculture make it more adaptable and resilient to erratic rain fall patterns under changing climate (Goh 2011). However, the vast yield gaps between organic and conventional agriculture farms and the perceived risk of decline in productivity has deterred many modern farmers from shifting to organic agriculture (Ponti et al 2012). In order to improve productivity and soil moisture regime, the present study was conducted to optimize different legume intercropping practices in combination with nutrient management under rain fed maize-barley rotation.

Material and methods

Field experiment: A field experiment was conducted under maize-barley rotation during period 2012-15, at Chandigarh, India (altitude of 370m above msl, latitude of 30°- 44' North and longitude of 76°-51' East). The agriculture land was undulating with 1% slope, moderately degraded, and sandy loam with low available soil nutrients. The climate was sub-tropical with mean monthly temperature highest at 41^{0}C and the lowest at 4.4 ^{0}C, and an annual average rainfall of 1100 mm, with 80% of total rainfall during monsoon season between mid-June to mid September. The composite maize variety, Girja and the green gram intercrop were sown at onset of monsoon rains and harvested by end of October.

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The malt variety of barley, DWRUB-52, was sown in November or December after winter rain and harvested in April.The nutrients as per N and P requirement of the crop were given through following main treatments: N0: Absolute Control (no nutrient added); N1: 100% nutrients through inorganic fertilizers (Urea, DAP and MOP); N2: Integrated Nutrient Management with 50% through inorganic fertilizers and 50 % through organic sources (FYM and vermicomposts in equal ratio); N3:100% through organic sources (FYM and vermicomposts in equal ratio). Green gram was intercropped with sub-treatments:I0: no inter cropping; I1: green gram intercropped and mulched in soil under maize; I2: green gram intercropped for grain production. The experimental design was split plot with plot size: 8m X 4m and three replications. No irrigation was given to both the crops. The pest or disease attacks were managed organically in all the treatments by commercially available Neem (*Azadirachta indica*) based pesticides.

Run off and soil loss: Soil erosion was monitored by installing specially designed multi-slot devisors installed at the lower end of treatment plots, so as to pass 2.5 % of the run off volume generated in the plots within 24 hours. The runoff waters from all the rain fall events were collected in the containers of capacity 200 liters placed in front of each plot. The run off volume was measured for each rain fall event during maize crop. The % run off was calculated from total volume of runoff water from each treatment and the total rainfall. The total soil loss was computed from dry weight of the sediment fraction present in run off water.

Soil profile moisture: Soil profile moisture percentage was determined every month gravimetrically from soil samples collected from different soil depths and was converted into volumetric water content (cm), using soil bulk density.

Statistical Analysis: The two-way ANOVA was applied for the analysis of variance to test the effect of nutrients, intercropping and their interactions on crop yields, run-off, soil loss and soil profile moisture. Standard deviation and Fisher's least significant difference (LSD) were determined to compare the significant differences between the means of the various treatments at $p< 0.05$.

Results

It was observed that both the maize and barley grain yields were higher than the control, but there was no significant difference between different nutrient management, but the straw yields were lower in organic treatments (Fig.1a and 1b). The grain yields from intercrop green gram ranged between 80 to 120 Kg ha^{-1}, with no significant difference between different treatments. Intercropping resulted in a significant decline in maize grain and straw yields (Fig 1a), while the barley yields were significantly improved (Fig.1b). Maize straw yields and barley yields were lower under organic treatments with no preceding intercrop; however intercropping improved the yields bringing it almost at par with the other nutrient treatments (Fig.1b).

Nutrients and intercropping significantly reduced the average run off % and soil loss, with minimum run off % under organic and inorganic treatments, and minimum soil loss under organic treatments when the intercrop was taken till maturity (2a and 2b). The soil profile moisture was significantly higher under organic treatments under both barley and maize, with highest moisture levels in deeper 30-90 cm profile (Fig.3a & 3b). The intercrop till maturity showed no significant effect on soil profile moisture under maize, but caused a significant decline under barley.

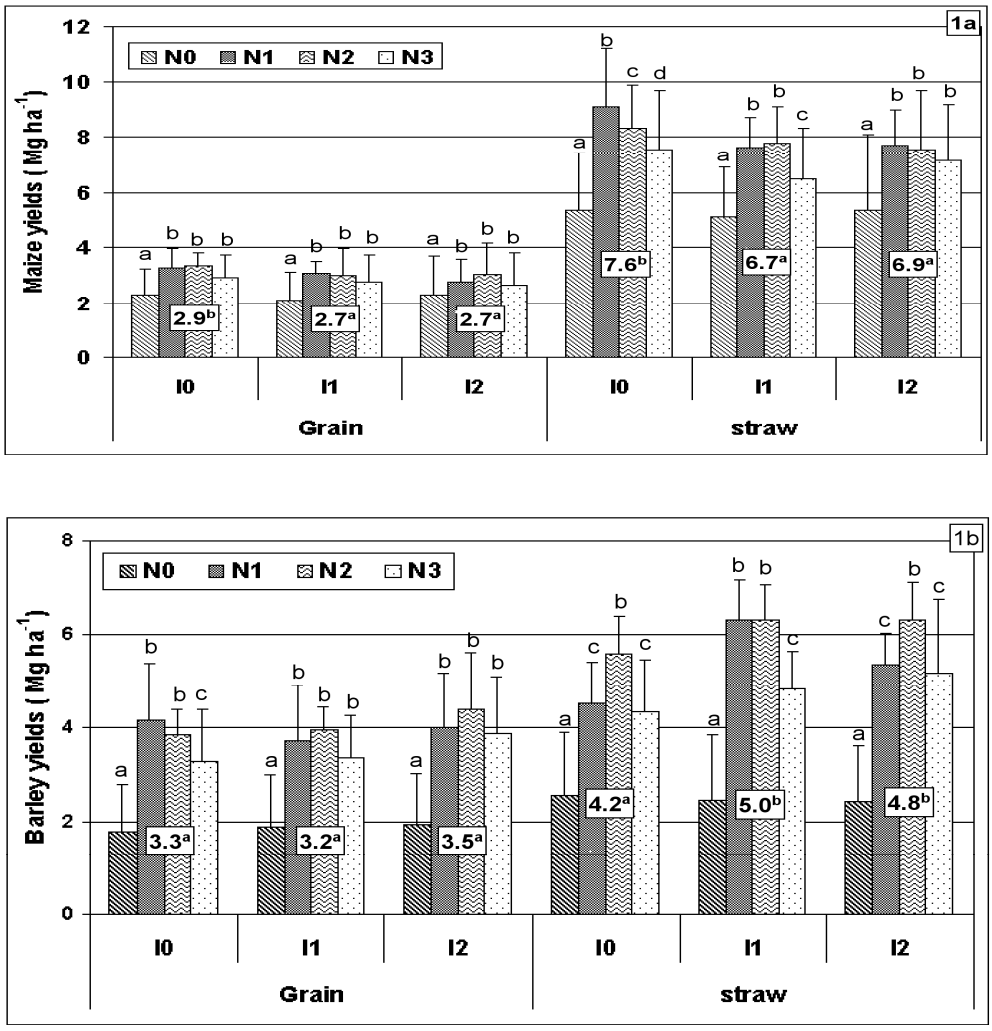

Figure 1 a & 1b: Grain and straw yields (3 years average 2012-15) of maize (1a) and barley (1b) as affected by nutrient source and intercropping. The means with same letter are not significantly different (p=0.05) within the group. The mean yield values of intercropping treatments are given in box and the values with similar superscript letters are not significant different. Error bars indicate standard deviation.

Discussion

The study shows that the legume intercropping not only plays a major role in reducing the yield gaps between organic and inorganic nutrient management, but also help to reduce runoff and soil erosion. Green gram intercropping till maturity reduced the maize yields, but this decline was compensated by additional green gram grain yields and improved barley yields due to a higher residual effects. Scalise *et al* (2015) reported that any decisive improvement in the soil fertility status of rain fed areas cannot be rapidly or easily achieved, unless crop rotations with intercropped legumes are adopted for several years. The present study also concludes that organic agriculture and green gram intercropping will sustain higher yields under rain fed conditions due to improved capacity to conserve rain water and soil moisture for combating drought.

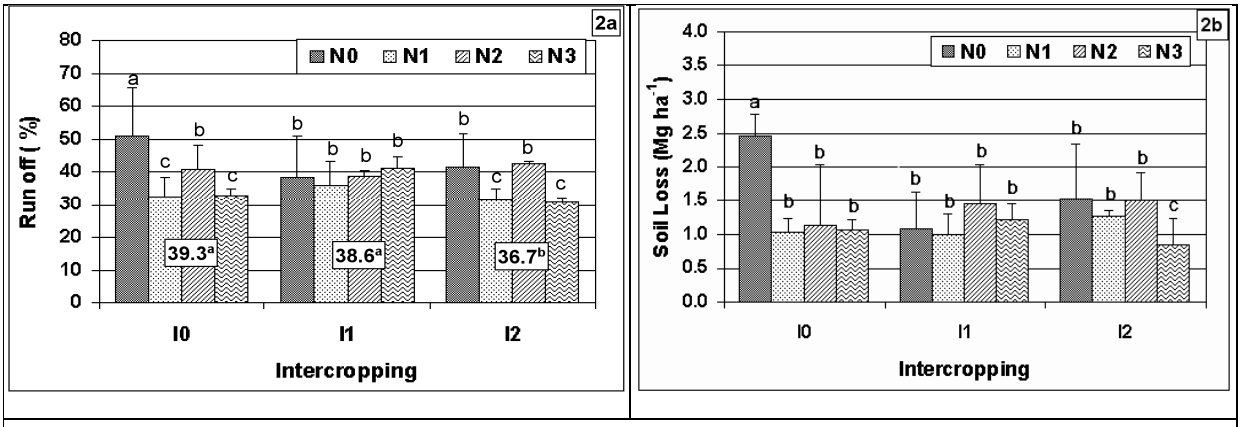

Figure 2 a-b: Average run off % (2a) and soil loss (2b) for years 2012-2015. The bars with the same letter are not significantly different (p=0.05). The mean intercropping effects in the box (1a) with similar superscript letter are not significantly different. Error bars indicate standard deviation

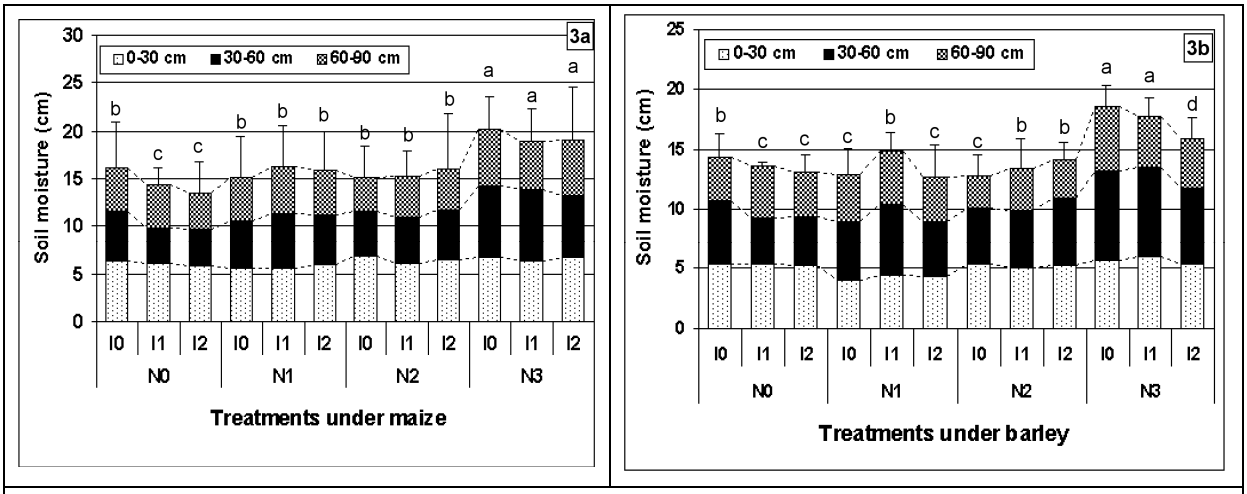

Figure 3 a-b: Soil profile moisture (0-90 cm soil depth) under maize (3a) and barley (3b) with relative contribution from different soil depths. The bars with the same letter are not significantly different (p=0.05). Error bars indicate standard deviation.

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Development of a growing media for producing organic tomato*(Solanumlycopersicum L.)* in greenhouse

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Key words: biochar, mycorrhizal dependency, organic tomato, worm casting

Abstract

Growing organic high-value vegetables and herbs in greenhouse is become increasingly popular; however, limited options are available as growing media. A pot experiment was conducted to investigate the interactive effects of few permitted organic inputs such as arbuscular mycorrhizal fungi, biochar and different ratios of peat: worm casting on tomato (Solanumlycopersicum L.) growth, mycorrhizal dependency, biomass production, fruit yield and soil respiration. Results indicated that worm casting × peat combination significantly affected all measured traits except for the number of fruits in plant and mycorrhizal dependency. Mycorrhizal symbiosis had a significant effect only on shoot dry weight and mycorrhizal dependency. Moreover, biochar application significantly affected shoot dry weight, stem diameter and carbon mineralization. Among the different ratios of worm casting and peat in the growing media, 15% worm casting × 85% peat formed the most suitable medium condition for plants and 100% peat without worm casting was the least suitable. The highest fruit fresh weight (229g/plant) was achieved in 15% worm casting × 85% peat and the lowest fruit fresh weight (175g/plant) was achieved in 100% peat treatment.

Acknowledgments
This experiment has been carried out at Trent School of Environment, Trent University, Ontario, Canada. The funding for this project supplied by Greenscience Technology Inc. and Natural Sciences and Engneering Research Council of Canada (NSERC). This short paper extracted from the project's report and a full paper is in preparation for publication in a peer-reviewed journal.

Introduction

Composting and vermicomposting can divert a significant amount of biowaste from landfills and incineration facilities, while provide a nutrient rich growing media for greenhouse organic vegetable production. worm casting is the decomposition of organic wastes through earthworms to aid the waste stabilization process (Riffaldi & Levi-Minzi 1983). Also, in comparison with composting, vermicomposting of organic wastes is a faster process and results in two useful products, earthworm biomass and vermicompost. Devliegher and Verstraete (1997) have reported increased availability of phosphate and the elements Mg, Ca, Fe, Mn and Cu in the worm-worked soil, compared with initial mineral concentrations in soil. Mycorrhizal symbiosis is the most common type of microorganisms-plant relations whit various beneficial effects on plants. The AM fungi increase plant productivity and P uptake in P deficient soils or when low to moderate P doses are applied (Hayman 1983). The fungal hyphae absorb phosphate, but also other elements in soils, and translocate them into the plant (Wiedenhoeft 2006; Smith & Read 2008; Mardukhi et al. 2015). Biochars have been used as soil amendments with encouraging results (Chan et al. 2007). The use of biochar as a soil amendment is an innovative and highly promising practice for organic

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production systems. Biochar usually has greater sorption ability than natural soil organic matter due to its greater surface area, negative surface charge, and high charge density (Liang et al. 2006). Biochar's high surface area and complex pore structure are hospitable to beneficial bacteria and fungi. The overall objective was to develop a worm casting-based growing medium for tomatoes that can support plant growth during its life cycle in a greenhouse setting. The optimum ratio of peat:worm casting and inclusion of biochar and arbuscular mycorrhizal fungi on some tomato agronomic parameters were studied.

Material and methods

The experiment was conducted in a Conviron closed-system environmental growth chambers. Certified organic seeds of tomato (*Solanum lycopersicum,* hybrid, Red Short Vine, Polbig F1.) provided from Johnny's Seed Company were sown in a multi-cellular jiffy container within peat-based jiffy pots. Fourteen days later, seedlings were transplanted to 5 L volume plastic pots containing prepared a growing media mixture (Table 1). Growing conditions remained constant during the course of the experiment: temperatures of 28°C (day) and 18°C (night), 40% relative humidity, natural daylight supplemented with HPS lamps (381 μmol/m^{-2}/s) for a 16 h photoperiod and no CO_2 enrichment. Worm casting at three levels (0, 15 and 30% of the media volume), organic peat-based potting soil at three levels (70, 85 and 100% of the media volume), mycorrhizal fungi (*Glomus intraradices*) at two levels (with and without application) and biochar at two levels (with 10% of total weight of the media and without application) provided twelve combinations. The experimental design was a factorial arrangement based on completely randomized design with three replicates. Worm casting, the product of Greenscience Technology Co. was used in this experiment [Ammonia 30 mg/kg; Nitrate 420 mg/kg; P (P_2O_5) 970 mg/kg; K (K_2O) 0.34%; Ca 3.1%; Mg 0.42%; S 280 mg/kg; B 14 mg/kg; pH 6.71; EC 1.4 mmhos/cm; organic matter 58.1% and C/N ratio17]. Solid powder of mycorrhizal inoculum which contained *G. intraradices* and produced by Company: MYKE Pro/ PS3, was used as seed inoculation. MYKE® PRO PS3 is a highly concentrated endomycorrhizal inoculant in powder form compatible with most vegetable crops. This product contained 1600 viable propagules per gram of MYKE Pro/ PS3. The inoculum was previously weighted for each mycorrhizal treatment (1 g/pot seed inoculation). The commercial biochar (Blue leaf® Inc., Drummondville, QC, Canada) which used in this study was obtained using Pyrocycling ™ technology and was derived from softwood bark of balsam fir (*Abies balsamea*), white spruce (*Picea glauca*) and black spruce (*Picea mariana*). Sunshine #4 Natural & Organic peat-based soil was used in this study, which formulated with Canadian sphagnum peat moss, coarse perlite, organic starter nutrient charge, Gypsum and dolomitic limestone. The dependency of a plant species on mycorrhizae was defined as "the degree to which a plant is dependent on the mycorrhizal condition to produce its maximum growth or yield, at a given level of soil fertility" (Ortaş 2003). Mycorrhizal dependency (MD) was calculated for each treatment using the equation given by Hetrick et al. (1993). CO_2 efflux emission from the potting soil, as an indicator of soil biological activity, was evaluated after plants harvested using closed chamber incubation method described by Hopkins (2008).

Table 1. The list of substrates and their proportion in growing media for each treatment.

Treatments	Worm Casting %	Peat %	Mycorrhiza	Biochar
a	0	100	NO	NO
b	15	85	NO	NO
c	30	70	NO	NO
d	0	100	YES	NO
e	15	85	YES	NO
f	30	70	YES	NO
g	0	100	YES	YES
h	15	85	YES	YES
i	30	70	YES	YES
j	0	100	NO	YES
k	15	85	NO	YES
l	30	70	NO	YES

Results and discussions

Results of this experiment indicated the significant effect of biochar on some studied parameters. The effect of biochar application in growing media is well documented. Quilliam et al. (2012) found the significant effect of repeated biochar application on soil quality and plant nutrient absorption; although the main function of biochar is the sequestration of carbon. Schulz and Glaser (2012) found that adding biochar to growing medium significantly increased plant growth. They reported that biochar had synergistic effects when applied in combination with mineral fertilizers or different types of composts. The effects of biochar on plants growth is attributed to its high nutrient holding capacity (Glaser et al. 2002). Results of our experiment showed that application of biochar increased mycorrhizal dependency in worm casting × peat treatments but reduced it in 100% peat treatment. This may be attributed to the adverse effect of biochar on plant nutrient absorption in some cases. LeCroy et al. (2013) tested the effect of biochar, mycorrhiza and chemical Nitrogen fertilizer on sorghum (*Sorghum bicolour* L.) seedling growth and reported that biochar, AM fungi and high nitrogen dose reduced above ground biomass by 42% compared with mycorrhizae and high Nitrogen dose treatment. They also observed that biochar application increased mycorrhizal colonization. Results of this experiment indicated that application of worm casting × peat and application of biochar affected carbon mineralization, or on other hand, soil respiration and biological activity. It is generally accepted that soil biological activity is related to carbon mineralization (Fontaine et al., 2003). The enhancement of C mineralization as the result of application of organic amendments was also observed in the experiment conducted by Watts et al. (2010). They tested the effect of tillage systems, poultry litter and inorganic fertilizer application in soil and observed that long term application of poultry litter increased C mineralization more than inorganic fertilizer.

In conclusion,the combination of 15% worm casting × 85% peat along with mycorrhiza and biochar application increased growth parameters of tomato in the controlled environment. The 100% peat treatment reduced plant height and shoot weight. Biochar application improved physical conditions of the growing medium and increased carbon mineralization. Our findings suggest that worm casting, peat, mycorrhiza and biochar improve soil biological properties, enhance the availability of nutrients to plant root and consequently increase plant growth and yield. Therefore, worm casting can be an alternative and efficient nutrient source for organic tomato production in greenhouse.

Table 2. Analysis of variance table for the effect of treatments on the measured traits.

SOV	df	Mean Squares (MS)						
		Plant height	Fruit fresh weight	Fruit in plant	Shoot dry weight	Mycorrhizal dependency	Stem diameter	Carbon mineralization
Replication	2	*	ns	ns	*	ns	ns	ns
WormPeat (WP)	2	**	*	ns	**	ns	*	**
Mycorrhiza (Myco)	1	ns	ns	ns	**	**	ns	ns
WP × Myco	2	ns	ns	ns	ns	ns	*	ns
Biochar	1	ns	ns	ns	*	ns	*	*
WP × Biochar	2	ns	ns	ns	*	**	**	*
Myco × Biochar	1	ns	ns	ns	ns	ns	ns	**
WP × Myco × Biochar	2	ns	ns	ns	ns	**	ns	ns
Error	22	420	92.4	17.9	663.6	1417	11.9	2.05
CV (%)	-	4.37	2.05	0.30	5.49	8.02	0.74	1.68

ns, non-significant; *, significant at $P \leq 0.05$; **, significant at $P \leq 0.01$.

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Study on The Utilization of Pig Manure in Vermicomposting Production by Earthworm (*Eisenia andrei*)

Po-Chin Chang, Yung-Song Chen[1]

Key words: Pig manure, vermiculture, vermicomposting, resource recycling, organic aquaculture

Abstract

The pig farming industry is the fourthlargest livestock industry in Taiwan; however, its value and manure production is the highest. It not only generates a considerable amount of waste, but also contains a wealth of nutrients, which can be utilized as compost by mixingwith the provision of agricultural production and possibly be used as a food source for earthworms.This study aims to evaluateif the largest amount of animal waste in Taiwan i.e. pig manure mixed with sawdust (spent mushroom substrate) in different proportions, can be used for the culture medium of earthworms. Their growth efficiency was also analysed.In the present study, 0% to 70% of the pig manure (PM0-PM7) was respectively mixed with 100% to 30% sawdust as the experimental groups (groups at every 10% interval) for vermiculture at the density 2.5g earthworm /100g substrate (dry weight) lasted for 8 -12 weeks. The results revealed that the groupPM7 (70% pig manure : 30% sawdust) was significantly higher than other groups in the final biomass of earthworms including total adult weight gain and mean adult weight、total juvenile weight gain and juvenile numbers. It was concluded that the earthworm can effectively utilize the pig manure as recycling resource after mixing suitable proportions with other agriculture waste. To meet the trend of marine pollution and the shortage of fish meal in the future, the study also analysed the nutrient contents of crude protein and crude lipid of treated earthworms ranged from 55 to 64 % and 9.5 to 12.8% respectively, which indicated that the earthworms can be a good candidate as an alternatively organic aquaculture feed. However, it is essential to analyse the heavy metals in earthwormsto explore whether it is readily applicable to utilize earthworms as animal feed after the worms fed with pig manure.

Acknowledgments

The authors wish to thank the Council of Agriculture, Executive Yuan, Taiwan (ROC) for project funds (Project Code: 99AS-1.2.2-ST-aB).

Introduction

The pig farming industry in Taiwan is the fourth largest industry with a total 5.4 million heads, however its value is the largest up to US $ 2.1 billion and the largest manure production sector estimated to 14.6 million tons a year (COA, 2017). The latter, *i.e.* pig manure, still contains a wealth of nutrients, which can be utilized as compost by mixingwith the provision of agricultural products and possibly be used as a food source for earthworms. In addition, the pig manure as waste disposal in an aqueous status possesses 3.5% protein which can be readily composted to increase its added value.

The earthworm can not only digest organic waste but also accelerate the transformation of organic matter into vermicompost (Mitchell *et al.*, 1980; Edwards *et al*., 1985; Chan and Griths, 1988; Hartenstein and Bisesi, 1989). It have been well documented that earthworm can be a good environmental indicator to monitoring the health of soil condition (Riley *et al.*, 2008). Furthermore,

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the earthworm with its high protein content is regarded as one of the potential supply for the animal protein source (Allen and Arnold, 2000; Bernal et al., 2009). This study aims to evaluate if the largest amount of animal waste in Taiwan i.e. pig manure capable to be used for the culture substrate of earthworms and its economic revenue via the vermicomposting to be evaluated based on the principle of integrated agriculture.

Material and methods

Cultivated substrates and experimental design

The cultivated substrate, i.e. pig manure for all the vermicomposting trials comes from the solid-liquid separator of local swinefarm (Yi Yang Pasture), mixed with sawdust (spent mushroom substrate) in different proportions, can be used for the culture medium of earthworms. The moisture for the combined substrates was adjusted to be 70% with homogenous mixture.

The earthworms *Eisenia andrei*purchased from Phuket Earthworm Farm (Tainan, Taiwan) were used in the study. The experimental design consisted in using plastic culture boxes (45 x 25 x 15 cm) and each box had an automatic water sprinkling system according to the ventilation and evaporation to maintain the moisture around 70% and soil temperature below 30 ºC. The earthworms of Trial 1 were put into 16 boxes and each box with 4kg dry mixing substrates. The combined substrates constitute 0% to 70% of the pig manure (PM0-PM7) was respectively mixed with 100% to 30% sawdust as the experimental groups (groups at every 10% interval) for vermiculture (stockedat 2.5g earthworm in 100g dry substrate) lasted for 8 weeks. As the difficulties in collecting and separating the earthworms from the substrates, it was adjusted to half the substrates into 2 kg dry weight in the later Trails 2, 3, 4.

Growth performance of earthworm cultured in different substrates of sawdust and pig manure ratio

Except the substrates and seasonal temperature variations, Trials 2-4 maintained the same environmental conditions as Trial 1 in outdoor shady pavilion next to the pig farm (Table 1). The growth effect of earthworms in Trials2-4 lasted 8-12 weeks were recorded respectively in the end of the trials and randomly weighed 20 adults and 20 juveniles for their mean weight, total biomass which can be used to estimate the abundance of the animals. The animals were then stored in -20 ºC freezer and prepared later to analyze moisture, ash, crude protein, crude lipid and nitrogen-free extract based on the Official Methods of Analysis of AOAC .

For easier operation on labour-consuming substrate mixture with pig manure and sawdust, Trial 3 was a preliminarily test with stratified culture, i.e. without mixing pig manure and sawdust and just leave them at their original status in the upper and bottom layer respectively, at the ratio of PM0, PM5, PM7 and PM10. Trial 4 modified the design with the ratio at PM0, PM5, PM7 which based on the result from Trial 3 as the earthworm not successfully survived at PM10 but well adapted to that of PM5 and PM7.

Statistical analysis

All data collected were subjected to descriptive statistics, student's t-test and Analysis of Variance (ANOVA).

Results and Discussion

Growth performance of earthworm cultured in Trials 1-4 for different ratios of pig manure

The total biomass of earthworm for different PM ratio in the end of Trials 1-4 was presented in Fig. 1. It can be seen that biomass increased with pig manure ratio in all trials ($p<0.01$) but Trial 3. The

latter may be due to higher temperature during the experimental period (Table 1)leading to slower growth rate. In contrast, Trial 2 possessed the best growth performance among the trials probably due to the lower temperature during the period (Table 1).

Table 1 Purposes and environmental conditionsfor different trials.

Trials	Purpose of the study	Temperature[1]
Trial 1 (outdoor)	Preliminarily established cultivation system	28.8℃
Trial 2 (outdoor)	Modified from Trial 1	15.7℃
Trial 3 (outdoor)	Preliminarily test with stratified bed culture	27.8℃
Trial 4 (outdoor)	Stratified bed for vermiculture	17.4℃

[1]mean air temperature during the experimental trials (from Central Weather Bureau, ROC)

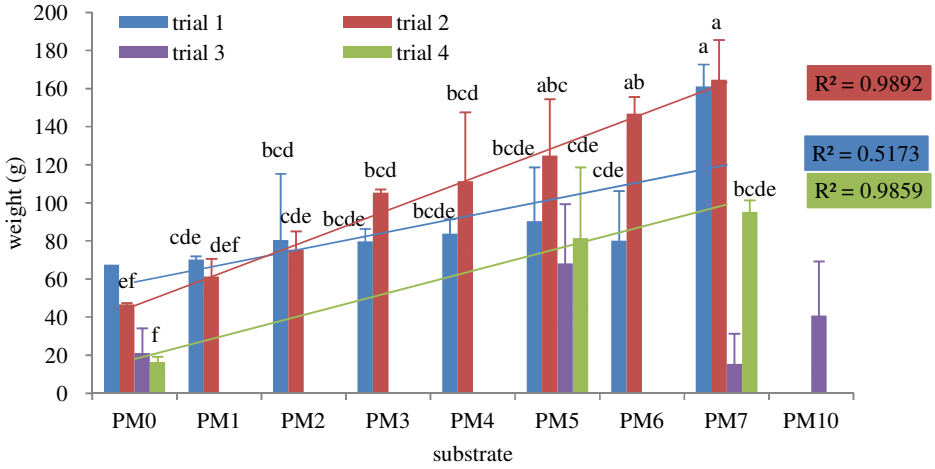

Fig.1. Growth performance of the earthworms cultured in Trials 1-4.

PM0-pig manure 0%-100% sawdust, PM1-pig manure 10%-90% sawdust,..PM10-pig manure 100%-0% sawdust. (Different small letters in the bar indicate significant differences)

The protein and lipid level for earthworm cultured in different PM ratios

The crude protein (CP) and crude lipid (CL) for different trials in different PM ratios were given in Fig. 2a and 2b respectively. The CP content ranged from 56.8-64.8% dry matter while the CL varied from 6.8-11.1%. The crude protein of earthworm recorded in this study were close to those of fish meal. Hence, the earthworm (*Eisenia andrei*) could be a potential protein supplement for animal feed (Velasquez*et al*., 1991). The range of lower CL value (6.8 %) in this present study was close to 7.8 % for *Eisenia foetida*(Tacon, 1994) while the higher CL value (11.1%) was likely to be associated with specific-ecology, food, seasons, life stages, and reproductive stages(Mason *et al*., 1990).

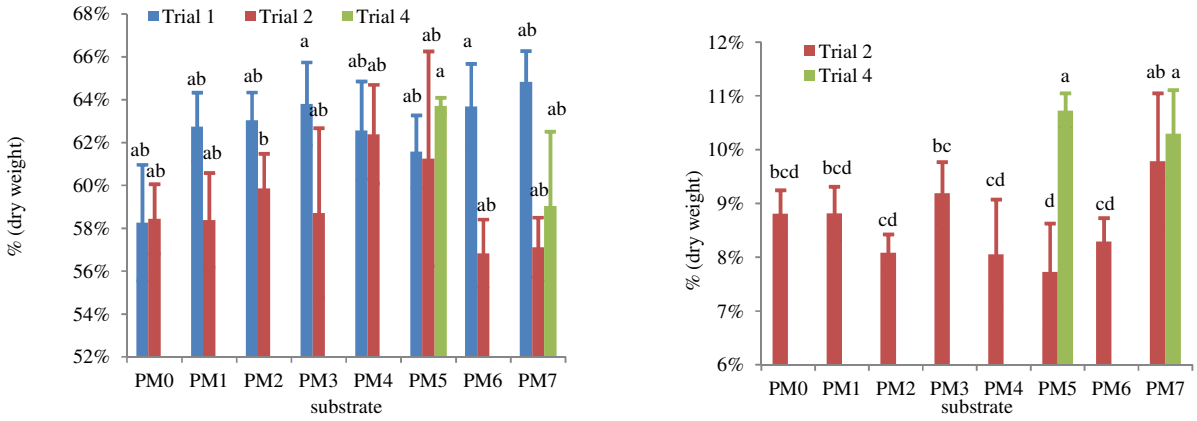

Fig.2a(left) The crude protein (CP) of earthworm fordifferent trials in different PM ratios.
2b (right)The crude lipid (CL) of earthworm for Trials 2 and 4 in different PM ratios.

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The Use of Neem and Pyrethrum Botanical Insecticides on Controlling *Crocidolomia pavonana*

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Keywords: Botanical insecticides, *Chrysanthemum* sp*, Azadirachta* sp*., Crocidolomia pavonana*

Abstract

A research has been conducted at Entomology Laboratory, Indonesian Spice and Medicinal Crop Research Institute (ISMCRI), Bogor. The research was arranged at completely randomized designed, 13 treatments and 4 replications. Treatments consisted of three formulas, i.e. (1) Pyrethrum extract; (2) Neem oil; and (3) Mixed of pyrethrum and neem at concentration of 20; 10; 5; 2.5 ml/l of water each and control treatment (water). Neem formula contain 0.6% of azadirachtin, meanwhile pyrethrum formula contain 1% of pyrethrin. *Crocidolomia pavonana* was used as testing insect resulted from rearing in the screen house of ISMCRI. Each treatment was applied as leaf residue feeding method, by spraying the leaf of *Brassica oleracea*, then feed to the ten of 2nd instar larva of *C. pavonana*. Observation was done on the mortality of the larva at the 1st, 3rd, 6th, dan 9th hours after introduced of the leaf. The results showed that pyrethrum extract was more toxic (LC_{50} = 0.47%) than neem (LC_{50} = 3.45%) as well as mixed of neem and pyrethtum (LC_{50} = 0.66%). At 1% concentration of pyrethrum killed 90% population of tested insect at the 9th hours after introduced to the treated leaf, meanwhile the neem killed 20%, as well as mixing of neem and pyrethrum killed 52.5% of tested insect. There was no synergism action between neem oil and pyrethrum extract, but additive only. Pyrethrum and neem botanical insecticides have good prospect to be used on controlling *C. pavonana* in the field.

Introduction

Crocidolomia pavonana (Lepidoptera: Carambidae) is a cabage pest (*Brassica oleraceae*) which often decreas the yield, even causing harvest failure. Some control techniques have been done by the farmer, especially by using chemical synthetic insecticides, that is not environmentally friendly technique since its negative impact against environmental and human health. The dependence of farmers on insecticides to control pests is very high because insecticides are instant, easy to obtain, the results can be directly seen (knock down effect) and various types of insecticides available in the market. However, *C. pavonana* has already resistant to Fenofos insecticides due to intensive and continuously use of this kind of insecticide (Dono *et al*., 2010).

Along with the increasing awareness and knowledge of farmers and scientists, the current paradigm of pest control is turning towards environmentally-friendly controls, including the use of natural materials, such as insecticides derived from plants or plant-based insecticide commonly known as botanical pesticide such as pyrethrum (Chrysanthemum cinerariaefolium) with the main active ingredient of Pyrethrinand neem (Azadirachta indica) with the main active ingredient of azadirachtin. The objective of the research is to obtain the botanical insecticide which is effective on controlling C. pavonana on cabbage, so that the dependence of farmers on synthetic insecticides can be reduced, and reduce the use of synthetic insecticides in the farm and finally affect to much better environmental and human health.

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Material and methods

The study was conducted in the Laboratory of Entomology, Indonesian Spice and Medicinal Crops Research Institute (ISMCRI). Insects test is 2nd instar of *C. pavonana* larvae resulted from rearing in the laboratory. Botanical Insecticides used are neem oil (*A. indica*) containing 0.6% azadirachtin and extract of pyrethrum flowers (*C. cinerariaefolium*) containing 1% pyrethrin. The study was designed in a completely randomized, consists of 3 botanical insecticides treatments, namely (1) neem; (2) pyrethrum; and (3) a mixture of (1: 1) neem and pyrethrum, in four concentrations, each i.e. (1) 20; (2) 10; (3) 5; (4) 2.5 ml/l of water. Each treatment was applied/sprayed to leaves of broccoli (Leaf Residue Feeding Method), then wind dried and then put 10 second instar larvae of *C. pavonana* to each treatment. Broccoli leaves was choosed, because it is favored by *C. pavonana*, even it can be used as a trap crop for *C. pavonana* (Karunji *et al.*2012). Observations on mortality were conducted on the 1st, 3rd, 6th, and 9th hour after introduction of larvae to the treated leaves of broccoli. Data were analyzed by ANOVA (Analysis of Variance), followed by Duncan's Multiple Range Test (DMRT) 5% level, and to determine the LC_{50} value was used Probit analysis.

Results

Effect of Formula Against Insect Mortality

The results showed that in the first hour after introduction of larvae to treated leaves of broccoli, only pyrethrum (either as a single use or as a mixing use with neem) affect the mortality to the test insects ranging from 15 to 22.5% at concentration of 0.5-2% (5-20 ml of extract per litre of water), while the neem insecticide did not affect mortality of the tested insect (Table 1). Pyrethrum with the active ingredient of pyrethrin is known as "rapid in action" botanical insecticide (Kardinan2000), whereas neem with the active ingredient of azadirachtin is slow to react, because it is more disturbing process of metamorphosis of insects (Kardinan and Suriati 2012).

Table 1. Effect of treatments against mortality of *C. pavonana*

Treatments	Consentration (ml/l)	Mortality (%) (at hours)			
		1	3	6	9
Pyrethrum extract	20	22.5a	72.5a	90.0a	92.5a
	10	17.5ab	60.0 a	72.5ab	90.0a
	5	15.0ab	22.5bc	40.0bc	42.5b
	2.5	0c	15.0	20.0cd	22.5c
Neem oil	20	0c	5.0c	22.5c	32.5bc
	10	0c	2.5c	10.0e	20.0c
	5	0c	0c	5.0e	12.5d
	2.5	0c	0c	2.5e	2.5d
Neem oil + pyrethrum extract	20	10.0bc	40.0ab	40.0bc	90.0a
	10	10.0bc	10.0c	30.0c	52.5b
	5	0c	5.0c	12.5de	40.0b
	2.5	0c	2.5c	20.0cd	25.0c
Control (water)		0c	0c	0 e	0 d

Note: Numbers followed by the same letters at the same coloumn are not significantly different at 5% DMRT

In the third hours after the introduction observation, mortality caused by pyrethrum extract formula increased sharply, to 72.5% at a concentration of 2%, while the formula of neem oil at the same

concentration only give low mortality of 5% and a mixture of pyrethrum and neem formula at the same concentration resulting 40% mortality of the test insect. There is no any synergism or antagonism between neem and pyrethrum formula, but merely additive.

At six hours after introduction observations, mortality caused by pyrethrum formula increased significantly to be 90%, followed by a mix formula of pyrethrum and neem as much as 40% and neem formula as much as 22.5%. From these results it appears that indeed pyrethrum formula is rapid in action than neem formula that is working on affecting the process of metamorphosis.

In the nine hours after the introduction observation, mortality rate caused by pyrethrum increased sharply which can be seen by the results obtained by the concentration of 1% that has reached 90% mortality, followed by a mixture of pyrethrum and neem formula at the same concentration that reached 52.5% mortality, while neem formula in the same concentration can only reach 20% mortality (Table 1).

Toxicity of Formula

The result showed that pyrethrum was the most toxic compared to other tested formulas, with LC_{50} values of 0.47% or equal to 47 ppm of pyrethrin, followed by a mixture of pyrethrum and neem formula with LC_{50} values of 0.66 % and neem formula with LC_{50} values f 3.45%, equivalent to 207 ppm of azadirachtin (Table 2) .

Table 2. Toxicity of formulas at 9th hours after introducing

Formulas	LC50 (%)	Fiducial limit
Pyrethrum extract	0.47	0.39–0.57
Neem oil	3.45	2.09–5.44
Pyrethrum extract + meem oil	0.66	0.53–0.85

Discussion

There is no synergism between pyrethrin extract and neem oil, but merely additive (Table 2). Rapid action of pyrethrum because of the pyrethrin which is the main active ingredient of pyrethrum that works as contact poison to attacks the nervous system of insects and often lead to paralysis and eventually death (Kardinan 2000), whereas neem with the active ingredient of azadirachtin work more on disrupting the physiology of insects, especially the process of metamorphosis, interfere juvenile hormones, so that the response is quite slow (takes 3-4 days) (Kardinan and Suriati 2012) . Both botanical insecticides is biodegradable, so that can be called is ecofriendly insecticides. Pyrethrium and neem are toxic to the insect but safe for human and livestock, so that those botanical insecticides is ideal to be used on organic farming.

Suggestions to takle with the future challenges of on organic farming

One of constraints on organic farming is pest problem causing intensive use of pesticide, especially synthetic pestisicide which is polluting environmental as well as affecting human health. Synthetic pesticide is not allowed to be used on organic farming and as an alternative measure is using natural pestiicides, such botanical pesticide comprise of pant material. Neem (*Azadirachta indica*) with main active ingradient of azadirachtin and Pyrethrum (*Chrysanthemum cinerariaefolium*) with main active ingradient of pyrethrin are indicated as potential botanical insecticides which can be used on organic farming, since those have biodegradable properties and safe for human and livestock.

Preparation of those botanical pesticides can be done by the farmer (simple technology), so that the farmers can be "insecticides self sufficiency" not deppend on external input, especially synthetic insecticides.

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Plant Production - Europe

Title	Author/s	Country
Organic farming with livestock raising vs. stockless farming - Development of soil organic matter stocks and cash crop yields	Franz Schulz, Andreas Gattinger, Christopher Brock, Günter Leithold	Germany
Participatory breeding for improved Phytophthora-resistance in the Organic Outdoor Tomato Project	Jonas Lange, Rahul P. Raj, Bernd Horneburg	Germany
INBIODYN: Integrated, bio-organic and biodynamic viticulture. A comparative study over a 10-year-period.	G. Meißner, J. Döring,M. Friedel, M. Stoll, R. Kauer	Germany
Benefits of grass-clover in an arable crop rotation: a case study from The Netherlands	Roos de Adelhart Toorop, Jan de Wit, Walter Rossing, Chris Koopmans	Netherlands
VASO Program 2.0, three decades of participatory plant breeding towards the chain value	Pedro Mendes Moreira, Isabel Dinis, Daniela Santos, Maria Carlota Vaz Patto	Portugal
On-arm management and site-specific adaptation. A case study with lentil.	Michael Ruland, Barbara Wedemeyer-Kremer, Heiko C. Becker, Bernd Horneburg	Germany
Bioporing: yield insurance during dry spells?	Miriam Athmann, Timo Kautz, Andrea Herkenhöner, Ulrich Köpke	Germany
Use of ducks in weed control in organic maize compared to other weed control techniques	Paulo Miguel Pereira, Carla Neves, Tiago Martins, Hélia Marchante, Daniela Santos, Filomena Miguens, Pedro Mendes Moreira, Óscar Crispim Machado, Maria Antónia Conceição	Portugal
Bioactive component prediction of oat by portable diffuse reflectance field spectroscopy	Tina Kovács, András Jung, Lyudmila Lyubenova, Ismail Cakmak, Bence Bolgár, Elek Dinya, Dagmar Janovská, Michael Vohland and Dóra Drexler	EU
Effect of soybean inoculation in high latitude environments	Insa Kühling, Bianka Hüsing, Nina Bome, Dieter Trautz	Germany
The use of copper pesticides in Germany	Stefan Kühne, Dietmar Roßberg,	Germany

	Jörn Strassemeyer, Peter Röhrig, Friedhelm von Mering, Florian Weihrauch, Sonja Kanthak, Jutta Kienzle, Wolfgang Patzwahl, Eckhard Reiners	
Optimizing breeding strategies and crop management for enhancing legume ecosystem services in organic farming	María José Suso and Carmen Mateos	Spain
Strategies to reduce or replace the use of copper for truly sustainable agriculture	Anna La Torre, Giacomo Pascali, Federica Caradonia, Lorenzo Righi, Francesco Riva, Corrado Ciaccia and Valerio Battaglia	Italy
Are old varieties less productive than modern ones? Dismantling a myth.	Carranza, G. Guzmán, G.I. Torremocha, E., Aguilera, E., González de Molina, M.	Spain
Screening of stand-alone and mixture of cover crops for ground cover management in a temperate organic peach orchard	Claude-Eric Parveaud, Johanna Brenner, Gilles Libourel, Sophie-Joy Ondet, Claude Bussi, Vincent Mercier	France
Optimising organic soybean growth under reduced tillage by inline fertilisation with rock phosphate and elemental sulphur	Sahar Brahim, Daniel Neuhoff, Ulrich Köpke	Germany
Agro-ecological Service Crops with roller crimper termination enhance ground-dwelling predator communities and pest regulation	David Navarro-Miró, Berta Caballero-López, José M. Blanco-Moreno, Alejandro Pérez-Ferrer, Laura Depalo, Antonio Masetti, Giovanni Burgio, Stefano Canali, F. Xavier Sans	Spain
Assessing the productivity of organic rotations using the NDICEA model	Laurence Smith, Adrian Williams, Guy Kirk	UK

Organic farming with livestock raising vs. stockless farming - Development of soil organic matter stocks and cash crop yields

Franz Schulz[1], Andreas Gattinger[1,2], Christopher Brock[1], Günter Leithold[1]

Key words: farm type, stockless farming, soil fertility, soil organic matter, rotational ley

Abstract

An organic long-term field experiment with two factors has been carried out since 1998 at the experimental station Gladbacherhof, University of Gießen, Germany. The effects of different farm types (with and without livestock raising) combined with tillage treatments on plants, soil and environment have been investigated. This article presents results on soil fertility and cash crop yields according to the farm type especially in the 2nd and 3rd rotation. All in all, the superiority of a management system with cattle over stockless organic farming is demonstrated. The mixed farm type led to higher amounts of humus in the soil and to higher yields. Long term reduction of humus in stockless farming is not acceptable. Apart from organic matter recycling crop rotation in organic farming should have elements of SOM accumulating green manure crops such as perennial fodder legumes.

Introduction

The classical ideal of an organic farm is a system with ruminant livestock, perennial fodder legumes in crop rotations and farmyard manure application. In the context of specialization and intensification processes taking place even in organic farming, about 30 % of the organic farms in Germany are managed stockless. In order to investigate the effects of stockless organic farming in comparison with a production with cattle and application of animal manure, the two-factorial (3 different farm types and 4 tillage systems) Organic Arable Farming Experiment Gladbacherhof (OAFEG) has been set up in 1998 at the experimental station Gladbacherhof, Gießen University. This paper presents the results on soil organic matter (humus) and crop yields in the first 3 crop rotations from 1998 to 2015 especially with regard to the 3 farm types.

Material and methods

The experiment is located at the Gladbacherhof experimental station of Gießen University,Germany at 50° 24' N, 8° 15' E. The soil under the experiment is a haplic luvisol with 285/680/35 g kg^{-1} clay/silt/sand. Mean annual precipitation is 654 mm, mean annual temperature is 9.3 °C. Table 1 outlines the three crop rotation/fertilization (farm type) treatments that correspond to a mixed farming system with perennial fodder legumes in the rotation and farmyard manure application (MF), a stockless farming system with rotational ley as a green manure crop (SFL), and a stockless farming system with cash crop in all main crop positions (SFC).

Supplementary details concerning the methodology are described elsewhere (Schulz 2012, Knebl et al. 2016). The soil organic carbon (SOC) contents in the topsoil (0-30 cm) were determined according to DIN ISO 13694 and used for the illustrated assessments. Soil organic carbon masses were calculated by taking the different bulk densities into consideration. The identification of trends over time was conducted by using linear regression because non-linear operations did not lead to

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better curve fittings. Additionally a two-factorial ANOVA of the data on the state of the carbon masses in 2015 was conducted because not all of the trends were significant.

Table 1: Crop rotations and fertilization for farm types of the OAFEG

Field no. in rotation	Year	MF (Mixed farm)	SFL (Stockless farm with mulched ley)	SFC (Stockless cash crop farm)
1	1998 2004, 2010	Alfalfa grass (harvested)	W.wheat (1998) Oats	W.wheat (1998) Oats
2	1999 2005, 2011	Alfalfa grass (harvested)	Alfalfa grass (incorporated)	Field beans
3	2000 2006, 2012	Winter wheat	Winter wheat	Winter wheat
4	2001 2007, 2013	# Potatoes	Potatoes	Potatoes
5	2002 2008, 2014	Peas+oats (2002) Winter wheat	Peas	Peas
6	2003 2009, 2015	## Winter rye	Winter rye	Winter rye

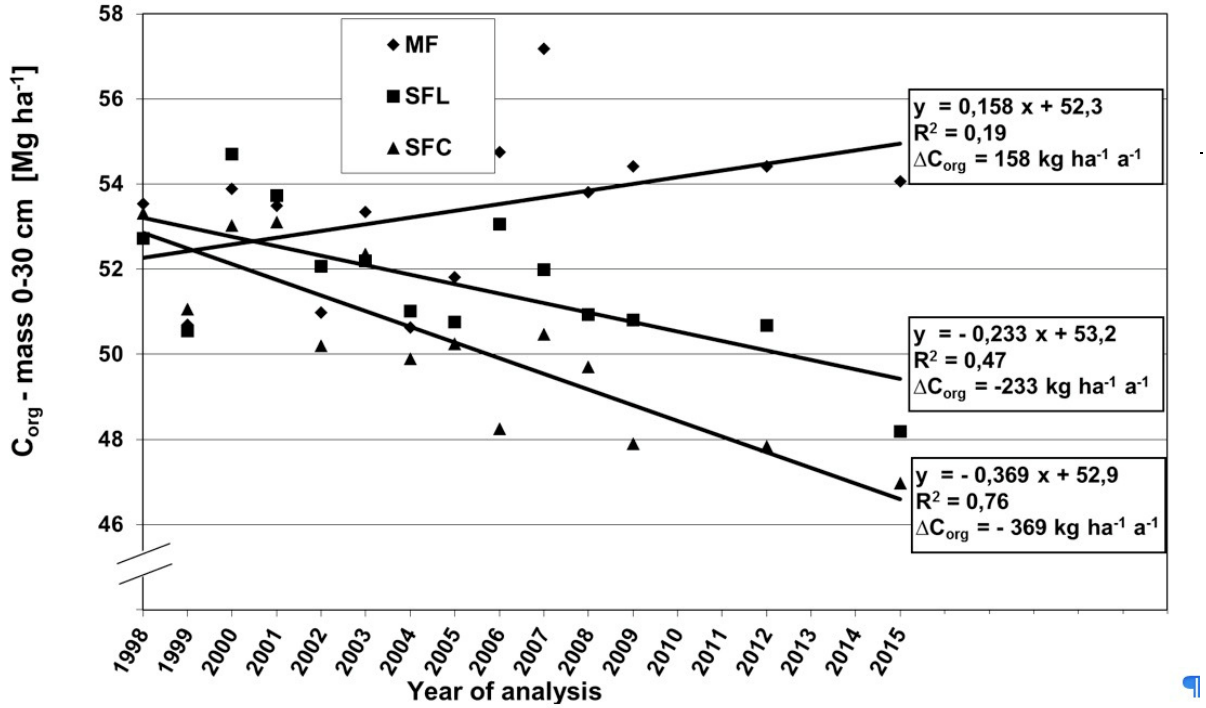
45 t ha^{-1} farmyard manure, ## 15 t ha^{-1} farmyard manure

Results

Figure 1 shows a trend towards SOC increase in the MF of 158 kg SOC ha^{-1} a^{-1}, corresponding to a SOM increase of roughly 0.27 t ha^{-1} a^{-1}. However, this trend was not significant due to high annual variation. The stockless system with rotational ley (SFL) apparently shows a slight decrease of SOC levels. The rotational ley in SFL obviously prevented considerable SOM loss in this stockless system. A significant SOC decrease, on the other hand, could be observed in the stockless cash crop system without ley (SFC). SOC loss was in the magnitude of 369 kg SOC ha^{-1} a^{-1} with this system. The value corresponds to 0.64 t SOM ha^{-1} a^{-1}, which is 10.8 t SOM ha^{-1} in 17 years, or roughly 11.9 % of the initial value. The differentiation of SOC levels dependent on the farming systems displayed in the experiment is supported by a state analysis in 2015 (Knebl et al. 2016).

As there were significant interactions between the two experimental factors concerning the crop yields (table 2) the farm types were compared at the levels of the single soil tillage treatments. The results of the two systems P30 (deep turning plough) and CR30/15 (non-inversion tillage) are displayed exemplarily. The mixed farming system (MF) had extensive as well as significant higher yields than both stockless farming types (SFL and SFC). The lower yields in reference to the parameter "aboveground biomass" amounts -23 % to -37 %, with regard to the "non-legume cash crop yield" -13 % to -24 % and as to the "sum of all harvested biomass" even -42 % to -49 %. Compared to the results of the 2nd rotation, the stockless system with rotational ley (SFL) decreased considerably with reference to the crop yields and moved towards the level of the stockless farm with cash crops only (SFC).

Referring to the soil tillage treatments (only the systems P30 and CR30/15 are shown in table 2) it can be found that all reduced tillage systems could cope with the regularly ploughed reference system if at least a shallow turning of the soil was carried out. In contrast; with the non-inversion soil system, lower yields have to be expected.



MF, Mixed farm with animal husbandry (upper line), SFL, Stockless farm with rotational ley (middle line), SFC, Stockless farm with cash crops only (lower line)

Figure 1. Development of soil organic carbon masses in OAFEG topsoil dependent on farm type

Table 2: Aboveground biomass production and yield indicators dependent on the farm type in the OAFEG. Data refer to the third rotation (2010-2015).

	Soil tillage system	MF (Mixed farm)	SFL (Stockless farm with mulched ley)	SFC (Stockless cash crop farm)
Aboveground biomass (dt DM ha^{-1})	P30	670 a (100 %)	514 b (77 %)	424 c (63 %)
	CR30/15	568 a (100 %)	377 b (66 %)	365 b (64 %)
Mean non-legume cash crop yields (dt DM ha^{-1} a^{-1})	P30	56,0 a (100 %)	48,7 ab (87 %)	42,7 b (76 %)
	CR30/15	47,4 a (100 %)	39,4 b (83 %)	37,8 b (80 %)
Sum of all harvested biomass (dt CU ha^{-1})	P30	373 a (100 %)	217 b (58 %)	212 b (57 %)
	CR30/15	316 a (100 %)	183 b (58 %)	161 b (51 %)

Different letters denote significant differences within rows (α = 0.05, Tukey-Test).
DM = Dry Matter, P30 = mouldboard plough to a depth of 30 cm
CU = Cereal Units (KTBL 2009), CR30/15 = cultivator (30 cm) + rotary harrow (15 cm)

Discussion

Soil organic matter is of great relevance for crop production in organic farming and for the production of non-legumes in particular (e. g. Brock et al. 2011). Therefore, losses of soil organic matter are likely to have a negative impact on crop yields in organic arable farming systems. After the 1st rotation, a decrease of SOM in both stockless systems was not clearly detected (Schmidt et al. 2006). This only became apparent after the 2nd rotation (Schulz et al. 2014). After passing

through the 3rd rotation the trends of SOM development could be verified. In the OAFEG the slight increase of SOM levels under MF is an effect of the combined impact of crop rotation and fertilization. Probably grain legumes cannot keep up with fodder legumes with regard to humus reproduction. Therefore it seems to be essential that every crop rotation in organic farming maintains fodder legumes as a main crop. Otherwise the sustainability of farming systems may be threatened.

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Participatory breeding for improved Phytophthora-resistance in the Organic Outdoor Tomato Project

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Key words: Tomato, organic plant breeding, participation, late blight, *Phytophthora infestans*

Abstract

In a participatory breeding approach breeding lines deriving from a cross between a commercial source of resistance and a resource from seed savers were selected at diverse locations. F6 breeding lines with field resistance transgressing the better parent without yield penalty were selected.

Acknowledgments

Many thanks to all colleagues involved in the Organic Outdoor Tomato Project for a successful cooperation and to the Software AG Foundation for providing funds.

Introduction

The Organic Outdoor Tomato Project (OOTP) started in 2003 at the University of Göttingen, Germany, as participatory organic plant breeding program that involves the entire value chain. It is based on the free exchange of knowledge and tomato genotypes and enhances organic plant breeding (Horneburg 2010). Initially out of 3,500 genotypes from seed traders, genebanks, private seed savers and NGO's the 33 best performing were selected for field resistance, yield and quality. Non-commercial sources accounted for the majority of the top group (Horneburg & Myers 2012). The best genotypes were used as parents in the breeding program.

The main challenge in outdoor production is late blight. The disease is caused by the oomycete *Phytophthora infestans* (Mont.) de Bary; it is a major cause of crop loss in tomato and potato around the globe (Foolad *et al*. 2008). It spreads quickly and can cause complete yield loss. In Central Europe outdoor production had almost ceased to exist due to increasingly aggressive *P. infestans* genotypes. Unlike temperate regions India as a tropical county was less under threat of late blight. Unfortunately, late blight has been reported in tomatoes in India in the recent past (Chowdappa *et. al*. 2013) and it has become a serious issue. The pathogenicity and nature of the disease makes it priority importance in breeding research, especially in organic cultivation.

Material and methods

Diverse crosses were made in the OOTP to combine sources of resistance to *P. infestans*, general robustness, yield quality, and earliness. Here we concentrate on the cross Phantasia F1 x Resi. Phantasia F1 was released by De Ruiter; Resi derived from a chance seedling at a seed saver, was supplied to the OOTP by Privates SamenArchiv Gernard Bohl and later released as amateur variety by Arche Noah. Phantasia F1 was chosen as parent because of the superior field resistance against *P. infestans* and the large fruits. Resi was chosen for the superior fruit quality and an intermediate level of field resistance. Offspring from this cross was selected from the F2 to F5 generation at locations in Germany including Reinshof (research farm University of Göttingen), Ballenhausen (Culinaris; organic breeder and seed company), WeidenHof (community supported agriculture),

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Kleinhohenheim (research farm University of Hohenheim) and Bamberg (Bayerische Landesanstalt für Wein- und Gartenbau; extension service) in differing population sizes. Each year the best performing breeding lines were distributed to all other locations. At additional locations a small number of breeding lines was evaluated. The best resulting F6 breeding lines and the parents were tested at Reinshof, Ballenhausen (randomized complete block design; 3 replications x 3 plants per plot) and WeidenHof (2 x 2) in 2015. As check we used Dorenia, recently released by Kultursaat e.V. for organic outdoor production. Plants were grown on trellises with a spacing of 0.5 m between plants and pruned to the main shoot. Yield was determined only every two weeks, thus reducing yield but increasing late blight infections.

To assess the inheritance of field resistance both parents and F2 plants were seeded at June 8, 2016 and transplanted to the field at Reinshof July 15, 2016 in two replications x 6 plants per parent and 21 F2 plants. Plants were grown without support and pruning at 2.5 x 1.5 m.

Late blight infections were scored according to the key given by Horneburg & Becker (2011) and calculated as area under the disease progress curve (AUDPC).

Results

Resi, the parent chosen for fruit quality and field resistance yielded poorly as expected. The best breeding lines reached the yield level of the better parent Phantasia F1 and the check (Figure 1) but had an increased field resistance (Figure 2). In breeding lines the correlation between yield and fruit weight was strong (r=0.73).

Leaf and fruit infections correlated at r=0.96; in Figure 2 only data on fruit infection are given. Significant differences in field resistance between both parents and the check were observed. Most breeding lines were less infected than the more resistant parent; the difference failed to be significant due to the high LSD. In breeding lines no correlation between late blight infection and fruit weight existed (r=0.078).

The F2 population segregated into two groups (Figure 3). 27 out of 42 F2 plants had a resistance level against fruit and/or leaf infections that transgressed the better parent resistance.

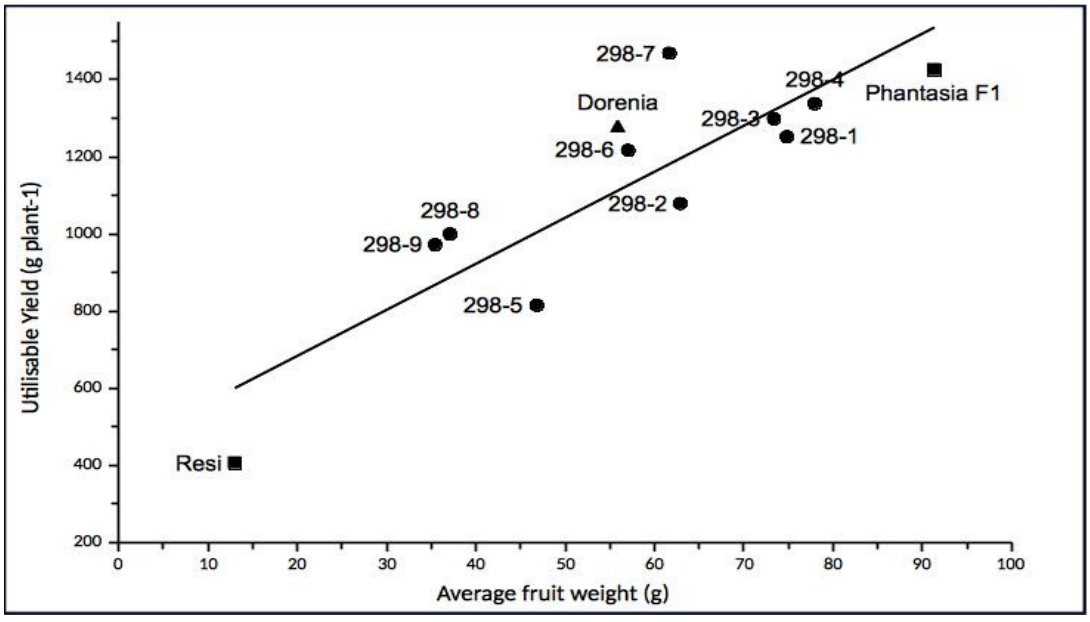

Figure 1. Yield and fruit weight of 9 F6 breeding lines, their parents and a check cultivar (Dorenia). Mean of Reinshof & Ballenhausen. LSD yield = 295.6 at p=0.05.

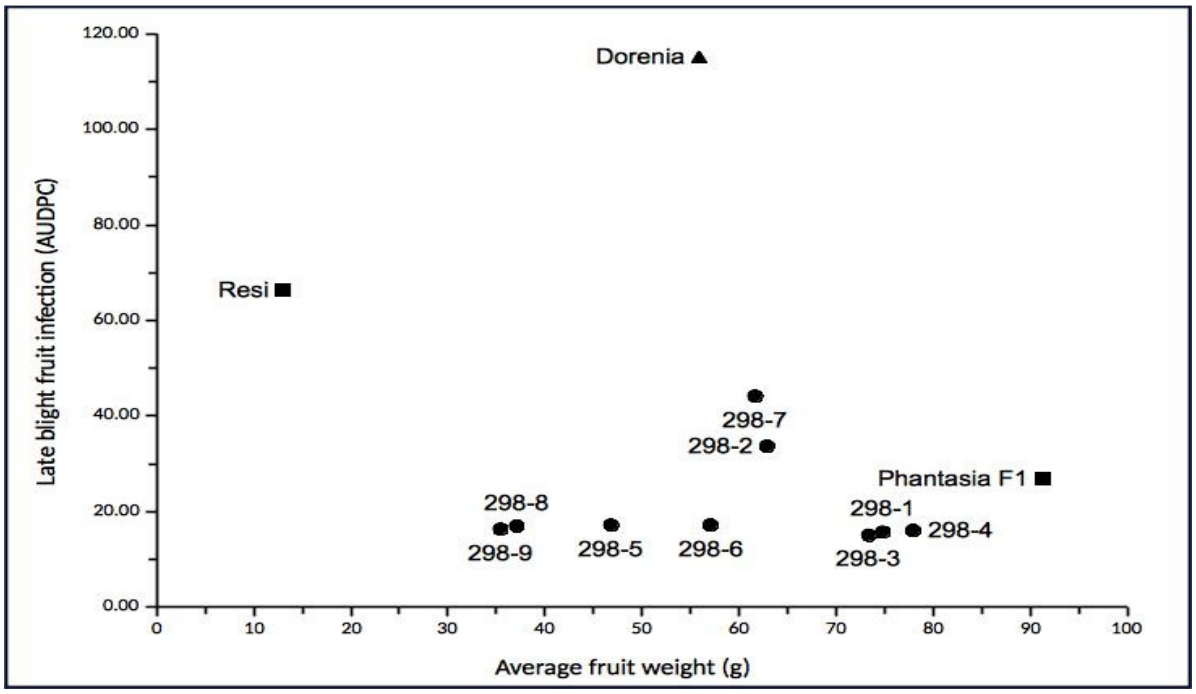

Figure 2. Fruit infection by *P. infestans* and fruit weight of 9 F6 breeding lines, their parents and a check cultivar (Dorenia). Mean of Reinshof, Ballenhausen and WeidenHof. LSD fruit infection=31.0 at p=0.05.

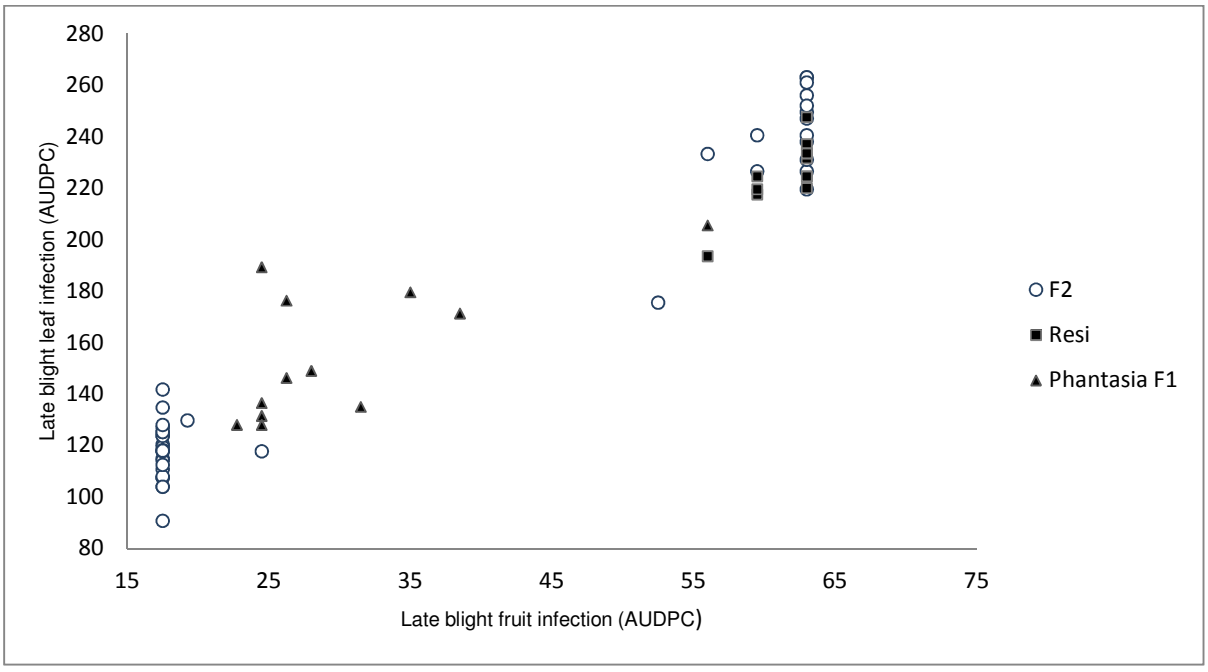

Figure 3. *P. infestans* fruit and leaf infection of 42 F2 plants and their parents.

Discussion

Transgression in field resistance was observed both in the F2 and F6 generation; breeding lines performed better than the better parent, indicating that the parents carried different sources of resistance that have been combined. The large network of the OOTP has successfully identified parents for an organic breeding program. F6 breeding lines could be selected in a nationwide participatory approach that combined the level of field resistance with yield potential and fruit quality (data not shown). In the near future a new organically bred cultivar will be released.

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INBIODYN: Integrated, bio-organic and biodynamic viticulture. A comparative study over a 10-year-period

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Key words: bio-organic viticulture, biodynamic viticulture, horn silica, biodynamic preparations

Abstract

Demand and production of organic and biodynamic crops have been growing exponentially in the last decades around the world. The organically managed viticultural surface in Europe increased substantially from 43.000 ha in 1998 to 230.000 ha in 2011, corresponding to around 5.3 % of all vineyards within Europe. Some of the most prestigious domains have converted to organic or biodynamic viticulture, respectively. However, little research has been conducted on the impact of these management systems on vine growth, yield and product quality.

In 2006 a viticultural field trial (INBIODYN) comparing integrated, organic and biodynamic viticulture was established at Geisenheim University in Germany. Yield, pruning weight and sugar content of the must differed significantly between treatments over a 7-year-period (2006-2012). The integrated treatment showed significantly higher pruning weight, yield and significantly lower sugar content of the must compared to the organic and the biodynamic treatment. Reasons for the changes in growth, generative performance and must quality will be discussed.

Introduction

Globally the viticultural surface managed according to organic and biodynamic standards tripled in the last 10 years.

Lately the biodynamic farming system is gaining more and more attention. Positive experiences of winegrowers working biodynamically stimulate the discussion within the wine sector.

A long-term field trial comparing integrated, bio-organic and biodynamic viticulture (INBIODYN) with a deeper look into the biodynamic system and the effects of the "biodynamic horn silica preparation" was established at Geisenheim University in 2006. The aim is to investigate the effects of the respective management systems on soil, vegetative and generative growth as well as on wine quality. The experiment is supervised by an advisory team with background from integrated, bio-organic and biodynamic agriculture.

Material and methods

The experimental field (0.8 ha; 49 ° 59'; 7 ° 56') was planted in 1991 (*Vitis vinifera* L. cv. Riesling, Gm clone 198-30; grafted on *Vitis berlandieri* Planch. x *Vitis riparia* Michx. cv. SO4 and *Vitis riparia* Michx. x *Vitis cinerea* Engelm. cv. Börner rootstock, respectively). The vines were planted at a spacing of 1.2 m within rows and 2 m between rows using a vertical shoot positioning system (VSP). Until the end of 2005 the vineyard was managed according to the code of *good practice* (BMELV 2010).

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Conversion to organic and biodynamic viticulture started in 2006. Each plot consisted of four rows with 32 vines each. Only the inner two rows of each plot were used for data collection. The outer rows were considered as buffer rows. The experiment was set up as a complete block design with four replicates.

In all three management systems compost was applied (same N-equivalents; 50 kg N ha^{-1} in 2006, 25 kg N ha^{-1} in 2007). In the integrated treatment green waste compost was used. In the organic and biodynamic management system compost made out of manure was used. In the case of biodynamic viticulture, the compost preparations 502-507 were applied.

In the integrated treatment (good practice) sward was mainly used as cover crop. In the organic (EC Regulation 834/2007 and ECOVIN standard) and the biodynamic (EC Regulation 834/2007 and DEMETER standard) plot a seed mixture rich in legumes (Wolff-mixture) was used. Nitrogen supply of the organic and the biodynamic treatment was ensured by ploughing up the cover crop mixture (rich in legumes) of every second row shortly before full-bloom. In the integrated treatment mineral fertilizer was added (25 kg N ha^{-1} in 2006, 50 kg N ha^{-1} in 2010, 25 kg N ha^{-1} in 2012) to compensate for the nitrogen introduction that occurred in the organic and in the biodynamic treatments due to the Wolff-mixture.

In the under-vine area of the integrated treatment herbicides (Glyphosate®) were applied twice a year. The under-vine-area of the organic and the biodynamic plot was worked mechanically.

Synthetic fungicides were used for plant protection in the integrated treatment. In the organic and the biodynamic plot, wettable sulfur, copper (max. 3 kg ha^{-1} a^{-1}) and plant strengtheners (Mycosin Vin® and Potassium Bicarbonate) were applied.

The organic and the biodynamic treatments received the identical plant protection and soil management except for the application of the biodynamic preparations that occurred only in the biodynamic plots. Horn silica (preparation 501) is applied three times during the growing season at the phenological stages shortly before full-bloom, at veraison and shortly before harvest. The horn manure preparation (preparation 500) was also applied three times per year during late autumn and spring. In the years where no compost application took place, the cow pat pit preparation was applied in the biodynamic plots.

Pruning weight was measured gravimetrically during the winter as the mean of 16 vines. Infestation with *Botrytiscinerea* and sour rot on clusters was determined shortly before harvest following the Eampp guidelines (Organisation Eampp Guideline for the efficacy evaluation of fungicides PP 1/31(3)). For this purpose 100 clusters per row were used for estimation of disease severity, 50 on each side of the canopy.

A balanced fixed factorial analysis of variance was carried out (fixed factors treatment, rootstock, block, year, interaction treatment:rootstock, treatment:year). If a main effect or an interaction was significant ($p<0.05$), a Tukey test ($p=0.05$) was carried out to compare the factor levels. For all the parameters measured averages per combination of treatment:rootstock:block:year (n=1) were calculated and used for statistical analyses. The statistical analyzes were performed with the software R®.

Results

Growth

During the investigation period, the growth rate of the organic and the biodynamic variant, as measured by the pruning weight, was significantly lower than in the integrated variant (ca.10-15%, Figure 1).

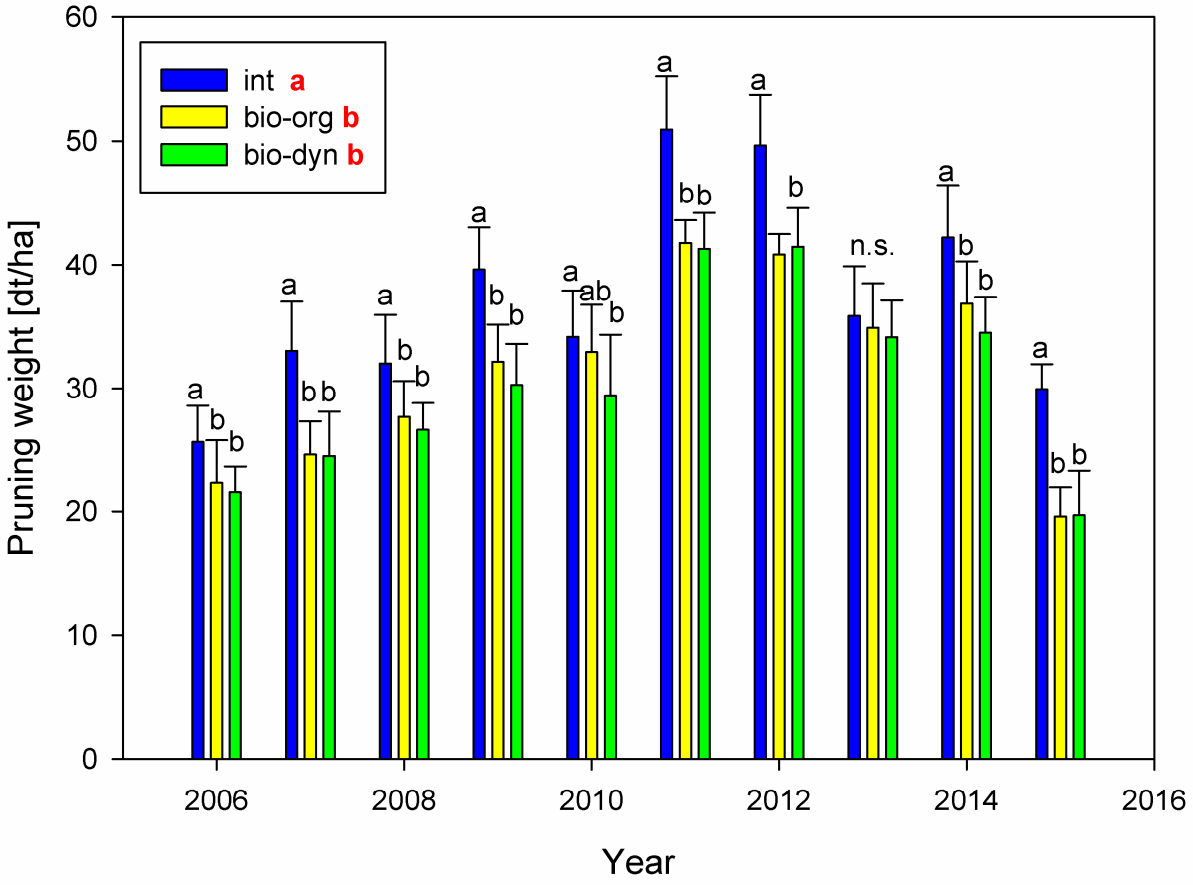

Figure 1. Pruning weight [dt/ha] in the system comparison INBIODYN

The significantly lower secondary shoot leaf area also contributed to the lower pruning weights within the organically managed plots (Döring et al. 2015; Meißner 2015).

In further investigations, a positive influence of the reduced growth of the organically managed plots on the canopy structure (shoot length, number of secondary shoots as well as secondary shoot length) could be demonstrated. In eight out of ten experimental years, the biodynamic management showed a tendency towards lower vigor compared to bio-organic management.

Botrytis cinerea and sour rot

The effects of the management systems on plant health also showed interesting results. Despite the use of botryticides in the integrated variant (twice a year), no lower disease incidence of *Botrytis cinerea* could be documented in this variant.

In the years 2008, 2009, 2010, 2011 and 2014, an incidence of sour rot could be observed due to humid weather conditions during the ripening phase. The organically and the biodynamically managed plots exhibited a significantly lower disease incidence of sour rot than the integrated treatment (Figure 2).

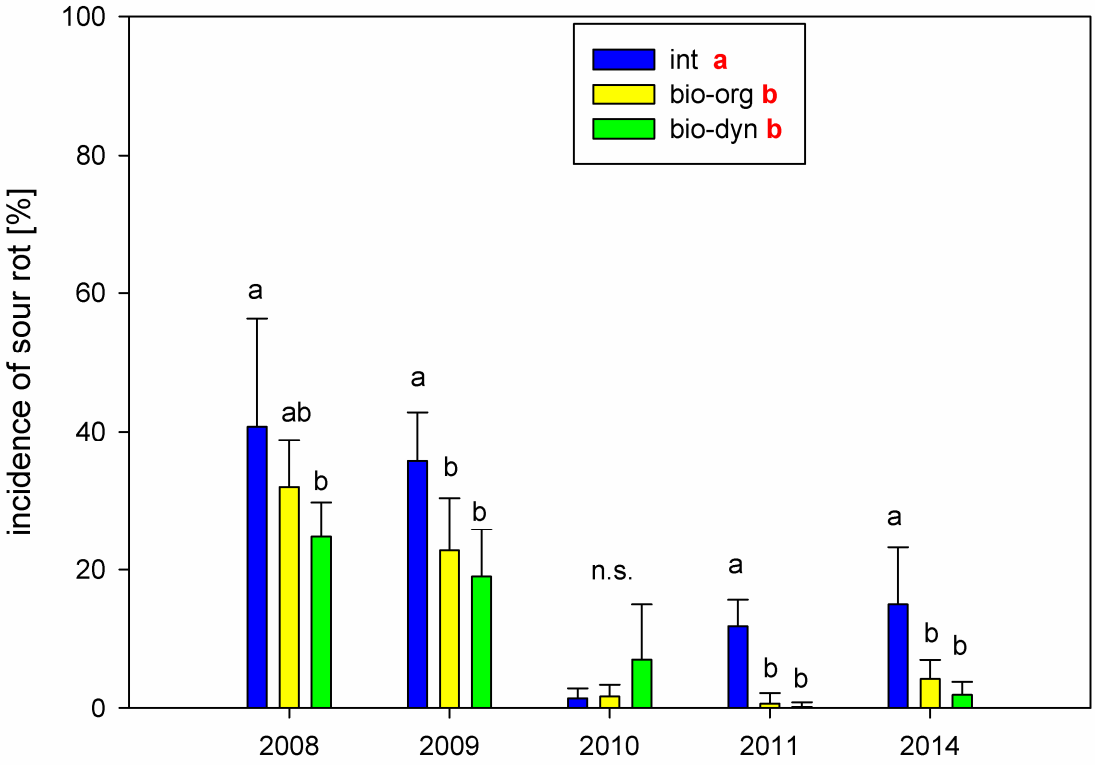

Figure 2. Incidence of sour rot [%] in the system comparison INBIODYN

The smaller berries as well as the improved cluster structure of the grapes combined with the bactericidal effect of the continuously used copper preparations in the bio-organic and biodynamic treatment can account for these differences (Döring et al. 2013; Meißner 2015). It is assumed that the biodynamic preparations stimulate the secondary metabolism of the vines by reducing the water potential (Botelho et al. 2015). Also effects on the regulation of phytohormones by the use of the biodynamic preparations have been observed (Fritz 2000). Some more favorable values for biodynamic farming could also be determined for the canopy structure (vegetative growth, secondary shoot leaf area), as well as for disease incidence of sour rot and downy mildew.

Discussion

These results of an experimental activity during a ten-year-period in the Geisenheim system comparison trial (INBIODYN) show that a conversion into bio-organic or biodynamic viticulture has significant effects. The differences between the systems can be observed in the soil, in vegetative and generative growth and in grape quality.

One reason for the differences in growth of the respective systems could be a regulation through certain phytohormones. In the future studies on various phytohormones should be carried out. According to Fritz (2000), the sensitivity of the plants to phytohormones could be influenced by the use of the biodynamic preparations, in particular the horn silica preparation.

Another reason could be the influence of different cover crop systems on vine growth. Several studies (Lopes et al. 2004; Monteiro and Lopes 2007) show that the management parameter, which highly influences the water availability and the growth of the vines in the existing systems, is the type of cover crop and its transpiration.

Despite the use of botryticides in the integrated variant twice a year, no lower incidence of *Botrytis cinerea* could be observed in this variant. However, incidence of sour rot was significantly lower in the bio-organic and the biodynamic variant. Sensorial ranking tests of the wines in different panels (Meißner 2015; Nikolaus 2014) revealed that the wines from biodynamic management were most frequently ranked #1 and the wines from integrated management were most frequently ranked #3.

For the following years further studies are planned on the canopy structure, the leaf angle and the aromatic potential of the berries.

Acknowledgments

Authors would like to thank the Departments of Geisenheim University (Soil Science and Plant Nutrition; Wine Chemistry and Beverage Research; Phytomedicine) and the different partners of the international advisory team for their help and their support. Furthermore, authors would like to thank Software AG Foundation and FDW for partially funding the project.

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Benefits of grass-clover in an arable crop rotation: a case study from The Netherlands

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Key words: Crop rotation, Arable farming, Grass-clover, Climate change, Adaptation, Organic matter

Abstract

Intensive crop rotations with low nutrient efficiencies, high pest and disease pressure, and decreasing soil quality are dominating in arable farming in The Netherlands. It is likely that these intensive arable crop rotations will be affected by climate change. To sustain agricultural productivity soil quality should be enhanced to cope with the adverse effects of climate change. In this study, we explored options to improve the atypically wide crop rotations of four farmers in West-Brabant (NL) with a leguminous 'rest' crop. We investigated the costs and benefits in terms of soil organic matter balance, labour use, farm profit and nutrient balances for both cereals and grass-clover as 'rest' crops. Combining model calculations and farmer interviews we conclude that grass-clover is a suitable 'rest' crop because it combines low labour requirements, N-fixation and contributes to soil organic matter in such way that subsequent cash crops are best facilitated.

Introduction

Socio-economic and technological development led to increased production intensity of farming systems in the Netherlands after the 1950s (Meerburg et al, 2009). The trend in arable farming has been specialization in one or a few cash crops resulting in intensive crop rotations with lower nutrient efficiencies, higher pest and disease pressure and decrease of soil quality (Van Dijk et al, 2012). Climate change is expected to result in more extreme wet and dry spells and higher temperatures in the Netherlands (KNMI, 2014). This requires improved water holding capacity, which may be done through 'rest' crops contributing to soil organic matter (Mäder et al, 2002). This paper describes a case study of atypical wide crop rotations including leguminous 'rest' crops to preserve soil quality. We investigated the costs and benefits of 'rest' crops in their rotations in terms of soil organic matter balance, labour use, farm profit and nutrient balances.

Material and methods

In 2015 four arable farmers from the west of the province of Noord-Brabant were interviewed. Each of the farms had a collaborative partnership with livestock farmers to exchange roughage for manure. The on average 90 minute interviews elaborated on cropping history and current crop rotation with special attention to soil care in order to be adapted to weather extremes.

To evaluate current crop rotations and explore alternatives, the model FarmDESIGN was used. This is a static multi-objective optimization whole-farm model (Groot et al, 2012) that calculates current

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farm performance in terms of a set of indicators (nutrient balances and flows, labour balance, soil organic matter balance and gross margins). Using the optimization component of the model, trade-offs between multiple objectives can be explored for alternative farm configurations.

Model inputs related to soil characteristics, crops, parcel division and fertilization were derived from the interviews. Yields and farm economics were taken from a national reference guide (PPO, 2015) since exact yields were not known. Grass-clover was treated as annual crop, although it is usually cultivated as multiannual (2 or 3 years). All farms were scaled on 100 ha with identical manure application (cattle slurry, cattle deep litter manure, compost, pig and chicken manure; 72 kg N/ha, 21 kg P/ha), and farm-specific crop rotations were slightly simplified.

Specific objectives for the model calculations were to maximize return to labour, organic matter and nitrogen balance, and to maximizing the labour surplus (i.e. to minimize labour use). A constraint was set for the N balance (N>0) and P balance was constraint to -5 to 15 kg/ha to remain within the legal limits of P application. Decision variables to meet objectives were crops and crop areas. Available crops were grass-clover; peas; wheat-faba bean mixture; maize; onion; chicory; potato; carrot; cabbage; celeriac; oats and wheat. Cereals and grass-clover were seen as 'rest' crops. Total crop area was restricted to 100 ha, and each crop was restricted to maximum 1/6, except for cereals (maximum 1/3 of the rotation) and grass-clover (no restriction). The model outcomes were discussed with the farmers in a 3 hour workshop.

Results

Current crop rotations on the farms consisted of 25-40% grass-clover; 20-35% root crops (potato, carrot) and 25-40% other crops (onion, cabbage, sweet corn). All farms had positive soil organic matter balances, ranging from 400 to 1000 kg/ha, an N surplus of about 80 kg/ha and an economic result (fixed costs excluded) of 3000 to 4000 euro/ha. Manure application was limited by phosphate rather than by nitrogen to meet the official Dutch requirements.

Figure 1 presents the percentage area of grass-clover and cereals in alternative farm configurations in relation to return to labour. Most configurations contained both grass-clover and cereals. Presence of grass-clover has a positive relation with the N, SOM and labour balances but a negative relation with return to labour. Cereals show a similarly positive relation with SOM balance, a slightly negative relation with return to labour, and trade-offs with N- and labour balances. Table 1 shows some configurations with different shares of 'rest' crops and the performance in terms of objectives. It should be noted that configurations with similar shares of ' rest' crops but other (cash)crops in the rotation may perform differently on the objectives.

Figure 2 shows the relation between SOM balance and return to labour, and the relation between labour surplus and N balance. The crop rotations associated with four configurations (A-D) all include at least 25% of rest crops (Figure 2, right hand side). Comparing farm configurations A-D in the two trade-off figures shows that the position of a configuration relative to the trade-off frontier is dependent on the specific objective.

In the workshop, farmers stressed the benefits of grass-clover in the rotation, both for the soil and in terms of labour, and stated that grass-clover is important to enhance soil quality by improving structure, soil organic matter and N fixation, and by having low labour requirements. Replacing grass-clover by cereals would decrease N supply for the succeeding crop, and in addition would involve more work especially for weed management. In relation to this, farmers considered the labour requirements for cereals derived from the reference guide to be too low. Implicitly they also

questioned SOM-balance as only proxy for soil quality as assumed in the model calculations by emphasizing the need of a good structure (e.g. careful use of machinery with GPS, legumes to improve structure).

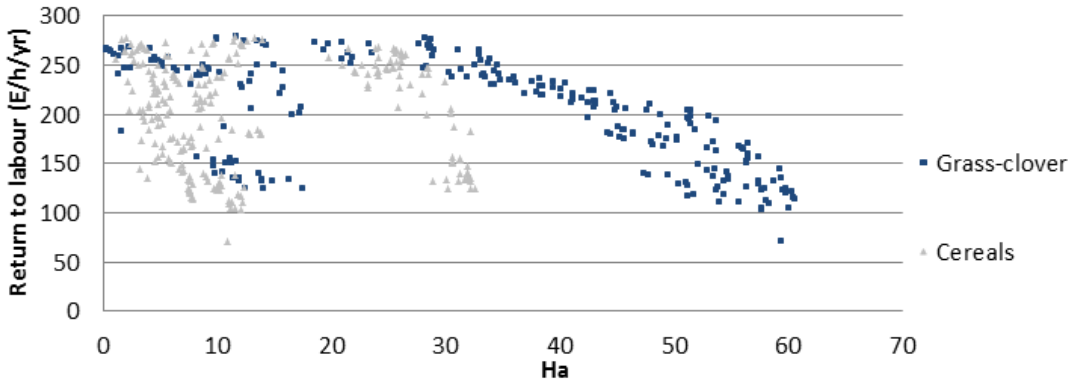

Figure 1: Share of grass-clover (squares) and cereals (triangles) and associated return to labour in the crop rotations found by the FarmDESIGN model. The table shows combinations of grass-clover and cereals in relation with specific objectives used in FarmDESIGN.

Table 1. Combinations of grass-clover and cereals in relation with specific objectives used in FarmDESIGN.

Grass-clover (%)	Cereals (%)	Rest crops (%)	SOM-balance (kg/ha)	N-balance (kg/ha)	Labour surplus (h/yr)	Return to labour (€/ha/yr)
60	8	68	1324	66	973	113
45	8	54	1154	45	251	205
33	0	33	834	31	-157	255
30	10	40	985	31	-8	237
15	27	42	1323	19	-195	220
10	14	24	898	11	-578	275
8	24	32	1142	12	-387	239

Major constraint for incorporation grass-clover, in comparison with cereals, in arable rotations is the uncertain marketing perspective. All arable farmers tackled this constraint by entering into long term collaborative partnerships with dairy farmers, with pre-agreed price and acreage agreements (De Wit and De Adelhart Toorop, 2017). In this way risks were shared between the arable and the livestock farmer. Farmers agreed that in average years cereals could lead to higher economic returns, but they considered cereal production to be more risky in terms of yield and weed infestation than grass-clover. Farmers indicated that other crops in the rotation were more important in determining the final operation profit and did not want to gamble with the rest crops. They were satisfied with their current crop rotations and stressed that important transition costs would be involved in learning to manage an alternative crop rotation.

Discussion

Model calculations showed that replacing grass-clover by cereals as rest cropcan improve current crop rotations in terms of SOM and return to labour, although at the expense of N-balance and labour requirements. If labour requirements for cereals are indeed underestimated as suggested by the farmers, then cereals become even less attractive from this perspective. Farmers mentioned the variability of success of cereal cultivation in terms of yields and weed management, along with potential negative heritage effects. Furthermore, they were content with their current crop rotations and reluctant to incur the transaction costs of moving to a new rest crop with these constraints.

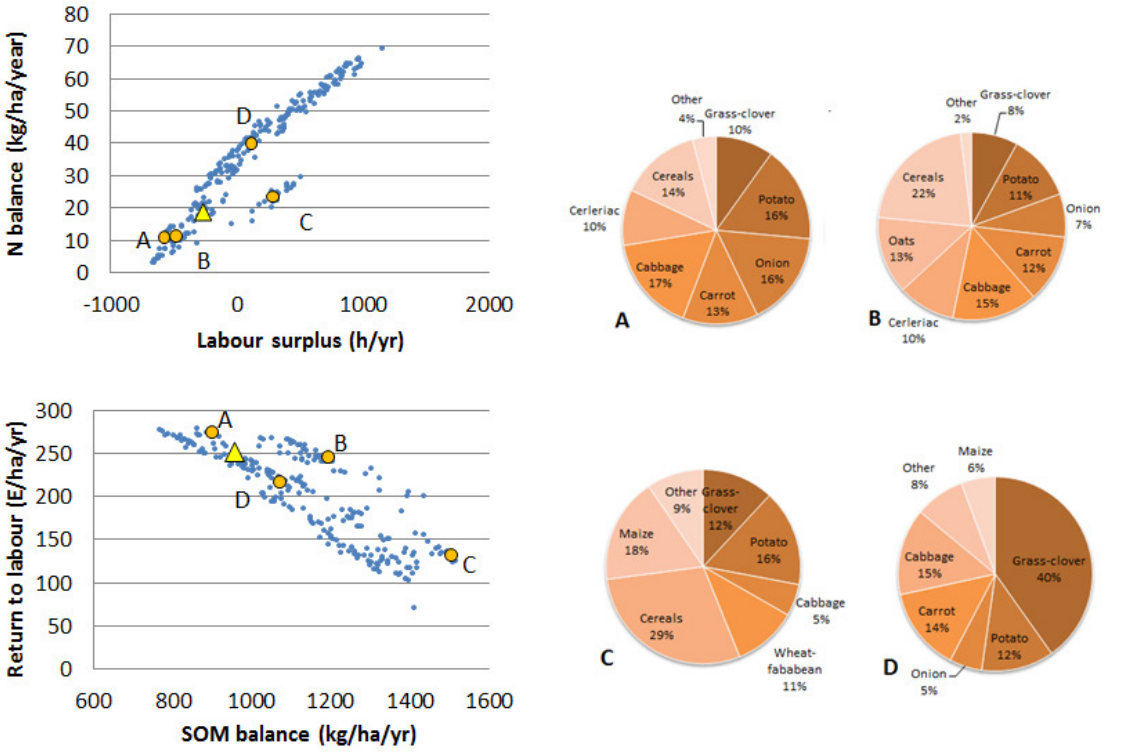

Figure 2: Performance of alternative farm configurations (blue dots) in terms of SOM balance and return to labour (top-left) and N-balance and Labour surplus (bottom-left), and 4 associated cropping patterns (right). The triangle represents the starting farm configuration.

Acknowledgements

The research leading to these results has received funding from the FACCE-ERANET+ Programme which is a transnational R&D programme jointly funded by national funding organisations within the framework of the ERA-NET FACCE-ERANET+.

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VASO Program 2.0, three decades of participatory plant breeding towards the chain value

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Key words: VASO, Maize landraces, PPB, germplasm, Maize bread

Abstract

More than 30 years have passed since the beginning of the Participatory Plant Breeding Program VASO in Sousa Valley Region, Portugal. An overview is presented about motivations, initial goals, development of the project towards transdisciplinary, multi-actor approach and chain development highlighting future needs.

Acknowledgments

Authors acknowledge the H2020-SFS-2014-2 project DIVERSIFOOD (Embedding crop diversity and networking for local high quality food systems- GA number: 633571) for financial support.
The authors acknowledge farmers of the project, ADERSOUSA, Lousada and Paredes Cooperatives, Rosário Bronze (ITQB), Carla Brites (INIAV) and to students, ESAC technicians, and Research fellows (Cláudia Brites, Daniel Gaspar, Manuel Paulo, Emanuel Amaral, Mara Alves, Elsa Mecha, Andreia Bento da Silva, Catarina Bicho, Beatriz Oliveira, Bruna Carbas) that have been contributed to the success of our work.

Introduction

VASO Program started in 1984 at the Portuguese region of Sousa Valley, based on: (i) representativeness of traditional maize area; (ii) the farmers' motivation to whom the decision power would be endorsed; and (iii) the germplasm availability.

Through its story, *VASO Program* aims included: i) breeding maize landraces composite and synthetics for human consumptionunder Participatory Plant Breeding (PPB); ii) development of tools for farmers' selection; iii) progress agronomic practices towards sustainable systems; iv)improve knowledge regarding genetics, food technology and quality; v) connecting actors of the food chain from seed to bread.

The *VASO Program* state of the art is presented considering its phases and perspectives (e.g. maize traditional varieties activities including its adaptation and use to organic agriculture).Organic Agriculture in Portugal, from 1994 to 2014, increased 40 and 30 times in the number of producers and dedicated area respectively.

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VASO Program 2.0. Additions and challenges

From the initial project, *VASO Program* has evolved, at biological to social sciences level, with the opportunity of beinga gathering arena of new insights, knowledge and know how provided from diverse national and international projects.

Germplasm development and use

VASO Program was implemented by a National Maize Breeding public company (NUMI) that considerthe genetic resources conservation crucial for germplasm development.Due to the awareness of the existence of genetic erosion, this institution led systematic collecting missions in the 1970s' with FAO support and the gave raised to a Gene Bank precursor of BPGV.
Gene Banks allowed the conservation of many accessions, however the conserved genetic resources information's from curators were far from the breeders and farmers use. These constraints led to the development ofpre-breeding approaches, such as HUNTERS, Overlapping Index, as well as test-crosses. For NUMI as a company who sold seeds, the option of breeding on farmers' fields for germplasm improvement was very appealing. Being at farmers' fields was also an opportunity to compare farmers with breeder's selection methods (Mendes Moreira et al. 2008).
In addition the initiated studies using diallel crosses and topcrosses started to better elucidate the germplasm applications and crosses potential.
New combinations were developed in order to increase diversity , and new synthetic (e.g. 'Fandango') and composite (e.g. SinPre) populations are presently being adapted and selected for particular locations.

Agronomy

Organic production is undoubtedly an important target for traditional genetic resources, because of intrinsic properties for local adaptation (e.g. tolerance or resistance to pest and diseases) and because generally traditional genetic resources are used to compete with weeds. In addition these resources are being constantly selected for germination and emergence capacity.
Weeds are undoubtedly an important issue in organic agriculture and a key question for some reconversion systems. With this purpose some studies have been conducted where some strategies are presented including animal weed control (e.g. ducks weed control (Pereira et al. 2017 in this conference).
Intercropping is another topic of research that is being explored using the concept of LER (Land Equivalent Ratio) and for which a co-breeding process is fundamental.

Statistical tools

To increase the perception and efficiency in selection work, some methods have been used according the bibliography; other methods have been developed to tackle with participatory approaches such as selection indexes, such as ear value (Mendes Moreira et al. 2014)). Some of this tools can be used to link environment and germplasm allowing to choose the most appropriated in each context.

Laboratory work

Portuguese maize landraces have been preserved on-farm, due to particular quality traits not found on their competing modern hybrid varieties. These landraces are mainly flint type open pollinated varieties (OPV) with technological ability for the production of the traditional maize leavened bread called "broa" that still plays an important economic and social role on Central and Northern rural communities of the country. Due to this, we decided to start studying in more detail the

technological ability for bread production of VASO maize landraces as the major quality trait to breed for. However, later on, it has been described that other quality traits, such a flavor or aromas were also contributing to the consumers' preferences for bread obtained from traditional maize landraces in detriment of maize hybrid varieties (Carbas et al. 2016). Volatile components responsible for the aroma were then also included into our detailed study. Presently and due to consumers higher concern about the quality of their food and how their diet can influence their well-being also antioxidant compounds and their bioactivity are being analyzed on the flour and bread made from our VASO maize varieties (Vaz Patto et al., 2013).

Genetics, particularly molecular genetics helps to determine whether there is a wide enough genetic base for future improvement of the in-situ materials, or whether there is sufficient diversity to provide system resilience. It can also underpin the identification of ways of supporting the maintenance of traditional varieties, such as in supporting protected geographical identification of certain plant or crop product. Presently in the VASO project we are conjugating the identification of agronomic and specific quality traits with molecular characterization (Vaz Patto et al., 2004; 2009) so as to exploit efficiently the local diversity and produce varieties that are superior in marginal environments, but have a broad genetic base and a high quality level. Different molecular markers were tested in order to create new decision supporting tools. We are using simple sequence repeat (SSR or microsatellite) markers and also single nucleotide polymorphisms (SNPs) molecular markers. Molecular markers are being used to achieve two main research objectives. We initially used molecular markers to evaluate the progress obtained in conserving or increasing diversity through participatory breeding, and we are now routinely characterizing genetic diversity of the newly introduced maize landraces to the participatory plant breeding net. This method enables us to check if sufficient diversity is present to allow selection and to select the most promising landraces in order to increase the genetic diversity by crossing genetically distant landraces. These studies have also allowed us to compare the genetic diversity with quality clustering of landraces. Second, we are developing genetic studies to identify the genes responsible for our quality traits of interest and subsequently develop molecular tools that target those genes and that can be useful for marker assisted selection (MAS). Quality parameters for bread making, such as technological, nutritional and organoleptic traits, are generally difficult to grasp by breeders and farmers. The identification of molecular markers that are linked to the controlling genes will be very helpful for the indirect selection through MAS of these complex quality traits. Our objective is that our improved varieties will be attractive to consumers, processing industry and farmers, answering health and environmental public concerns and increasing sustainability of farming systems.

Social environment

VASO Project implementation had direct and indirect results.

The direct results are generally related with selection procedures and its trials, in which farmer can see the results of their options, when, for example, farmer compares his selection with the breeder selection, i.e., conclusions are drawn from his reality and not from what he has been told. Other direct results can be drawn from participatory field trials analyses.

The indirect results are related with the opportunity to interact with local initiatives and to improve them, such as the example of 'Sousa Valley Best Ear Annual Contest' (selection for big ears) organized by the local Farmers' Cooperative Association (Cooperativa Agrícola de Paredes). In this initiative, VASO scientists were able to improve the traits and provide a formula to be used to measure the best ear. On the first edition only the number of kernels were used.

The early connection of VASO project with local institutions and initiatives were able to influence positively the recognition of the farmer by the community, but also has attracted new farmers and

new germplasm to the program that in this way could be identified and preserved on-farm (Mendes-Moreira et al., 2008).

VASO project actors provided an excellent basis to expand the work already done at different level of communication (e.g. from the researcher to researcher, researcher to farmer and vice versa and farmer to farmer). In addition to experiences communication aiming at increasing trust among actors it is crucial to identifyremaining bottlenecks, address political issues and to develop the next research agenda, following a transdisciplinary vision and a multi-actor participatory approach.

Networks

To increase knowledge and know how relations among individuals and institutions are fundamental. VASO Program was able to connect individual farmers and local associations (ADERSOUSA, Cooperativa de Lousada, Cooperativa de Paredes), national associations (Zea +), with academia (PC-ESAC and ITQB NOVA) in a Multi-actor and transdisciplinary approach.
This effort at national and international level is being supported by several projects. In particular, SOLIBAM FP7 and presently DIVERSIFOOD H2020 allowed us to support, enlarge and upgrade to *VASO Program* 2.0.

Discussion

VASO Program addresses our attention to germplasm improvement and its use, in order that our improved varieties will be attractive to consumers, processing industry and farmers, answering health and environmental public concerns, increasing sustainability of farming systems and contributing for a short supply chain and farmers' welfare.

VASO Program 2.0 demands for an increase in organic farming, for which, it is needed education, tuition, guidelines, networks and platforms of communication both at national and international level.

In Conclusion *VASO Program* 2.0 is synergically connected with the overall goals of DIVERSIFOOD (see at this conference Chable et al. 2017).

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On-arm management and site-specific adaptation. A case study with lentil.

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Key words: On-arm management, plant genetic resources, lentil, natural selection, adaptation

Abstract

The effect of 10 generations of natural selection on three diverse farms was studied using three old cultivars of lentil, an autogamous grain legume. On-farm management led to population changes in agronomic, morphological, and phenological traits in time and space. A 'home field advantage' was not observed but a slight yield increase over time and in one case by selection at the most stress prone farm. In one cultivar at each farm a specific seed weight was favoured by natural selection. To use the full potential of on-farm management diverse initial populations should be used. On-farm management has the potential to increase the supply with adapted organic seed.

Acknowledgments

We are grateful for funding by the DFG and Software AG Foundation. Many thanks to our colleagues on farm for many years of cooperation.

Introduction

Farm saved seed is widely used on the global scale in organic agriculture for two reasons: i) The concept of the 'farm organism' aims to reduce external input and to increase the mutual benefit of the different parts of the farm including crops adapted to the local conditions (Steiner 1974; original lecture 1924). ii) In particular in highly diverse pedoclimatic conditions and poor areas adapted cultivars often are not available or are too expensive. Despite limited resources smallholders have a fundamental role in the stewardship of biodiversity, in food production and sustainable rural economies (IFOAM 2011a). On-farm management of plant genetic resources (PGR) is also discussed as a valuable complementary approach to *ex situ* maintenance in genebanks to keep PGR in use and in addition contribute to agricultural biodiversity as well as reduce the risk of erosion of knowledge about minor crops (Veteläinen et al. 2009; CBD 2016). On-farm management allows for evolutionary adaptation to site-specific conditions by natural selection. However, knowledge about the development of genetic diversity by on-farm management at multiple sites is still scarce. Earlier studies had shown significant changes in agronomic, morphological, and phenological traits in generation 5 of natural selection (Horneburg and Becker 2008).

In this study lentil was used as a model crop to study temporal and regional development of old cultivars on-farm, to measure the changes of phenotypic and genotypic diversity, and reveal the potential of adaptation to diverse farms by natural selection. Lentil is one of the most important grain legumes in the world. It is an autogamous species with an outcrossing rate of about 0 to five percent (Horneburg 2006).

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Material and methods

In a long-term experiment, three old lentil cultivars received from the genebank IPK Gatersleben were exposed to ten generations of natural selection at three farms under rainfed conditions during 1996-2010. Two of the farms are situated in Central Germany (Reinshof, loess, conventional; Schönhagen, clay, biodynamic), one in Northern Germany (Tangsehl, sand, biodynamic). The biodynamic farms are on poor or marginal soils.

For the present study, populations in generations 0, 5, and 10 were multiplied once in 2014 to obtain equal seed quality for subsequent field tests. This was done in a low stress environment with low planting density and covering by a rainout shelter during ripening to assure for optimal conditions and reduce non-intended natural selection during seed multiplication. In 2015 and 2016 all populations were tested in 5 m² field plots with 100 seeds per m². A split-plot design (main factor cultivar) with four replications was used at all three farms.

Results

Results from the 2015 field trials indicated a yield increase **over time** resulting in a higher mean yield for generation 10 (Figure 1). However, yield increase was not significant at $p<0.05$.

Observations in generation 5 (Horneburg and Becker 2008) indicated **site-specific adaptation** ('home field advantage'), i.e. a superior performance at the site of selection (the farm) compared to populations selected at the other farms. This could not be confirmed (Figure 2). The **selection site** did have an effect on natural selection: In the cultivar Pisarecka Perla the population selected at Tangsehl produced the highest seed and straw (data not shown) yields (Figure 2). Tangsehl is the farm with the most stress prone conditions as indicated by the low yield level shown in Figure 2. In Pisarecka Perla significant site-specific changes in seed weight and flowering were observed (Figure 3). At Reinshof larger seeds were selected and flowering was delayed; at Tangsehl natural selection reduced seed weight and favoured early flowering.

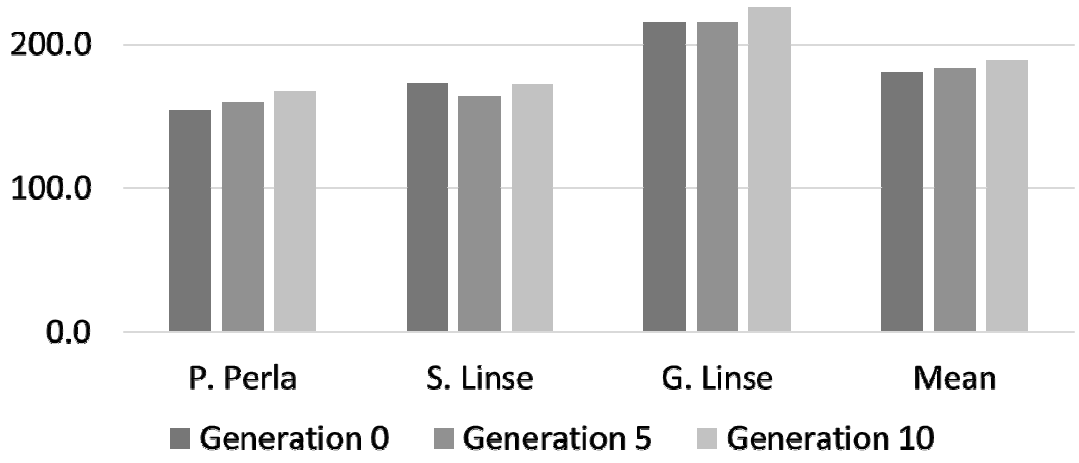

Figure 1. Seed yield [g m^{-2}] of three lentil cultivars (Pisarecka Perla, Schwarze Linse, Gestreifte Linse) in generation 0, 5, and 10 of natural selection. Mean of three farms.

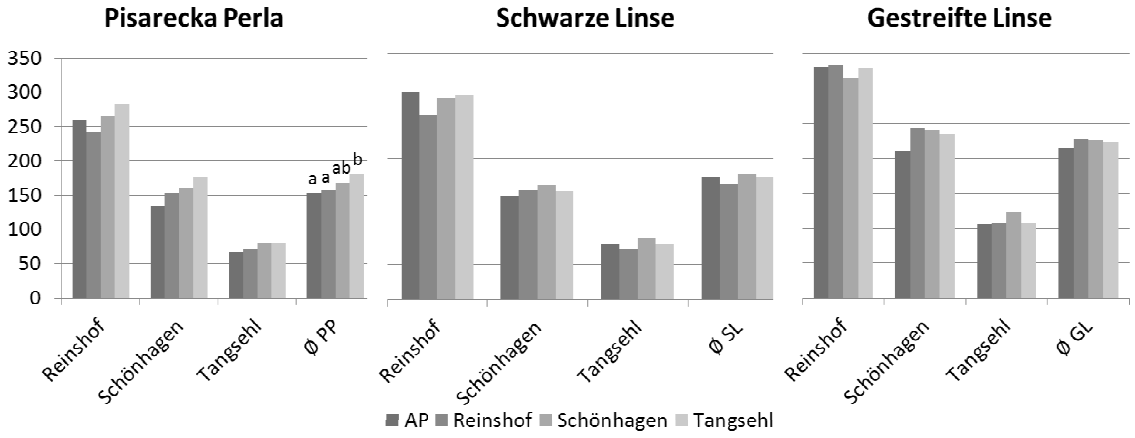

Figure 2. Seed yield [g m^{-2}] of three lentil cultivars grouped by four populations within each cultivar (left to right, AP = generation 0, generations 10 selected at Reinshof, Schönhagen, and Tangsehl) tested at the same three farms.
Data with different letters are significantly different in Tukey's Test at p=0.05.

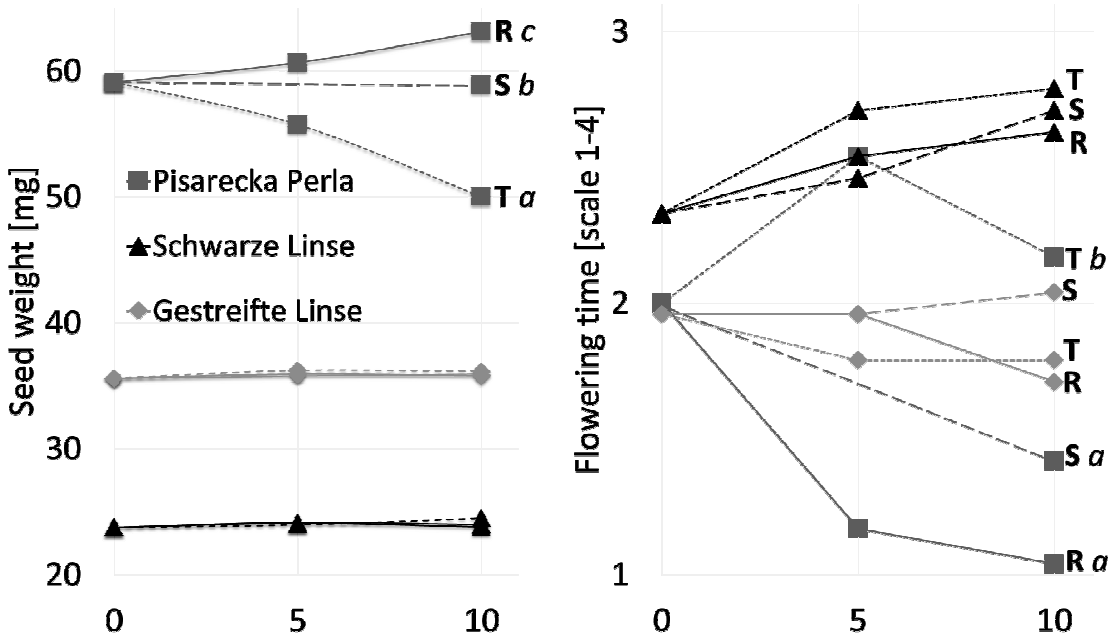

Figure 3. Generation- (0, 5, 10) and site-specific (R, S, T) changes in seed weight [mg] and flowering time (higher value=earlier flowering) for three lentil cultivars.
Data with different letters are significantly different in Tukey's Test at p=0.05.

Discussion

Despite the relatively short period of 10 generations, natural selection on-farm led to significant differentiation in agronomic, morphological, and phenological traits in time and space. The strongest evolution was observed for Pisarecka Perla, the cultivar with the highest level of diversity at the beginning of the project (Horneburg & Becker 2008). There are no simple answers how to select for increased yield on-farm; there are clear indications, however, that stress prone farms should be included. Interestingly natural selection did not necessarily lead to reduced seed weight, as might be expected; selection was site-specific and apparently changed towards the local optimum.

The experiment was continued for a second year; data are not yet available. In addition adaptive traits and site specific development are studied by single plant progenies and SNP molecular markers.

To use the full potential of on-farm management populations with high initial genetic diversity should be used. In the research presented here the strongest site-specific effects where observed in Pisarecka Perla, the most diverse cultivar. Improved on-farm management has the potential to improve sustainable organic smallholder systems as demanded by IFOAM (2011a). With mutually supportive networking organic plant breeding can select and develop populations for on-farm management while genotypes deriving from natural selection on-farm can improve breeding programs. According to the IFOAM Position on the Use of Organic Seed and Plant Propagation Material in Organic Agriculture (2011b) we need to increase quality and quantity of organic seed available. On-farm management can help to improve future supply.

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Bioporing: yield insurance during dry spells?

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Key words: rooting density, nutrient acquisition, biopores, crop sequence

Abstract

Large vertical biopores generated from growing tap-rooted precrops can serve as preferential growth paths for roots of subsequent crops and generally enhance root growth in the subsoil. In this study, the effect of biopores generated by chicory (tap-rooted) vs. fescue (homorhizous root system) grown as precrops on crop performance of spring barley and spring oilseed rape was assessed under dry conditions. In the first year following a dry winter, chicory resulted in higher root length and higher shoot biomass and grain yield of spring barley. In the second year, spring oilseed rape grown after chicory under rain shelters had a higher ratio of shoot biomass to root length. The results indicate that higher biopore densities in the subsoil can result in an optimized spatial distribution of roots in the subsoil with respect to the acquisition of water and nutrients under dry conditions and thus increase resilience.

Acknowledgments

This study was supported by the German Research Foundation (Deutsche Forschungsgemeinschaft – DFG) within the framework of DFG PAK 888. Details of the field trials potentially open for external researchers: www.for1320.uni-bonn.de.

Introduction

Increased use of subsoil resources by annual crops enables enhanced nutrient and water acquisition. This is relevant particularly i. under conditions of limited nutrient availability, as under organic management renouncing the application of easily plant available mineral fertilizers, and ii. during dry spells, which are predicted to increase in the course of climate change in Southern and Central Europe (IPCC 2007). One option to increase yield stability is to support root growth in the subsoil via generating large vertical biopores by growing tap-rooted precrops. These biopores can serve as preferential growth paths for roots of following crops, which is presumably relevant particularly under conditions of drought and nutrient limitation.

In the presented study, the effect of growing two precrops with contrasting root systems on root-length (RL) and biomass or grain yield of spring barley and spring oilseed rape as first and second subsequent crop was tested under conditions of natural or induced drought (rain shelter) and nutrient limitation (omitted fertilization). Our hypothesis was that the increased density of large sized biopores after chicory would result in higher RL in the subsoil and higher yields. We expected the positive effects on roots to be more pronounced, resulting in a lower ratio of shoot biomass to root length.

Material and methods

The field trial is situated at the experimental station Klein-Altendorf near Bonn on a deep loamy soil (WRB: Haplic Luvisol) which before had been used for growing sugar beets and cereals. The

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soil is frequently plowed to 30 cm depth. In the Bt horizon (41-115 cm depth) the clay content is about 25-30% and the bulk density is up to 1.6 g cm^{-3}.

The perennial fodder crops chicory (*Cichorium intybus* L.) with a pronounced taproot and tall fescue (*Festuca arundinacea* Schreb.) with a homorhizous root system were grown in a field trial with four field replicates and 12 x 9.5 m plot size in the years 2012 and 2013. After plowing the fodder crops in fall 2013 and growing *Phacelia tanacetifolia* Benth. as a cover crop, spring barley (*Hordeum vulgare* L.) was grown in 2014, followed by spring oilseed rape (*Brassica napus* L.) in 2015. Both crops were not fertilized.

During the vegetation period of spring oilseed rape, rain shelters were installed over half of the plots. The shelters were removed during dry periods to minimize greenhouse effects. Root-length density was quantified for both crops with the profile wall method (Boehm, 1979) five times during crop growth, 2014 in three and 2015 in two field replicates. Simultaneously, shoot dry matter was determined on 2 x 0.25 m². From both parameters, the ratio of shoot biomass to root length was calculated. For barley, grain yield was measured, for oilseed rape total biomass was determined close to harvest since grain yield was severely affected by pollen beetle attack. Figure 1 shows the climatic water balance before and during the growing seasons.

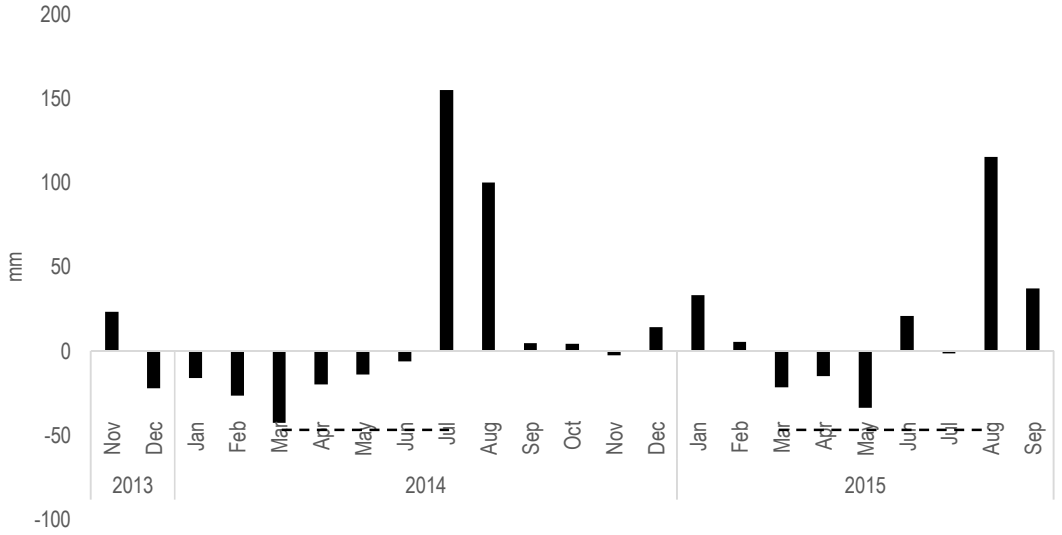

Figure 1. Climatic water balance at the experimental station Klein-Altendorf November 2013 to September 2015. - - - Vegetation phases.

Results

Chicory and fescue stands were well established during the precrop phase with yields of 8.1 and 6.6 t ha^{-1} shoot dry matter for chicory and 5.8 and 5.6 t ha^{-1} for fescue in 2012 and 2013 respectively.

Spring barley (2014): Grain yield was generally very low (Tab. 1). RL in the subsoil (Fig. 2a) was consistently higher after chicory during the vegetation period except for the last sampling date, grain yields were also significantly higher (+29%, Tab. 1).The ratio of shoot biomass to root length was slightly higher in later growth stages (Fig. 2c).

Spring oilseed rape (2015): Shoot dry matter of spring oilseed rape was also generally very low (Tab. 1). Without rain shelter, RL (Fig 2b) was consistently higher throughout the vegetation period and shoot dry matter (Tab. 1) was 3% lower after chicory, resulting at most dates in a lower ratio of shoot biomass to root length (Fig. 2d). With rain shelter, RL was about equal after both precrops

and shoot dry matter was 12% higher after chicory, resulting in a consistently higher ratio of shoot biomass to root length (Tab. 1, Fig. 2b,d).

Table 1: Grain yield of spring barley (t ha^{-1}) 2014 and shoot dry matter of spring oilseed rape (t ha^{-1}) 2015 as affected by 2012/2013 precrops chicory and fescue and rain shelter 2015

Precrop	Spring barley (2014)	Spring oilseed rape (2015)	
	unsheltered	unsheltered	sheltered
chicory	2.46 a	5.08	5.21
fescue	1.90 b	5.21	4.64

Small letters: significant differences between precrop treatments (ANOVA, $p<0.05$).

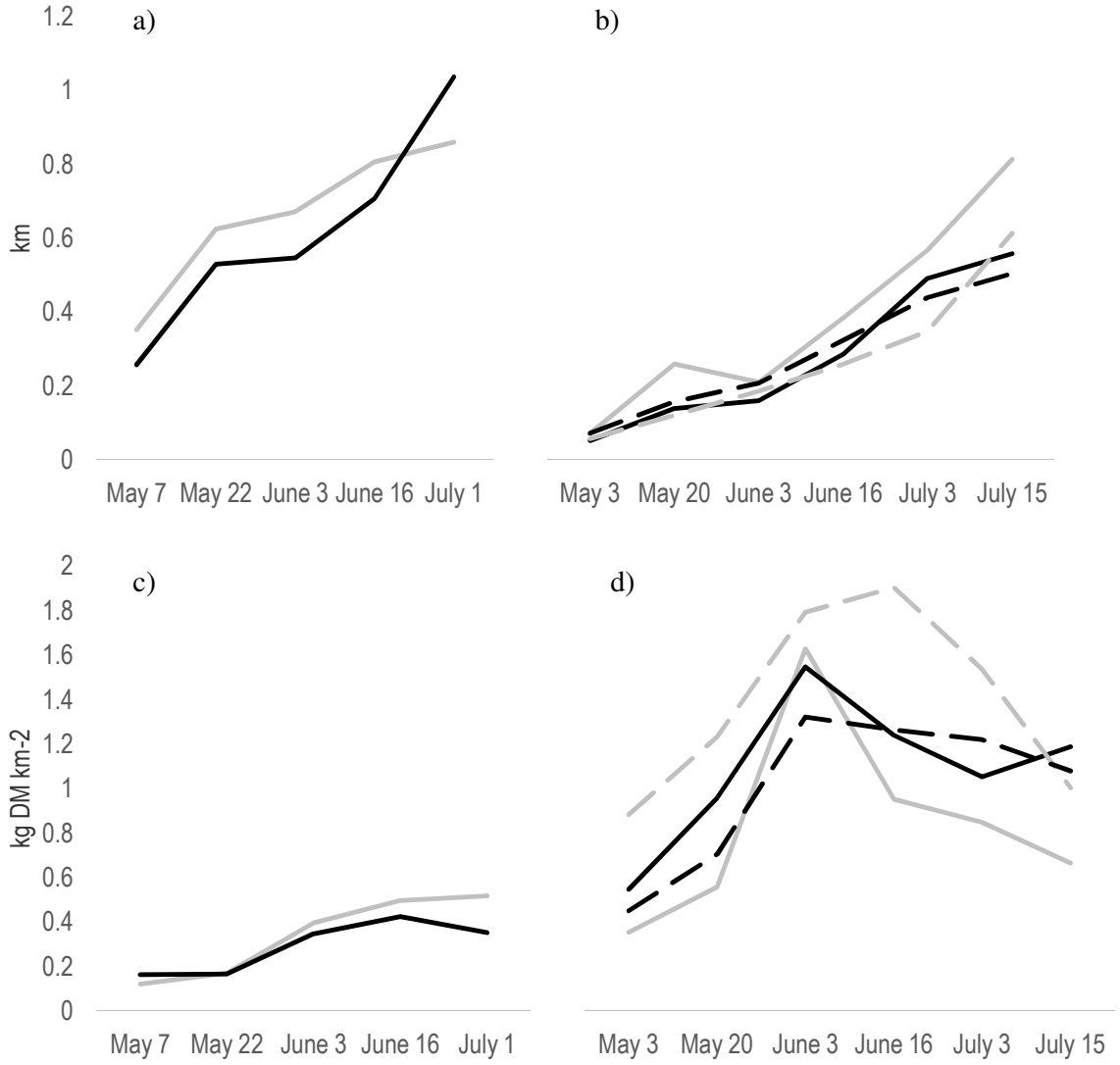

Figure 2. Root length (a, b) and ratio of shoot biomass to root length (c, d) of spring barley 2014 (a, c) and spring oilseed rape 2015 (b, d) after precrops chicory and fescue, 2015 also with and without rain shelter.

–precrop chicory, **–**precrop fescue, dashed: with rainshelter, solid: without rainshelter.

Discussion

Preceding investigations at the site under study have shown that fescue as a precrop increased air capacity in the subsoil (Perkons et al. 2014), while precrop chicory resulted in an increased number of large sized biopores (Han et al. 2015). Consequently, precrop fescue promoted growth of fine roots of following crops in the topsoil and upper subsoil (Perkons et al. 2014, Han et al. 2016). Root-length density and water uptake in the deeper subsoil was increased after tap-rooted precrops (Perkons et al. 2014, Gaiser et al. 2012), as biopores were intensively colonized by roots, which were apparently able to re-enter the bulk soil (Athmann et al. 2013). These previously described differences in root growth did not affect yields. In the presented study, crop performance was assessed under dry conditions. Our hypothesis that the increased density of large sized biopores after chicory would result in higher RL in the subsoil and higher yields was confirmed for spring barley after the comparably low winter rainfalls in 2013/14. At moderate drought underneath the rain shelters in 2015 the chicory precrop resulted in lower RL of spring oilseed rape in the subsoil – but also in a consistently higher ratio of shoot biomass to root length throughout growth.

These results indicate that with the overall strategy to increase yield stability by optimizing root systems we have to describe root growth not only in terms of root-length density, but also consider increases in efficiency through optimized spatial distribution of roots in the structured subsoil with respect to the acquisition of water and nutrients.

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Use of ducks in weed control in organic maize compared to other weed control techniques

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Key words: ducks, maize, organic farming, weeds, yield, soil

Abstract

The present study aimed to compare the effect of grazing with Pekin duck on weed control in a maize traditional variety conducted in organic farming with other weed control methods: technical control, propane flaming and mulching with woodchips. In addition, changes of soil physicochemical parameters were monitored from sowing to after harvest. The weight of the ducks was evaluated throughout the essay and the yield of the maize was quantified.

The analyses of the treatments revealed that the yield of maize (kg.ha^{-1}) did not vary significantly amongst treatments. In soil, the use of ducks led to a decrease in calcium content and to an increase in bulk density.

Grazing with ducks resulted in similar control of the weeds as flaming and mulching, when both were applied after weeding. Results of these three treatments were similar to technical control and better than the control without any weed removal, indicating that such treatments may be worthwhile in weeds control in organic maize.

Acknowledgments

Authors acknowledge the H2020-SFS-2014-2 project DIVERSIFOOD (Embedding crop diversity and networking for local high quality food systems- GA number: 633571) for financial support.

The authors acknowledge to José Borralho, Manuel Nunes and Emanuel Ferreira for their support on field work, and to PC-ESAC soil laboratorypersonal.

Introduction

Weed control emerges as one of the major problems of organic farming in temporary crops. The most common used control measures are mechanical or manual weeding. The use of ducks has shown success in other crops, such as orchards (Pardini 2001) and rice (Li *et al.*2012;Suh 2014), where they have contributed to simultaneously control weeds and pests associated with crops. The expectation is that ducks can be a profitable solution also in the maize crop. The maize used was "Pigarro" a regional variety (FAO 300) (Mendes Moreira *et al*. 2008), and Pekin duck was selectedfor the alternative control of weeds.

The goal of this study was to compare the effect of grazing with Pekin ducks, with the traditional technique, the propane flaming and the mulching with woodchips in the row as weed control techniques. The parameters evaluatedwere the percentage of cover of weeds, maize yield and physicochemical changes in the soil.

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Material and methods

The maize sown was "Pigarro" (Mendes Moreira *et al.* 2008), a landrace under long term mass selection, obtained in organic production the previous year, on the farm of the Coimbra College of Agriculture. Mechanical sowing was carried by a 4 row sowing machine spaced 75 cm, using a seed density of 86 000 seeds per ha. Each plot had an area of approximately 20 m^2 (3 m x 6.67 m).

Twenty five Pekin ducks were bought from an intensive housing system with 4 weeks of age with a mean body weight of 1.88 kg. During the assay they had a 20 % quantitative food restriction, with weekly correction. The ducks stayed overnight at the shelter and were daily transported to the test field; water was supplied to ensure their water needs. The ducks were placed in the field at 8:30 am and removed around 4:30 pm.

Trials were established according to a randomized complete block design with three replications. The treatments were: T1= woodchips applied after sowing, T2 = woodchips applied after weeding, T3= propane flaming applied after the appearance of the first seedlings, T4= propane flaming applied after weeding, T5= grazing with ducks after weeding, T6=technical control, T7= traditional weeding, T8= control without any weed removal.

The data collection of yield was performed in the two central rows of each plot, corresponding to an area of 7.50 m^2 (1.50 m x 5 m). The weed species inventory in each plot was carried out in the beginning and in the end of the weed interference critical period with the maize, and at harvest. Soil cover and abundance were registered for each weed species, as well as its identification to species level and their phenological stages. The soil samples were collected three times: before the entry of the ducks in the field (1), shortly after their departure (2) and 6 weeks after (3), in order to check possible changes in the medium term. The soil parameters assessed were: pH, EC (electrical conductivity), OM (organic matter), P_2O_5, K_2O, Ca, Mgand bulk density.

Results

Weed cover in the different treatments

T1 and T8 treatments presented similar results between the rows and statistically different within the row, at the end of the critical period of weed interference with maize, evidencing the effect of the woodchips on the row (Figure 1A).

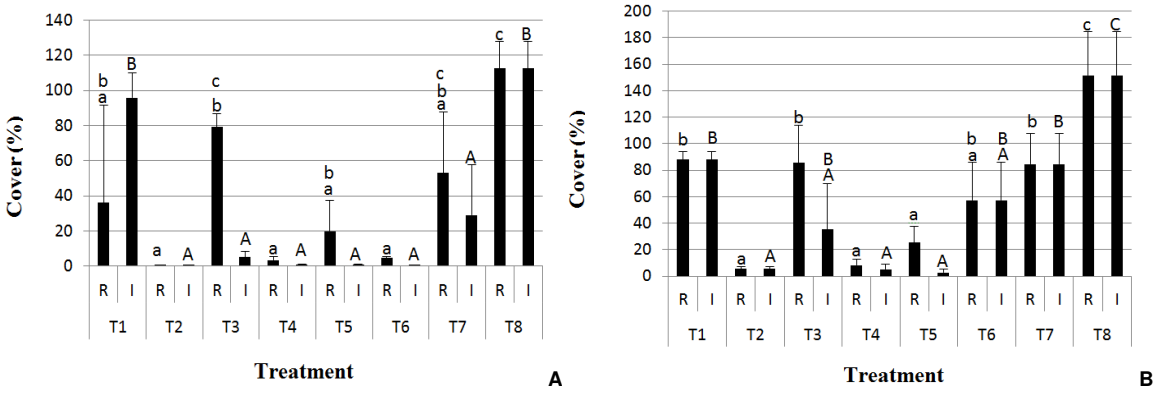

Figure 1: Total weed cover (mean + standard deviation at row (R)/ inter row (I), at the end of the critical period of weed interference with maize (A) and at the harvest (B), in the different treatments applied

(T1 = woodchips applied after sowing, T2 = woodchips applied after weeding, T3= propane flaming applied after the appearance of the first seedlings, T4= propane flaming applied after weeding, T5= grazing with ducks after weeding, T6= technical control, T7= weeding, T8= control without any weed removal). Bars with the same letter (separating capital and small letters) are not significantly different (Tukey's test P<0.05).

Treatments T2, T4, T5 and T6 (after weeding) and T7 (weeding) proved to be more effective in preventing the weeds, more pronouncedly into the row but also between the rows.

At harvest, weed development increased at T7, which revealed a proportion of weed cover statistically higher to T2, T4 and T5 treatments (Figure 1B).

Phenological status of the main weed species at harvest

In the treatment T2 only the species *Amaranthus retroflexus* completed its life cycle in the inter row and *Portulaca oleracea* in the row (Table 1). With the use of the propane flaming in the inter row of T3 and T4 no species completed its life cycle until harvest. With grazing of ducks in T5, *Cyperus esculentus* revealed a delay in its development when compared with the other treatments.

Table 1: Phenological status of the main weeds at harvest, at row (R), inter row (I)

Species	Treatments															
	T1		T2		T3		T4		T5		T6		T7		T8	
	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I
Amaranthus retroflexus	3,4	3,4			2,3,4	2	2,3,4	1,2	2,3,4	2,3,4	2,4	2,3,4	2,3,4	2,3,4	3,4	3,4
Cyperusesculentus	2,5	2,5		2	3	2	2	1,2	3	2	5	5	5	5	5	5
Daturastramonium	3,4,5	3,4,5	2	2	2,3,4		2,3,4	2	2,3,4	3,4	2,3,4	-	3,4	2,3,4	4,5	4,5
Portulaca oleracea	4,5	4,5	5	2,3	2,3,4	3	2,3,4	2,3	2,3,4	2,3,4	2,3,4	-	2,3,4	-	4,5	4,5

1=seedlings, 2= leaves only, 3=with flower, 4= with fruits, 5= dead

Yield of maize in different treatments

The maize production was similar amongst all the treatments (Figure 2) but it was conditioned by other factors (e. g. wild animal damage) which limited the conclusions about this parameter beyond the application of treatments.

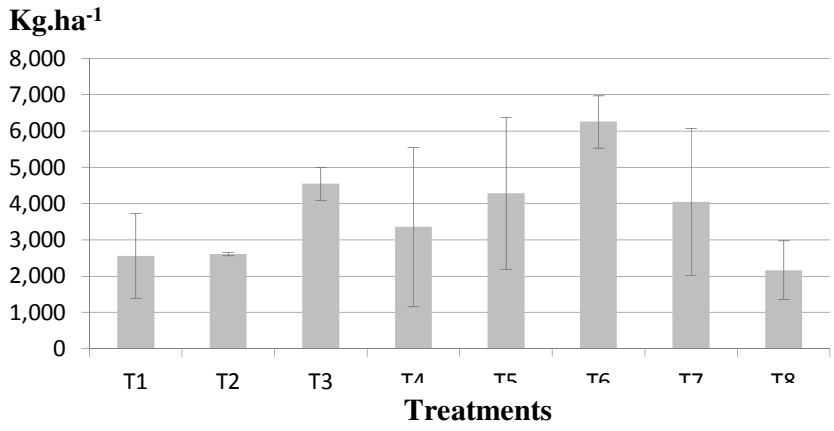

Figure 2: Maize production at 14 % moisture (mean +/- standard deviation) in the different treatments (Abbreviations as for Figure 1).

Soil analysis

Regarding soil parameters (Table 2), changes were only observed in the calcium content, shortly after the departure of ducks, for the duck grazing (T5) and woodchip mulching (T2) treatments with a significantly lower value in this nutrient. In addition, a higher value of bulk density was observed

6 weeks after in the treatments with ducks (T5), propane flaming (T4) and woodchips mulching (T2).

Table 2: Physicochemical changes in soil during the experiment (1- before the entry of the ducks in the field, 2- shortly after their departure, 3- 6 weeks after ducks departure). (Other abbreviations as for Figure 1)

	Treatment	pH	EC	OM	P_2O_5	K_2O	Ca^{2+}	Mg^{2+}	Bulk density
			mS. cm^{-1}	%	$mg.kg^{-1}$		meq.100 g^{-1}		$g.cm^{-3}$
1	T2	6,43	0,05	2,45	174	187	5,86	0,77	1,32
	T4	6,30	0,09	2,37	166	184	4,88	0,69	1,26
	T5	6,10	0,13	2,45	167	185	8,33	0,68	1,30
	T6	6,17	0,08	2,28	139	188	3,97	0,57	1,40
	T8	6,33	0,04	2,36	126	165	3,85	0,58	1,27
2	T2	6,67	0,07	2,69	167	190	6,11b	0,65	1,27
	T4	6,53	0,05	2,56	157	180	7,97a	0,69	1,35
	T5	6,43	0,07	2,74	172	199	5,03b	0,60	1,39
	T6	6,50	0,06	2,50	138	186	7,94a	0,63	1,31
	T8	6,53	0,05	2,72	126	150	9,35a	0,70	1,29
3	T2	6,60	0,06	2,67	173	194	3,01	0,63	1,43a
	T4	6,50	0,08	2,44	168	176	2,96	1,09	1,40a
	T5	6,50	0,06	2,53	169	173	2,78	0,54	1,38a
	T6	6,33	0,07	2,24	133	164	2,33	0,48	1,34ab
	T8	6,37	0,04	2,64	139	175	2,93	0,62	1,24b

Means followed by the same letter are not significantly different (Tukey's test $P<0.05$)

Discussion

The results indicated that the proposed treatments can be interesting alternatives for weed control in maize.The different treatments revealed some influence in the normal development of the weeds, preventing, in some cases, that they completed their life cycle (Table 1).

For the tested and short-term conditions, control of weeds with ducks showed no significant improvement in yield and the physicochemical properties evaluated in the soil, compared to the methods regularly used in organic farming. A higher value of soil bulk density with ducks may be tied up with the drinking water spillage and tamping, considering they were growing and getting reaching 3.1 kg at the end of the trial. An additional option to be tested could be to allow the ducks to spend 24 hours in the field. In such option the risk of predators should be overcome. A previous training period should be also considered to adapt the ducks behaviour for grazing, what could contribute to achieve better results.

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Bioactive component prediction of oat by portable diffuse reflectance field spectroscopy

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Key words: oats, field spectroscopy, Healthy Minor Cereals, phytonutrients

Abstract

The demand for functional food with high phytonutrient content is continuously increasing, and breeding strategies are the first steps in order to fulfil new human requirements and environmental challenges. The main research goal of this study was to develop a method for identifying secondary metabolites, polysaccharide β-glucan and macro and micro nutrients of oats by using diffuse near-infrared reflectance spectroscopy, in order to complete, and if possible substitute standard wet chemistry analyses. In the first step, database and spectral libraries were built up with spectral measurements and corresponding wet chemistry results that were obtained in the frame of the Healthy Minor Cereals FP7 project in 2013. Database analyses were conducted using different variable selection strategies and regression modelling. Preliminary results showed good prediction possibilities, and confirmed that it is essential to continue with the research and to enlarge the database so as to build more robust prediction model.

Acknowledgments

The authors wish to thank to the Hungarian research Institute of Organic Agriculture for financial support and to M. Chourova (Selgen, Krukanice) for growing and providing the oat samples, as well as to S. Kutschka and H. Grausgruber for samples dehulling.

Introduction

Oat is a great source of phytonutrients as well as well-balance amino acid components (Butt *et al.* 2008, Sur *et al.* 2008). Moreover, crops with high antioxidant capacity showed also resistance to biotic and abiotic stress, and more stable yield (Finckh 2008). Incorporating these components as breeding targets may be essential for food security and improvement of organic farming due to expected challenges of climate change. Numerous studies have evaluated bioactive components through wet chemical methods that are reliable but expensive, have toxic waste, and are destructive with respect to samples. For overcoming these limitations, the application of non-destructive techniques increased in the last years (Alander *et al.* 2013). Nevertheless, in the context of health-beneficial components in oat, the use of portable NIR spectroscopy on whole grain has not yet been reported. Therefore, our research aim was to identify antioxidant capacity, phenolic acids, β-glucan,

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protein, phosphorus, iron and zinc of oats by using diffuse near-infrared reflectance field spectroscopy, as an "out-of-the-lab" method.

Material and methods

Materials

Oat samples were obtained in the frame of the Healthy Minor Cereals FP7 project. The dataset contained 100 oat genotypes that were grown on the Krukanice breeding station, Czech Republic in 2014. The aim of trails was characterized oat accessions to determine their potential (resistance, yield, processing quality and phytonutrients) for developing new commercial varieties under organic and low-input cropping system. All samples were stored at room temperature in packages of 2-3 g per sample. The samples were scanned first as a whole seed and then as a whole-meal flour.

Measurements of phytochemicals

Diffusion reflectance field spectroscopy

The first step was to capture spectral data with the use of ASD FieldSpec 4 Wide-Res spectroradiometer device. FieldSpec is a mobile spectroscopy device that has a spectral range of 350 - 2500 nm with a spectral resolution of 3 nm at 700 nm and 30 nm at 1400/2100 nm and sampling interval of 1.4 nm at 350 - 1000 nm and 2 nm at 1000 - 2500 nm. It has also three detectors for the spectral region of 350 nm to 1000 nm it uses a 512 element silicon array diode, from 1001 nm -1800 nm and 1801 nm - 2500 nm it uses Graded Index InGaAs Photodiode, Two Stage TE (FieldSpec 4 Wide-Res Field Spectroradiometer, 2016). 100 oat samples have been scanned with four replications which were averaged and smoothened with ASD ViewSpecPro version 6.2 software. Diffuse reflectance measurements were carried out at the Leipzig University, Germany. Afterwards, averaged spectrum from each sample was used for further extraction of valuable information on demand chemical components.

Traditional laboratory analysis

Wet analyses of oats were carried out at the Sabanci University, Faculty of Engineering and Natural Sciences in Istanbul, Turkey. The chemical analysis served as reference data in our trial. The dataset of oat phytochemicals was used as the validation dataset of spectroscopy data. For determination of mineral nutrients dried and ground grain samples were acid-digested in a closed-vessel microwave system (MarsExpress; CEM Corp., Matthews, NC, USA). The concentrations of all mineral nutrients were determined by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) (Vista-Pro Axial; Varian Pty Ltd, Mulgrave, Australia) as described by Kutman et al. (2014). Nitrogen concentrations in the samples were determined after dry combustion (950°C) of dried and ground sample by using LECO TruSpec® CN Analyzer (Leco Corp., St Joseph, MI, USA). The determination of phytic acid in 0.2 N HCl extracted samples based on precipitation of ferric phytate and measurement of iron in the supernatant as described by Haug and Lantzsch (1983). The total antioxidant activity assay was conducted according to Miller and Rice-Evans (1997) with some modifications. Folin-Ciocalteu specterophotometric method of Dragovic-Uzelac *et al.* (2010) was used for the determination of the total phenolic content (TPC) concentration. β-glucan concentration of seeds samples was analyzed by using the Megazyme analysis kit (Megazyme Ltd. Ireland) that is based on the mixed-linkage β -glucan assay procedure (McCleary method) (McCleary and Glennie-Holmes 1985).

Statistical analysis

Data analysis was conducted using different regression methods in conjunction with variable selection and dimensionality reduction techniques. In particular, a mutual information-based

variable selection strategy (Durand *et al*. 2007), Competitive Adaptive Reweighted Sampling (CARS) (Li *et. al* 2009), Principle Component Analysis (PCA) and kernel Principle Component Analysis (KPCA) (Wold et al. 1987) have been utilized. Regression analyses were conducted using Partial Least Squares (PLS) (described by Wold 2001) Support Vector Regression (SVR) (Rinnan *et al*. 2009), Gaussian Process Regression (GPR) and neural networks (Chen *et al.* 2007). This multivariate calibration tools has been incorporated in order to handle collinear and noisy data. Data set was divided in 80:20 ratio for cross-validation performance. Improvements in estimation accuracies are often achieved by selecting the most informative spectral variables instead of using the entire available spectral range. The optimal selection of spectral variables also tends to reduce the complexity of the multivariate model and the computational effort to finally retrieve estimates for the studied properties. Statistical analyses and calibration model development were performed in R and MATLAB statistical programs.

Results and Discussion

The demand for out-of-the-lab inventories initiated the early field spectroscopic experiments with non-imaging point measurements, which originated from laboratory spectroscopy and required developments in photonics and portable platform techniques. From the beginning, portable or hand-held field spectroradiometers were very popular as they assured flexible, non-destructive and rapid data acquisition. Thus, spectroscopy in the visible (VIS) and near-infrared (NIR) wavelengths have been widely used either in the laboratory or for in-situ monitoring. Non-imaging field spectroradiometers provide the highest available spectral resolution and thus high information content for estimating nutrient properties with multivariate methods.

Spectral measurements and data from wet chemical analysis were utilized to develop a calibration model for phytochemical prediction in oat kernels. Bioactive components were modelled individually. Data set incorporated 100 different naked and husked oat varieties. With use of different combinations of mathematical pre-treatments and regression analysis best root mean squared error (RMSE) values were selected for measuring components, indicated with bold numbers in Table 1. First row of the header, in Table 1, shows the variable selection/dimensionality reduction method, while the second one contains the regression method. Four regression methods were utilized: Gaussian Process Regression (GPR), Support Vector Regression (SVR), Partial Least Squares Regression (PLSR) and Neural Network-based regression (NN)

Table 1: The averaged root-mean-squared-error (RMSE) values of bioactive components of 100 oat varieties

		Mutinfo			KPCA		CARS	PCA
Variable	GPR	SVR	PLSR	GPR	SVR	PLSR	PLSR	NN
TKW	0.116	**0.096**	0.097	0.115	0.100	0.111	0.097	0.097
Zn	0.176	0.170	0.170	0.159	**0.151**	0.158	0.167	0.170
Fe	0.137	**0.129**	0.130	0.131	0.133	0.141	**0.129**	0.140
P	0.101	0.098	0.101	**0.079**	0.084	0.090	0.097	0.099
Phytic acid	0.286	0.250	0.242	0.226	0.217	**0.215**	0.233	0.242
Protein	0.091	0.084	0.086	0.079	**0.078**	0.085	0.084	0.092
Trolox	0.909	0.728	0.721	0.323	0.339	**0.198**	0.703	0.763
TPC content	0.104	0.093	0.092	0.100	**0.088**	0.092	0.092	0.099
β-glucan	0.225	0.206	0.207	0.203	**0.192**	0.215	0.197	0.199

The lowest error values (Table 1) were obtained by SVR and PLSR regression method and this resulted in the successful prediction of the desired components (example of prediction plot for total antioxidant content, expressed in the Trolox equivalent, is shown on Figure 1).

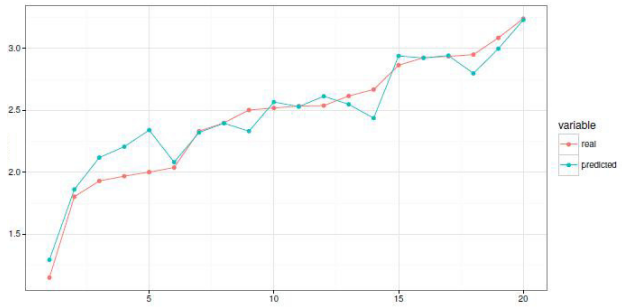

Figure 1.The figure illustrates the real and predicted values by the KPCA+PLSR method for the variable "Trolox equivalent" (total antioxidant content) in a 80%-20% cross-validation iteration, sorted by their real value.

Zhang *et al.* (2008) reported that where wavelengths 1656, 1904 and 2140 nm significant for determination of antioxidant capacity in rice cultivars and that the developed PLS and modified PLS methods could be used for early screening of the large number of samples in the rice breeding program. These findings are consistent with our results that are shown in Figure 2

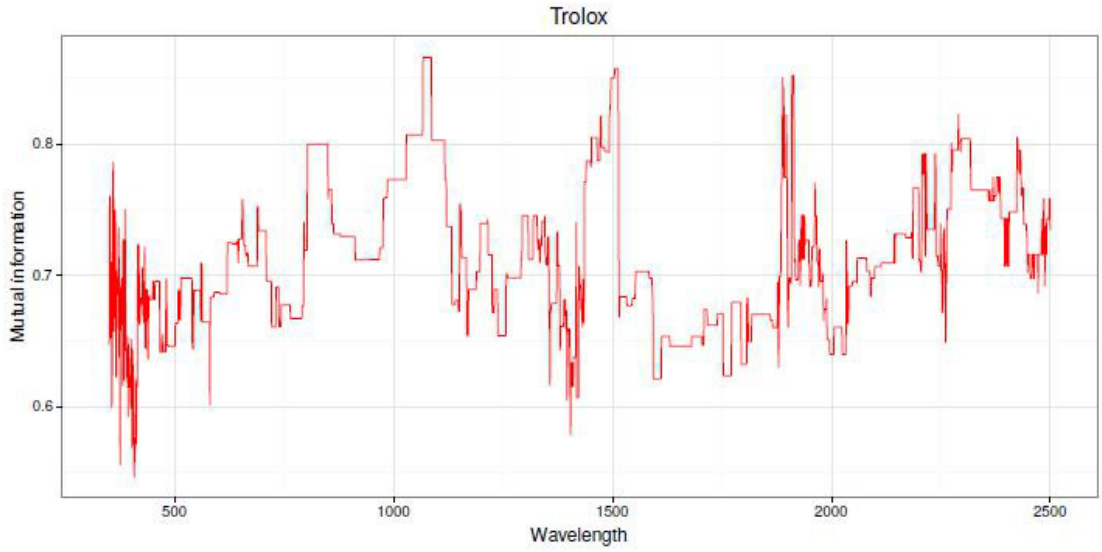

Figure 2. Variables with the largest mutant information (MI) with respect to target component

We may conclude that it is worthwhile to continue this preliminary study and further enlarge our database in order to provide a more robust model for practical application. A handheld NIR device could be of great importance for accelerating the breeding of oat with high bioactive compounds, and could be utilized in in-situ prediction of important nutritional quality parameters. Further results

may be used not only for research, but also for processing and trading industry, seed production and by farmers involved in on-farm breeding.

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Effect of soybean inoculation in high latitude environments

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Key words: biological nitrogen fixation, legumes, inoculation, effect size, chlorophyll-meter

Abstract

Driven by a growing demand for GMO-free soya, the production of organic soybeans (Glycine max (L.) Merr.) increases. Soybeans need specific rhizobia bacteria for biological nitrogen fixation (BNF). If soils lack the soy-specific strains (Bradyrhizobium japonicum), bacteria material is added manually. In a field trial with 5 site-years we investigated the benefit of inoculation at 5 varieties in 2 different high latitude environments (humid, Germany/semi-arid, Russia). Leaf chlorophyll as indicator for BNF was determined by a Minolta SPAD-502. Results showed significant differences between sites, years and varieties. At all site-years inoculation was successful. The SPAD-values of inoculation compared to control were rising over time. Seed yields were not significantly affected, but protein content was higher after inoculation. Since soybeans will only profit from BNF after manual inoculation, the additional effort seems beneficial if soya substitutes pulses in organic crop rotations.

Acknowledgments

We are grateful for funding by the German Government, Federal Ministry of Education and Research (project 'SASCHA - Sustainable land management and adaptation strategies to climate change for the Western Siberian grain belt', funding reference 01LL0906D) and by the German Government, Federal Ministry of Food and Agriculture (project 'Expansion of soybean cultivation in Germany through adaptation by breeding as well as optimization of crop production and processing technology',funding reference 11NA002).

Introduction

Driven by a growing demand for GMO-free soya as food or fodder, the production of organic Soybeans (*Glycine max* (L.) Merr.) increases. As a legume crop, soybeans need specific rhizobia bacteria to be supplied by biological nitrogen fixation (BNF). In particular, in organic cropping systems a good performance of BNF is of great importance for nitrogen supply across the entire crop rotation. Most soils lack the soy-specific strains (*Bradyrhizobium japonicum*). Therefore, bacteria material is usually added manually, especially if soya is grown on a field for the first time. We set up a field trial with 5 site-years to investigate the benefit of this inoculation procedure in two different environments (humid, Germany/semi-arid, Russia) under organic farming conditions. Overall 5 different varieties were used, at each site two individual and one joint, which was cultivated in both environments.

Material and methods

The trial was installed in randomized complete block design with split-plot arrangement (inoculation as main plot, varieties as sub-plots) with 4 replications to compare inoculation (with peat-based *B. japonicum* strain 532C) against untreated control. Leaf chlorophyll as indicator for

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BNF was determined by using a Minolta SPAD-502 (Uddling et al. 2007). To make the SPAD-meter readings of different varieties comparable, we calculated effect sizes 'Hedges' d' (Nakagawa and Cuthill 2007). The two high latitude environments were located in different climatic zones: the organic experimental farm 'Waldhof' of Osnabrück University of Applied Sciences, Germany (52.3 °N 8.0 °E) in the temperate oceanic zone and the biological station 'Kuchak' of Tyumen State University, Russia (57.4 °N 66.1 °E) in temperate continental zone according to Köppen/Geiger classification (Peel et al. 2007). All used varieties were early to very early maturity groups. SPAD-measurements were done at 30 fully developed uppermost leaves at several development stages (Fehr and Caviness 1977).

Results

Results showed significant differences between sites, years and varieties. At all site-years inoculation was significantly successful, as there were zero to few nodules on untreated plants in contrast to huge numbers of active nodules at the roots on all inoculated plots (Fig. 1).

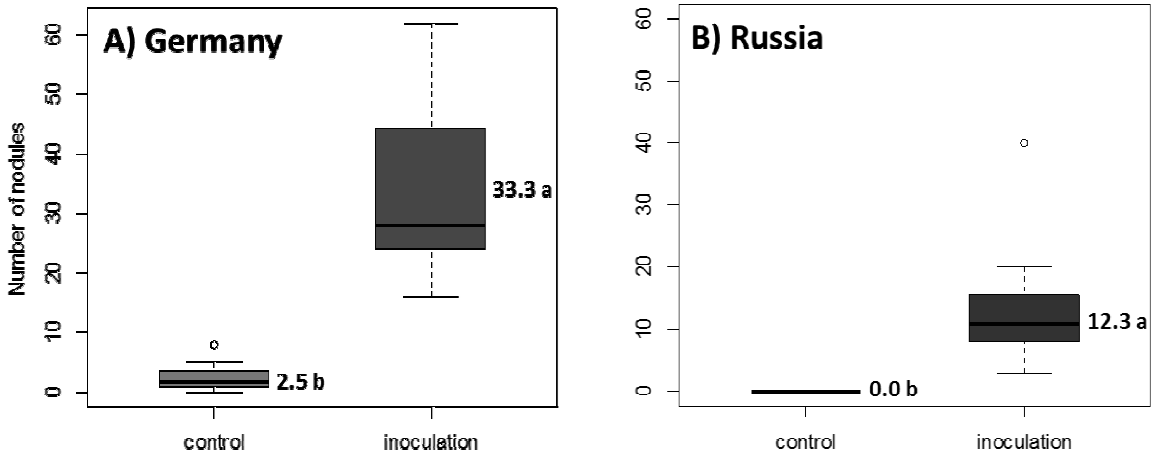

Figure 1:Mean number of nodules at untreated control plots and inoculated plots for all site years in both environments.

The effect sizes for SPAD-values of inoculation compared to control were rising over time (Fig. 2). In the humid environment, the effect was only significant at the latest observation date (Fig. 2A). Under semi-arid conditions, leaf chlorophyll content was significantly higher after inoculation at most measuring dates (Fig. 2B).

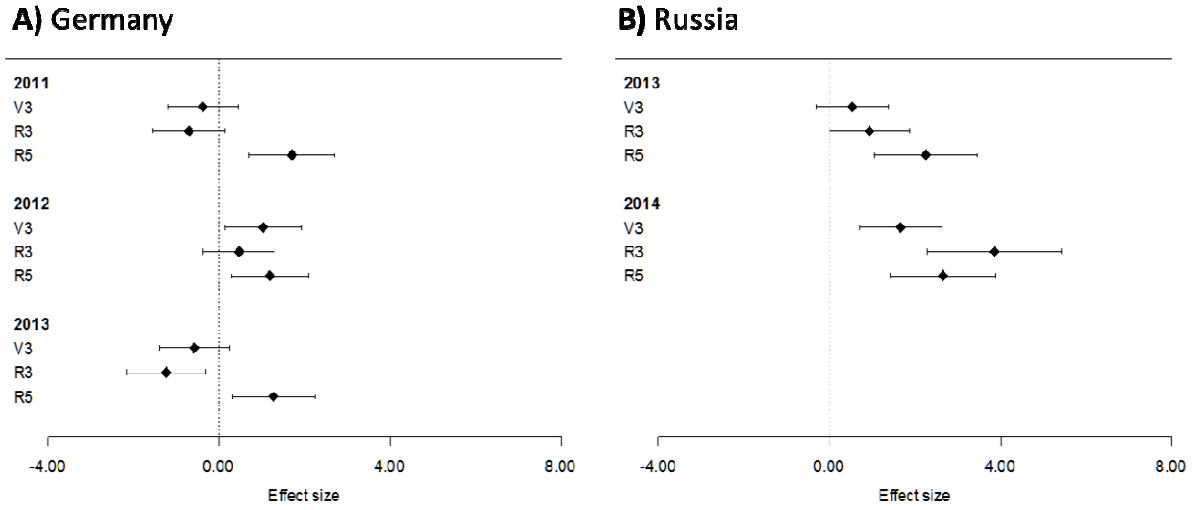

Figure 2: Effect sizes ('Hedges' d') of mean leaf chlorophyll content with inoculation compared to control from 3 varieties at each study site for 3 development stages V3: 3 nodes, R3: beginning pod, R5: beginning seed.

Only in one year (2011 in Germany) the seed yield was significantly positively affected by inoculation (Fig. 3), this was mainly caused by one out of 3 tested varieties ('ES Mentor'). In both studied environments, the inoculation led to significant higher protein content.

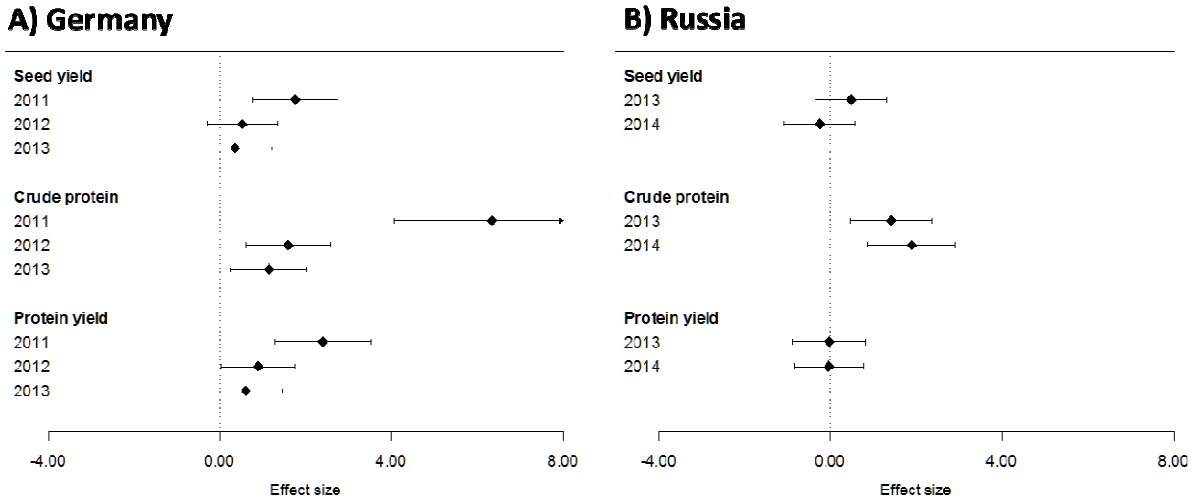

Figure 3: Mean effect sizes ('Hedges' d') of inoculation for selected yield parameters (average from 3 varieties in each environment)

Discussion

The results from our high latitude sites showed a successful nodulation but a later onset of BNF compared to other studies located less far north. Differences between inoculated seeds and control were only in selected site-years significant at V3 and R3 stage, but always at the R5 stage. Vollmann et al. (2011) observed already at V5 stage significant differences in Austria; Zapata et al.

(1987) reported the maximal BNF from R3 to R5 stages, whereas our investigations showed a later average peak.

Since soybeans will only profit from BNF after manual inoculation, this additional effort seems to be beneficial as soya is likely to substitute other pulses in organic crop rotations. This seed inoculation is a standard procedure in traditional soybean regions, but still not common in Siberia. Hence, soybeans could not be accounted as a legume crops within the rotation. In the context of ORGANIC 3.0, this knowledge has to be transferred from science into practical organic agriculture.

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The use of copper pesticides in Germany

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Key words: copper, application rate, pesticides, sales volumes

Abstract

Copper pesticides used to control fungal and bacterial diseases such as grapes downy mildew (Plasmopara viticola), downy mildew of hops (Pseudoperonospora humili), apple scab (Venturia spp.), fireblight (Erwinia amylovora) and potato late blight (Phytophthora infestans) play an important role in plant protection. In a survey of copper application in Germany we found that the amounts of copper used per hectare in conventional grape (0.8 kg/ha), hop (1.7 kg/ha) and potato-farming (0.8 kg/ha) in Germany in 2013 were well below those used in organic farming (2.3, 2.6 and 1.4 kg/ha, respectively), but nearly equivalent amounts were used in apple growing (1.4 kg/ha). Due to the smaller farming area, only 24% (26.5 tonnes) of the total amount of copper was applied in organic farming compared to 76% (84.8 tonnes) in conventional farming.

Introduction

Copper pesticides have been used to control plant diseases such as downy mildew of grapes (*Plasmopara viticola*) and hops (*Pseudoperonospora humuli*), apple scab (*Venturia* spp.), fire blight (*Erwinia amylovora*) and potato blight (*Phytophthora infestans*) in Germany for about 150 years. This makes them some of the oldest plant protection products (PPPs) still relevant today. Until well into the last century, application rates of 20 to 30 kilograms per hectare per year (kg/ha/year) and occasionally even 80 or more kg/ha/year of copper pesticides were used in conventional farming in Germany (Kühne et al. 2009).

Soil persistence and effects on soil organisms are discussed nationally and internationally as possible impacts of the many years of copper pesticide use. Strumpf et al. 2011conducted extensive surveys on copper pollution of soils in organic and conventional grapes, hops- and tree fruit-growing in Germany. They later performed a risk assessment of soil copper levels based on bioavailable copper instead of total copper, the previous standard. Research has shown that less than 10% of the total copper in the soil is easily mobilized and that not only the total copper content, but also the texture [% sand content] and pH of the soil are significant factors influencing copper mobilization (Herwig et al. 2015).

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The European Commission extended its approval for the use of copper compounds as fungicides/bactericides until January 31, 2018. However, this was done on the condition that appropriate measures are taken to reduce their use. Germany and some other EU Member States already passed resolutions to substantially reduce the maximum limits permitted for pure copper pesticides as early as 2009. Instead of the limit of 6 kg/ha/year permitted by EU regulations, Germany has a limit of 3 kg/ha/year and 4 kg/ha/year in hops. Under the aegis of the German Federation of the Organic Food Industry (BÖLW), German organic farming and integrated pest management associations, in coordination with the competent authorities, developed a targeted copper minimization strategy that aims to reduce the annual net amount of copper used in crop protection per hectare and year even further (Rossberg 2013).

Material and methods

The estimated amounts of copper used in conventional farming in Germany based on pesticide reports from manufacturers, distributors and importers of plant protection products. Article 64 of the German Plant Protection Act requires that the annual domestic sales of such products and the active substances contained in them by amount report to the Federal Office of Consumer Protection and Food Safety (BVL). The BVL kindly provided the statistics on the sales of copper pesticides in Germany. Also the Julius Kühn Institute (JKI) has regularly conducted surveys on use of chemical plant protection products in the main agricultural and horticultural crops in Germany since 2000. Data on the use of copper pesticides can also be gathered from these surveys from conventional farms. However, German organic farming associations collected the corresponding data on copper use in organic farming.

Results

The estimated amounts [kg/ha] of copper used in conventional farming in Germany in 2003 are shown in Table 1. The amounts used for conventional farming of potatoes, hops and grapes were significantly lower than those used in organic farming. The copper application rates were less than 1 kg/ha/year in potato and grapes-growing and approximately 1.7 kg/ha/year in hop-growing. Conversely, the amounts of copper used for apple-growing were almost equal in organic farming (average of 1.41 kg/ha/year in 2010 to 2013) and conventional farming (1.4 kg/ha/year in 2013). However, comparison of the total amounts of copper used in both farming systems (Tables 1 and 2) showed that, when adjusted for differences in the sizes of application areas, only 24% (26.5 metric ton, t) of the total amount of copper was used in organic farming compared to 76% (84.8 t) in conventional farming.

Table 1: Estimated amounts of copper used in conventional farming in Germany in 2013.

	Potatoes	Apple	Grapes	Hops	Total
Application area [ha]	2,500	25,500	36,800	10,400	75,200
Copper spray rate [kg/ha]	0.8	1.4	0.8	1.7	-
Pure copper total [t]	2	35.7	29.4	17.7	**84.8**

Table 2: Estimated amounts of copper used [pure copper in kg/ha] in organic farming in Germany in 2013 relative to the application area.

	Grapes	Apple	Hops	Pota-toes	Vege-tables	Total
Application area [ha]	7,700	2,100	84	3,500	400	13,784
Copper spray rate [kg/ha]	2.29	1.5	2.6	1.38	2	-
Pure copper total [t]	17.6	3.1	0.2	4.8	0.8	**26.5**

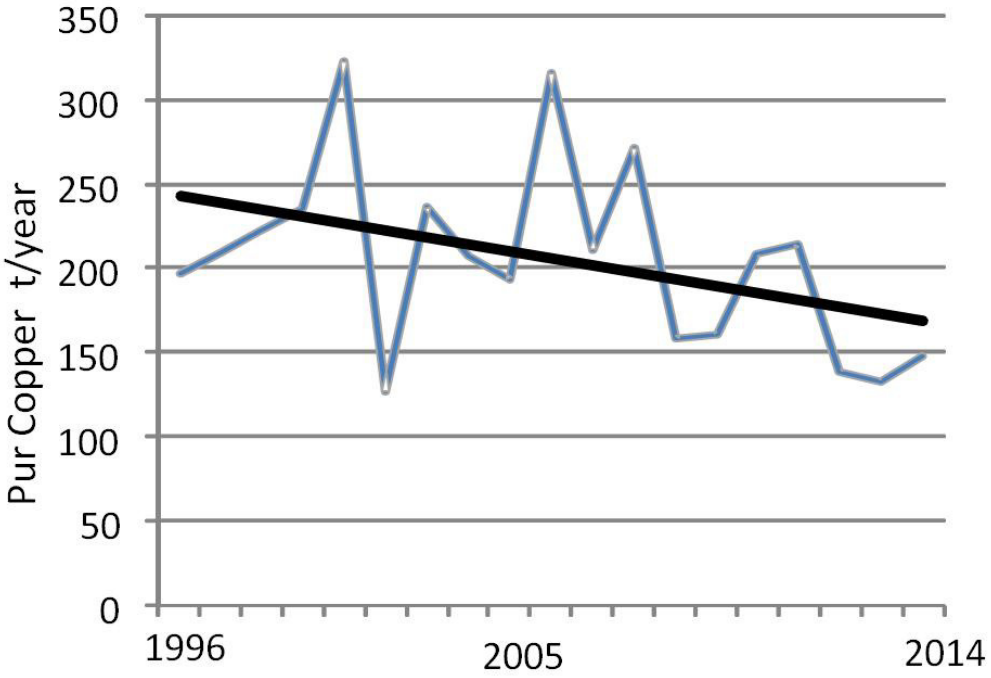

Figure 1: Estimated amounts of pure copper [t] based on the sales of copper pesticides in Germany from 1996 to 2014, EXEL trend line.

In organic farming, the application of copper-containing pesticides is based on forecast model predictions and not always on the total cultivated area (except in hop-growing). Figure 1 shows a steady decline in the annual rate of pure copper use in German plant protection. The differences in copper application rates between the different years are sometimes substantial. This can be attributed to differences in climatic conditions and weather profiles between the years and the stockpiling of the farmers.

Discussion

The collaboration between organic farms, researchers and medium-sized pesticide companies to promote copper reduction in recent years has led to further reduction of the amounts of copper used in various crops. Key factors that have contributed to successful copper reduction include the development of forecasting models that accurately determine the need for and timing of pesticide application, the implementation of agronomic and technical measures and the selection of less susceptible varieties. The use of alternative natural pesticides and plant strengtheners must incorporation in an overall strategy. Then, less effective products may also be useful components of

copper minimization under certain conditions (e.g., weather, timing of application). Despite these advances, it is still neither possible nor advisable to completely refrain from using copper pesticides in organic farming.

Suggestions to tackle with the future challenges of copper as plant protection product in organic farming

At current, it still not possible to completely refrain from using copper pesticides in organic farming. Emerging diseases such as grape black rot (*Guignardia bidwellii*) can result in partial to total yield losses. Currently, the combination of copper-containing pesticides with sulfur-based products is the only effective way to combat grape black rot in organic viticulture. It should be noted that research funding in Germany is accompanied by other measures that contribute to successful copper minimization. This includes the advancement of Strategy Paper on Copper Reduction in Plant Protection (Mering et al. 2016)] and the annual conferences on the theme of "Copper as a Pesticide", which are jointly organized by the German Federation of the Organic Food Industry (BÖLW) and the Julius Kühn Institute. These are important contributions to continuously documenting the progress made and measures needed to achieve copper reduction.

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Optimizing breeding strategies and crop management for enhancing legume ecosystem services in organic farming

María José Suso[1] and Carmen Mateos[1]

Key words: bee-pollination, crop yield, intercropping *vs* monoculture, organic farming, crop-pollinator-farmer interaction

Abstract

Legumes may facilitate the diversification on the agroecosystem both directly, e.g. via growing legumes in association with cereals, and indirectly by enhancing associated diversity of wild fauna. Organic farming systems attract more pollinators such as bees compared to conventional fields. Our goal is to gain understanding on the nested architecture of the legume crop-bee pollinator-farmer–breeder network by using as exemplar case a bi-crop system, faba bean-spelt. Intercropping management and open-pollination breeding scheme interactively increase number and seed weight suggesting that intercropping intensifies the positive effect of outcrossing breeding scheme (breeding in presence of pollinators) in yield. Moreover, our outcome prompted the development of cultivars, by evolutionary participatory breeding, for organic farming that incorporate traits providing suitable floral resources. Thus, creating opportunities for a synergy between production and pollination ecosystem services.

Acknowledgments

Authors gratefully acknowledge the H2020-SFS-2014-2 project DIVERSIFOOD (Embedding crop diversity and networking for local high quality food systems- GA number: 633571) for financial support. Also authors wish to acknowledge the support from the COST Action FA1307 Super-B (www.superb-project.eu),supported by COST (European Cooperation in Science and Technology).

Introduction

Legumes may facilitate the diversification on the agroecosystem both directly, e.g. via growing legumes in association with cereals, and indirectly by enhancing associated diversity of wild fauna. Organic systems attract more pollinators such as bees compared to conventional fields (Bartomeus *et al.* 2014). Legumes providing feeding habitats could be especially good for supporting native bees. Local bees could be managed by the farmers as agents of crossing with the aim of increasing intra crop variation. Our goal is to gain understanding on the nested architecture of the legume crop-bee pollinator-farmer–breeder network. We have the vision that the the analysis of this network could help to increase crop resilience and yield potential, on the one side, and to mitigate pollinator decline, on the other side.

Material and methods

In legumes, two major approaches, based on the pollination environment, have been held by breeders: a) inbred line breeding: cultivars are developed under cages that exclude pollinators and enforce self-fertilization and b) open–pollinated cultivar breeding. This approach makes use of the local pollinators as agents of crossing for yield and resilience-mediated by heterogeneity and heterozygosity exploitation. We create a bi-crop system, faba bean-spelt, to compare two cropping

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management systems (intercropping vs. monoculture) and different faba bean genepools derived from two breeding schemes. Genepools highly homozygous and homogeneous, derived from selfing vs. highly heterozygous and heterogeneous, derived from open-pollination.

Two-factor ANOVAs (faba bean genepool, and the combinations of intercropping vs monoculture and inbreeding vs open-pollination as main effects, plus the two- way interaction) comparing the cropping management and breeding schemes across gene-pools, were performed on the data from each variable (yield and yield determinants, plant architecture and leaf size and shape). To address issue of the natural selection acting on many traits simultaneously in more detail, the data were subjected to multivariate discriminant function analysis (DFA). DFA, performed for the four combination groups (intercropping vs monoculture and inbreeding vs open-pollination) provides a useful technique to visualize the patterns of change in the response to the different cropping management and breeding schemes and the complex relationship between the plant yield and yield determinants.

Results

Over all our ANOVA results illustrate the influence of breeding scheme and cropping management on yield and yield determinants, plant architecture and leaf size and shape. Intercropping management and open-pollination breeding scheme interactively increase number and seed weight suggesting that intercropping intensifies the positive effect of outcrossing breeding scheme (breeding in presence of pollinators) in yield. Conventional selfing breeding schemes fail to bred for the use of the beneficial effects of local bee-pollinator fauna as agents of crossing. However, open pollination is a method of crossing well adapted to farmer management as well as to site-particularities to make the beneficial effects of heterozygosity and heterogeneity available to farmers in a timely manner (Weltzien *et al*. 2005). This outcome prompted the development of cultivars, by evolutionary participatory breeding that incorporate traits providing suitable floral resources and higher attractiveness for pollinating insects**.**

Table 1: Patterns of change in the response to the different cropping management and breeding schemes. DFA model summary.

Discriminant function	**I**	**II**
Eigen value	0.32	0.14
% variance explained	62.7	26.5
Chi square statistic for testing significance of DF	77.6	30.6
Significance	0.00	0.11
Standardized discriminant function coefficients		
Traits		
Yield determinants		
Seed per plant	-3.08	-0.65
Seeds on the secondary stems	2.75	0.81
Pods on the main stem	1.13	-0.16
Pods per plant	-0.27	-0.81
Seed abortion	-0.38	0.65
Leaflet		
Area	-1.22	-0.27
Perimeter	0.96	0.60

Regarding the DFA, we report the results on the two first discriminant functions (Table 1) because they accounted for around 90% of the variation. The first discriminant function contained highly significant amount of discriminatory power. Three yield determinants traits were found to contribute mostly and significantly to the discrimination among the cropping management and breeding scheme groups. According to the results of the DFA, both intercropping management and open-pollination breeding scheme result in genepools with greater number of seeds per plant distributed on more secondary reproductive stems and larger leaflet size and rounded shape.

Discussion

To achieve improvement objectives related to yield enhancement and biodiversity conservation in legume organic farming, using faba bean and spelt as exemplar case, we propose two mechanisms: utilizing intercropping and open-pollinated breeding schemes as well as breeding, by participatory breeding, for traits that promote beneficial crop-pollinator interactions. In addition, this approach indirectly will benefit farmers by their contribution to the mitigation of pollinator decline. Furthermore, the magnitude of the cropping management and breeding scheme interaction is strongly dependent on the genepool response to the exclusion of pollinators showing specific adaptation of the plants whose parents had been selected under different pollination conditions. The differential response of the faba bean genepools suggests opportunities to use cultivars derived from the conventional selfing schemes on farmer pollination landscapes where the abundance of pollinators has been deteriorated.

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Strategies to reduce or replace the use of copper for truly sustainable agriculture

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Key words: organic farming, copper pollution, *Plasmopara viticola*, grapevine, natural products, low copper formulations

Abstract

The aim of this paper is to contribute to the resolution of one of the main problems of organic farming: the use of copper as plant protection product. Copper, in fact, poses risks for the environment due to accumulation of this heavy metal in soils. To this end, research concerning natural alternative solutions and low copper formulations able to reduce or replace the use of copper against Plasmopara viticola *were carried out in laboratory, greenhouse and field experiments. Laboratory tests showed the effectiveness of all tested products in reducing disease symptoms on leaf disks and sporangia germination compared with the untreated control. Greenhouse trial, carried out using Mimoten formulation, showed inhibitory activity of the product against grape downy mildew. Field trials showed a good protection with the use of low copper formulations. Natural alternatives to copper showed ability to control grape downy mildew only under low and medium pressure of disease.*

Introduction

In organic farming the control of pests and diseases is based on precautionary and preventive measures. Plant protection products may only be used in the case of an established threat. Copper is the cornerstone of crop protection in organic farming but its use can cause serious problems to the environment related to the cumulative effect of this heavy metal in soil. Therefore, European Union fixed a maximum limit of copper use in organic farming, with the Commission Regulation EC n. 473/2002. In 2018 copper authorization as plant protection product will be reviewed and further restrictions will be fixed. In view of the above, it is very important to find appropriate alternatives. To contribute to reduce or replace the use of copper, as to improve the quality and safety of food and to reduce environmental damage, natural products and low-copper formulations were evaluated in laboratory, greenhouse and field experiments against *Plasmopara viticola* (Berk. & M.A. Curtis) Berl. & De Toni.

Material and methods

Laboratory tests entailed leaf-disk assay and spore germination assay. Leaf-disks were prepared according to Boso and Kassemeyer (2008). The leaf-disks were immersed for 20 minutes in solutions of different concentrations of the tested products (extract from tea tree oil, terpinen-4-Ol that is the main component of tea tree oil, BM-608 formulation containing 23.8 % (w/w) of tea tree oil, BIOXEDA formulation containing 20 % (w/w) of clove oil, SPORATEC formulation containing 18 % rosemary oil, 15 % clove oil and 5 % thyme oil and Mimoten formulation obtained from *Mimosa tenuiflora* extract) and inoculated 24 hours later with sporangial suspension of *P.*

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viticola. Spore germination assay concerned the calculation of percentage of sporangia-releasing zoospores (i.e. empty sporangia) in order to evaluate the effectiveness of the tested products on sporulation in comparison with a water control and a reference product.

Greenhouse pot experiment was carried out using Mimoten formulation. The effectiveness of this product, in comparison with an untreated control and a reference product, was evaluated on grape plants cv. Malvasia di Candia infected with sporangial suspension of *P. viticola* after the treatments.

The field trials were carried out in organic vineyards to evaluate the activity of a wide range of natural products, combined with preventive measures, against grapevine downy mildew. Copper formulations characterized by low metallic content (King and Mastercop, Glutex Cu 90, Labicuper), natural products applied alternately to copper or in combination with it (Propolin, Solithe, Agribioprop, Brotomax, Chitoplant and Biomacro, Bentotamnio, Biplantol, Ortalg and CS5-F) and natural products tested alone (Biorange and Fitovital and Ascocin, Croplife, EcoMate Armicarb "0", Biplantol, Mimoten, Stimulase, Myco-sin Vin, Sporatec, BM-608) were included in the trials. The characteristic of products and the year of activity are reported in Table 1.The trials were carried out according to the EPPO (2004) guidelines. The experimental design was fully randomized blocks with four replications and plots consisting of twelve vine plants. The assessments to evaluate the anti-grape downy mildew activity were carried out every week on the 10 central plants of each plot. One hundred leaves and 100 bunches per plot were observed to estimate the percentage of affected organs (disease incidence) and the percentage of the infected area (disease severity). Obtained data were subjected to statistical analysis.

Results

Laboratory tests

All tested products showed a reduction in the development of *P. viticola* on leaf disks compared with the untreated control. They showed almost the same efficacy of the reference product. The inhibitory activity increased with increasing concentrations but the highest concentrations of all tested products, with the exception of Mimoten formulation, showed phytotoxic effects consisting of complete or partial necrosis of leaf tissues. Regarding sporangia germination, all tested products reduced the percentage of empty sporangia in comparison with the percentage of empty sporangia in the control. The inhibitory activity on sporulation of tested products generally was lower than the reference product.

Greenhouse trial

Mimoten formulation reduced the incidence and severity of disease, compared to the untreated control. The differences between Mimoten and reference product were not statistically significant.

Field trials

The pressure of disease recorded during the tests and the effectiveness at the harvest calculated using Abbott's formula (1925) are reported in Table 1. All tested low copper formulations provided almost the same efficacy level as the reference products with fewer amounts of copper. Under low infection pressure all tested products, both copper formulations and non-copper based alternative products, were able to ensure a good control of *P. viticola*. Under medium disease pressure, alternatives to copper compounds, used alone or in combination with cupric formulations, showed less effectiveness than copper but nevertheless guaranteed an acceptable level of activity against grape downy mildew. Under high disease pressure non-copper based alternative products generally have not shown a satisfactory disease control.

Table 1: Characteristics of products tested in field trials, disease pressure and effectiveness at the harvest

Type of product	Treatment		Composition	Year of activity	Pressure of disease	Effectiveness (%)	Uc	Rp
Copper formulations	King		Tribasic Copper sulphate	2004	H	33.0	n.s.	n.s.
	Mastercop		Pentahydrate Copper sulphate	2007	M	0.34	*	n.s.
	Glutex Cu 90		Copper hydroxide	2008	H	0.19	n.s.	n.s.
				2009	L	73.79	n.s.	n.s.
				2010	M	53.42	*	n.s.
	Labicuper		Copper gluconate	2009	L	66.02	*	*
				2010	M	43.15	*	n.s.
Natural products applied alternately or in combination with copper	Cutril +		Copper sulphate +	2002	H	17.7	n.s.	*
	Propolin		Propolis					
	Solithe +		Calcium and Magnesium and olygoelements of sea origin	2004	H	3.3	n.s.	n.s.
	Coprantol ultramicron		Calcium and Magnesium and olygoelements of sea origin + Copper hydroxide					
	King		Calcium and Magnesium and olygoelements of sea origin + Copper sulphate					
	Agribioprop		Fluid mixture of microelements - Copper (0.5 %) & Iron (2 %)	2004	H	7.7	n.s.	n.s.
	Brotomax + Copper	Brotomax	Cu - Zn - Mn - N from urea	2006	L	1.0	*	n.s.
		Cupravit idro WG	Copper hydroxide					
		Brotomax	Cu - Zn - Mn - N from urea	2007	M	0.13	n.s.	n.s.
		Coprantol ultramicron	Copper hydroxide					
		Brotomax	Cu - Zn - Mn - N from urea	2008	H	0.11	n.s.	n.s.
		Borboflow	Copper sulphate					
	Chitoplant +		Chitosan	2006	L	0.57	n.s.	n.s.
	Biomacro		N 6 %, P_2O_5 6 %, K_2O 5 %, organic carbon of biological origin 30 %					
	Coprantol ultramicron		Copper hydroxide					
	Bentotamnio +		Bentonite, lithotamnion, rock meal	2006	L	0.43	*	n.s.
	Snow crystal Copper sulphate +		Copper sulphate					
	Bed		Bather					
	Biplantol + Copper	Biplantol agrar	Minerals and microelements in homeopatic dynamic form (D6 – D200)	2007	M	0.23	*	n.s.
		Biplantol mycos V forte						
		Cupravit idro WG	Copper hydroxide					
		Biplantol agrar	Minerals and microelements in	2008	H	0.16	n.s.	n.s.

		Biplantol mycos V forte	homeopatic dynamic form (D6 – D200)					
		Tepan 55 Cu	Copper pentahydrate sulphate					
	Ortalg +		B - Fe, vegetable substances resulting from the fermentation of *Urtica dioica* and brown algae	2009	L	45.63	*	*
	CS5-F +		Essential oils - based Cu 0.5 % - Fe - Mn - Mo - Zn - chelates					
	Bordolow		Bordeaux mixture					
Natural products	Biorange +		*Bacillus subtilis*, *Candida olephila*, *Pseudomonas* spp., *Streptomyces* spp.	2002	H	0	n.s.	*
	Fitovital +		Alfa-Tocoferolo (Vit. E)					
	Ascocin		*Ascophillum nodosum* extract, amino acids, peptides					
	Croplife	Croplife	Citrofresh - Ethyl alcohol - Octanoic acid	2006	L	0.86	n.s.	n.s.
		Invigorator	N - P - P_2O_5 - K - K_2O - Ca - Mg - Na - S - B - Fe - Mn - Cu^{++} - Zn - Mo - Co	2007	M	0.29	*	n.s.
		Calcium carbonate	Calcium carbonate	2008	H	0.13	n.s.	n.s.
		Citofresh	Orange extract	2008	H	0.13	n.s.	n.s.
	EcoMate Armicarb "0"		Potassium bicarbonate	2007	M	0.12	n.s.	n.s.
				2008	H	0.11	n.s.	n.s.
				2009	L	60.19	*	*
	Biplantol	Biplantol agrar	Minerals and microelements in homeopatic dynamic form (D6 – D200)	2009	L	52.43	*	*
		Biplantol mycos V forte		2010	M	26.71	*	*
	Mimoten		*Mimosa tenuiflora* - based B - Cu^{++} 0.5 % - Fe - Mn - Zn - chelates	2009	L	52.43	*	*
	Stimulase		Enzymes purified from *Trichoderma* sp.	2010	M	23.97	*	*
	Myco-sin Vin		Aluminium sulphate, yeast cells, *Equisetum arvense*, *Salvia* spp. extract	2010	M	27.40	*	*
	Sporatec		Clove oil 15 % - Rosemary oil 18 % - Thyme oil 5 %	2010	M	28.77	*	*
	BM-608		*Melaleuca alternifolia* oil 23.8 %	2010	M	30.14	*	*

Pressure of disease: H (high); M (medium); L (low)
Effectiveness (%): percentage effectiveness was obtained by using Abbott's formula
Uc:difference from the untreated control; Rp:difference from the reference product.
* = significant difference according to Tukey's test ($p < 0.05$), n.s. = not significant difference according to Tukey's test ($p < 0.05$).

Discussion

Results suggest that it is necessary to adopt flexible protection strategies depending on the infection risk that, as known, is strongly influenced by climate conditions. Although copper cannot be fully replaced to date, it is possible at present reduce its amount using new formulations developed by agrochemical companies. These new products have more copper ions available to provide disease control at a lower rate and thus minimize the environmental impact. The alternative natural products have shown the ability to control downy mildew only in conditions of low and medium pressure of the pathogen. Under high pressure, they can however be used in the phenological stages with a lower risk of infection to reduce copper treatments. Studies concerning the identification of natural alternatives to copper must be continued as it is essential to solve this issue so important for organic farming, being the use of copper incompatible with organic philosophy of environmentally friendly farming. Reducing or replacing the use of copper with natural products and low-copper formulation, could represent an advanced agroecological method and a new viable and sustainable answer to the "*P. viticola* challenge", which could help farmers to convert from conventional to organic agriculture.

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Are old varieties less productive than modern ones? Dismantling a myth.

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Key words: old variety, wheat, yield, agroecology.

Abstract

Breeding programs of the Green Revolution based their success on increasing the production of harvestable biomass, in relation with non-commercial parts, of modern varieties (MV). Due to wheat's relevance in human food consumption, its varietal modification was especially intense and resulted in a remarkable harvest index increase, with the consequent decrease of straw production. The first-year results of a field experiment that compares old wheat varieties (OV) to modern ones under three different managements (traditional, organic and conventional), question the assumption that OV are less productive. They produced more biomass under organic and traditional management, and the same amount under conventional management. MV only sorted out as more productive for grain yield under conventional management. The greater OV capacity for producing biomass can have important advantages for Mediterranean rainfed organic farming in a climate change context, because it can allow maximizing soil organic carbon under low and medium inputs conditions, with benefits for mitigation and adaptation

Acknowledgments

The study was funded by both an i+d project from the Ministry of Economy and Competitiveness of Spain (HAR2012-38920-C02-01), and a project from Canada's Social Sciences and Humanities Research Council (895-2011-1020). G. Carranza held a pre-doctoral scholarship from the Ministry of Education, Culture and Sports of Spain (FPU13/04346).

Introduction

The Green Revolution entailed a productive model change that involved the substitution of old varieties (OV) by modern varieties (MV) with higher yields, simultaneously to the increase in industrial fertilizers and fossil energy use. In the case of cereals, "high yielding" MV replaced OV, whose high straw production was not anymore useful, nor for feeding draught animals nor for edaphic fertilization, ignoring consequences of lower residue production on soil quality and agroecosystems sustainability (Guzmán and González de Molina, 2015).

Generally, rainfed cereal systems are abundant in Mediterranean areas. In Spain, they cover 37% of cropland area (MAGRAMA 2013). Productivity growth due to increases in external inputs is irrelevant in those semi-arid agroecosystems (Moreno *et al.* 2011). Under these semi-arid conditions, organic farming (OF) is more cost-effective, and more stable than conventional one (Lacasta and Meco, 2000). Additionally, a higher agroecosystem resilience is desirable for a more sustainable agriculture. For reaching this aim, many authors confirm the need for selecting better adapted varieties to OF (Fagnano *et al.* 2012; Sassi *et al.* 2014), since more productive varieties used in conventional farming are not suitable for OF (De Lucas and Sánchez del Arco, 2004). In such a way, the lower production usually assumed for OF in cereal systems (Arncken *et al.* 2012) could be compensated with an adequate selection for better adapted varieties.

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In the present study, we present the first-year results of a wheat field experiment where OV and MV have been assessed under three different agronomic managements: organic one third rotation, organic legume rotation, and conventional. As starting hypothesis, we consider that OV under organic conditions would be more productive than MV, whether considering grain yield or Net Primary Production (NPP). Under conventional farming conditions, MV would only overcome OV referring grain yield, but not NPP.

For testing our hypothesis, we have assessed differences on NPP, grain and straw yield, and the presence of weeds under the three managements above mentioned.

Material and methods

In order to assess and compare twelve wheat varieties, three essays have been carried out at three different locations of Andalusia (South of Spain) -Ronda and Sierra de Yeguas in Málaga province, and La Zubia, in Granada- during three growing seasons (2013-2016). Locations were separated a maximum of 187 km between Ronda and La Zubia, and a minimum of 69.5 km between Sierra de Yeguas and Ronda. The main soil physico-chemical properties are shown in Table 2. The same twelve wheat varieties were sown at every location. Six of them were durum wheat varieties (Triticum durum Desf.), and six where common wheat varieties (Triticum aestivum (L.) Thell.) (Table 1). Among durum and common wheat varieties, we chose three OV and three MV. OV were landraces grown during the first third of the 20th century in Andalusia, and their seeds came from the Phytogenetic Resource Centre of the National Agrarian Research Institute of Spain (CRF-INIA). MV were chosen among lately released varieties, considering their good reputation among farmers from the region. Each essay was representative of different soil fertility and agronomic management conditions, as described below. The results presented here refer to the first year of the field experiment (2013-2014).

Table 1: Wheat varieties grown at the field experiment

Durum wheat		Common wheat	
OV	MV	OV	MV
Rubio	Avispa	Barbilla Roja	García
BlancoVerdial	Simeto	Rojo Pelón	Chamoro
Recio	Vitrón	Sierra Nevada	Galera

OV= Old varieties; MV=Modern varieties

Trial 1 was located in Ronda. Wheat varieties were grown under organic management conditions (no fertilization and no weed control) in rotation with two fallow periods. This cereal rotation, called *one third* rotation, was characteristic of rainfed low productivity lands before the industrialization of agriculture in the region. This piece of land had been under organic management for more than 15 years and it is part of a dehesa landscape.

Trial 2, located in Sierra de Yeguas, was managed under organic conditions. Although no organic fertilization was applied throughout the experiment duration, it had occasionally been fertilized with manure previously, as this farm had been under organic management for the previous 15 years. One labour of manual weeding was done along February, eliminating only larger weeds. Crop rotation was wheat-legume (faba bean, Vicia faba). This rotation, called *ruedos*, is characteristic from areas with fertile soils, thus, with a higher productivity.

At trial 3, located in La Zubia, wheat varieties were grown under conventional agriculture conditions, based on synthetic inputs use. 570 kg ha-1 of a complex chemical fertilizer was applied before seeding and weeds were controlled by applying a broad-leaf herbicide (2 L ha-1 of MCPA 40% at the end of wheat tillering and the beginning of stem elongation).

Table 2: Soil physico-chemical properties of the field trials at the beginning of the experiment in 2013

Properties	Sierra de Yeguas		La Zubia		Ronda	
	Mean	SD	Mean	SD	Mean	SD
CEC*	31.19a	2.09	16.86b	1.89	10.55c	1.82
Ca exchange *	21.94a	1.79	13.83b	2.09	8.23c	1.26
Mg exchange*	5.80a	1.21	2.05b	1.62	1.76b	0.67
Na echange*	1.34a	0.16	0.50b	0.15	0.34b	0.01
K echange*	2.12a	0.11	0.48b	0.04	0.21c	0.03
Carbonate (%)	12.27a	7.09	18.62a	0.46	2.07b	0.31
Limestone (%)	4.61a	3.82	4.71a	0.97	0.12b	0.14
Assimilable P (ppm)	33.76a	9.92	27.08a	14.66	3.98b	1.19
MO (%)	2.39a	0.24	2.61a	0.38	1.03b	0.23
N org (%)	0.16a	0.01	0.17a	0.02	0.07b	0.01
Ph	8.18a	0.04	7.99a	0.11	7.66b	0.19
ph in ClK	7.46a	0.04	7.46a	0.06	6.53b	0.23
Assimilable K (ppm)	927.00a	60.93	208.40b	13.94	76.20c	3.77
Clay (%)	42.22a	2.54	16.42b	2.61	14.28b	2.33
Sand (%)	18.66a	3.12	28.76b	7.88	75.60c	2.91
Silt (%)	39.12a	1.89	54.82b	5.37	10.12c	1.88
Texture	Clay		Silt-loam		Sandy-loam	

Different letters in the same raw represent significant differences for each propriety at a significant level of 0.05 (Tukey test). SD=standard deviation; CEC=cation exchange capacity; OM=organic matter; *(meq/100g).

Fields were planted between October 25 and November 12 in all cases. In order to keep plots seeded with strictly one variety, we seeded by hand. Sowing rate was 200 kg ha-1 for wheat and 110 kg ha-1 for faba bean (in case). Sampling for ulterior analysis and harvest took place between June 5 and June 25, at the end of the cereal cycle.

Table 3: Data set from the experimental sites and farming conditions.

	Ronda	*Sierra de Yeguas*	*La Zubia*
Rainfall (mm)	611.5	386.4	325.4
Farming system	Organic	Organic	Conventional
Rotation	Wheat-fallow-fallow	Wheat-Faba bean	Monoculture
Fertilization	No	No	NPK (8:15:15) (570 kg ha^{-1})
			45.6 kg N ha^{-1}
			85.5 kg P ha^{-1}
			85.5 kg K ha^{-1}
Weed control	No	Manual weeding	Herbicide control (MCPA 40%) (2 l ha^{-1})
Irrigation	Rainfed	Rainfed	High water

Each experiment consisted of a split-plot design with four blocks separated with a non-seeded stripe 1 m width. Type of wheat (durum and common) was the main factor, while origin of wheat varieties (old and modern) was the subfactor. Plot size was 4x6 m. At La Zubia field, each block comprised 12 plots corresponding to the 12 wheat varieties assessed, while in the blocks at Ronda and Sierra de Yeguas experiments, there were 36 and 24 plots, respectively, in order to represent all phases of the rotations (crop and fallow plots). Cultivars were randomly arranged in each replicate of the experiment.

Variables studied were: Aerial Net Primary Productivity (NPP, related to total crop dry matter and total weed dry matter), total dry matter of the crop at the end of the cycle (grain dry matter, straw dry matter plus grain husk dry matter); grain yield; straw yield and weed yield at harvest time. We calculated the ratio between weed yield and NPP (weed:NPP ratio), as agroecosystem biomass allocated to weed.

Plots were sampled at the end of the wheat cycle with a sampling square of 0.25 m side, throwing it to the centre of the plots (to avoid the border effect), randomly and twice per plot. Cereal and weed plants in the square were cut at ground level. Wheat plants were separated into spike and stem. Wheat and weed biomass were dried at 70ºC using a laboratory drier oven (University of Jaén) to obtain dry weight. Fresh spikes were threshed to separate grain and grain husk before they were dried in the oven.

Split-plot variance analysis and Tukey test were carried out at a significance level of 0.05 with Statistix statistical software (Analytical Software, Version 10).

Results

We found some differences between durum and common wheat, but here we will focus on the results concerning OV and MV as they are more relevant for the aim of this communication. Data of variables assessed for wheat varieties are shown in Table 4. Notice that grain husk data are neither presented, nor discussed, so total crop biomass does not match grain and straw biomass sum. Finally, wheat variety and environment interaction has not been analysed yet. Statistical analyses are in process by the time of this communication.

Trial 1. One third rotation (Wheat-fallow-fallow).

We found significant differences between OV and MV within the following variables: NPP, total crop biomass at the end of the cycle, grain yield, straw yield and weed:NPP ratio. OV produced higher amounts of biomass than MV in all these variables but for weed:NPP ratio, in which MV showed a higher value. We did not find significant differences for the rest of the variables (Table 4).

Trial 2. Ruedos rotation (Wheat-Faba bean).

OV produced more NPP, total crop biomass at the end of the cycle and higher grain and straw yield than MV. Contrary, for MV we found larger amount of weed biomass and a greater ratio between weed and NPP (Table 4).

Trial 3. Conventional monoculture.

Because of technical problems, we could not sample weed biomass at the end of cycle. Data related to this variable and those for weed:NPP ratio are not reported as we could not asses weed biomass at La Zubia trial. Under conventional management, we found significant differences for grain yield, higher for MV (Table 4).

Discussion

The first-year results of this experiment question that OV are less productive than modern ones, as they produced more biomass under organic and traditional management, and the same amount of biomass under conventional management except for grain yield, which was the only variable for which MV had higher results. In other words, OV productive disadvantage is only true when referring to grain yield under conventional management. In contrast with our findings and for more humid farming conditions, Hildermann *et al.* (2009) did not find that grain yield of cultivars bred under low-input conditions outperformed grain yield of conventionally bred cultivars, and under no fertilization regime, they did not find significant differences among cultivars. As authors explain,

this could be due to the conditions of the experiment site (DOK trial, Switzerland), like low weed pressure high inherent soil fertility and good water retention.

Table 4: Net Primary Production, total crop biomass, grain, straw and weed dry matter production (kg ha^{-1}) and weed:NPP ratio for OV and MV at the three field trials. Data for rotation crop or fallow are not presented.

	OV		MV		
	Mean	SD	Mean	SD	*P value*
Ronda					
NPP	1,249	562	893	432	0.0031*
Total crop biomass	992	454	593	360	0.0003*
Grain	256	219	153	175	0.0411*
Straw	597	194	374	186	0.0001*
Weed	257	170	300	177	0.3135
Weed:NPP	0.19	0.10	0.36	0.20	0.0009*
Sierra de Yeguas					
NPP	11,807	2,844	9,292	3,413	0.0060*
Total crop biomass	9,387	3,406	5,580	1,924	0.0000*
Grain	2,187	1,174	1,223	969	0.0005*
Straw	6,186	2,409	3,812	1,530	0.0002*
Weed	2,421	2,044	3,712	2,982	0.0386*
Weed:NPP	0.21	0.19	0.37	0.20	0.0001*
La Zubia					
NPP	17,800	4,957	17,192	5,498	0.6516
Total crop biomass	17,800	4,957	17,192	5,498	0.6516
Grain	2,401	807	3,300	1,612	0.0239*
Straw	13,805	4,876	12,305	4,851	0.1823
Weed	-	-	-	-	-
Weed:NPP	-	-	-	-	-

*Significant differences at a significant level of 0.05. NPP= Net Primary Production; OV= Old variety; MV= Modern variety; SD= Standard Deviation.

Our results suggest that breeding programs of the Green Revolution increased the grain yield of wheat varieties under modern management conditions, exclusively. Nonetheless, under organic farming conditions of a semi-arid climate, we did not find advantages for MV in this sense and, what is more, we found OV being more productive in terms of grain yield and more competitive against weeds, a fact that could be considered as an important advantage for organic farmers. Despite this weed biomass reduction, the total amount of biomass that can be incorporated to soil was higher for OV.

Other studies show a lower productivity of organic cereal production when compared to conventional management due to a lower nutrient availability and a greater presence of weeds. Our results indicate that these problems could be relatively ameliorated by employing a more suitable genetic material.

Moreover, this greater capacity for producing biomass of OV can have other important advantages for organic farming in arid conditions. In a climate change context, the greater straw yield under low and medium input use intensities can allow to maximize soil organic carbon, helping to mitigate climate change through carbon sequestration and to adapt to it through improved soil physical properties (Aguilera *et al.*, 2013). In Spain, the majority of the land devoted to cereal

production has low and medium management intensity characteristics, due to the lack of water (Meco *et al.* 2011). Those rainfed cereal land areas cover over 5.4 million hectares (MAGRAMA, 2013). On the other hand, OV can increase grain yield in organic farming systems, decreasing their land cost (Guzmán *et al.* 2011). Besides, they can increase soil organic matter adding part of the residue biomass, without jeopardizing incomes from straw commercialization.

Suggestions to tackle the future challenges of organic farming

Greater straw production with OV can result advantageous for organic farmers, because once separated the straw needed as organic amendments to maintain soil fertility, they could dispose of a greater quantity of straw biomass susceptible of becoming animal feeding, for their own farms or as a market product for others farmers.

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Screening of stand-alone and mixture of cover crops for ground cover management in a temperate organic peach orchard

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Key words: cover crop, Fabaceae, Poaceae, peach, nitrogen, soil, management

Abstract

Cover crops are alternative strategies for managing weeds within the tree row in organic orchards. The choice of the botanical composition of cover crops is a key issue to propose a reliable alternative. In this study, we investigated the interest of cover crops composed of stand-alone or a mixture of species of the Fabaceae and Poacaea family, respectively chosen for their soil nitrogen release and soil bearing capacity, and mixed according to biological complementarity. Eight cover crops were assessed in an irrigated organic Peach orchard in southeastern France during 3 years. Results highlight the high potential of three species for ground coverage and different patterns of interspecific competition. Cover crop dynamics pointed out the importance of mowing in weed vs. cover crop development and appropriate mowing schemes need to be further tackled.

Acknowledgments

The authors wish to thank the technical and the temporary staff for orchard maintenance and data gathering. This program was supported by the French Ministry of Agriculture and Rhône-Alpes region.

Introduction

In temperate commercial organic orchards, ground cover within the row is commonly managed using mechanical methods based on tillage or cover-crop destruction. These methods have some limits e.g. the restriction of superficial root development (Parker and Meyer 1996), increased risk of erosion (Duran Zuazo et al. 2008), modification of soil properties (Oliveira and Merwin, 2001) and the disruption or destruction of habitat for natural enemies of pests (Halley and Hogue, 1989) or earthworms (Parveaud et al., 2012).

The effect of cover crops in organic orchard systems has been assessed (e.g. Hoagland et al. 2008) but implementation in commercial orchards is still rare. As potential nitrogen input, nitrogen-fixing plants used as cover crops are of great interest in organic orchards. In this study, we assessed 8 cover crops during 3 year to (1) identify and quantify the soil covering capacity of stand-alone or mixtures of species and to (2) quantify soil nitrogen dynamics.

Material and methods

The experimental design was located at the INRA Gotheron experimental station in the Rhône Valley production area, in the South-East of France. Peach trees cv. 'Benedicte' grafted on *Prunus* cv. 'Montclar' rootstock were planted in 1999 at 4 x 5 m planting distances in a sandy loam soil. Each treatment was composed of 6 trees x 3 rows, i.e. 18 trees.

Cover-crops species were sowed manually the 8 April 2014 after seed bed preparation. The botanical composition of the 8 treatments was determined according to (1) expected intraspecific

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services (table 1) and (2) interspecific complementarity in time (e.g. soil covering dynamics) and/or in space (height and clumpyness). The cultivars used are *Trifolium repens* 'Klondike' (N°1, 4), *Trifolium pratensis* 'Montana' (N°3, 6), *Medicago sativa* 'Luzelle' (N°7), *Festuca ovina* 'Spartan' (N°4, 5) and *Festuca rubra* 'Maxima' (N°6). The 'Mythopia' commercial species mixture from Camena Company composed of 5 leguminous and 16 companion plant species was assessed (N°8).

Table 1: Botanical composition and agronomic characteristics expected of the 8 cover crops

N°	Species and seed rate (kg/ha)	Agronomic characteristics expected
1	*Trifolium repens* (20)	Fast covering + nitrogen release
2	*Medicago lupulina* (30)	Fast covering + nitrogen release + resowing
3	*Trifolium pratensis* (22)	Nitrogen release + dwarf canopy
4	*Trifolium repens* (10) *Festuca ovina* (30)	Fast covering + nitrogen release Clumpy development
5	*Medicago lupulina* (15) *Festuca ovina* (30)	Fast covering + nitrogen release + resowing Clumpy development
6	*Trifolium pratensis* (11) *Festuca rubra* (18)	Nitrogen release + dwarf canopy Clumpy development
7	*Medicagosativa*(27) *Hordeum vulgare* (100)	Dwarf canopy + low water requirement Fast covering
8	*Medicago lupulina* (8) *Lotus corniculatus* (4) *Trifolium repens* (3) *Anthyllis* sp. (0,06) *Hippocrepis* sp. (0,15) Others (<0,5%)	Fast covering + nitrogen release + resowing Nitrogen release Fast covering + nitrogen release Nitrogen release Nitrogen release Functional biodiversity

In 2014 and 2015 cover crops were mowed at 15 cm height (N°1, 2, 4, 5, 8), at 25 cm height (N° 3, 6) and at 40 cm height (N° 7) with a lawn-mower (model Olivia 'X', Tagliaerba Co.). Cover crops were mowed three times in 2014 (19/05/14, 17/06/14, 28/07/14), twice in 2015 (29/04/15, 25/06/15) and once in 2016 (21/09/16). All cropping practices except cover crops mowing were the same for all treatments.

In 2014, 2015 and 2016, total yearly nitrogen supplies were 65, 57 and 15 $kg.ha^{-1}$ respectively. These total nitrogen amounts were fractioned in one (2016) or two applications (2014, 2015). Water within the row was supplied by microjet® and driven by tensiometers with a 50kPa threshold value. In 2014, 2015 and 2016, total water supplies were 271 mm, 275 mm and 297mm, respectively.

The percentage of soil surface coverage by sowed species, weeds and bare soil was visually determined every 1-3 month according to season (11 observations from May 2014 to September 2016). Quadrat samples of $1m^2$ positioned at 1.5m from the trunk were observed. Six repetitions per treatment were realized.

Mean and standard deviation of soil coverage were mentioned as mean±standard deviation in the text. Statistical analyses were performed using R software (R core Team).

Results

Except for the two *Festuca* sp., a pattern of annual ground cover dynamics was observed for all species i.e. an increase of cover crops ground coverage from April to September and a decrease of it from October to March (figure 1a,b,c). Furthermore, a decrease of cover-crop coverage, at the expense of weed development, was observed in 2016 for all the species, except for the two *Festuca* sp. (figure 1b). These results can be explained (1) by the biological characteristics of the species

(annual or bi-annual cycle, rate of development) and (2) by cover-crop management. Indeed, in 2016, an important weed development was observed in all the treatment, which could be explained by the absence of mowing from April to September during this year.

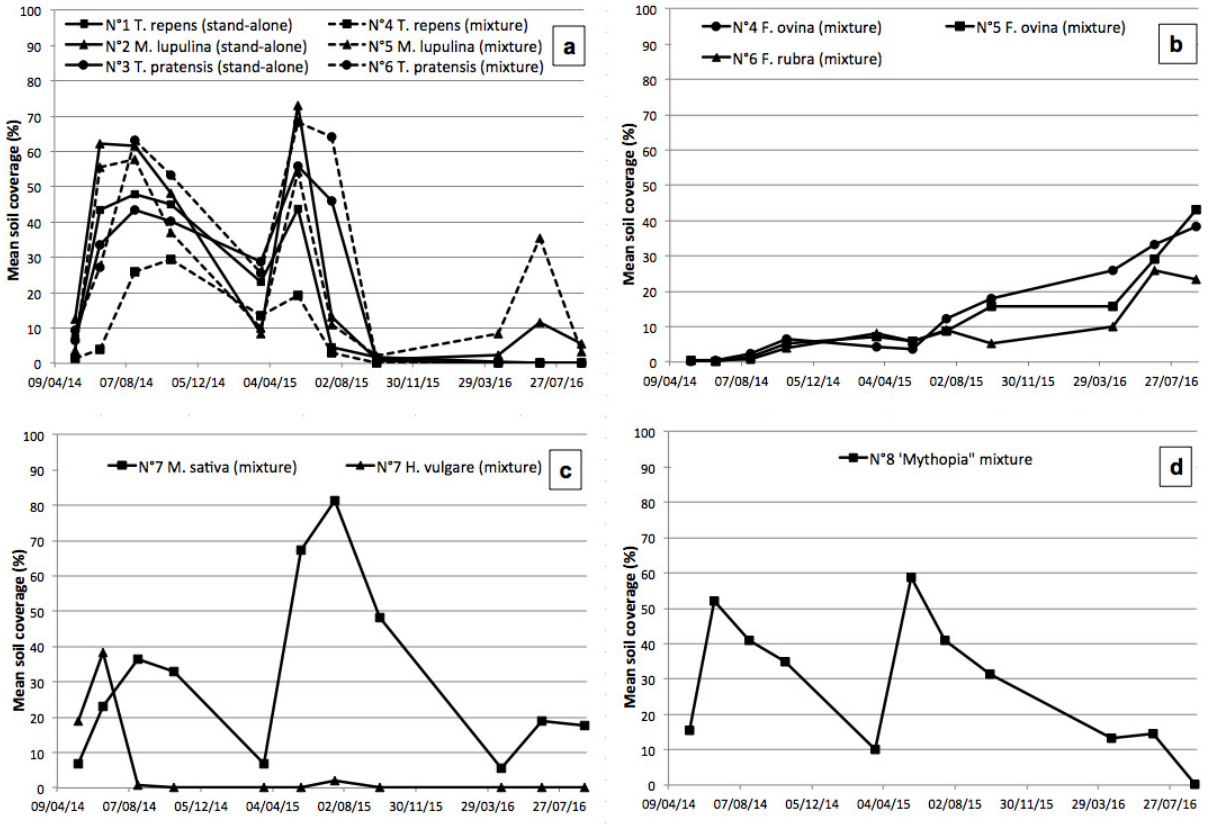

Figure 1. Mean soil coverage of the species tested in the 8 treatments (N°1 to 8) as stand-alone or within species mixtures during 3 years

The highest rate of ground coverage was observed on *M. sativa*(81±22%), *M. lupulina* (73±21%), *T. pratensis* (68±23%) and *T. repens* (48±22%). Weed development started quickly after sowing. In 2014, dominant weed species were *Ambrosia artemisifolia*, *Cirsium sp*. and *Polygonum aviculare*. *Elymus repens* and *Rumex* species were located in patches. In 2015 and 2016, annual weed species were mainly replaced by grasses (*Dactylus glomerata*, *Poa* sp.) and others species (*Fragaria vesca, Verbena vulgare*). No effect of the botanical composition of cover crops on weed composition was observed (result not shown).

During spring and summer seasons in 2014 and 2015, the mean ground coverage of *T. pratensis* was higher when it was grown in a mixture (N°6) than as stand-alone (N°3) despite a lower sowing density in the mixture (figure 1a). Conversely, the mean ground coverage of *T. repens* was significantly higher when it was grown as stand-alone (N°1) than in the mixture (N°4) (Wilcoxon test, $p<0.05$).

The two *Festuca* sp. showed a low but constant ground covering capacity during 2014, 2015 and 2016 (figure 1b). Both species were characterized by a very clumpy development and no weed development was observed in *Festuca* sp. clusters. The mixture of *Festuca rubra* and *Trifolium pratensis* (N°6) reached 64±19% and 74±18% in 2014 and 2015, respectively.

H. vulgare (annual cycle) and *M. sativa* (perennial cycle) contributed equally to ground coverage in 2014 (figure 1c). In 2015, an increase of *M. sativa* was observed and *H. vulgare* near had

disappeared. The ground coverage of the 'Mythopia' mixture reached 52±33% and 59±32% respectively in 2014 and 2015 (figure 1d).

Discussion

Despite the effect of the biological cycle of each species (annual/bi-annual/perennial), interpretation of cover-crops dynamics highlights the influence of cover crop management. The mowing scheme (height, rhythm) of cover crops and weeds during spring and summer needs to be sufficiently regular to control weed development satisfactorily. The two *Trifolium* sp. and *M. sativa* presented two contrasted patterns of interspecific competition ability, which could be implemented in further studies.

Soil nitrogen dynamic demonstrated that nitrogen availability increased in May-July and tended to be higher under *T. pratensis* and *M. sativa* than under *T. repens* and *Medicago lupulina* (result not shown). Nitrogen release under leguminous cover crops in the tree row was likely to largely contribute to peach trees nitrogen requirements.

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Optimising organic soybean growth under reduced tillage by inline fertilisation with rock phosphate and elemental sulphur

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Key words:*Glycine max*, grain yield, yield components, nutrient ratios

Abstract

Field trials were carried out over three years (2013-2015) at the organic research farm Wiesengut (WG), to evaluate the effect of inline fertilisation with rock phosphate (RP) alone or combined with elemental sulphur (ES) on grain yield and nutrient uptake of soybean (Glycine max (L.) cv. Sultana). Compared with an unfertilized control inline fertilization of RP and/or ES showed no significant effect on soybean grain yield, yield components and nutrient uptake. In 2013 and 2014 soybean grain yield and yield components were significantly lower than in 2015 due to either seed inoculation failure (2013) or dry spell (2014). It can be concluded that under organic management regular farmyard manure application common at the WG site results in sufficient soil P and S contents to sustain grain yields. The approach to increase P solubility of RP by using ES requires further investigations.

Introduction

In Organic Farming mineral P-fertilizers can only be applied by using rock phosphates (RP). Soybean are known to have a high P-demand. Low solubility of RP at optimum soil pH for plant growth however, may result in P deficiency with subsequent yield depression (Walker *et al*. 2006). A century ago, Lipmann *et al*. (1916) reported that combining RP with elemental sulphur (ES) can increase the dissolution of RP and subsequent P availability to plants. Increased solubility of RP is supposed to be an effect of sulphuric acid production resulting from oxidation of ES, i.e. on-site production of sulphuric acid by *Thiobacillus* spp. Further research confirmed the efficiency of such a combination (Rajan 1987; Stamford *et al*. 2003; Aria *et al*. 2010). Most of these experiments were performed under tropical conditions implying higher soil temperature and humidity. The objective of this work was to evaluate the effect of inline fertilizer application on soybean development under conditions of temperate climate and reduced tillage.

Material and methods

The field trials were conducted from 2013-2015 at the research station for organic farming Wiesengut (WG), University of Bonn, Germany. The farm is managed as a mixed farm with about 0.8 livestock units ha^{-1} (cow manure). The mean annual temperature (T) was 10.9 °C and the mean annual precipitation was 765 mm for the period 2013-2015 (Figure 1). The topsoil had a slightly acid pH, a sufficient level of P in 2013 and 2014 (7.3 and 5.3 mg 100 g^{-1}) while lower P levels (2.6 mg 100 g^{-1}) were recorded in 2015. The soil S_{min}-content (0-60 cm) at sowing ranged between 26 to 40 kg S ha^{-1} (Table 1).

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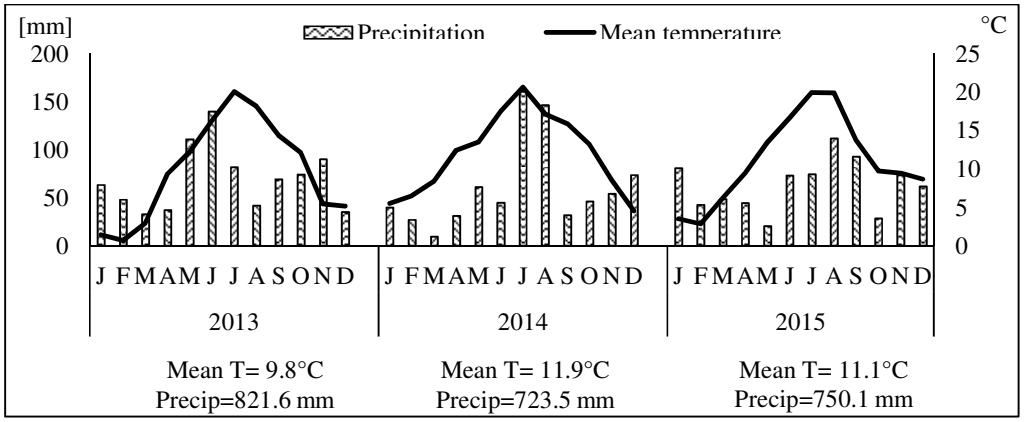

Figure 1. Mean monthly temperature (°C) and precipitation (mm) at Wiesengut farm (2013-2015)

Table 1: Soil properties before seeding

	Trial's year		
	2013	2014	2015
pH (0-30 cm)	6.8	5.8	5.9
P (ppm, 0-30 cm)	70	53	26
S_{min} (kg ha^{-1}, 0-60cm)	40.0	30.6	26.0

Four treatments arranged in a randomized complete block design with at least three replications were tested including elemental sulphur (ES: 40 kg S ha^{-1}) dried, milled and applied in powder form, fine-ground rock phosphate (RP: 50 kg P ha^{-1}), either alone or combined with ES (RPES) and an unfertilized control (CON). Soybean (*Glycine max* (L.) cv. Sultana) seed inoculation with *Bradyrhizobium japonicum* (Radicin®) had failed in 2013, while in 2014 and 2015 seeds were successfully inoculated using HiStick®. Seed beds were prepared using a rotary harrow followed by a compactor. Soybean was sown in May with five rows per plot and a row spacing of 32 cm, using a triple-disc direct seeding machine (Semeato Company, Brazil) with an integrated inline fertilization system. At harvest time, shoots (pooled stems, leaves and empty pods) and grains of the soybean were dried and weighed separately. Grain nutrient (N, S and P) contents were analysed after milling the dried grains in a cryogenic mill (spex certiprep 6750, flex). P was measured with a photometer (SAN plus System, Skalar), soil and plant N as well as S contents were determined with an elemental analyser (Eurovector).

Data sets were first checked for normal distribution and homogeneity of variance. The subsequent analysis of variance was carried out using SPSS version 23 followed by the Tukey-test ($\alpha = 0.05$). Since most evaluations gave no significant interactions between treatment and year, only main effect averages will be presented.

Results

Fertilizer effect:The grain dry matter yield (GDMY) as well as the yield components were not affected by the different fertilisers averaging 3.1 t dm ha^{-1} independent of the treatment. The number of pods per plant recorded after inline fertilizer application tended to be higher (>21, not significant) than the control (19 pods $plant^{-1}$). Likewise grain nutrient ratios and removal were not significantly affected by the treatments. However, compared with the control a slightly higher N and S grain removal was noted after application of RP alone or combined with ES.

Year effect: Although the lowest final plant density was recorded in 2015, the respective average GDMY (4.3 t ha^{-1}) was 1.5 to 2 times as high compared with 2014 (2.8 t ha^{-1}) and 2013 (2.3 t ha^{-1}). Hence the significantly highest number of pods per plant (27) and seeds per pod, were recorded in 2015 followed by 2014 and 2013. Likewise, N:S ratio (20) and N:P ratio (13) as well as N and S grain removal (290.7 and 15 kg ha^{-1} resp.) were significantly higher in 2015 than in the two previous years. In contrast, the significantly highest P:S ratio and P grain removal were noted in 2013.

Table 2: Effects of fertilizer and year on soybean yield and yield components, grain nutrient ratios and removal (2013 – 2015)

Fertilizer /Year	Yield and yield component				Grain nutrient content ratios			Nutrient removal by grain (kg DM ha^{-1})		
	FPD (plant m^{-2})	GDMY (t ha^{-1})	Seeds pod^{-1}	Pods $plant^{-1}$	N:S	N:P	P:S	N	P	S
CON	25±1.6	3.1±0.2	2.0±0.1	19 ±1.6	18±0.2	8±0.3	3±0.1	195.1±13.1	26.1±2.0	10.7±0.7
RP	27±1.6	3.1±0.2	1.9±0.1	21±1.6	18±0.2	8±0.3	3±0.1	198.0±13.1	26.5±2.0	10.9±0.7
ES	26±1.6	3.1±0.2	1.9±0.1	22±1.6	17±0.2	8±0.3	3±0.1	195.3±13.1	24.6±2.0	10.9±0.7
RP+ES	27±1.6	3.1±0.2	1.8±0.1	21±1.6	17±0.2	9±0.3	3±0.1	196.9±13.1	24.8±2.0	11.0±0.7
2013	31±1.2**a**	2.3±0.1**b**	1.2±0.1**b**	16±1.2**b**	15±0.2**c**	3±0.2**c**	4±0.1**a**	111.3±9.9**c**	33.4±1.5a	7.6±0.5**c**
2014	31±1.4**a**	2.8±0.2**b**	2.3±0.1**a**	19±1.3**b**	19±0.2**b**	10±0.3**b**	2±0.1**b**	187.0±11.1**b**	19.7±1.7**b**	10.0±0.6**b**
2015	17±1.6**b**	4.3±0.2**a**	2.1±0.1**a**	27±1.5**a**	19±0.2**a**	13±0.3**a**	2±0.1**c**	290.7±12.8**a**	23.4±1.9**b**	15.0±0.7**a**

Data followed by different letters are significantly different (Tukey-Test, $\alpha = 0.05$) Data are mean ± standard error of means. RP=rock phosphate, ES=elemental sulphur, CON = control, DM: dry matter; FPD: final plant density; GDMY: grain dry matter yield.

Discussion

Inline fertilisation of RP alone or combined with ES did not result in significantly higher grain yield or yield components of soybean at the Wiesengut site. This fact could be due to the low solubility of both RP and ES in a soil with a neutral or only a slightly acid pH. Experiments in Australia with much lower soil pH (4.3-5.4) in contrast have shown increased P uptake of wheat and rye grass after combined RP and ES fertilization (Evans *et al*. 2006). Likewise, a similar effect was given on calcareous soils in Iran, where sulphur application reduced the soil pH dramatically resulting in a higher RP solubility and P availability (Heydarnezhad *et al*. 2012). The available P content of the Wiesengut soils ranged between middle and low (B and C classes) suggesting that P was not a yield limiting factor. In fact, Ferguson *et al*. (2006) have reported that P application is not likely to increase seed yield at soil P concentrations above 12 ppm. High average grain S contents (>0.34% dm) and N:S ratios (>15) suggest that there was no S deficiency, because these values were on average within the critical range(N:S <22:1 and S%> 0.27 %) suggested by Salvagiotti *et al*. (2012). Other factors explaining the missing effect of combined RP and ES fertilization on P-solubility in our study include temperature and humidity, which were both far below the optimal range for high microbial activity. Soil temperatures above 30°C and humidity of 60% are supposed to strongly favour sulphur oxidizing bacteria with temperature playing a dominant role (Janzen and Bettany 1987). Own greenhouse pot experiments with soybean resulted in significantly higher grain yield after combined RP and ES application underlining the importance of abiotic factors (Brahim *et al*. 2017). The missing successful inoculation with *Bradyrhizobium japonicum* in 2013 was a major stress factor for soybean development resulting in nitrogen deficiency, explaining the low GDMY, number of pods per plant and N and P grain removal recorded in that year. For organic farmers, in particular, it is essential to ensure an optimal inoculation of legume seeds, if soil inoculum is insufficient. In that case using a

mixture of at least two quality bacteria strains is essential. According to our results mixed organic farms with regular farm yard manure application are not likely to suffer from P or S deficiency.

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Agro-ecological Service Crops with roller crimper termination enhance ground-dwelling predator communities and pest regulation

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Key words: Roller crimper, agro-ecological service crops, ground-dwelling arthropods, aphids, parasitoids, aphidophagous predators

Abstract

The high dependence on soil tillage in organic vegetable cropping systems has raised questions regarding soil management. Agro-ecological Service Crops (ASC) are sown before cash crops to provide agro-ecosystem services. Recently, the ASC termination with roller crimper (RC) technology has attracted attention in organic farming circles. RC permits the creation of a mulch on the soil surface consisting of ASC plant material with no need for tillage. Studies carried out in the USA, Canada and Latin America on RC reveal some of the potential benefits and drawbacks of this technology. However, only a few such studies have taken place in European agroecosystems. The objective of the SoilVeg project (ERA-Net CORE Organic Plus) is to study RC under European environmental and agronomic conditions. This paper shows how sowing ASC before autumn-winter cash crops and the RC termination strategy reduce aphid infestation and enhance ground-dwelling predator communities.

Acknowledgments

This research was carried out within the framework of SoilVeg, a project funded by ERA-Net CORE Organic Plus and also partially funded by the Natural Sciences Museum of Barcelona. This research is also supported by the grant FPU-MECD to David Navarro Miró (FPU14/03868).

Introduction

Preserving the fertility and health of soil – and the organisms it contains – is one of the fundamental principles of organic farming as defined by IFOAM (2014). However, vegetable cropping systems often depends on soil disturbance for weed control, green manure incorporation and seedbed preparation, which may have negative effects on soil organisms (Roger-Estrade *et al*. 2010). In this context, Agro-ecological service crops (ASC) are introduced before cash crops in order to promote agroecosystem services. Several studies have shown the benefits of ASC terminated with roller crimper (RC) to control weeds, decrease soil erosion, and reduce the use of labour and fossil energy consumption (Canali *et al.* 2013; Altieri *et al.* 2011). Nevertheless, certain drawbacks have also been observed (Altieri *et al.* 2011) and to date few RC studies have been performed in European agroecosystems.

This study was carried out within the frame of the European project SoilVeg (ERA-Net CORE Organic Plus) which involves 14 institutions in nine countries and aims to study the effectiveness of

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RC under different scenarios, i.e. different combinations of crops, soils and climatic conditions. This project aims to verify the hypothesis that the use of ASC and termination by RC (1) maintains the productivity and quality of organic vegetable crops, (2) improves agronomic and environmental soil quality, (3) reduces the consumption of fossil fuels, and (4) helps to create a suppressive environment for pests, diseases and weeds. In this study, we focused on the fourth of these objectives in an experiment performed simultaneously in Italy and Spain. Our aim was to study how the sowing of an ASC before autumn-winter cash crops and the termination strategy, i.e. the incorporation of ASC into the soil as green manure (GM) vs. flattening of ASC on soil with RC, affect the ground-dwelling arthropod assemblages and, in particular, the communities of the natural enemies of aphids.

Material and methods

In winter 2015, two experiments wereestablished to study the effect of the type of ASC and the termination strategy on ground-dwelling arthropods**,** aphids and their natural enemies in Spain at the Gallecs Area of Natural Interest (Barcelona) (41° 33' 42" N 2°12' 7" E) and in Italy at Metaponto (CRA-SCA) (40° 23' 00" N 16° 48' 26" E). In Spain, the ASC mixture consisted of 50% *Vigna unguiculata* and 50% *Sorghum bicolor*, while in Italy four different combinations of *V. unguiculata*, *Pennisetum glaucum* and *Raphanus sativus* were used. ASCs were terminated with either RC or GM before the sowing of the cash crop. In Italy the cash crop was cauliflower, while in Spain it was cabbage. In Spain a control treatment based on keeping the soil bare without any plant cover (hereafter BS) was also established.

Data collection

In all the experiments, pit-fall traps and standard methods were used to investigate the soil arthropod fauna (Döring and Kromp 2003). Each pit-fall station consisted of two pit-fall traps connected to a 10 cm high and 1 m long Plexiglas barrier. Traps were filled with propylenglycol (40%). In Spain, eight samplings were carried out every fortnight, while in Italy four samplings were carried out every three weeks. In the laboratory, the most relevant taxa were counted in each sample.

Aphid colonies were assessed visually and separated into four infestation categories: class 0 (no aphids), class 1 (presence of a few aphids), class 2 (small colonies) and class 3 (large colonies). Aphid infestation was expressed as the weighted percentage (%) using the Townsend Heuberger's equation (Townsend and Heuberger 1943). In Spain, a total of 15 leaves per plot were assessed, three leaves per plant from five randomly selected cabbages. Aphidophagous predators such as hoverfly larvae, lady bugs and predatory bugs were also recorded from the same leaves. Aphid mummies were collected in order to identify the parasitoid species.

The same sampling protocol was performed in Italy, with the exception of the number of leaves sampled per plot (30, three leaves per plant on 10 randomly selected plants).

Statistical analyses

In Spain, the effects of the ASC termination, including the control without ASC, on activity density of ground-dwelling arthropods, aphid infestation and the abundance of parasitoids and aerial predators were analysed using a one-way ANOVA with three treatments (BS, RC and GM) and four repetitions per treatment. Post-hoc comparisons were performed using a Tukey test.

In Italy, the effects of the ASC termination technique on the activity density of ground-dwelling arthropods, aphid infestation and density of mummies were analysed using a two way ANOVA. The two factors were the termination technique (two levels, RC-GM) and ASC mix (four levels). Data were log- or square-root-transformed to meet the requirements of normality and homoscedasticity.

Results

Ground-dwelling arthropods

In Spain, the most abundant group was beetles (59.92%), followed by spiders (16.73%), earwigs (11.55%) and crickets (11.80%). The ANOVA showed significant differences between treatments for the activity density of spiders ($F = 5.80$, $df = 2$, $p < 0.05$), beetles ($F = 15.01$, $df = 2$, $p < 0.01$) and crickets ($F = 6.25$, $df=2$, $p < 0.05$) (Figure 1. A). No significant differences were found for earwigs. Spider and beetle abundances benefited from RC treatments, while cricket abundances were greater in BS plots.

In Italy, springtails were the most abundant group (68.6%), followed by isopods (24.1%), ground beetles (3%), spiders (2.9%) and rove beetles (1.2%). Ground and rove beetles and isopods were more abundant in roller crimper (RC) plots than in green manure (GM) plots (Figure 1. B). Springtails showed no differences between the different termination techniques.

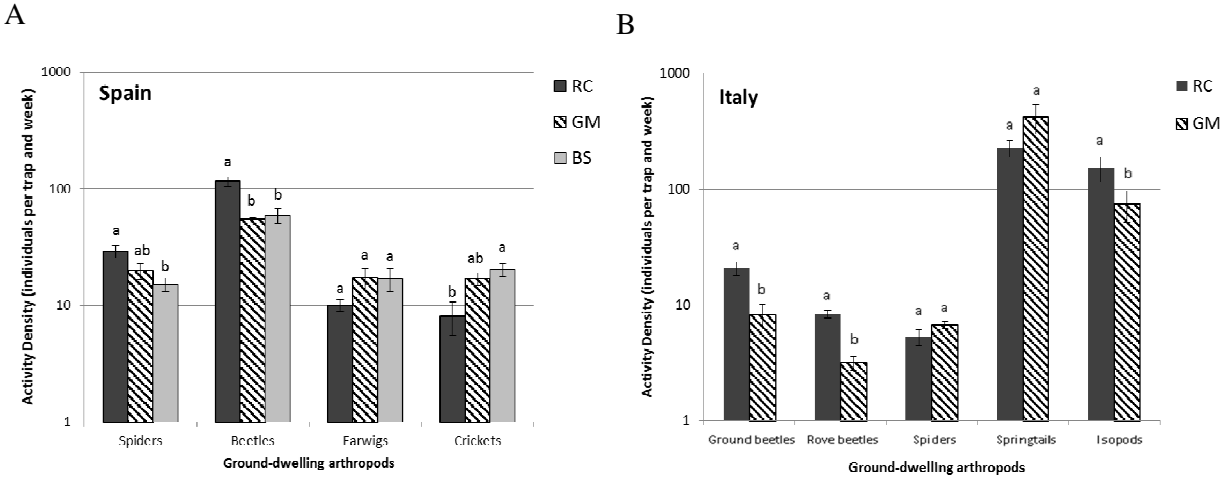

Figure 1. Activity density (individuals per trap and week) (mean ± standard error) of the most abundant ground-dwelling arthropod orders. A - Spain; B - Italy. In each order, treatments with the same letter were not significantly different at P □ 0.05 (Tukey test).

Aphids, aphid mummies, parasitoids and aphidophagous predators

In Spain, aphid infestation varied between treatments ($F = 6.43$, $df = 2$, $p < 0.05$) and RC plots suffered less aphid infestation than BS treatment plots (Figure 2. A). However, there were no differences between RC and GM plots.

The abundance of aphidophagous predators was influenced by the soil treatment ($F = 4.48$, $df = 2$, $p < 0.05$) and there were greater abundances of these communities in BS plots than in GM plots; no differences were found between GM and RC plots (Figure 2. A). The abundance of aphid primary parasitoids varied according to treatment ($F = 6.57$, $df = 2$, $p < 0.05$) and there was a greater abundance of parasitoids in BS plots than in RC plots (Figure 2. A).

In Italy, aphid infestation was higher in GM than in RC plots in the third sampling date; no differences between termination techniques were found for the remaining sampling dates. The density of mummies was higher in GM than in RC plots on the fourth sampling date (Figure 2. B).

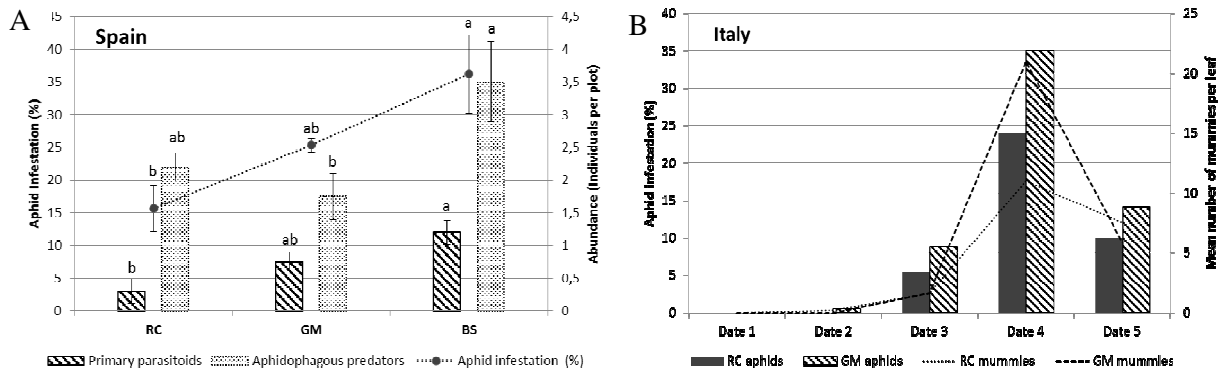

Figure 2. A – Aphid infestation (expressed as the weighted percentage %), primary parasitoids and aphidophagous predator abundances per plot under each treatment (mean ± standard error) in Spain. For each order, treatments with the same letter were not significantly different at P □ 0.05 (Tukey test). B - Trends in aphid infestations (expressed as weighted percentage %) and mummy occurrence for each treatment during the sampling season in Italy.

Discussion

The hypothesis that RC would help suppress pests was supported in both countries by the enhancing of ground-dwelling aphid-predator communities. In Italy in particular, ground and rove beetles greatly benefited from RC termination in comparison with GM, whereas in Spain spiders were the group that most benefited from the RC treatment. In Spain, the abundance of aphidophagous predators was mainly determined by the abundance of their potential prey items. Consequently, a greater abundance of aphids in the BS treatment led to higher predator abundances. In Italy, canopy infestation was very low under both treatments and the higher aphid infestation was only recorded in green manure plots on one sampling date. Parasitoids were the most abundant aphids' natural enemies in Italy and effectively controlled aphid infestation on cabbages. The abundance of parasitoids appears to be closely associated with the abundance of aphids in both countries, which may account for the aggregation response to the prey (Pareja et al. 2008).

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Assessing the productivity of organic rotations using the NDICEA model

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Key words: organic crop yields, nitrogen modelling, nutrient budgeting

Abstract

Organic farms rely on biological fixation by legumes and organic fertilisers to supply nitrogen (N) to crops over the course of a rotation. This can lead to a limited supply of N and lower yields compared to non-organic systems. As soil type and rainfall can affect N availability, the effect of both factors on organic crop yields was investigated using the NDICEA model. Typical organic yields were adjusted for 16 rainfall / soil-type combinations at 3 rates of N fixation. Results revealed significantly higher yields on high organic matter and heavy soil types and under dry rainfall conditions. The lower yields for high rainfall areas and light soils suggest that average organic yields may be an overestimate for these conditions. Higher yields for the high N fixation rate suggest that effective ley establishment may offset losses on wetter/lighter soils, however keeping N within the system can be a challenge particularly where over-winter cover crop establishment is poor and in cases where winter cereals are grown immediately after the ley.

Acknowledgements

The material presented was produced within a PhD supported by the Organic Research Centre and the Engineering and Physical Sciences Research Council (EPSRC).

Introduction

Organic farms rely on biological nitrogen fixation and organic fertilisers for the supply of N which generally leads to lower crop yields compared to non-organic systems using targeted manufactured N. Higher rates of N leaching can also occur under organic management as effective synchronisation of N supply with crop uptake can be difficult. Nevertheless organic crop yields can reach levels comparable to non-organic farming under the right conditions, although this will depend on N being available in sufficient quantities at key points in the rotation. As soil type and rainfall will both influence the amount of N supplied and lost in cropping systems, the effect of both factors on potential yield was investigated for a range of typical organic rotations.

Material and methods

A range of organic crop rotations were assessed using the NDICEA model (Nitrogen Dynamics In Crop Rotations in Ecological Agriculture, Van der Burgt et al. 2006). Smith et al. (2015) showed that NDICEA is a reasonably accurate tool for predicting N availability in a range of UK soil types and rainfall zones. The rotations assessed were drawn from literature and advice from organic farming advisors (see Table 1).

Table 1: Typical organic rotations assessed with NDICEA:

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	Course									
Rotation	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Stocked 'complex'	G/WC	G/WC	G/WC	WW	WO	RC/G	RC/G	P	SB	SW
Stocked 'simple'	RC/G	RC/G	WW	P	WW	WR				
Stockless 'complex'	RC/G	RC/G	P	WO	SB	SW				
Stockless 'simple'	RC/G	WW	PE	SO						
Field vegetable	RC/G	RC/G	P	BR	L					
Market garden	RC/G	RC/G	CB	O	B	C	SB	BR	PE	CG
Dairy	G/WC	G/WC	G/WC	G/WC	G/WC	G/WC	G/WC	FB	WS	SB
Cattle and sheep	G/WC	G/WC	G/WC	G/WC	G/WC	G/WC	G/WC	G/WC	FB	WW
Mixed	G/WC	G/WC	G/WC	RC/G	WW	WO	SB	WB	WR	

(G/WC = Grass/white clover, WS = wholecrop silage, WB = winter barley, WW = winter wheat, WO = Winter oats, RC/G = red clover SW = spring wheat, SB = Spring beans, P = potatoes, WR = Winter rye, FB = Fodder beet, PE = peas, SO = spring oats, PE = peas BR = broccoli, L = leeks, CB = cabbage, O = onions, B = beetroot, C = carrots, CG = courgettes, SB = spring barley)

Each rotation was assessed under 16 soil/rainfall combinations based on rainfall bands derived from the UK Meteorological Office and soil properties from long term organic trials (see Smith et al. 2015). The N-balance and N-availability predictions within NDICEA were compared for each site class and average organic yields adjusted iteratively to calibrate the model[38]. In a second phase, "high" and "low" nitrogen fixation thresholds were applied to explore the effect on productivity. Crop offtake data (kg N/ha/yr^{-1}) were analysed for treatment effects using one-way analysis of variance (ANOVA).

Results

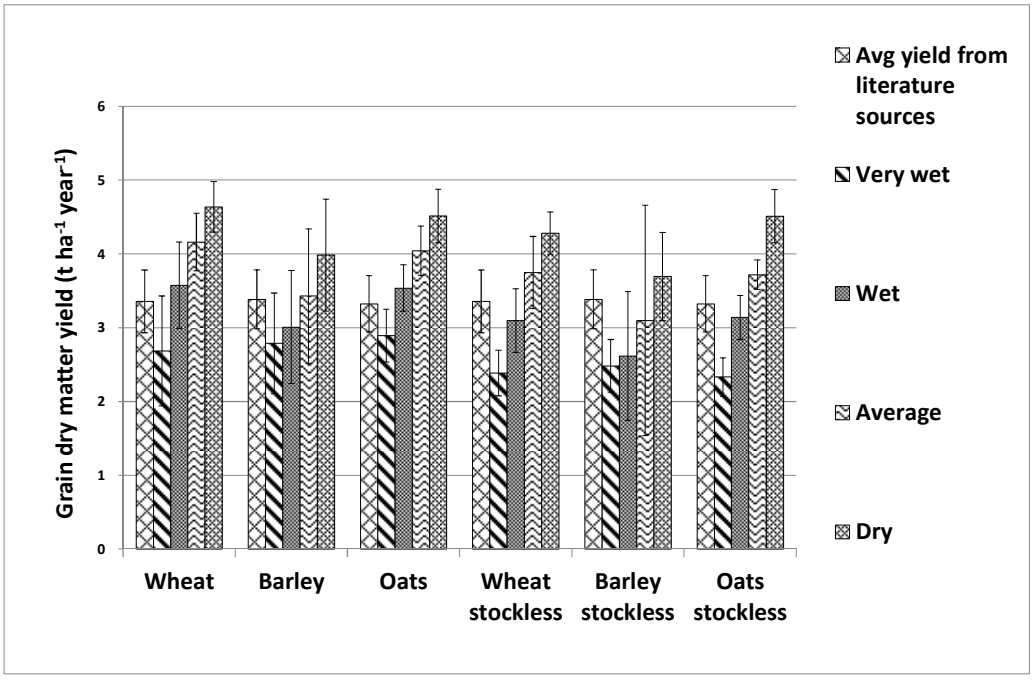

Figure1. Adjusted yield for organic crops grown under a range of rainfall conditions (avg. N fix scenario only) error bars = s.d.

[38]Average crop yield data were obtained from sources providing technical information to the organic sector, recent meta-analyses (e.g. Seufert et al., 2012) and the organic module of the Defra Farm Business Survey.

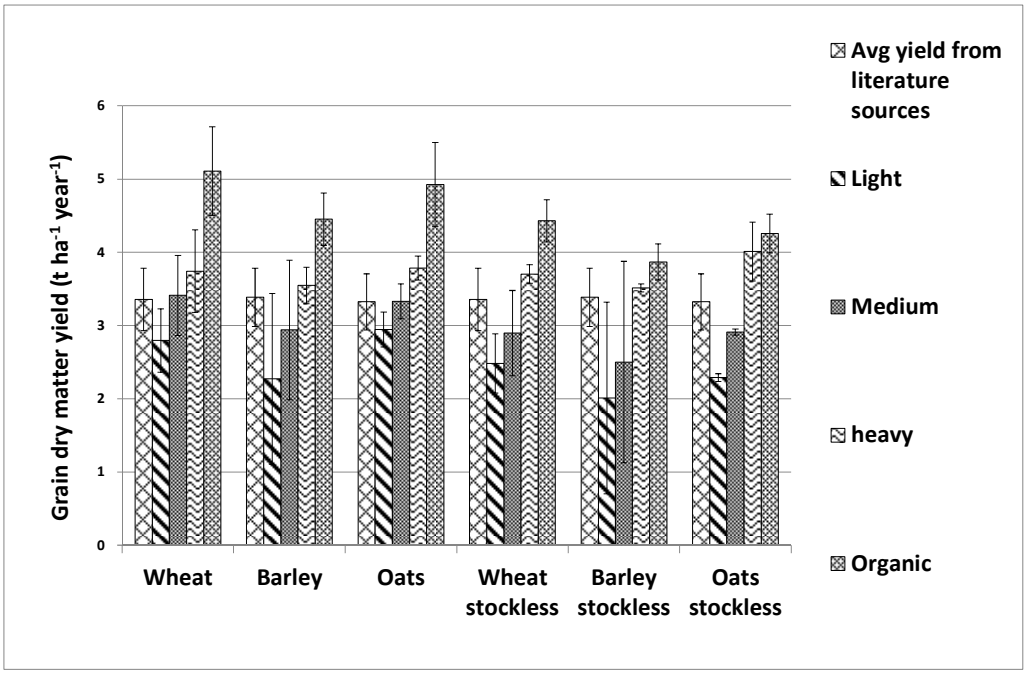

Figure 2. Adjusted yield for organic crops grown on a range of soil types (avg. N fix scenario only) error bars = s.d. Organic = high organic matter soil (i.e. >15% organic matter)

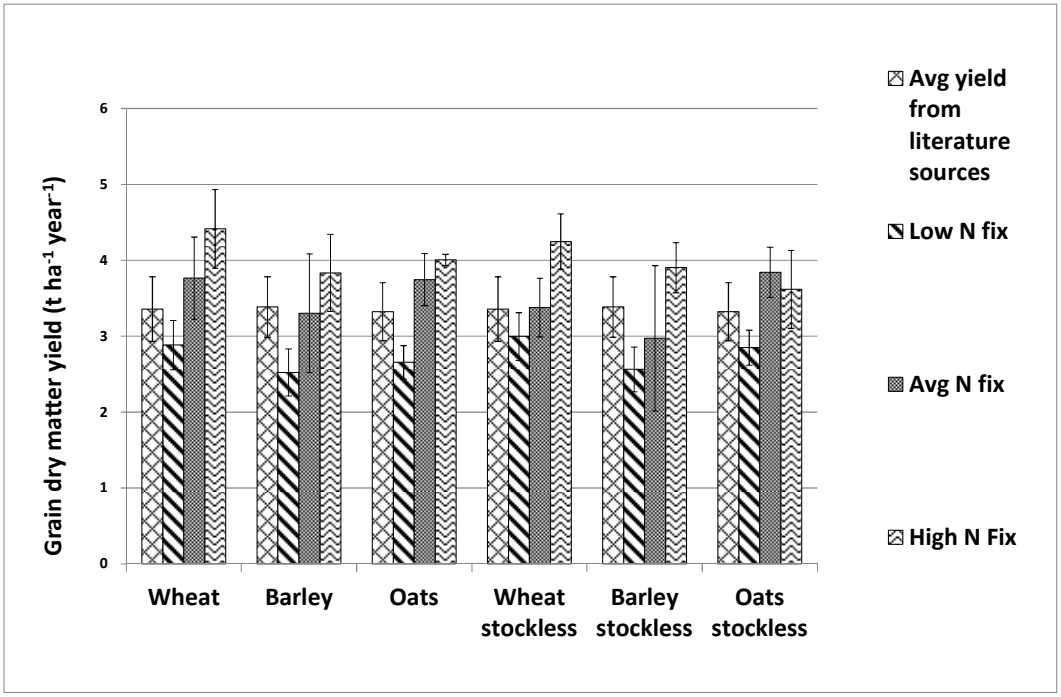

Figure 3. Adjusted yield for organic crops by N fixation rate within NDICEA. Error bars = s.d.

For all crops higher yields were found under dry conditions and on heavy and organic soil types. Adjusting the N fixation rate had the greatest overall effect on productivity over a rotation. For all rotations total product removal was significantly higher on dry soils in relation to wet and/or very

wet conditions ($P<0.01$). Product removal was also found to be significantly higher for heavy and organic soils compared to light and medium soil types respectively ($P<0.05$).

Discussion

The results suggest that the average yields reported in the literature may be overestimates under wet rainfall conditions and on light soil types. Higher rates of leaching under these conditions have been observed in previous studies and the unpredictable nature of the available N-supply in organic systems can exacerbate this. The effective use of over-winter green manures could help to reduce losses however establishment can be unreliable (Smith et al. 2015). Avoiding the common practice of growing a winter-cereal following ley cultivation could also help reduce N losses within organic systems (Stopes et al. 2002). The higher yields obtained in dry conditions and on high organic matter soils illustrate the potential benefits of expanding organic farming into these areas, which are currently dominated by the conventional sector in the UK (i.e. the eastern regions). In common with previous studies most of the rotations assessed resulted in phosphorus (P) and potassium (K) deficits per hectare (data not shown). Although K deficits can be addressed through mineralisation of reserves from parent material, a P deficit represents a fundamental issue that could be partly addressed by allowing sewage sludge application on organic land.

The results from this study also illustrate the importance of biological nitrogen fixation in organic rotations. With a higher N fixation rate it was possible to substantially increase organic crop yields to levels comparable with non-organic production for some crops (e.g. oats). Effective ley establishment and associated N fixation rates could therefore offset the effect of higher rainfall and/or light soils, although keeping the N provided by biological fixation within the system may present a challenge. It should also be noted that NDICEA does not account for crop yield losses from pests, diseases and plant water stress. Adjusting the model to include these factors could allow for its wider application. The model could also be adapted to incorporate an automatic yield adjustment to allow scenarios to be explored more efficiently. Despite this the model remains an effective and reasonably accurate tool and its wider application could help to improve nitrogen use efficiency within cropping systems.

Suggestions to tackle the future challenges of Organic 3.0

The potential for a more detailed consideration of crop rotation design and associated nitrogen dynamics as part of the certification process could be explored to promote sustainability and improved yields. In addition the prohibition of sewage sludge and urine application on organic land in Europe may no longer be justified.

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Plant Production - India

Title	Author/s	Country
Evaluation of Nutrient Management Practices for Organic Chickpea (Cicer arietinum L.)	S. K. Sharma, Roshan Choudhary and Amit Trivedi	India
Comparative performance of organic vis-à-vis inorganic management practices in potential vegetable cropping sequences	JP Saini, Rameshwar and Raj Kumar	India
Nutrient management recommendations for smallholder organic Basmati rice production in Northern India	Lenora Ditzler, Tor Arvid Breland, Charles Francis, Monojit Chakraborty,D.K. Singh, Ashish Srivastava, Frank Eyhorn, Jeroen C.J. Groot, Johan Six, Charlotte Decock	India
Seaweed an organic fertilizer source for boosting the productivity of crops	C.S. Singh, M.K. Singh, S.K. Singh and Shikha Singh	India
Agricultural waste recycling: a new method to produce good quality compost at large scale	Shiva Dhar	India
Response of various inputs on yield, fruit quality and economics of organic production of mango cv. Mallika	Ram Awadh Ram, Anil Verma, Gundappa and Supriya Vaishya	India
Growth and yield of organic capsicum (Capsicum annuum L. var. grossum) as influenced by different sources, levels of organic manures and panchagavya application	B Boraiah, N Devakumar, K B Palanna, S Shubha	India
Organic production is safe, sustainable and profitable: Evidences from tuber crops	Girija Suja, Alummoottil Narayanan Jyothi, Janardanan Sreekumar, Ambikakumari Radhakrishnan, Seena Radhakrishnan, Cherian Lintu Maria and Rakhi Kanjiramthottiyil Raj	India
Influence of different levels of jeevamrutha and panchagavya on yield and quality parameters of organic frenchbean (Phaseolus vulgaris L.)	Basavaraj Kumbar, Devakumar N.	India
Effect of Farm Yard Manure (FYM) and Jeevamrutha on yield attributes and yield of Fieldbean (Dolichos lablab L.)	Siddappa, K. Murali, N. Devakumar and Ninganna Biradar	India
Influence of organic liquid formulations on soil beneficial microbial population of organic frenchbean (Phaseolus vulgaris L.)	Ninganna Biradar, K. Murali, N. Devakumar and Lavanya G	India
Efficient method of composting for production of good	Tarak Kate, Sonali Phate	India

quality manure from hard crop residues

Influence of Organic in different methods of rice (Oryzae sativa.L) cultivation – SRI vs NTP on microbes, soil health and productivity	Rapolu Mahender Kumar, Kuchi Surekha, S. Gopalakrishnan, Ch Padmavathi , P.C. Latha and V. Ravindra Babu	India
Biofertilizer and bioirrigation: Tools for sustainable pigeon pea and finger millet production in India	Natarajan Mathimaran, Ansgar Kahmen, Ashok Ettigi Gurubasappa, Thimmegowda Matadadoddi Nanjundegowda, Sathish Ayappa, Bhavitha Nayakanahalli Chikkegowda, Shashidhar Gurudevarahalli Chikkathamegowda, Manjunatha Baiyapalli Narayanswamy, Prabavathy Vaiyapuri Ramalingam, Jegan Sekar, Yuvaraj Perisamy, Bagyaraj Davis Joseph, Thomas Boller and Paul Mäder	India
Organic Rice farming – A viable option for sustaining Productivity, Grain quality, Soil health and Economic returns	Surekha Kuchi, Sreenivasa Rao Illuri and Mahender Kumar Rapolu	India
Yield and yield attributes of organic frenchbean (Phaseolus vulgaris L.) as influenced by farm yard manure and liquid manures	Basavaraj Kumbar, Devakumar N.	India
Effect of various sources of Zinc with particular reference to Nano Zinc carrier on Growth and Yield parameters in Rice (Oryza sativa.L)	M.R. Apoorva, P. Chandrashekar Rao	India
Dry matter accumulation and nutrient content in frenchbean (Phaseolus vulgaris L.) as influenced by organic liquid formulations	Ninganna Biradar, K. Murali and N. Devakumar	India
David against Goliath - Participatory non-GM cotton breeding in India	Monika M. Messmer, Amritbir Riar, Seraina Vonzun, Yogendra Shrivas, Lokendra Mandloi, Mahesh Birla, Ishwar Patidar, Ramprasad Sana, Gobinda Mahapatra, Arun Ambatipudi, H.G. Kencharaddi, Shreekant S. Patil	India
Soil health response to Organic nutrient management in vertisols under aerobic rice (Oryza sativa L.) cultivation	Jaffar Basha S, R. Basavarajappa and H. B. Babalad	India

Evaluation of Nutrient Management Practices for Organic Chickpea (*Cicer arietinum* L.)

S. K. Sharma[1],Roshan Choudhary[2] and Amit Trivedi[3]

Key words: Organic sources of nutrients, BD-500 &BD-501, Mustard cake, Rhizobium, Chickpea, Vermicompost

Abstract

A field experiment was conducted on sandy clay loam soil at Instructional farm, Department of Agronomy, Rajasthan College of Agriculture, Udaipur (Rajasthan) during Rabi seasons of 2012-13, 2013-14 and 2014-15 to study the development of nutrient management practices for production of organic chickpea (Cicer arietinum L.).The soil application of organic manures and foliar spray of biodynamic manures significantly enhanced the growth and yield parameters of chickpea viz., plant height, number of branches, number of pods per plant, 100-seed weight, grain yield and haulm yield. Application of vermicompost 2 t ha^{-1} as basal + vermicompost 2 t ha^{-1} at 40 DAS + mustard cake 1 t ha^{-1}as basal + Rhizobium + PSB + BD 500 75 g ha^{-1} before sowing and 30 DAS + BD 501 @ 2.5 g ha^{-1} at 2-4 leaf ans pre-flowering stage recorded significantly higher seed yield (1748 kg/ha), haulm yield (5416 kg ha^{-1}), number of pods plant^{-1} (114.92) and number of grains pod^{-1} (1.48) compared to other treatments. Significantly maximum net return (Rs. 40631 /ha) was recorded with application of vermicompost 2 t ha^{-1}as basal + vermicompost 2 t ha^{-1}at 40 DAS + mustard cake 1 t ha^{-1}+ Rhizobium + PSB + BD 500 + BD 501 which recorded an increase of 76.08 and 26.49 per cent over control and application of FYM 8 t ha^{-1}+ Rhizobium + PSB, respectively.

Acknowledgments

We acknowledge the financial support received from ICAR under the Network Project on Organic Farming, MPUAT, Udaipur

Introduction

Chickpea (*Cicer arietinum* L.) is the third most widely grown grain legume in the world after bean and soybean. In India, Chickpea remarkably predominates among other pulse crops in terms of both area and production. In India, it is cultivated on an area of 10.2 million hectare with a production of 9.9 million ton and productivity of 967 kg ha^{-1} (Economic Survey, 2015). Rajasthan state occupies 19.23 lakh hectare area under chickpea of with production 1.64 million tones and the productivity is 853 kg ha^{-1} (Agricultural Statistics, 2015). It is often hard to quantify the effect of organic management practices on nutrient cycles because of the fact that organic agriculture is not about substitution of input for input, but the overall development of soil health. However, single organic source of nutrient supplementation may not cope up with the nutrient demand of crops.

In the present study, effect of farm yard manure (FYM), vermicompost, mustard cake, BD-500 and BD-501, Rhizobium and PSB have been investigated on productivity & economics of organic chickpea. Integration of different organic nutrient sources and growth enhancers help to solve dual

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problem of supplementation of sufficient nutrients besides synchronized nutrient availability as per crop demand associated with variable nutrient release pattern among different organic manures.

Material and methods

Chickpea (*Cicer arietinum* L.) was grown under organic management practices at Instructional Farm, Rajasthan College of Agriculture, Udaipur situated in North-West India during *rabi* seasons of 2012-13, 2013-14 and 2014-15.The soil of the experimental site was sandy clay loam in texture with bulk density of 1.42 g/cc, pH of 7.90, organic carbon of 0.42 per cent. The soil containing available N (223.42 kg ha^{-1}) and P_2O_5 (30.96 kg ha^{-1}) and available K_2O (262.25 kg ha^{-1}). The experiment was laid out in randomized block design with three replications. There were 10 treatments consisting of T_1: FYM 8 t ha^{-1} + *Rhizobium* + PSB, T_2: FYM 4 t ha^{-1} + Mustard cake 1 t ha^{-1} + *Rhizobium* + PSB, T_3: FYM 8 t ha^{-1} + BD 500 + BD 501 + *Rhizobium* + PSB, T_4: FYM 4 t ha^{-1} + Mustard cake 1 t ha^{-1} + *Rhizobium* + PSB+ BD 500 + BD 501, T_5: Vermicompost 4 t ha^{-1} + *Rhizobium* + PSB, T_6: Vermicompost 2 t ha^{-1} + Mustard cake 1 t ha^{-1} + *Rhizobium* + PSB, T_7: Vermicompost 4 t ha^{-1} + BD 500 + BD 501 + *Rhizobium* + PSB, T_8: Vermicompost 2 t ha^{-1} + Mustard cake 1 t ha^{-1} + *Rhizobium* + PSB + BD 500 + BD 501, T_9: Vermicompost 2 t ha^{-1} as basal + Vermicompost 2 t ha^{-1} at 40 DAS + Mustard cake 1 t ha^{-1}+ *Rhizobium* + PSB + BD 500 + BD 501 and T_{10}: control. The recommended dose of nitrogen & phosphorus for chickpea was 20 and 40 kg ha^{-1}. Organic manures were applied considering equivalency of recommended dose of phosphorus. Seed were treated with *Rhizobium* and phosphorus solublising bacteria (PSB) 600 g per 10 kg seed. Biodynamic manure, BD 500 (cow horn manure) was applied on soil in evening a day before sowing and 30 DAS 75 g ha^{-1} with 40 litre water. While BD 501 (cow horn silica) was sprayed as foliar application 2.5 g ha^{-1} with 40 litre water at 2-4 leaf stage and at pre- flowering stage. The chickpea variety GNG- 469was sown with a spacing of 30 cm x 10 cm. Soil application of neem cake at 2 q ha^{-1} (for soil borne insects) + Trichoderma 2 kg/ha incubated for 15 days on 100 kg FYM was applied before sowing.

Results

Results of the pooled data of three years i.e. 2012-13, 2013-14 and 2014-15 revealed a significant effect of organic practices of nutrient management on yield attributes and yield of chickpea. Application of vermicompost 2 t ha^{-1} as basal + vermicompost 2 t ha^{-1} at 40 DAS + mustard cake 1 t ha^{-1}+ *Rhizobium* + PSB + BD 500 + BD 501 recorded significantly higher plant height, number of pods/plant (114.92) and number of grains pod^{-1} (1.48) as compared to other treatments (Figure1).

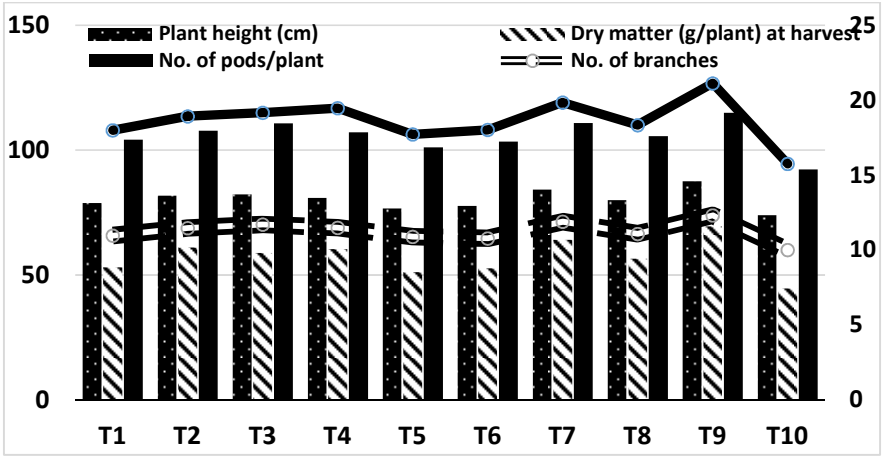

Figure 1: Effect of different nutrient management practices on growth attributes of organic gram (Pooled data of three years)

Similarly, application of vermicompost 2 t ha^{-1} as basal + vermicompost 2 t ha^{-1}at 40 DAS + mustard cake 1 t ha^{-1}+ Rhizobium + PSB + BD 500 + BD 501 gave significantly higher seed yield

(1748 kg ha^{-1}), haulm yield (5416 kg ha^{-1}), seed index (21.12) and biological yield (7164 kg ha^{-1}) compared to other treatments (Figure2).

Application of vermicompost 2 t ha^{-1} as basal + vermicompost 2 t ha^{-1}at 40 DAS + mustard cake 1 t ha^{-1}+ Rhizobium + PSB + BD 500 + BD 501 gave maximum net return of Rs. 40631 ha^{-1} and recorded an increase of 76.08 and 26.49 per cent over control and application of FYM 8 t ha^{-1}+ Rhizobium + PSB. Split application of vermicompost 2 t ha^{-1} at 40 DAS along with two spray of BD 500 and BD 501 gave an additional net return of Rs. 10671 ha^{-1}over vermicompost 4 t ha^{-1} + *Rhizobium* + PSB.

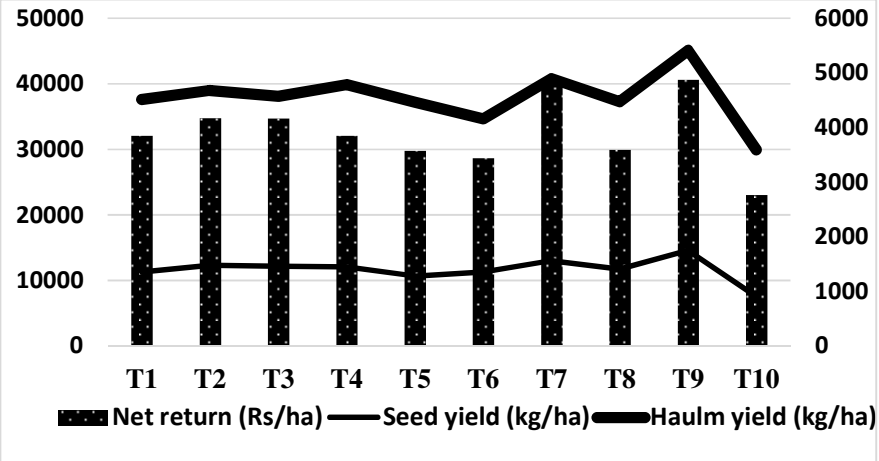

Figure 2: Effect of different nutrient management practices on yield and economics of organic gram (Pooled data of three years)

Discussion

Results reveal that application of vermicompost 2 t ha^{-1}as basal + vermicompost 2 t ha^{-1}at 40 DAS + mustard cake 1 t ha^{-1}+ Rhizobium + PSB + BD 500 + BD 501 increased plant height, number of branches, number of pods $plant^{-1}$, number of grains pod^{-1}, seed yield and haulm yield which might be due to the improvement in soil physical condition for the plant growth along with increased availability of micro and macro nutrients at the early stage of crop growth.

BD-500 and BD-501 also called as bio-enhancers are rich source of microbial consortia, macro and micronutrients and plant growth promoting substances including immunity enhancers (Pathak and Ram, 2012). Pfeiffer, 1984 reported that spray of biodynamic manure BD 501 increases the photosynthesis and as such compliment the activity of the preparation BD 500, which works mostly in the root zone of the plant. He discussed the polar effects of this preparation as related to environmental factors of soil, light, intensity and moisture. Koepf *et al.* (1976) reported that preparation 500 increase soil biological activity and stimulate root formation. Preparation 500 is substantially endowed with enzymatic-specific activities, rich in microbial cells, whose culturable fraction is dominated by the Bacillus genus and exhibits an auxin-like activity. humic- like materials obtained from green compost or vermicompost, the large amount of undegraded lignin residues found in BD-500 by Spaccini *et al.* (2012), may account for the bio stimulations towards microbes and plants.The foliar spray of BD 501 at 2-4 leaf and pre-flowering stage had a significant influence on growth of chickpea crop. It enhanced the growth rate of plant since it contains the favourable micro and macronutrients and growth hormones. The favourable effect of biodynamic manures (BD 500 & BD 501) on growth & productivity of cumin was also reported by Sharma *et. al.* (2012)

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Comparative performance of organic *vis-à-vis* inorganic management practices in potential vegetable cropping sequences

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Key words: Organic agriculture, physical, chemical, biological, vegetables & composts

Abstract

A field experiment was conducted at Research Farm of Department of Organic Agriculture, CSKHPKV, Palampur (H.P) India w.e.f. kharif 2012 to kharif 2015 to find out the most economical cropping sequence and the best management practice. Pooled Okra equivalent yield (2012-15) of the system in organic treatment was significantly higher which ultimately resulted in higher net returns in organic management over the other management practices. The available N, P & K contents in soil were comparatively higher in integrated nutrient management practice. The dehydrogenase activity in organic and integrated practice was at par with each other but significantly higher than chemical practice. Organic practice resulted in significantly highest soil microbial biomass carbon (SMBC) over all other treatments.

Acknowledgements

Assistance in the form of funding by the **Indian Council of Agricultural Research (ICAR), New Delhi** and facilities provided by the **CSK HPKV Palampur** is duly acknowledged

Introduction

The concept of organic agriculture builds on the idea of the efficient use of locally available resources as well as the usage of adapted technologies. In organic agriculture carbonic material, organic compost and natural resources are utilized in a proper and justified manner, which enhance the production potential and improves the physical, chemical & biological properties of the soil. Organic agriculture combines modern scientific knowledge with traditional farming technologies in a sustainable farming system. The studies have shown that small farmers who adopt organic agriculture earn higher income and achieve better living standards. Thus as an engine for sustainable development, organic agriculture has a role to play in furthering the cause of food security with sustainability, poverty alleviation and environment protection.

Material & Methods

A field experiment was conducted in split plot design with three replications and twelve treatment combinations at Research Farm of Department of Organic Agriculture, CSKHPKV, Palampur (H.P) India *w.e.f.kharif* 2012 to *kharif* 2015. The potential and economically viable vegetable cropping sequences of Himachal Pradesh were studied under different nutrient management practices with an objective to find out the most economical cropping sequence under the organic management practices as per the treatment details given below.

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Treatments

Cropping sequences

C_1:	Okra- Cauliflower- French bean	**T1:**	Organic- (Vermicompost @ 10 t/ha in vegetables & 5 t/ha in pulses)
C_2:	Tomato- Radish- Pea	**T2:**	Integrated (Vermicompost 50%+ Chemical fertilizers 50%)
C_3:	Brinjal- Cabbage- French bean	**T3:**	Chemical (Recommended NPK of each crop)
		T4:	Farmer's practice (1/4th of recommended NPK & vermicompost)

After the harvest of *Kharif* 2014, the soil samples were collected from surface (0-0.15 m) and subsurface (0.15-0.30 m) soil and were analyzed for various physical, chemical and microbiological properties.

Results

Effect on yield

It is evident from the table 1.1 that among the cropping systems, Okra-Cauliflower-Frenchbean (C_1) cropping system produced comparatively higher yields which ultimately resulted in significantly higher average okra equivalent yield of the system (*kharif* 2012-*kharif* 2015), net returns and benefit-cost ratio over other two cropping sequences. Integrated nutrient management practice being, at par with chemical and organic treatment resulted in significantly higher yields over the farmer's practice. The pooled yield of the system in organic being at par with integrated practice was significantly higher over other management practices which ultimately resulted in higher net returns.

Effect on soil physical & chemical properties

Water holding capacity of the soil was comparatively higher in organic and integrated treatment as compared to the chemical treatment. Similar results have been reported by Johnston *et.al* (1995) who observed that the crop yields were increased by using animal manures due to the corresponding improvement in soil quality. On the surface soil the highest soil organic carbon was recorded under organic treatment (T_1) and lowest in treatment control (T_4). Almost, similar was the trend in sub-surface soil. Integrated nutrient management practice being at par with chemical and Organic treatment resulted in significantly higher available N, P & K over other treatments.

Effect on biological properties

Dehydrogenase activity (DHA) and soil microbial biomass carbon (SMBC) were significantly higher in organic as compared to the chemical practice, however, it was at par with the integrated nutrient management. The dehydrogenase activity was highest in Brinjal-Cabbage-Frenchbean (C_3) sequence closely followed by Tomato-Raddish-Pea (C_2). The highest dehydrogenase activity was recorded in organic treatment and lowest in control. The highest soil microbial biomass carbon (SMBC) was recorded under organic treatment and lowest in control.

Table 1: Effect of different crop rotation and management practices on equivalent yield of different crops

Treatments		*Kharif* 2012	*Rabi* 2012-13	*Kharif* 2013	*Rabi* 2013-14	*Kharif* 2014	*Rabi* 2014-15	*Kharif* 2015	Pooled okra equivalent yield of the system (q ha^{-1}) 2012-2015	Economics	
		Okra equivalent yield (q ha^{-1})	Pea equivalent yield (q ha^{-1})	Okra equivalent yield (q ha^{-1})	Pea equivalent yield (q ha^{-1})	Okra equivalent yield (q ha^{-1})	Pea equivalent yield (q ha^{-1})	Okra equivalent yield (q ha^{-1})		Net returns (Rs/ha)	B:C ratio
Crop rotations											
C1	Okra-Cauliflower-French bean	72.7	94.7	78.2	75.4	50.4	104.2	112.5	211.21	358728.6	5.63
C2	Tomato-Radish- Pea	68.2	82.1	62.1	65.5	35.8	99.4	104.3	187.11	318528.6	5.72
C3	Brinjal-Cabbage-French bean	62.4	90.3	60.4	65.4	29.3	102.1	107.4	188.63	319557.1	5.54
CD (P=0.05)		NS	NS	NS	NS	13.2	NS	NS	18.50	25024	NS
Management practices											
T1	Organic	73.5	99.6	93.3	96.1	42.4	127.7	120.7	232.86	392309.3	5.30
T2	Integrated practices	79.4	94.0	103.8	73.5	48.4	111.6	113.2	218.13	377866.1	6.41
T3	Chemical practices	77.9	101.9	99.4	63.2	53.0	98.6	117.3	212.33	369080.1	6.57
T4	Farmers practice	39.4	60.9	33.2	33.4	16.9	60.8	68.2	111.53	181652.1	4.63
CD (P=0.05)		**9.87**	**9.52**	**14.6**	**11.0**	**10.1**	**8.5**	**8.6**	**20.12**	**26058**	**0.50**

**Organic: VC 5t/ha in pulses & VC 10t/ha in other crops+Bifertilizers (Rhiz.+PSB)+Vermiwash (Liquid manure)*

Table 2: Effect of different crop rotation and management practices on soil physical, chemical and biological properties of soil

Treatments	Physical properties				Chemical properties			
	Bulk density (Mg m^{-3})		Water holding capacity (%)		Soil pH		Organic carbon (%)	
Crop rotations	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15cm	15-30 cm	0-15cm	15-30 cm
Okra- Cauliflower- French bean	1.20	1.22	54.08	54.35	5.7	5.6	1.41	1.36
Tomato- Radish- Pea	1.21	1.23	54.20	54.49	5.8	5.6	1.44	1.40
Brinjal- Cabbage- French bean	1.20	1.22	54.04	54.38	5.7	5.7	1.41	1.37
CD (P=0.05)	NS	NS	NS	NS	NS	NS	0.03	0.03
Management practices								
Organic	1.19	1.20	54.48	54.79	5.9	5.7	1.58	1.54
Integrated practices	1.20	1.22	54.08	54.38	5.8	5.7	1.41	1.37
Chemical practices	1.23	1.24	53.94	54.16	5.7	5.6	1.34	1.30
Control	1.21	1.23	53.85	54.11	5.6	5.4	1.29	1.25
CD (P=0.05)	NS	NS	NS	NS	NS	NS	0.07	0.07
Initial	**1.19**		**53.5**		**5.5**		**1.22**	

Treatments	Chemical Properties						Biological properties			
	N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})		DHA (µg TPF g^{-1} hr^{-1})		SMBC (µg g^{-1} soil)	
Crop rotations	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Okra-Cauliflower- French bean	326.4	319.4	35.3	33.0	166.2	157.4	3.53	3.20	117.5	106.5
Tomato- Radish- Pea	330.0	322.6	37.1	33.7	168.8	159.6	3.79	3.56	121.4	111.4
Brinjal-Cabbage- French bean	329.2	322.0	36.7	33.5	168.4	160.4	3.95	3.71	119.7	109.6
CD (P=0.05)	2.23	NS	NS	NS	NS	NS	0.36	0.29	NS	NS
Management practices										
Organic	328.3	323.0	36.8	33.6	173.3	165.3	4.17	3.83	140.7	129.3
Integrated practices	335.7	326.7	40.3	37.0	177.0	167.7	4.16	4.28	116.9	107.5
Chemical practices	333.0	324.0	39.1	36.2	171.7	163.7	3.49	3.20	106.5	94.8
Control	321.7	316.0	32.0	29.2	155.7	145.7	3.08	2.94	102.9	92.6
CD (P=0.05)	9.93	9.33	4.97	4.47	11.00	10.40	0.89	0.82	11.33	11.17
Initial	**295**		**27.8**		**137**		**1.80**		**88.0**	

Discussion

Organic management practices gave significantly higher equivalent yield of the system and ultimately resulted in highest net returns over the chemical and integrated practices. The use of organic manures in organic treatment have proven to be the effective means of improving soil structure, enhancing soil fertility and increasing crop yields (Johnston *et al.*1995 and Canellas *et al.* 2000). Organic treatment improved the available nutrients, DHA and SMBC which had the positive effect on the crop yield. The high SMBC in organic practice might be due to the readily available carbon fraction of vermicompost.

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Nutrient management recommendations for smallholder organic Basmati rice production in Northern India

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Key words: Basmati rice, manure management, farmyard manure, biogas slurry, green manure

Abstract

In this study we identify viable interventions to reduce nutrient gaps at the farm level, with the aim of magnifying the livelihood benefits of farmers' involvement in an organic and fair trade market scheme. Farmers in Uttarakhand rely on few livestock for nutrient inputs, and achieve smaller than potential Basmati yields. Nutrient exports are generally not balanced by inputs, causing mining scenarios. We surveyed 42 farmers and sampled their manure composts in order to trace the farm-level flow of manure nutrients, identify avoidable nutrient losses, and systematically identify locally relevant and feasible system improvements. Three options emerged from the research: adoption of green manuring, import of nutrients via purchased farmyard manure, and modified manure handling and storage. Cost-benefit analyses predicted that the interventions considered could increase farmers' net profit by up to 65% while also addressing the problematic nutrient gap.

Acknowledgments

This research was part of the project "How to sustainably intensify organic Basmati rice in Uttarakhand, India? (BasmaSus)", funded by the World Food System Center COOP Research Program. We also thank the Agroecology Unit at the Norwegian University of Life Sciences for providing travel funding through the Indo-Norwegian Cooperation Program (SIU): INCP-2014/10096: "Action research and education in Agroecology - Cooperation and Comparison"; Intercooperation Social Development India for facilitating the fieldwork; the faculty and staff at G. B. Pant University of Agriculture and Technology; Helvetas Swiss Intercooperation; the farmers of Patkote, Kotabagh, and Betalghat; and our translator Rakesh Kumar.

Introduction

A development project in Uttarakhand introduces smallholders to a fair trade organic Basmati value chain with the aim of improving livelihoods. Farmers rely on few livestock for organic inputs and achieve smaller than potential yields, related in part to insufficient manure supply and consequently inadequate nutrient inputs. If not offset by input, continual nutrient export via sales will cause mining, and livelihood improvements won by participating in the value chain could be negated by soil degradation. To magnify the livelihood benefits of farmers' involvement in the development scheme, the issue of scarce nutrient supply must be addressed. This study aims to describe actual nutrient management practices on farms producing organic Basmati rice, compare farmers'

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practices with best practice recommendations to identify potential points of nutrient loss, and systematically identify locally relevant and feasible solutions to increase nutrient supply and recycling at the farm level.

Material and methods

The research was conducted in the Nainital district in Uttarakhand, India, following the DEED (Describe, Explain, Explore, Design) methodology described by Giller *et al.* (2011). We made a modification to re-name the fourth phase 'Act', inspired by the final phase of Kolb's Learning Cycle (Kolb 1976). The methods employed in each research phase are outlined in Figure 1.

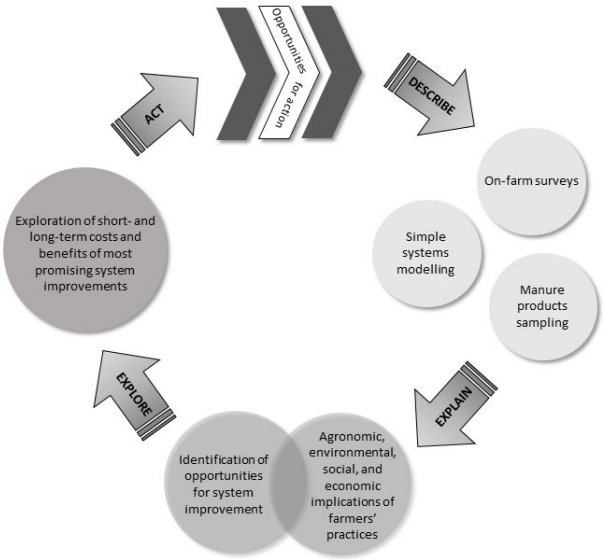


Figure 1. The four research phases and their components.

First, we collected primary data via 42 on-farm surveys and manure sampling to describe actual farmers' manure management practices, nutrient supply, and Basmati yields (*Describe*). Next, farmers' practices were systematically examined to identify which management actions likely lead to nutrient loss, the magnitudes of these losses were estimated by comparing farmers' practices with best practice recommendations cited in the literature, and each point of probable nutrient loss was paired with potential management modifications to identify a pool of options to improve farm-level nutrient availability and recycling (*Explain*). Then, we cross-checked the applicability of modifications within identified constraints, developed a short list of most feasible interventions, and explored the viability of each intervention by conducting a cost–benefit analysis and evaluating the trade-offs of projected short- and long-term impacts (*Explore*). Finally, we validated proposed interventions with a panel of local experts and identified potential challenges and constraints of implementation (*Act*). These phases represent four practical extensions of Kolb's Learning Cycle.

Results and Discussion

Describe

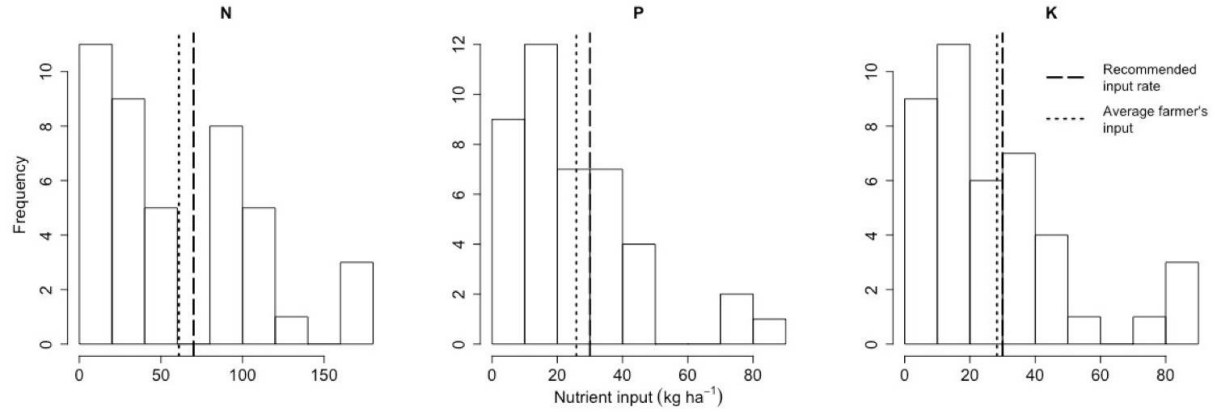
Among the 42 surveyed farmers, average farm size was 1.1 ha (range: 0.3–3.3 ha). Livestock holdings ranged from 1.4 livestock units[9] (LU) to 7.8 LU with an average stocking rate of 5.4 LU ha^{-1}. Basmati yields reported for the period 2013–2015 ranged from 600 to 3600 kg ha^{-1}, with an

[9] We define livestock unit (LU) in local terms as an adult cow or buffalo (300 kg LW) of an indigenous or nondescript hill breed.

average 26–37% smaller than potential (Singh *et al.* 2017). We estimated that farmers had on average just over 10 Mg total fresh manure per farm available for fertilizing all *kharif* (monsoon) crops. This value is less than 1/3 of the recommended per hectare dry weight manure application rate for Basmati[10] , indicating that the average farmer lacked outright the raw manure resources to meet agronomic recommendations for Basmati fertilization on the hectares managed.

The results of the on-farm manure fertilizer products sampling showed that the nutrient contents of farmers' manure fertilizers generally fell in the mid to lower range of what is reported in the literature, indicating that there is room for management interventions to improve the nutritive quality of manure fertilizers. Farmers were almost exclusively unable to supply the nutrient needs of Basmati crops and maintain positive nutrient balances by applying manure fertilizers alone. Few farmers supplied the recommended manure input rates; on a farmyard manure (FYM) equivalent basis, there was an input gap of 68% between the average farmer's practice and the local agronomic recommendation.

On a nutrient basis, farmers growing an *in situ* green manure prior to Basmati were able to meet the recommended nitrogen (N) input rates, while farmers not growing a green manure were on average only able to supply 43% of the recommended N rate. For phosphorus (P) the average input gap was 14% (4 kg P ha^{-1} deficit), while for potassium (K) the average farmer was able to meet the input recommendation of 30 kg K ha^{-1}. Of the farmers not growing a green manure, only one was able to meet the recommended NPK input rates by applying solely livestock manure. Figure 2 shows the



range and frequency of farmers' NPK inputs compared to the recommended rates.

Figure 2. Range and frequency of NPK inputs by all farmers compared to recommended input rates.

Farmers growing a green manure had significantly higher field-level N balances than those not growing a green manure (p=<0.001). Despite input rates, K appeared to be the nutrient with the most potential for mining; 71% of farmers had negative K balances. P was the nutrient farmers had the least problem with in terms of negative balances, with 83% of farmers maintaining positive P balances.

Explain

We identified the following reasons for nutrient losses related to farmers' manure handling and storage practices: suboptimal animal housing, lack of animal bedding materials, urine run-off, and lack of cover over FYM and biogas slurry (BGS) piles during storage. Improved housing and urine

[10] The locally recommended fertilization rate for Basmati rice is a manure dose equivalent to 70:30:30 kg NPK ha^{-1}.

collection with bedding materials could increase farm-level N supply by up to 104 kg season^{-1}. Covering manure piles could reduce nutrient losses during storage by up to 21% (Shah *et al.* 2012).

Explore & Act

Three solutions emerged as potentially feasible for farmers in the study region. First, we explored green manuring (GM) with *Sesbania aculeata*as a solution for closing the N gap. Our projections show that GM could increasenet profit by up to 65%. In addition to financial gains, GM could improve soil quality. Despite these benefits, we hypothesize that three constraints would likely impact a farmer's ability and willingness to adopt GM: water availability, cost and accessibility of seed, and an increased labor requirement.

Second, we explored the option of purchasing FYM off-farm as a way to fill the nutrient gap. We predicted the economic return on incremental increases in N input for different purchase scenarios, and found that the highest net profit increase (8%) was achieved at an import level equivalent to 45 kg N ha^{-1}. While the profit increase is relatively small, a farmer would theoretically also see long-term gains—namely a reduced risk of soil mining—that could be considered from an ecological standpoint as having equal or greater value. Access to FYM for sale and increased labor could constrain adoption. To the extent that this strategy implies potential externalization of soil mining to the farms from which the manure is being purchased, it may be seen as unsustainable.

Third, we explored options to improve manure handling and storage. By utilizing animal bedding to capture urine, farmers could potentially meet the recommended per hectare N input rate and thereby achieve a net profit gain of up to 50%. Additionally, covering FYM and BGS could help farmers reduce N losses during storage and increase the average N input via manure from 30 to 36 kg N ha^{-1}, and result in a 7% net profit increase. Although yield gains are smaller than what could be achieved by the FYM purchase scenario, profit gains are similar and implementation is considerably lower cost. Introducing plastics to the farm system, however, should be considered with care.

Conclusion

We found that farmers in the study region are achieving smaller than potential Basmati yields from their organic systems, likely in part as a result of low average NPK input rates. Nutrients exported in Basmati grain are generally not balanced by inputs, resulting in mining scenarios on many farms. We recommend that advisory efforts focus on structural modifications to patch leaks in manure handling and storage subsystems (animal bedding to capture urine, covering FYM piles, and enclosed BGS storage). Importing nutrients via green manures or purchased FYM is another option. These interventions could help farmers move towards more closely meeting crop nutrient needs, build soil fertility, and feasibly increase yields. Our research approach is transferable and could be a valuable tool, in any farm context, for systematically identifying locally relevant interventions from the wide range of best practice recommendations in academic and extension literature.

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Seaweed an organic fertilizer source for boosting the productivity of crops

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Key words:*Gracilaria edulis, Kappaphycus alvarezii*, Maize, Rice, Sesamum, Soybean, Wheat

Abstract

To meet the increasing demand of organic fertilizer many viable options have to be explored and one such option is use of seaweed extracts as fertilizer.Application of liquid seaweed fertilizers on some plant species has been reported to decrease application doses of nitrogen, phosphorus and potassium on some crop plants, as well as stimulating growth and production of many plants. The beneficial effect of seaweed extract is attributed to the presence of natural plant growth hormones (i.e. cytokinin, auxin) as well as other plant biostimulants (e.g. betaines, polyamines, oligosaccharides), which improve plant resistance and tolerance to environmental disease and insect stresses. This study aimed to determine suitable sap (Kappaphycus alvarezii and Gracilaria edulis) with appropriate concentration level (2.5%, 5.0%, 7.5%, 10.0% and 15%) and their combination with recommended rate of chemical fertilizers on the yield of rice, wheat, maize, soybean and sesamum plant as organic fertilizer. Spraying of seaweed extract of K-sap @ 10.0 per cent along with recommended dose of fertilizer recorded significantly higher yield of rice and sesamum while, the wheat and soybean crop responded upto 7.5% concentration level of K-sap with recommended dose of fertilizer. In maize crop, G-sap performed better than K sap and gave higher grain and stover yield with 7.5% concentration level along with recommended fertilizers.

Acknowledgements

The authors are highly thankful to the We express our gratitude to Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavnagar, Gujarat, India, Bhavnagar, Gujarat for providing sap of Kappaphycus alvarezii (K-sap) and Gracilaria edulis (G-sap)to conduct the study and financial support to conduct the research.

Introduction

In the last decades, environmental pollution, chemical treatment and upgrading food using additive substances create a new dimension to the problem of rational nutrition, with direct implication of human health. It has become vital and necessary to promote organic farming techniques. Use of seaweed extract in organic farming techniques is one of the safest ways to conserve environmental resources and avoid pollution to obtain quality food and agricultural crops. Seaweed, a natural source of nutrients is of great importance to substitute the chemical fertilizers. Seaweeds are the macroscopic marine algae found to the bottom of relatively shallow coastal waters. The liquid extracts obtained from seaweeds popularly known as SLF/LSF contains not only nitrogen, phosphorus and potash but also contain ample amount of trace elements like Zn, Mn, Mg, Fe etc., metabolites, growth promoting hormones i.e. auxins (IAA, IBA), cytokinins, vitamins and amino acids. These seaweed extract application have been found beneficial to crop plants as it increased the crop yield, delay of fruit senescence, improved overall plant vigour, quality and to improve ability to withstand adverse environmental conditions (Featonby and Van Staden, 1983). In

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addition, the carbohydrates and other organic matter present in seaweeds alter the nature of soil and improve its moisture retaining capacity of soil.

Material and methods

The field experiment was conducted during kharif and rabi season of 2012-13 at Birsa Agricultural University, Ranchi, Jharkhand. The soil was sandy loam in texture, with pH 5.7 having organic carbon 4.5 g/kg soil, available nitrogen 255.9 kg/ha, phosphorus 14.0 kg/ha and potassium 169.4 kg/ha. The climate of the region is subtropical with hot and dry summer, comparatively cool rainy season followed by moderate winter. Rice, wheat, maize, soybean and sesamum were used as test crop. The experiment on rice and wheat were conducted in split-split plot design and replicated thrice. Treatment consisted of two fertilizer levels viz., 100 and 50% recommended fertilizer in main plot, two seaweed sap source viz., Kappaphycus alvarezii (K-sap) and Gracilaria edulis (G-sap) in sub plot and 6 sap concentration viz., 0 (water), 2.5, 5.0, 7.5, 10.0 and 15.0% in sub-sub plot. The experiment on maize, soybean and sesamum were conducted in randomized block design with seventeen treatments, replicated thrice. Treatments comprised of Kappaphycus alvarezii (K-sap) and Gracilaria edulis (G-sap) each of which is applied at five concentration level i.e. 2.5, 5.0, 7.5, 10.0 and 15.0% with 100% RDF and three concentration level i.e. 7.5, 10 and 15% with 50% RDF along with one control plot with 100% RDF. All the crops were grown with recommended package and practices. The details of agronomic practices are given in table 1. The nutrient requirement of all the crops was met through urea (46% N), DAP (18% N and 46% P_2O_5) and muriate of potash (60% K_2O). Full doses of phosphorus and potassium along with 50% nitrogen were applied as basal to all the kharif and rabi crops. Remaining nitrogen was given in two equal splits to rice, wheat and maiize and in single split to soybean and sesamum.

Table 1: Agronomic practices followed in different crops

Agronomic Practices	Crops				
	Rice	Wheat	Maize	Soybean	Sesamum
Seed rate (kg/ha)	40	125	18	75	6
Fertilizer (NPK kg/ha)	120:60:40	120:60:40	150:60:40	20:80:40	40:40:20
Spacing (cm X cm)	20 X 10	20 X 10	60 X 25	45 X 7	30 X 10
Genotypes	Naveen	K-9107	HQPM-1	RKS-18	Gujrat Til-1
Sap spray (time of application)	25, 45 and 75 DAT	25, 45 and 75 DAS	30, 50 and 70 DAS	30, 45 and 60 DAS	20, 35 and 50 DAS
Sowing/ Transplanting time	27th July	15th Nov	4th July	4th July	10th July
Date of Harvesting	9th Nov.	7 March	20th October	16th October	8th October

DAS : Days after sowing, DAT: Days after transplanting

Results

Transplanted rice and wheat with 100% recommended dose of fertilizer (120 Kg N, 60 Kg P_2O_5 and40 kgK_2O/ha)produced significantly higher grain and straw yield of rice and wheat than crop with 50% recommended dose of fertilizer. Among the sap, transplanted rice and wheat receiving K. sap spray produced significantly higher grain and straw yield of rice and wheat than crop receiving G. sap spray. The grain and straw yield of rice and wheat enhanced with each increment in sap

concentration upto 10% sap concentration in rice and 7.5% concentration level in case of wheat. Further, increase in concentration level led to decline the grain and straw yield of rice and wheat.

Maize fertilized with 100% recommended dose of fertilizer and sprayed with 5 % G sap produced significantly higher grain and stover yield than all other combination of sap concentration and fertilizer level except maize with 100% recommended dose of fertilizer and sprayed with 7.5 % K sap. In case of soybean, application of 100% recommended dose of fertilizer along with 7.5% K sap recorded highest grain yield and was significantly higher to rest of the fertilizer and saps

Table 1. Effect of seaweed sapon productivity of rice & wheat

Treatment	Rice Yield (kg/ha)		Wheat Yield (kg/ha)	
	Grain	Straw	Grain	Straw
Fertilizer level				
100% RDF	3149	4289	4458	5410
50% RDF	2629	3652	3518	4402
CD (P=0.05)	137	120	74	284
Sap Source				
K-sap	3008	4129	4123	5045
G-sap	2770	3811	3853	4768
CD (P=0.05)	199	294	73	149
Spray concentration (%)				
Water	1838	2852	3409	4257
2.5	2324	3350	3767	4609
5.0	2876	3955	3958	4854
7.5	3257	4343	4435	5351
10.0	3636	4744	4287	5227
15.0	3403	4579	4071	5140
CD (P=0.05)	195	253	190	189

Concentration except 100% recommended dose of fertilizer with 10% K sap, 10 and 15% G sap. The sesamum seed yield was recoded higher with 10% K sap alongwith 100% reccommended fertilizer dose. Similar trend was noted in case of stover yield.

Discussion

As a step toward the expansion of nature source of other manures seaweed fertilizer application will be useful in enriching the soil and achieving higher production in the place of costly chemical fertilizer. In the developing world, the use of seaweed liquid fertilizer should be urged to avoid environmental pollution by heavy doses of chemical fertilizer in the soil. In general, it was observed in the present study, that the seaweed liquid fertilizer prepared from the *Kappaphycus alvarezii* (K-sap) applied to crop plant gave better results when compared to the seaweed fertilizer of *Gracilaria edulis* (G-sap) except in maize where G-sap performed better than K-sap (Subramanian, 1987). It is probably due to the presence of growth promoting hormones and nutrients in more quantities in the *Kappaphycus alvarezii* than seaweed sap of *Gracilaria edulis* which enrich the nutrient content of the soil and intern to increase the growth and yield of cultivable plants (Singh *et al.* 2015). The response of crops to concentration level of seaweed extract also vary as *10.0* per cent concentration level ofK-sap along with recommended dose of fertilizer gave higher yield of rice and sesamum. The wheat and soybean crop responded upto 7.5% concentration level of K-sap while, maize crop gave higher grain and stover yield with 7.5% concentration level along with recommended fertilizers. The promotive effects of seaweed application in the present investigation might be due to increased root proliferation and establishment; thereby plants were able to mine more nutrients even from distant places and deeper soil horizons, in balanced proportion. Besides, seaweed extract,

regulated the plant bio-physiological activities which collectively resulted in maintaining higher photosynthetic activities (Singh and Chandel, 2005) and explore the possibility to reduce the inorganic fertilizers dosage for crop cultivation.

Table 2: Yield of maize, soybean and sesamum as affected by seaweed sap

Treatment	Maize (kg/ha)		Soybean (kg/ha)		Sesamum (kg/ha)	
	Grain	Stover	Grain	Straw	Grain	Straw
100%RDF+ water	3371	6556	1202	1768	603	2064
100%RDF+2.5% K	3699	6922	1353	1852	644	2067
100% RDF+5% K	3759	7121	1468	1937	668	2120
100% RDF+7.5%K	4092	7534	1673	2137	710	2226
100%RDF+10%K	3608	6853	1554	2030	796	2359
100%RDF+15%K	3421	6557	1424	1985	738	2284
50% RDF+7.5%K	2909	5913	1011	1629	484	1513
50% RDF+10%K	2519	5558	1147	1751	527	1634
50%RDF+15% K	2405	5359	1292	1883	563	1684
100%RDF+2.5G	3356	6642	1267	1847	642	2053
100% RDF+5% G	4375	7703	1394	1931	655	2085
100% RDF+7.5G	3728	7255	1507	2020	676	2109
100%RDF+10G	3738	7389	1668	2128	705	2157
100RDF+15%G	2939	6186	1541	2032	746	2252
50%RDF+7.5G	3039	6244	1000	1609	452	1400
50%RDF+10% G	2592	5862	1124	1711	509	1579
50% RDF+15% G	2480	5720	1270	1878	525	1606
CD(P=0.05)	331	917	146	209	84	291

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Agricultural waste recycling: a new method to produce good quality compost at large scale

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Key words: organic sources, nutrients, crop residue, horticultural waste, cow dung, windrow composting

Abstract

An experiment was conducted using agricultural wastes like cow dung, crop residue, horticultural wastes, etc. to produce various kinds of composts at Biomass Utilization Unit, ICAR-IARI New Delhi. Windrows of 125m length were used to test various proportions of different agricultural wastes and compost was prepared using microbial consortium and four-five turnings of the substrate. The final product took 60 to 90 days to reach at C:N ratio of 20:1. It was observed that mixture of mustard stover took the least time and the rice straw took the maximum time to decompose. Different quality parameters and nutrient concentrations of composts were recorded.

Introduction

With the increased agricultural production due to green revolution, a huge amount of agro waste is also produced in the country. Disposal of such organic wastes from various sources like domestic, agriculture and industries has caused serious environmental hazards and economic problems. Waste from the fruit and vegetable market is collected and dumped into the municipal landfills, causing a nuisance because of high biodegradability (Bouallagui *et al.,* 2004). This results a great loss of potentially valuable nutrients (Baffi *et al.,* 2005). Moreover, the composts prepared from such materials may be a good source of nutrients for organic agriculture. Windrow composting process involves aerobic process, exposing the composting material to oxygen. In this process aerobic microorganisms break down organic matter and produce carbon dioxide, ammonia, water, heat and humus. The intermediate compounds that may be produced are further oxidized and there is no risk of phytotoxicity.

Material and methods

An experiment was conducted using the mixtures of raw materials (rice straw, mixed stover of soybean, guar and cowpea, stover of maize, stover of sorghum and mix grass clippings, pruning's of lawns, fruit and vegetable wastes etc.) and cowdung (in the ratio of 5:1) was placed in 125 m long narrow (3.0 m wide and 2.5 m high piles called windrows. Those were agitated or turned on a regular basis. Frist turning and mixing was done immediately after placing the material and spreading of microbial consortium, second turning after 15 days of frist turning third at 30 days, fourth at 40 days and final turning was done at 50 days. However, for rice straw a fifth turning was done at 80 days. The carrier based microbial consortium prepared at Division of microbiology of the IARI was used @ 500 g per tonne of composting substrate. The microbial consortium mainly consisting cultures of *Aspergillus awamori*, *Aspergillus nidulans,Phanerochaete chrysosporium*and *Trichoderma viride,* is used before turning and mixing of the raw material. Bucket loader with a long-reach was used to permit high wind-rows, while turning machines permit

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low, wide wind-rows. A specialized machine was used for turning wind-rows that considerably reduce time and labour involved. Optimum level of moisture in the heap (about 40 %) of compost was maintained by frequent sprinkling of water. Turning process was continued till the amorphous compost material formed. The samples were drawn from the wind rows periodically to record changes in substrate in subsequent turnings. Temperature of windrows was also recorded at different intervals. The analysis of final product was done for nutrient concentration and other quality parameters.

Results

Drastic changes were recorded in decomposition patterns of different substrates. Temperature of windrows varied due to nature of substrate. Variation in temperatrue during different satages after turning was recorded in the range of 8 ^{o}C to 70 ^{o}C.The heat generated destroys many plant pathogens and kills weed seeds. Initial 2-3 days, the temperature of windrows is around 20-45^{o}C and mesophilic organisms multiply rapidly, mostly on easily decomposable organic compounds such as sugars and amino acids. They generate heat by their own metabolism and raise the temperature to 50-70^{o}C, where their own activities become suppressed. Thermophilic fungi and bacteria then dominate and continue the process of composting and raise the temperature of compost to 65^{o}C or higher. This heat kills pathogen and weed seeds.

Active composting stage is followed by a curing stage and the wind-row's temperature declines gradually. At this stage another group of thermophilic fungi start to grow. These fungi decompose cellulose and hemicellulose. Curing of the compost provides a safety net against the risks of using immature compost such as N hunger, oxygen deficiency and toxic effects of organic acids on plants. The active composting stage was recorded between 3-6 weeks depending upon the nature of materials and frequency of turning. In case of rice straw it was exeeded upto 9 weeks. The process of composting took about 60-65 days for all the materials used except the rice straw. The C:N ratio of of the composts at 60 days varied from 15.4 to 20.5 depending upon the type of raw material used. The final products contain 4.8 to 7.0 % humus, 0.4 to 1.0 percent N, 0.2 to 0.4 per cent P and about 1.0 percent K depending upon the type of crop residue. It also contains secondary nutrients like Ca 0.6 to 0.95% and Mg 0.7 to 0.9%, and micro-nutrients like Fe 135-158 ppm, Mn 65-75 ppm, Zn 15-22 ppm and Cu 3-5 ppm.

Discussion

The windrow method of composting reduced the time period by half as compared to composting through traditional methods. The quality of produce also better with respect to uniformity and nutrient level.

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Studies on yield, fruit quality and economics of organic production of mango cv. Mallika

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Key words: Mallika, BD-500, mycorrhiza, biodynamic compost, green manure and amritpani

Abstract

Indiscriminate use of agro-chemicals over 4-5 decades, have adversely affected the soil fertility, crop productivity and produce quality. In general 4-5 sprayings of insecticides and fungicides other than chemical fertilizers is common practice in mango production. Looking in to various hazards of agrochemicals based mango production; various organic inputs comprised of seven treatments were applied in 35 years old tree of mango cv Mallika. Maximum fruit yield (160.30 kg tree^{-1}) was recorded with T2 while minimum (88.46 kg tree^{-1}) with T7. Improvement in fruit quality with application of different treatments was also observed and maximum TSS (26.36^{0}Brix), total caretonoids (6.40 mg 100g^{-1}), fluorescence recovery after photo bleaching (FRAP) 74.98 per cent) and anti oxidant per cent inhibition (DPPH) (76.823) were also recorded with T2. Maximum productivity 0.51 kg INR^{-1}), net return INR128857.86 ha^{-1} and benefit cost ratio (5.10) was also worked out with same treatment. Insect pest management was effectively done with use of bio biodynamic liquid pesticides and lime sulphur. Based on the results, it may be concluded that application of biodynamic compost (30 kg tree^{-1}) +bio-enhancers (cow pat pit- 100 g, BD- 500 and BD-501 as soil and foliar spray, respectively) was more remunerative in comparison to agrochemical based treatment i.e.1000g N P K tree^{-1}.

Acknowledgments

Authors are thankful to the Director, ICAR-Central Institute for Subtropical Horticulture, Lucknow, Uttar Pradesh, India for providing all types of facilities to complete the study.

Introduction

Mango production is not sustainable because of multi nutrient deficiency in soil, surface and ground water pollution, shortages of non-renewable resources and low farm income from high agrochemicals based production costs. 50-75 % damage has been recorded in mango production with occurrence of insect pests. The mango production strategy in India is to be focused on reduced external inputs use and higher output without any adverse effect on environment (Pathak and Ram, 2003). Emphasis should be given to protect the environment from overuse of agrochemicals (Ayala and Prakasa Rao, 2002). Mango like other horticultural crops has become dependent upon electricity, fuels, and agrocemicals, largely due to nutrient, insect and pest management. Singh *et al*, 2002, suggested that efficient use of agri-inputs may achieve optimum production and productivity that contributes to rural economy. Looking in to above, an attempt was made to standardize organic production package of practice in mango cv. Mallika. Treatments comprised of on farm and off farm organic inputs and recommended dose of fertilizers were selected for nutrient management

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and common practice for insect pest management with biodynamic liquid pesticide was adopted in all experimental trees.

Material and methods

Various inputs along with biofertilizers, vermi compost, farmyard manure and recommended dose of fertilizers were applied in 35 years old trees of mango cv Mallika during 2015 in a field experiment designed in randomized block design with 3 replications at experimental farm of the institute (26.47o North and 80.56o East). The treatments comprised of T1- FYM (40 kg tree-1 + Azotobacter + Azospirillum + PSB (phosphorus solublizing bacteria) (108 cfu g-1) + Mycorrhiza (inoculum), T2- Biodynamic compost (30 kg tree-1) + bio-enhancers (Cow pat pit- 100 g, BD- 500 and BD- 501 as soil and foliar spray, respectively), T3- Neem cake + farmyard manure (20 kg tree-1) + Azotobacter + Azospirillum + PSB (108 cfu g-1), T4- Vermi compost (30 kg tree-1 + Azotobacter + Azospirillum + PSB (108 cfu g-1), T5- Farmyard manure (40 kg tree-1) + bio-enhancer (Amritpani 5% soil application), T6- Farmyard manure (40kg tree-1) + green manuring (sunhemp) Azotobacter + Azospirillum + PSB (108 cfu g-1) and T7-1000g N P K tree-1. Insect pest management in all experimental trees were done with spraying of biodynamic liquid pesticides and lime sulphur. Observations on hopper population were recorded periodically. Data on fruit size, weight and yield attributes were recorded at full maturity. In fruit quality analysis, total soluble solids were recorded by refractometer and acidity was determined by standard procedure of A.O.A.C, 1975. Total caretonoids, FRAP and DPPH were analysed in ripen fruits (Litchenthaler, 1987; Benzie, 1966 and Williams et al, 1995). Experimental data were statistically analysed following the analysis of variance method (Panse and Sukhatme, 1978). Farm gate value of mango fruit was taken INR 10 kg-1 as per local market price. Productivity of production was the amount of produce obtained per unit of input cost. Its relationship to benefit cost ratio is direct. Their ratio is the input and output cost of the produce. Productivity was calculated as mango yield divided by production cost. Production value, net return and benefit cost ratio was worked out as per following formula (Akdemir et al. (2012).

- Total production value (INR ha^{-1}) = Mango yield (kg ha^{-1}) x Mango price (INR kg^{-1})
- Total production cost (INR ha^{-1}) = Sum of cost of inputs and all the cultural operations (ha^{-1})
- Productivity = Mango yield (kg ha^{-1})/ Total production costs (INR ha^{-1})
- Net return =Total production value (INR ha^{-1}) - Total production cost (INR ha^{-1})
- Benefit cost ratio =Total production value (INR ha^{-1})/Total production cost (INR ha^{-1})

Results

Yield and fruit quality

Improvement in fruit yield and its attributes were recorded with application of different treatments. Maximum yield (160.30 kg $tree^{-1}$) was recorded with T2, which was 81.21 % more than T7 (88.46 kg $tree^{-1}$) (Table 1). Observations on average fruit weight, diameter and length were varied non-significantly. Improvement in fruit quality with application of different treatments was also observed and maximum TSS (26.36 ^{0}Brix) recorded with T2 and minimum 22.36^{0}Brix in T7.Maximum total caretonoids (6.40 mg $100g^{-1}$), fluorescence recovery after photo bleaching (FRAP) (74.98 micromole $liter^{-1}$) and anti oxidant per cent inhibition (DPPH) (76.82 %) was recorded with T2 which was 5, 58.5 and 50.5 % more than T7 (6.09 mg $100g^{-1}$, 46.97 micromole $liter^{-1}$ and 51.033 %). respectively. It indicates that fruit quality was improved with application of T2 compared T7. (Table 2).

Economic analysis

Economic analysis of production resulted that productivity in T2 (0.51 kg INR^{-1}) was worked out 71.14 % more than T7 (0.298 kg INR^{-1}) and maximum net return INR 128857.86 ha^{-1} was also achieved with T2 which was 2.19 times more than net return achieved (INR 587743.51 ha^{-1}) in T7. Maximum benefit cost ratio (5.10) was also obtained with T2 and 2.98 in T7 (Table 3).

Insect pest management

The hopper management in experimental mango trees was effectively done with use of biodynamic liquid pesticide. Spraying was carried out with neem based biodynamic liquid pesticides after panicle emergence. The observations were recorded before and 3, 7, 15, 20 and 25 days after spray (DAS). The mango hopper count was recorded in three panicles from each direction of tree and expressed as number of hopper $panicle^{-1}$. Before spray, the hopper population varied between 0.3 - 6.5 $panicle^{-1}$. After 3 days of spraying, there was reduction in hopper population which was in range of 0.0 - 1.0 $panicle^{-1}$. At 25 days after spray, hopper population was observed below economic threshold limit. Powdery mildew was managed with spraying of BD - 501 and 02 % lime sulphur. No damage of insect pest was observed after effective management plan.

Discussion

Improvement in fruit yield and quality was recorded with application of various organic inputs. This may be due to the balance nutrient management, as organic inputs contained major, micro nutrients and plant growth promoting microbes. While recommended dose of fertilizers contained only N, P and K. Results of present study is in support with the study of Ram and Rajput (1998) in which they had reported significant increase in fruit yield and its attributes with application of 250g *Azospirillum* and phosphorus solublizing bacteria along with farm yard manure (30 kg $tree^{-1}$) in mango cv. Dashehari.In another experiment on guava cv. Allahabad Safeda, application of different organic inputs has also improved the fruit yield and quality (Ram *et al.* 2014). On farm produced inputs viz; biodynamic compost, cow pat pit, BD-500, BD-501 and biodynamic liquid pesticides are cost effective and resulted in maximum net return and benefit cost ratio. Ram and Verma (2015) have also worked out 3.74 benefit cost ratio in organic production of mango cv Dashehari. Contrary to this result Akdemir *et al*. (2012) reported maximum benefit cost ratio (1.48) in conventional apple production.

Table 1: Response of various organic inputs on fruit yield and its attributes

Treatments	Yield and fruit parameter				
	Fruit number/tree	Av. fruit wt. (g)	Fruit yield (Kg $tree^{-1}$)	Av. Fruit diameter (cm)	Av. Fruit length (cm)
T1	326	349.33	111.18	7.99	12.93
T2	484.33	330	160.30	7.66	12.89
T3	530	309.33	147.13	8.24	12.36
T4	405.33	326	131.37	8.13	12.45
T5	354.66	285	97.95	7.65	12.28
T6	393.33	305	123.89	7.77	12.66
T7	262.66	327	88.46	7.71	12.89
CD at 5 %	149.86	NS	42.33	NS	NS

Table 2: Response of various organic inputs on quality parameters of fruits

Treatment	Fruit quality parameters				
	TSS (^{0}Brix)	Titrable acidity (%)	Total caretonoids (mg/100g)	FRAP (micromole/liter	**DPPH** (Anti oxidant) percent inhibition
T1	22.93	0.27	5.40	44.980	51.037
T2	26.36	0.27	6.40	74.478	76.823
T3	23.33	0.28	5.10	66.759	43.798
T4	22.66	0.26	4.70	44.813	52.900

T5	23.40	0.29	5.83	56.460	58.577
T6	24.16	0.27	5.50	48.129	67.822
T7	22.36	0.28	6.09	46.970	51.033
CD at 5 %	2.08	NS	1.045	19.163	19.833

Table 3: Economic analysis of production

Particular	T1	T2	T3	T4	T5	T6	T7
Total production costs (INR ha^{-1})	39094	31442	59013	38759	28893	39407	29716
Yield (Kg ha^{-1})	11118	16030	14713	13137	9795	12389	8846
Total production value (INR ha^{-1})	111180	160300	147130	131370	97950	123890	88460
Productivity (Kg INR^{-1})	0.284	0.510	0.249	0.339	0.339	0.314	0.298
Net return (INR ha^{-1})	72085	128857	88116	92610	69056	84482	58743
Benefit cost ratio	2.84	5.10	2.49	3.39	3.39	3.14	2.98

1 USD = 67.0736 INR (July, 2016).

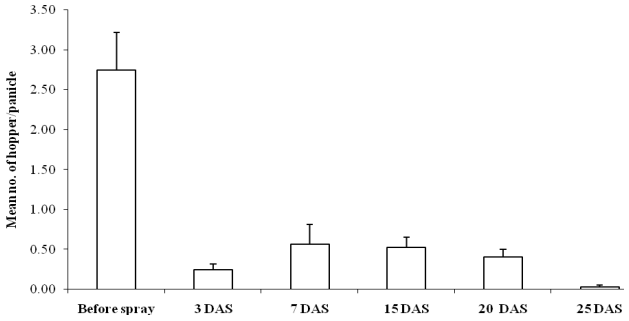

Figure 1: Mean mango hoppers population (number) in experimental mango orchard before and after spray of biodynamic liquid pesticides

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Growth and yield of organic capsicum (*Capsicum annuum* L. var. *grossum*) as influenced by different sources, levels of organic manures and panchagavya application

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Key words: Panchagavya, Composted coir pith, Farm yard manure, Capsicum, N equivalent, organic farming

Abstract

A field experiment was carried out to study the effect of different sources and levels of organic manures and panchagavya spray on growth and yield of Capsicum at Agricultural Research Station, Arsikere, Karnataka. Significantly higher growth, yield and yield attributes were recorded with different sources and levels of organic manures. Among the sources, higher yield of 651.26 q ha-1, fruits (84.48 no), branches (42.66 no) and plant height (43.76 cm) were recorded with FYM compared to composted coir pith, CCP (497.70 q ha-1, 52.28, 24.67 and 32.02 cm respectively) application. Among fertility levels, FYM at 200 % N equivalent recorded higher yield of 709.33 q ha-1, fruits (99.11 no), branches (41.33 no) and plant height (47.98 cm). Application of FYM with 3 % panchagavya spray recorded higher yield of 692.14 q ha-1, fruits (89.28 no), branches (43.58 no) and plant height (44.83 cm). Whereas, CCP with 6 % panchagavya spray recorded higher yield of 529.60 q ha-1, fruits (57.55 no), branches (25.31 no) and plant height (32.96 cm).

Introduction

Capsicum is one of the most nutritious and remunerative vegetable crop grown mainly for its green fruits. There is a good demand in both the local and international markets. As this crop needs and respond well to high quantity of fertilizers, farmers are forced to dump large quantity to the soil. Use of high inorganic inputs have an adverse effect on soil health and environment, expensive, not much affordable by small and marginal farmers (Rekha and Gopal Krishnan, 2001). This could be overcome by the use of judicious combination of organic and liquid organic manures like Panchagavya. The cost of fertilizers can be reduced by using liquid manures as they can be prepared on-farm by farmers themselves. The current global scenario firmly emphasizes the need to adopt eco friendly agricultural practices for sustainable food production. Hence, organic farming is an opt solution that too for the crop like capsicum which fetches high value for organic products (Parvatha Reddy, 2008). Keeping all these points in view the present study was conducted to know the effect of composted coir pith (CCP),farm yard manure (FYM) and Panchagavya on growth and yield of capsicum.

Material and methods

A field experiment was conducted at Agricultural Research Station, Arsikere, University of Agricultural Sciences, Bengaluru. It is classified under agro climatic zone IV: Central Dry Zone (CDZ) of Karnataka, India. Soil of the experimental plot was analysed at a depth of 15 cm and it is red sandy loam, grouped under the classification of Alfisols. Soil is neutral to slight acidic in reaction pH (6.42), low organic carbon (0.40 %) and medium in available nitrogen (241.50 kg ha^{-1}), low available phosphorus (8.80 kg ha^{-1}) and potassium (231.00 kg ha^{-1}). There were 18 treatment combinations laid out in split plot design consisting of three factors *viz*., Main plot: Sources of organic manure - (2 sources) - farm yard manure (FYM - S_1) and composted coir pith (CCP - S_2), sub plot: fertility levels (3 levels) - 100 % of recommended N as FYM/CCP (F_1), 150 % of recommended N as FYM/CCP (F_2) and 200 % of recommended N as FYM/CCP (F_3) and sub-

subplot: panchagavya (3 levels) – without panchagavya spray (P_0), 3 % panchagavya (P_1) and 6 % panchagavya (P_2). Well decomposed farm yard manure (FYM) and composted coir pith (CCP) were applied to each plot 3 weeks before transplanting of capsicum seedlings and incorporated into the soil. Panchagavya was sprayed at 25, 50, 75 and 100 days after transplanting (DAT). All cultural operations were performed as per package of practice. Growth parameters were recorded on 30, 60, 90 DAT and at harvest and observations on yield and yield attributes were recorded on 60, 70, 80, 90, 100, 110 and 120 DAT.

Preparation of panchagavya: Panchagavya was prepared by following Coimbatore method, wherein 7 kg fresh cow dung and 1 kg ghee were mixed well and incubated in a plastic container for 2 days and it was mixed daily once. On third day, 10 litres cow urine and 10 litres water were added and mixed thoroughly and incubated for fermentation for 13 days. Then, 3 litres milk, 2 litres curd, 3 litres tender coconut water, 3 kg jaggery and 12 ripened Cavendish banana were added and contents were incubated for 6 days and the mixture was stirred thoroughly thrice a day. Plastic drum was kept in shade and it was covered with wet jute bag. After 21 days of fermentation mixture was filtered through a cotton cloth and was used for application.

Results

Plant height, number of branches per plant, number of fruits per plant and fruit yield per hectare varied significantly due to the application of different levels of nitrogen and panchagavya. Significantly higher capsicum yield of 651.26 q ha^{-1}, number of fruits per plant (84.48), number of branches per plant (42.66) and plant height (43.76 cm) were recorded with FYM (S_1) compared to composted coir pith (CCP- S_2) (497.70 q ha^{-1}, 52.28, 24.67 and 32.02 cm respectively (Table 1 and 2) application. Among fertility levels, FYM at 200 % N equivalent (F_3) recorded maximum capsicum yield of 709.33 q ha^{-1}, number of fruits per plant (99.11), number of branches per plant (41.33) and plant height (47.98 cm) and CCP at 100 % (F_1) recorded maximum capsicum yield of 548.69 q ha^{-1}, number of fruits per plant (59.74), number of branches per plant (24.09) and plant height (34.54 cm). Whereas, FYM at 100 % N equivalent (F_1) recorded capsicum yield of 603.08 q ha^{-1}, number of fruits per plant (71.39), number of branches per plant (40.47) and plant height (39.86 cm) and CCP at 200 %(F_3) recorded capsicum yield of 450.02 q ha^{-1}, number of fruits per plant (43.13), number of branches per plant (26.99) and plant height (29.66 cm).The effect of panchagavya application was found significant on capsicum yield. Application of FYM with 3 % panchagavya spray recorded maximum capsicum yield of 692.14 q ha^{-1}, number of fruits per plant (89.28), number of branches per plant (43.58) and plant height (44.83 cm). Interaction effect due to sources and levels of fertility, panchagavya were found to be significant. Significantly higher yield of 709.33, 692.14 and 604.58 q ha^{-1} capsicum yield respectively with the above interaction effects while, application of CCP with 6 % panchagavya spray recorded maximum fruit yield of 529.60 q ha^{-1}, number of fruits per plant (57.55), number of branches per plant (25.31) and plant height (32.96 cm) respectively.

Discussion

Higher capsicum yield (651.26 q/ha) was recorded with the application of FYM might be due to increased plant height, number of branches and fruits per plant. This was due to improvement in soil physical condition coupled with increased availability of nutrients to plants due to narrow C: N ratio of FYM resulted in faster mineralization compared to CCP. Due to increasing sink potential could be attributed to better availability and uptake of nutrients which helped in production of more photosynthates and its translocation to the fruits during their development (Gopinath *et al.,* 2009). The lower yield with CCP might be due to wider C: N ratio, higher lignin and cellulose content (Ravichandra, 1988). Foliar spray of panchagavya at 3 % along with FYM enhanced the yield parameters due to the better availability of nutrients and effective conversion of Fe, Mg and zinc at

the sight of photosynthesis into pigments, the enzymes and growth promoting substances present in panchagavya which favour rapid cell division and multiplication (Vasumathi, *et al.,* 2001, Devakumar *et al*., 2008 and 2011 and Srinivas *et al.,* 2009).

Table 1: Plant height (cm) and number of branches per plant of capsicum as influenced by sources and levels of organic manures and panchagavya application

Treatments			Plant height (cm)			No. branches per plant		
			Sources of organic manure (S)					
Fertility levels (F)			FYM	CCP	Mean	FYM	CCP	Mean
			S_1	S_2		S_1	S_2	
F_1		100 %	39.86	34.54	**37.20**	40.47	24.09	**32.28**
F_2		150 %	43.45	31.85	**37.65**	46.19	22.93	**34.56**
F_3		200 %	47.98	29.66	**38.82**	41.33	26.99	**34.16**
Mean			**43.76**	**32.02**		**42.66**	**24.67**	
			S.Em ±	**C.D.**		**S.Em ±**	**C.D.**	
Sources (S)			1.00	6.08		1.40	8.53	
Fertility levels (F)			0.68	NS		0.80	NS	
S x F			0.96	3.15		1.13	3.70	
Panchagavya spray (P)								
P_0		0 %	42.48	31.06	**36.77**	39.78	22.41	**31.09**
P_1		3 %	44.83	32.03	**38.43**	43.58	26.29	**34.94**
P_2		6 %	43.96	32.96	**38.46**	44.63	25.31	**34.97**
Mean			**43.76**	**32.02**		**42.66**	**24.67**	
			S.Em ±	**C.D.**		**S.Em ±**	**C.D.**	
Panchagavya spray (P)			0.31	0.92		0.56	1.63	
S x P			0.44	NS		0.79	2.31	
			Fertility levels (F)					
			F_1	**F_2**	**F_3**	**F_1**	**F_2**	**F_3**
Panchagavya spray (P)								
P_0		0 %	36.29	37.22	36.80	29.49	31.06	32.74
P_1		3 %	37.29	37.77	40.23	32.12	37.00	35.69
P_2		6 %	38.01	37.95	39.43	35.22	35.63	34.06
F x P			**S.Em ±**	**C.D.**		**S.Em ±**	**C.D.**	
			0.54	NS		0.97	2.83	

DAT = Days after transplanting FYM = Farm yard manure CCP = Composted coir pith
F1, F2 & F3 = N equivalents C.D. at 5 % level NS = Non significant

Table 2: Number of fruits per plant and fruit yield per hectare (q) of capsicum as influenced by sources and levels of organic manures and panchagavya application

Treatments			No. fruits per plant			Fruit yield per hectare (q)		
			Sources of organic manure (S)					
Fertility levels (F)			FYM	CCP	Mean	FYM	CCP	Mean
			S_1	S_2		S_1	S_2	
F_1		100 %	71.39	59.74	**65.56**	603.08	548.69	**575.89**
F_2		150 %	82.94	53.98	**68.46**	641.36	494.39	**567.88**
F_3		200 %	99.11	43.13	**71.12**	709.33	450.02	**579.68**
Mean			**84.48**	**52.28**		**651.26**	**497.70**	
			S.Em ±	**C.D.**		**S.Em ±**	**C.D.**	
Sources (S)			0.69	4.21		7.11	43.28	
Fertility levels (F)			0.51	1.67		2.50	8.16	
S x F			0.72	2.36		3.54	11.54	

Panchagavya spray (P)

P_0		0 %	78.78	45.50	**62.14**	609.85	462.24	**536.05**
P_1		3 %	89.28	53.80	**71.54**	692.14	501.27	**596.70**
P_2		6 %	85.38	57.55	**71.47**	651.79	529.60	**590.69**
Mean			**84.48**	**52.28**		**651.26**	**497.70**	
			S.Em ±	**C.D.**		**S.Em ±**	**C.D.**	
Panchagavya spray (P)			0.53	1.55		2.61	7.62	
S x P			0.75	2.19		3.69	10.77	
			Fertility levels (F)					
			F_1	**F_2**	**F_3**	**F_1**	**F_2**	**F_3**
Panchagavya spray (P)								
P_0		0 %	58.06	64.18	64.18	535.07	539.95	533.12
P_1		3 %	69.45	70.45	74.71	588.02	578.38	623.71
P_2		6 %	69.18	70.75	74.47	604.58	585.30	582.20
F x P			**S.Em ±**	**C.D.**		**S.Em ±**	**C.D.**	
			0.92	NS		4.52	13.20	

Conclusion

Application of 3 % panchagavya with 200 % N equivalent FYM application recorded higher plant height, number of branches, number of fruits per plant and the higher yield of capsicum followed by 150 % N equivalent FYM application and 6 %panchagavya spray with 100 % N equivalent composted coir pith recorded maximum capsicum yield. The organic inputs available with the rural farming community could be effectively utilized to increase the production and productivity of crops.

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Organic production is safe, sustainable and profitable: Evidences from tuber crops

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Key words: eco-friendly farming, root crops, yield stability index, profit, tuber quality, soil quality index

Abstract

Concerns regarding environmental pollution, resource conservation, safe and healthy food spurred the growth of organic farming. Cassava, elephant foot yam, yams, taro and Chinese potato are ethnic tuberous vegetables and food security crops. Twenty five on-station and on-farm validation trials were conducted by the ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, India, over a decade (2004-2016) to compare varietal response, yield, economics, quality and soil properties under organic vs conventional system. The industrial and domestic varieties of cassava, improved and local varieties of elephant foot yam and taro and the three species of yams, including trailing and dwarf genotypes, responded equally to both systems. Organic management enhanced yield (+10-20%), net profit (+20-40%) and tuber quality over chemical farming. Yield stability index of organic system was same as conventional. The organic system scored significantly higher soil quality index with significant improvement in soil pH (+0.46-1.2 units), water holding capacity (+8-28%) and SOM (+14-40%).

Introduction

The growing demand for safe foods and concerns regarding environmental degradation and human health, led to rapid expansion of alternative environmentally benign systems like organic farming. Tropical tuber crops viz., cassava, elephant foot yam, yams, (*Dioscorea* spp.), taro, etc., are climate smart and food security crops for about 500 million of the global population. Besides these are high energy tuberous vegetables with good taste and medicinal values. They respond well to organic manures and have ample scope for organic farming and export. The objectives were to compare varietal response, yield, economics, quality and soil properties under organic vs conventional in these crops based on 25 on-station and on-farm experiments done over a decade.

Material and methods

Seven separate field experiments were conducted at the ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, India, for more than a decade (2004-2016) to compare organic vs conventional farming in cassava, elephant foot yam, yams, taro and Chinese potato in an acid Ultisol (pH: 4.3-5.0). In cassava, the experiment was laid out in split plot design with three varieties, H-165 (industrial variety), Sree Vijaya and Vellayani Hraswa (domestic varieties) in main plots and five production systems, traditional, conventional, integrated and two types of organic in sub plots. The impact of conventional, traditional, organic and biofertilizer farming was evaluated in RBD in elephant foot yam. Comparative response of five varieties of elephant foot yam (Gajendra, Sree Padma, Sree Athira and two locals) under organic and conventional farming was also evaluated in another experiment. Like wise, the response of three varieties of taro (Sree Kiran, Sree Rashmi and local) to the various production systems was studied. All the three trailing

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genotypes 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 systems in split plot design. The dwarf genotype of white yam (var. Sree Dhanya) as well as Chinese potato (var. Sree Dhara) were also evaluated in two separate experiments under conventional, traditional, organic and integrated systems in RBD. In "conventional plots" farmyard manure (FYM) + NPK fertilizers were applied. Farmers practice of using FYM and ash was followed in "traditional plots". In "organic farming plots", FYM, green manure, ash, neem cake and/or biofertilizers were applied to substitute chemical fertilizers. In "biofertilizer farming", FYM, mycorrhiza, *Azospirillum,* phosphobacterium and K solubilizer were applied. In "integrated farming", FYM, chemical fertilizers and biofertilizers were used. The N addition varied between 110-225 kg ha^{-1} in conventional and 146-353 kg ha^{-1} in organic in these crops. The on-station developed organic farming technologies for cassava, elephant foot yam, yams and taro were on-farm validated in 18 different farmers' sites. Varietal response, tuber yield, yield stability index, economics, tuber quality, soil physico-chemical and biological properties were compared; soil quality index was computed.

Results

Varietal response

The industrial as well as domestic varieties of cassava, the improved and local varieties of elephant foot yam and taro and all the three species of *Dioscorea* responded similarly to both the systems. However, the industrial variety of cassava, Gajendra variety of elephant foot yam and all the species of *Dioscorea* yielded more under organic farming.

Yield and economics

Organic farming resulted in 10-20% higher yield in cassava, elephant foot yam, white yam, greater yam, lesser yam, dwarf white yam and Chinese potato ie., 8, 20, 9, 11, 7, 9 and 10.5% respectively (Figure 1) (Suja *et al*. 2012; Suja and Sreekumar 2014). However, in taro, slight yield reduction was noticed under organic farming (-5%) (Suja *et al*. 2017). The yield stability index computed over a five year period indicated that organic was as stable as conventional. Cost-benefit analysis indicated that the net profit under organic farming was 20-40% higher over chemical farming (Suja *et al*. 2016) (Table 1).

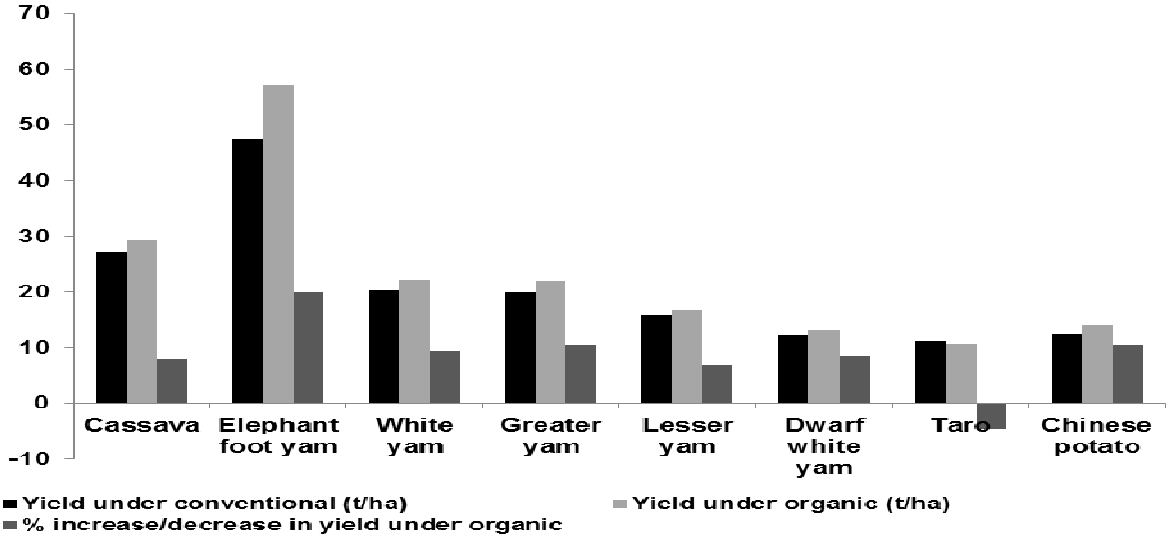

Figure 1. Productivity: Organic vs conventional system in tuber crops

Tuber quality

In general, the tuber quality was improved under organic management with higher dry matter, starch, crude protein, K, Ca and Mg contents. The anti-nutritional factors, oxalate content in elephant foot yam and cyanogenic glucoside content in cassava were lowered by 21 and 12.4% respectively under organic farming (Suja 2013).

Table 1: Economic analysis: Organic vs conventional system in tuber crops

Crop	Gross income (Rs. ha^{-1})		Gross cost (Rs. ha^{-1})		Net income (Rs. ha^{-1})		Benefit: Cost ratio	
	*Con	Organic	Con	Organic	Con	Organic	Con	Organic
Cassava	407700	439800	105831	106575	301869	333225	3.85	4.13
Elephant foot yam	953400	1142000	319812	344150	633588	797850	2.98	3.32
Taro	281540	363580	155500	189420	126040	174160	1.81	1.92
Greater yam	858140	928960	394600	430020	463540	498940	2.17	2.16
Lesser yam	328640	385640	294600	330020	34040	55620	1.12	1.17
Dwarf white yam	404640	491520	268600	303900	136040	187620	1.51	1.62
Chinese potato	504400	557600	118086	144600	386314	413000	4.27	3.86

*Con: Conventional

Soil quality indicators

Organic system scored significantly higher soil quality index, largely driven by water holding capacity (WHC), pH, available Zn and SOM. The WHC was significantly higher under organic management in elephant foot yam (14 g cm^{-3}) and yams and higher in taro over conventional (11-12 g cm^{-3}). Thus WHC improved significantly by 8-28%. There was significant improvement in pH in organic farming (+1.0, 0.77, 0.46, 1.20 and 0.65 units over conventional) in cassava, elephant foot yam, yams, taro and Chinese potato. The SOM increased by 20-40% in organic plots. In elephant foot yam, exchangeable Mg, available Cu, Mn and Fe contents were significantly higher in organic plots.Organic plots showed significantly higher available K (by 34%) in yams and available P in taro. The population of bacteria was considerably higher in organic plots than in conventional; 41% and 23% higher in elephant foot yam and yams respectively. Organic farming also favoured the fungal population by 17-20%. While the N fixers showed an upper hand in organically managed soils by 10% in elephant foot yam, P solubilizers remained more conspicuous under organic management of yams (+22% over conventional). The count of actinomycetes was favoured by 13.5% in taro. The dehydrogenase enzyme activity was higher by 23% and 14% in organic plots in elephant foot yam and yams (Suja *et al*. 2015).

The Package

Use of organically produced seed materials, seed treatment in cow-dung, neem cake, bio-inoculant slurry**,** farmyard manure incubated with bio-inoculants, green manuring, neem cake, bio-fertilizers and ash formed the strategies for organic production. The organic farming package for elephant foot yam is included in the Package of Practices (POP) Recommendations for crops by Kerala Agricultural University (KAU 2011) and yams and taro in POP Crops (2016) of KAU.

Discussion

Organic farming resulted in 10-20% higher yield in tropical tuber crops,contrary to some of the reports that crop yields under organic management were 20–40% lower than for comparable conventional systems (de Ponti *et al*. 2012; Seufert *et al*. 2012).Traditionally these crops are grown default using plenty of organic manures and wastes available in homesteads and have a low intensity of use of external chemical inputs.The yield increase under organic may be attributed to the inherent positive response of these crops, especially aroids, to plenty of organic manures that provide sufficient room in the soil for tuber expansion. In general, the yield increase was certainly due to increase in soil pH towards neutrality from acidity (+0.46-1.2 units) (which in turn provides almost all essential nutrients in available form), higher WHC (+8-28%) and SOM (+14-40%). These crops were mainly rainfed and higher WHC under organic management might have led to higher yield. In taro, slight yield reduction was observed as taro leaf blight could not be managed organically. The pH increase may be obviously 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 might be attributed to the large addition of organic manures, particularly green manure cowpea. 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 conventional ones. Thus organic farming is an eco-friendly strategy in tuber crops that enables 10-20% higher yield of quality tubers, 20-40% higher profit and improvement in soil health.

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Influence of different levels of jeevamrutha and panchagavya on yield and quality parameters of organic frenchbean (Phaseolus vulgaris L.)

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Key words: Jeevamrutha, Panchagavya, Organic frenchbean, Crude protein, Shelf life and Carbohydrates

Abstract

Field experiments were conducted at organic farming block of RIOF , University of Agricultural Sciences, Ghandhi Krishi Vignan Kendra (GKVK), Bengaluru during kharif 2014 and 2015, to study the effect of jeevamrutha and panchagavya on growth and quality of organic frenchbean. Among the treatments, application of jeevamrutha at 2000 l ha-1 recorded significantly higher green pod yield of 134.3 and 156.9 q ha-1, crude protein (21.53 and 22.07 %), carbohydrates (5.09 and 5.22 %) and shelf life (10.11 and 10.56 days) as compared to without jeevamrutha application ie., pod yield of 99.8 and 112.8 q ha-1, crude protein (20.33 and 20.76 %), carbohydrates (4.21 and 4.32 %) and shelf life (8.44 and 9.11 days) during 2014 and 2015. Similarly, application of higher level of panchagavya (6 %) recorded significantly higher frenchbean yield of 124.4 and 142.8 q ha-1, crude protein (21.22 and 21.73 %), carbohydrates (4.86 and 4.98 %) and shelf life (9.83 and 10.42 days) as compared to without panchagavya application e., pod yield (101.4 and 120.1 q ha-1), crude protein (20.67 and 21.13 %), carbohydrates (4.60 and 4.72 %) and shelf life (8.83 and 9.42 days) during both the years.

Introduction

Traditional Agriculture has been generally considered every where as a joint effort of man and cattle. In recent past, a great deal of importance has been given to individual animal product and formulation. Among the formulations, the most widely mentioned and discussed is Panchagavya and jeevamrutha. These are eco-friendly organic preparations and they are locally prepared from native cow products such as cow dung, urine, milk, curd and ghee. They are known to improve the growth and yield of crops besides imparting resistance to pest and diseases. Use of organic liquid products such as beejamrutha, jeevamrutha and panchagavya results in higher growth, yield and quality of crops and improve the soil physico-chemical and biological properties (Devakumar et al., 2008 and 2010). The liquid organic manures such as panchagavya and cow urine are commonly used in organic farming to provide balanced nutrition to the crop. In view of the above facts, the present investigation was therefore conducted to elucidate effect of jeevamrutha and panchagavya on pod yield and quality of organic frenchbean.

Material and methods

Field experiment were conducted at organic farming block of Research Institute on Organic Farming (RIOF), GKVK, University of Agricultural Sciences, Bengaluru under protective irrigation during *kharif* 2014 and 2015 (July to September), to study the effect of jeevamrutha and panchagavya on growth and yield of frenchbean. The experiment was laid out on factorial randomised complete block design with three replications. Treatment combinations includes four jeevamrutha levels (0, 1000, 1500 and 2000 l ha^{-1}) and three panchagavya levels (0, 3 and 6 %). Treatment combinations include T_1: J_1P_1, T_2: J_1P_2, T_3: J_1P_3, T_4: J_2P_1, T_5: J_2P_2, T_6: J_2P_3, T_7: J_3P_1, T_8: J_3P_2, T_9: J_3P_3, T_{10}: J_4P_1, T_{11}: J_4P_2 and T_{12}: J_4P_3. Soil of the experimental site was red sandy loam with neutral pH (6.6), medium in organic carbon (0.46 %) and medium in available nitrogen (331 kg ha^{-1}), phosphorus (38 kg ha^{-1}) and potassium (231 kg ha^{-1}).

Jeevamrutha was prepared by mixing 10 kg of cow dung, 10 litre of cow urine, 2 kg of jaggery, 2 kg of pigeon pea flour and hand full of soil collected from farm. All these were put in 200 litres plastic drum and mixed thoroughly and volume was made up to 200 litre by adding water. The mixture was stirred well in clock wise direction thrice a day plastic drum was kept in shade covered with wet jute bag. Jeevamrutha was fermented for 10 days applied to base of the plants manually at of 15, 30 and 45 days after sowing (DAS) as per treatments.

Panchagavya was prepared by mixing 7 kg fresh cow dung and 1 kg ghee were mixed well and incubated in a container for 2 days and on third day, 10 litres cow urine and 10 litres water were added, mixed thoroughly and incubated for fermentation for 13 days. Then, 3 litres milk, 2 litres curd, 3 litres tender coconut water, 3 kg jaggary and 12 well ripened Cavendish banana were added and contents were incubated for 6 days. The mixture was stirred thoroughly thrice a day at morning, afternoon and evening. Plastic drum was kept in shade and it was covered with wet jute bag. After 21 days of fermentation mixture was filtered through a cotton cloth and used for spray. Panchagavya spray was given at of 15, 30 and 45 days after sowing (DAS) as per treatments.

Results

Application of jeevamrutha at 2000 litre ha-1 recorded significantly higher green pod yield of 134.3 and 156.9 q ha-1 followed by jeevamrutha at 1500 litre ha-1 (115.0 and 136.5 q ha-1) and jeevamrutha at 1000 litre ha-1 (106.7 and 123.1 q ha-1) as compared to without jeevamruta application (99.8 and 112.8 q ha-1) during 2014 and 2015. Panchagavya at 6 per cent application recorded significantly higher green pod yield (124.4 and 142.8 q ha-1) followed by panchagavya at 3 per cent application (116.1 and 134.1 q ha-1) as compared to without panchagavya application (101.4 and 120.1 q ha-1) during both the years. Green pod yield did not differ significantly due to the interaction effect between various levels of jeevamrutha and panchagavya application during both the years. However, higher green pod yield was observed with jeevamrutha at 2000 litre ha-1 and panchagavya at 6 per cent (141.8 and 165.8 q ha-1) and it was lower jeevamrutha levels and without panchagavya application (83.0 and 93.9 q ha-1) (Fig. 1).

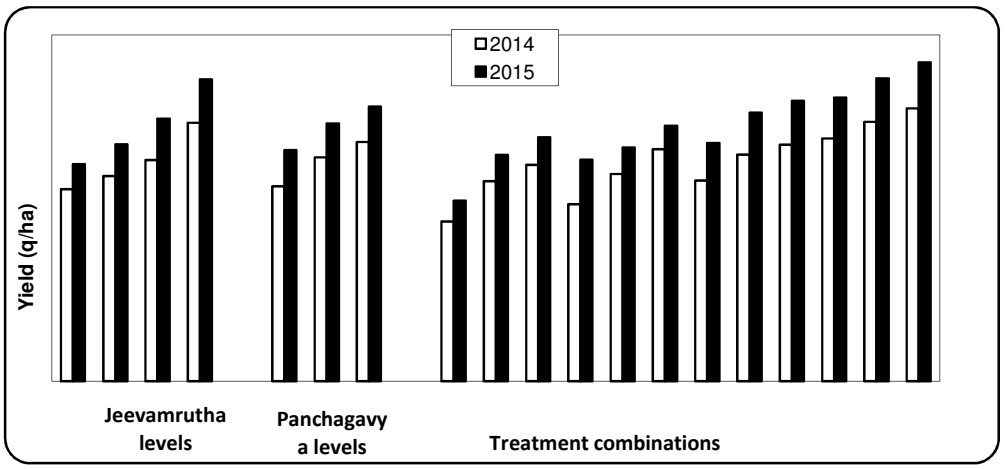

Figure 1. Influence of jeevamrutha and pachagavya application on yield (q/ha) of organic french bean

Table 1: Influence of jeevamrutha and panchagavya application on quality parameters of organic frenchbean during 2014 and 2015

Treatments	Crude Protein (%)		Carbohydrates (%)		Shelf life (days)	
	2014	2015	2014	2015	2014	2015

J_0	20.33	20.76	4.21	4.32	8.44	9.11
J_1	20.81	21.28	4.70	4.81	9.22	9.89
J_2	21.12	21.64	4.96	5.08	9.67	10.22
J_3	21.53	22.07	5.09	5.22	10.11	10.56
S.Em ±	**0.09**	**0.09**	**0.05**	**0.05**	**0.21**	**0.22**
CD at 5%	**0.25**	**0.26**	**0.15**	**0.15**	**0.61**	**0.63**
P_0	**20.67**	21.13	4.60	4.72	8.83	9.42
P_1	20.94	21.45	4.76	4.87	9.42	10.0
P_2	**21.22**	21.73	4.86	4.98	9.83	10.42
S.Em ±	**0.08**	**0.08**	**0.04**	**0.04**	**0.18**	**0.19**
CD at 5%	**0.22**	**0.22**	**0.13**	**0.13**	**0.52**	**0.55**
Interactions						
T_1: J_0P_0	20.21	20.58	3.99	4.10	8.33	8.67
T_2: J_0P_1	20.29	20.77	4.20	4.31	8.33	9.00
T_3: J_0P_2	20.48	20.93	4.44	4.55	8.67	9.67
T_4: J_1P_0	20.65	21.08	4.62	4.74	8.67	9.33
T_5: J_1P_1	20.71	21.21	4.71	4.83	9.33	10.00
T_6: J_1P_2	21.06	21.55	4.76	4.88	9.67	10.33
T_7: J_2P_0	20.73	21.23	4.74	4.86	8.67	9.67
T_8: J_2P_1	21.25	21.78	5.03	5.16	10.0	10.33
T_9: J_2P_2	21.37	21.90	5.10	5.23	10.33	10.67
T_{10}: J_3P_0	21.08	21.63	5.05	5.18	9.67	10.00
T_{11}: J_3P_1	21.52	22.05	5.08	5.21	10.00	10.67
T_{12}: J_3P_2	21.98	22.54	5.14	5.26	10.67	11.0
S.Em ±	**0.15**	**0.15**	**0.09**	**0.09**	**0.36**	**0.37**
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

NS- Non significant at 5 %

Quality parameters of frenchbean differed significantly due to levels of jeevamrutha and panchagavya levels. Among the treatments, application of jeevamrutha at 2000 l ha^{-1} recorded significantly higher crude protein (21.53 and 22.07 %), carbohydrates (5.09 and 5.22 %) and shelf life (10.11 and 10.56 days) as compared to without jeevamrutha application *ie.,* crude protein (20.33 and 20.76 %), carbohydrates (4.21 and 4.32 %) and shelf life (8.44 and 9.11 days) during 2014 and 2015 respectively. Similarly, application of higher level of panchagavya (6 %) recorded significantly higher crude protein (21.22 and 21.73 %), carbohydrates (4.86 and 4.98 %) and shelf life (9.83 and 10.42 days) as compared to without panchagavya application *ie.,* crude protein (20.67 and 21.13 %), carbohydrates (4.60 and 4.72 %) and shelf life (8.83 and 9.42 days) during 2014 and 2015 respectively. Interaction of these two parameters didn't differ significantly (Table 1).

Discussion

Application of higher levels of jeevamrutha and panchagavya enhanced the growth of the plants and these intern improved the yield and quality of organic frencghbean as compared to the without application of organics. These results are in conformity with Siddappa (2015) in fieldbean where jeevamrutha at 1500 litres ha^{-1} recorded significantly higher grain yield (1245.8 kg ha^{-1}) of

fieldbean an increase of 35.12 per cent over without jeevamrutha application (808.3 kg ha^{-1}). Similar results were also reported by Devakumar *et al*., (2008) and Boraiah (2013) in field bean and capsicum. The increase in pod yield of frenchbean might be due to better availability of nutrients throughout the crop growth period. Increased yield due to increasing sink potential as indicated by higher number of pods. This could be attributed to better availability and uptake of moisture, nutrients which helped in production of more photosynthates and its translocation to the pods during their development (Srivastava, 1988 and Gopinath *et al.,* 2009). These findings are in accordance with Kasbe *et al*., (2009) and they reported that higher nutrient status of jeevamrutha formulation (2500 litres ha^{-1}) resulted in better crop growth and yield.

Conclusion

It can be concluded thatcombined application of jeevamrutha at 2000 litres $ha^{-1}$and panchagavya at 6 per cent will enhance the growth rate of the frechbean and these liquid manures will supply required micronutrients, thereby increase the yield and quality parameters of the frenchbean. These formulations would serve as potential sources of traditional inputs and could be prepared early by the organic farmers.

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Effect of Farm Yard Manure (FYM) and Jeevamrutha on yield attributes and yield of Fieldbean (Dolichos lablab L.)

Siddappa, K. Murali, N. Devakumar and Ninganna Biradar

Key words: Farm Yard Manure (FYM), Organic liquid formulations, Fieldbean, Jeevamrutha.

Abstract

A field experiment was conducted to study the effect of Farm Yard Mannure (FYM) and jeevamrutha on yield attributes and yield of fieldbean at research institute on organic farming (RIOF), UAS, GKVK, Bengaluru.The experiment comprised of two factors and three Farm Yard Manure (FYM) levels (100% N, 150% N and 200% N equivalents through FYM) and four Jeevamrutha levels (0 liters ha^{-1}, 500 liters ha^{-1}, 1000 liters ha^{-1} and 1500 liters ha^{-1}) Jeevamrutha is prepared by using cowdung, cowurine, pulse flour and the soil of experimental site which is diluted with water and kept for fermentation for two weeks. Significant differences were observed in yield attributes and yield of fieldbean with respect to FYM and jeevamrutha application alone but interaction between FYM and jeevamrutha found to be nonsignificant. However higher number of pods plant^{-1}(30.6), pod weight plant^{-1}(22.5 g), number of seeds pod^{-1} (3.6) and total seed weight plant^{-1} (16.9 g), hundred seed weight (18 g), grain yield (1378 kg ha^{-1}) and haulm yield (1478 kg ha^{-1}) were recorded with FYM at 200 per cent N equivalent and jeevamrutha at 1500 l ha^{-1}.

Introduction

General acceptance of organic farming is not only due to the greater demand for pollution-free food but also due to natural advantage of organic farming in supporting the sustainability in agriculture. Organic production systems are based on specific standards precisely formulated for food production and aim at achieving agro ecosystem, which are socially and ecologically sustainable (Ramesh *et al.* 2005). The natural inputs used in organic farming are easily available, releases nutrients slowly and provides favorable soil environment for microbial population (Shashidhara, 2000; Devakumar *et al.,* 2011). Application of compost apart from supplying plant nutrients it also improves soil properties. Jeevamrutha is an traditional organic liquid manures used as microbial inoculant and also provides nutrients to certain extent (Devakumar *et al.,* 2008). An experiment was conducted with an objective to study effect of FYM and Jeevamrutha on yield and yield attributes of fieldbean.

Material and methods

A field experiment was conducted at organic farming block of research institute on organic farming (RIOF), University of Agricultural Sciences (UAS), Gandhi KrishiVignan Kendra (GKVK), Bengaluru, Karnataka. The experiment was laid out on factorial randomized complete block design with factorial concept having three replications. The experiment comprised of two factors at different levels, the treatment combination includes three Farm Yard Manure (FYM) levels (100% N, 150% N and 200% N equivalents through FYM) and four Jeevamrutha levels (0 liters ha^{-1}, 500 liters ha^{-1}, 1000 liters ha^{-1} and 1500 liters ha^{-1}).Soil of the experimental site was red sandy loam with neutral pH (6.5). The soil was medium in organic carbon (0.52 %)and availablenitrogen (329 kg/ha) and medium in available phosphorus (36 kg/ha) and potassium (230.5 kg/ha). Nitrogen equivalent basis of well decomposed farm yard manure (FYM) was applied to each plot 3 weeks

before sowing and incorporated into the soil. Jeevamrutha was prepared by mixing 10 kg of desi cow dung, 10 liter of cow urine, 2 kg of jaggery, 2 kg of pigeon pea flour and hand full of soil collected from farm. All these were put in 200 liter capacity plastic drum and mixed thoroughly and volume was made up to 200 liter. The mixture was stirred well in clock wise direction and kept in shade covered with wet jute bag. The solution was regularly stirred clockwise in morning, afternoon and evening continuously for 9 days and it was used for soil application. Jeevamrutha was applied near the root zone of the crop. Four Jeevamrutha levels were maintained (0 l ha^{-1}, 500 l ha^{-1}, 1000 l ha^{-1} and 1500 l ha^{-1}) and applied manually at regular intervals of 30, 45 and 60 days after sowing as per the treatments.

Results

Application of FYM at 200 Per cent N equivalent recorded significantly higher grain yield (1135.8 kg ha^{-1}) an increase of 8.02 and 16.74 per cent over FYM at 150 Per cent N equivalent and FYM at 100 Per cent N equivalent, respectively (Table 1). Significantly higher haulm yield was also recorded with FYM at 200 Per cent N equivalent (1477.5 kg ha^{-1}) an increase of 2.57 and 9.92 per cent over FYM at 150 Per cent N equivalent and FYM at 100 Per cent N equivalent, respectively. Increase in grain yield and haulm yield of fieldbean with FYM at 200 Per cent N equivalent could be attributed to higher availability of nitrogen, phosphorous and potassium through FYM leading to enhanced growth and yield of crop. The increased yield components viz. more number of pods per plant (27.4), higher pod weight per plant (18.4 g), number of seeds per pod (3.3), seed weight per plant (15.5 g) and higher test weight of fieldbean (16.5 g) might have helped for higher grain yield, haulm yield and harvest index. Application of jeevamrutha at 1500 l ha^{-1} recorded significantly higher grain yield (1245.8 kg ha^{-1}) an increase of 35.12 per cent over without jeevamrutha application (808.3 kg ha^{-1}). Similarly significantly higher haulm yield was also recorded with jeevamrutha at 1500 l ha^{-1} (1567.2 kg ha^{-1}) an increase of 22.58 per cent over without jeevamrutha application (1213.2 kg ha^{-1}). Significantly higher grain yield and haulm yield was recorded with application of jeevamrutha at 1500 L ha^{-1} which was reflected by yield attributing characters like number of pods per plant (29.2), pod weight per plant (21.0 g), number of seeds per pod (3.5), seed weight per plant (16.9 g) and test weight of fieldbean (17.3 g).

Discussion

Increase in grain yield and haulm yield of fieldbean with FYM at 200 per cent N equivalent and higher Jeevamrutha levels could be attributed to higher availability of nitrogen, phosphorous and potassium through FYM and Jeevamrutha leading to enhanced growth and yield of the crop. Ghuman and Sur (2006) who reported 10.7 per cent higher yield of wheat with the application of FYM 18 t ha^{-1} over FYM 6 t ha^{-1}. The increase in grain yield and haulm yield of fieldbean in jeevamrutha at 1500 l ha^{-1} could be due to better availability of nutrients throughout the crop growth. This is ensured by improved microbial activity in the soil. Somasundaram (2003) reported that favourable effects of IAA, GA_3, nutrients and also beneficial microorganisms present in the liquid organic manures. Further similar results were also observed by Shwetha and Babalad (2008) as they reported that 25 to 35 per cent increase in yield of soybean with the application of beejamrutha, jeevamrutha and panchagavya.

Table 1: Number of pods plant^{-1}, Pod weight plant^{-1} and Number of seeds pod^{-1} and total seed weight plant^{-1} (g) of fieldbean as influenced by different levels of Farm Yard Manure and jeevamrutha

FYM Levels	Jeevamrutha levels (litresha^{-1})																			
	Number of pods plant^{-1}					Pod weight plant^{-1}					Number of seeds pod^{-1}					Total seed weight plant^{-1} (g)				
	0	500	1000	1500	Mean	0	500	1000	1500	Mean	0	500	1000	1500	Mean	0	500	1000	1500	Mean
100% N Equivalent	21.3	24.5	26.5	27.8	**25.0**	12.0	13.6	16.5	19.0	**15.3**	2.5	2.9	3.1	**3.3**	**3.0**	11.4	13.1	14.5	16.1	**13.8**
150% N Equivalent	22.6	25.3	28.1	29.2	**26.3**	12.8	15.8	19.5	21.5	**17.4**	2.6	3.1	3.4	**3.5**	**3.1**	11.9	13.6	16.3	17.2	**14.7**
200% N Equivalent	22.6	27.3	29.0	30.6	**27.4**	13.2	17.8	20.3	22.5	**18.4**	2.8	3.2	3.4	**3.6**	**3.3**	12.4	15.2	16.9	17.5	**15.5**
Mean	**22.2**	**25.7**	**27.9**	**29.2**		**12.6**	**15.7**	**18.8**	**21.0**		**2.6**	**3.0**	**3.3**	**3.5**		**11.9**	**14.0**	**15.9**	**16.9**	
	S.Em ±		CD at 5%			S.Em ±		CD at 5%			S.Em ±		CD at 5%			S.Em ±		CD at 5%		
FYM	0.49		1.44			0.35		1.04			0.06		0.17			0.25		0.75		
Jeevamrutha	0.57		1.67			0.41		1.20			0.07		0.20			0.29		0.86		
F X J	0.98		NS			0.71		NS			0.12		NS			0.51		NS		

Table 2: Hundred seed weight (g), grain yield (kg ha^{-1}), haulm yield (kg ha^{-1}) and harvest index (HI) of fieldbean as influenced by different levels of Farm Yard Manure and jeevamrutha

FYM Levels	Jeevamrutha levels (litresha^{-1})														
	100 Seed weight (g)					Grain yield (kg ha^{-1})					Haulm yield (kg ha^{-1})				
	0	500	1000	1500	Mean	0	500	1000	1500	Mean	0	500	1000	1500	Mean
100% N Equivalent	14.1	14.9	15.5	16.3	**15.2**	723	931	1020	1108	**945.6**	1088	1301	1469	1465	**1330.9**
150% N Equivalent	14.3	15.2	16.8	17.6	**16.0**	810	974	1143	1251	**1044.6**	1276	1385	1542	1555	**1439.4**
200% N Equivalent	14.6	16.0	17.5	18.0	**16.5**	892	1102	1171	1378	**1135.8**	1276	1476	1478	1681	**1477.5**
Mean	**14.3**	**15.4**	**16.6**	**17.3**		**808.3**	**1002.4**	**1111.4**	**1245.8**		**1213.2**	**1387.1**	**1496.4**	**1567.2**	
	S.Em ±		CD at 5%			S.Em ±		CD at 5%			S.Em ±		CD at 5%		
FYM	0.21		0.63			28.65		84.03			32.88		96.42		
Jeevamrutha	0.25		0.72			33.08		97.03			37.96		111.34		
F X J	0.43		NS			57.30		NS			65.75		NS		

DAT = Days after transplanting FYM = Farm yard manure CCP = Composted coir pith
F1, F2 & F3 = N equivalents C.D. at 5 % level NS = Non significant

Conclusion

Fieldbean yield could be enhanced by applying higher levels of FYM and jeevamrutha. These inputs are readily available with most of the organic farmers and they can be prepared using locally available material. Higher levels of FYM and jeevamrutha application has further enhanced fieldbean yield besides improving soil physical, chemical and biological properties. These practices would ensure improvement in soil productivity and sustainability.

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Influence of organic liquid formulations on soil beneficial microbial population of organic frenchbean (*Phaseolus vulgaris* L.)

Ninganna Biradar, K. Murali, N. Devakumar and Lavanya G

Key words: Organic liquid formulations, Frenchbean, Panchagavya, Jeevamrutha, GMX soil pro max, beneficial microbes

Abstract

A study on influence of organic liquid formulations on growth and yield of organic frenchbean conducted at organic farming block of University of Agricultural Sciences (UAS), GKVK, Bengaluru under protective irrigation condition during summer 2016. Application of organic liquid formulations resulted in significant improvement with microbial population of frenchbean. The results revealed that bacteria, fungi, actinomycetes, N fixer and PSB population at different growth stages of frenchbean were significantly higher in T_{12} recorded maximum population of soil bacteria, fungi, PSB, actinomycetes and nitrogen fixer (final: 37.67X10^6 CFU/ g, 23X10^4 CFU/ g, 35.33 X10^3 CFU/ g 29.67X10^3 CFU/ g, 28.00X10^3 CFU/ g) as compared to initial microbial population (13.5X10^6 CFU/ g, 10.5X10^4 CFU/ g, 12.45X10^3 CFU/ g 12.30X10^3 CFU/ g, 13.33X10^3 CFU/ g). The results indicated that the organic liquid manures have supported the multiplication of different beneficial microbial population in frenchbean crop.

Introduction

Organic farming provides balanced nutrition thereby taking care of soil health by improving physical, chemical and biological properties of the soil through nutrient cycling (Anon, 2008). Frenchbean (*Phaseolus vulgaris* L) is an important vegetable crop commonly known as garden bean. It is a good source of protein (20 to 25 %). The natural inputs used in organic farming are localy available, releases nutrients slowly, supplies macro and micro nutrients and provides favourable soil environment for microbial population (Devakumar*et al*., 2011).Nutriend demand Nutriend demand of short duration crops are high in a short span and it should be mediated by biological process. Jeevamrutha is a process of nutrients and has very high beneficial microbial population (Devakumar et al., 2008) certain plant and weed extracts are used to promote growth and yield of crops. In view of this study was conducted to study the Influence of organic liquid formulations on soil beneficial microbial population.

Material and methods

A field experiment was conducted at research and demonstration blocks of research institute on organic farming (RIOF) University of Agricultural Sciences (UAS), Bengaluru in Karnataka, India. Soil of the experimental site was red sandy loam classified as *Alfisols*. Organic carbon(0.512 %), available nitrogen (340 kg/ha), phosphorus (40.5 kg/ha) and potassium (239 kg/ha) content of the soil were medium. The experiment was laid out on randomized complete block design having three replications and twelve treatments that is T_1 - Control - Recommended package of practice (63:100:75 kg NPK/ha and 25 t/ha FYM), T_2 – Package of practice (PoP) + soil application of GMX soil pro max (GSP) at 15 and 30 DAS, T3 - PoP + soil application of GSP at 15 and 30 DAS + foliar application of GSP at 15 and 30 DAS T_4 - Soil application of GSP at 15 and 30 DAS + foliar application of GSP at 15 and 30 DAS + 80 % recommended N T_5- PoP + soil application of Jeevamrutha 2000 l/ac at 15, 30 and 45 DAS T_6 - PoP + soil application of Jeevamrutha 2000 l/ac at 15, 30 and 45 DAS + foliar application of Panchagavya 5 % at 15 and 30 DAS, T_7- Soil

application Jeevamrutha of 2000 l/ac at 15, 30 and 45 DAS + foliar application of Panchagavya 5 % at 15 and 30 DAS + 80 % recommended N, T_8 - PoP + soil application of Jeevamrutha 2000 l/ac at 15, 30 and 45 DAS + foliar application of GSP at 15 DAS + foliar application of Panchagavya 5 % at 30DAS, T_9 - Soil application of Jeevamrutha 2000 l/ac at 15, 30 and 45 DAS + foliar application of GSP at 15 DAS + foliar application of Panchagavya 5 % at 30 DAS + 80 % recommended N, T_{10} - PoP + soil application of Jeevamrutha 2000 l/ac at 15, 30 and 45 DAS + foliar application of GSP at 15 DAS + foliar application of Panchagavya 5 % at 30 and 45 DAS T_{11} - PoP + soil application of Jeevamrutha 2000 l/ac at 15, 30 and 45 DAS + foliar application of GSP at 15 and 30 DAS + foliar application of Panchagavya 5 % at 30 and 45 DAS and T_{12}- PoP + soil application of Jeevamrutha 2000 l/ac at 15, 30 and 45 DAS + foliar application of GSP at 15, 30 and 45 DAS + foliar application of Panchagavya 5 % at 15, 30 and 45 DAS. The experiment comprised of three different organic liquid formulationsvizJeevamrutha, Panchagavya and GMX soil pro max. Jeevamrutha was applied through soil and while Panchagavya was applied as foliar spray. Lliquid manures – Jeevamrutha GMX soil pro max andPanchagavya were applied to frenchbean crop at 15, 30 and 45 days after sowing and were prepared using standard procedures. Farmyard manure was applied to the plots three weeks before sowing at 25 t ha^{-1} and it was incorporated into the soil. The entire quantity of recommended dose of nitrogen 63 kg ha^{-1} was applied through FYM along with basal dose. Short duration (65-70 days) variety of frenchbean was used for the field experiment. frenchbean crop was sown on 1st February 2016 with seed rate of 60 kg ha^{-1} and seeds were sown at spacing of 45cm and seed to seed spacing of 15cm (45cm X 15cm). Necessary aftercare operations were followed as per the recommendations. No major pest and disease incidences were noticed during crop growth. Microbial population was enumerated at different stages of crop growth. The soil samples were air dried and analyzed for soil microorganisms; bacteria, fungi, actinomycetes, N fixers and PSB. Standard plate count technique was followed to enumerate the soil microbial population with suitable agar medium(Soil extract agar for bacteria, Martins rose bengal agar for fungi, Kusters agar for actinomycetes, Jensens agar medium for N fixers). The plates were incubated at 28±2 ºC and the observations were recorded after 48 hours of incubation for bacteria, N-fixers, PSB, *Pseudomonas* and 72 hours of incubation for fungi and actinomycetes. Experimental data collected was subjected to statistical analysis by adopting Fisher's method of Analysis of Variance (ANOVA) as outlined by Gomez and Gomez (1984). Critical Difference (CD) values were calculated whenever the 'F' test was found significant at 5 per cent level.

Results

The data related to influence of different organic liquid formulations on frenchbean showed significant increase in microbial population at different growth stages of crop. At 20 DAS, significantly higher number of bacterial population was recorded in treatment 12 (T_{12}) 28.67×10^6 CFU g^{-1} which was on par with the treatment T_{11} 26.00×10^6 CFU $g^{-1}$and treatment $T_{10}$$25.67 \times 10^6$ CFU g^{-1}. Significantly lower number of bacterial population was recorded with the control14.00×10^6 CFU g^{-1} and similar trend is noticed at 40 DAS and at harvest also.There was significant difference in fungal population in the soil due to the application of varied levels of FYM and organic liquid formulations (Table 1). At 20 DAS, significantly higher number of fungal population was recorded with treatment $T_{12}$$20.67 \times 10^4$ CFU g^{-1}which was on par with the treatment T_{11} 19.67×10^4 CFU $g^{-1}$and $T_{10}$$17.67 \times 10^4$ CFU g^{-1}. Significantly lower number of fungal population was recorded with the control 9.33×10^4 CFU g^{-1}. Similar trend of fungal population is noticed at 40 DAS and at harvest also.

Actinomycetes population at 20 DAS was significantly higher in treatment T_{12} 26.33×10^3 CFU g^{-1} which was on par with the treatment T_{11} 24.33×10^3 CFU $g^{-1}$and treatment T_{10} 23.33×10^3 CFU g^{-1}. Significantly lower number of actinomycetes population was recorded with the control (12.00×10^6CFU g^{-1}). The similar trend is noticed with 40 DAS and at harvest also.

There was significant difference in Phosphorus solubalizerspopulation in the soil due to the application of varied levels of FYM and organic liquid formulations (Table 2). At 20 DAS, significantly higher number of Phosphorus solubalizerspopulation was recorded with treatment T 12 29.00 × 10^3 CFU g^{-1} which was on par with the treatment T $_{11}$ 26.67 × 10^3 CFU g^{-1} and treatment T_{10} 24.67 × 10^4 CFU g^{-1}. Significantly lower number of fungal population was recorded with the control (13.00 × 10^3 CFU g^{-1}). Similar trend of Phosphorus solubalizers population is noticed at 40 DAS and at harvest also.

Nitrogen fixer population at 20 DAS was significantly higher in treatment T_{12} 26.33 × 10^3 CFU g^{-1} which was on par with the treatment T11 24.00 × 10^3 CFU g^{-1} and treatment T_{10} 22.67 × 10^3 CFU g^{-1}. Significantly lower number of nitrogen fixer population was recorded with the control (11.00 × 10^3 CFU g^{-1}). Similar trend of nitrogen fixers population is also noticed at 40 DAS and at harvest.

Table 1: Soil bacteria. Fungi and PSB offrenchbean as influenced by application of Jeevamrutha, panchagavya and GMX soil pro max.

Treatments	Bacteria (No. × 10^6 CFU g^{-1} of soil)			Fungal (No. × 10^4 CFU g^{-1} of soil)			PSB (No. × 10^3 CFU g^{-1} of soil)		
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest
T_1	14.00	20.33	16.33	9.33	12.67	11.00	13.00	16.00	14.67
T_2	15.33	22.00	18.33	10.67	14.00	11.67	14.00	18.00	16.33
T_3	18.00	25.67	21.00	12.00	16.00	14.33	15.33	21.33	19.00
T_4	16.67	23.67	19.00	10.67	15.33	13.33	14.33	19.33	17.67
T_5	19.00	26.67	23.33	13.33	18.33	15.33	15.67	24.00	21.33
T_6	21.33	31.00	26.33	16.67	21.67	17.00	18.67	28.00	23.67
T_7	19.67	28.67	24.33	14.67	19.00	15.33	16.33	26.00	22.33
T_8	22.67	33.67	31.33	17.00	23.33	18.67	23.00	30.33	26.33
T_9	21.00	32.33	30.67	15.00	22.00	18.00	21.00	29.00	24.67
T_{10}	25.67	37.33	32.67	17.67	24.67	20.00	24.67	33.00	30.00
T_{11}	26.00	40.33	35.00	19.67	25.00	21.67	26.67	35.00	33.33
T_{12}	28.67	42.67	37.67	20.67	28.00	23.00	29.00	37.33	35.33
S.Em±	1.05	2.33	2.15	1.19	1.50	1.36	1.62	2.30	1.89
C.D. at 5%	3.07	6.83	6.31	3.49	4.40	3.98	4.75	6.76	5.54

T_1 : Control
T_2 :PoP + GSP*
T_3 :PoP + GSP* +FA of GSP at 15 and 30 DAS
T_4 :GSP* +FA of GSP at 15 and 30 DAS + 80 % RDN
T_5 :PoP + Jeevamrutha**
T_6 : PoP + Jeevamrutha** + FA of P 5 % at 15 and 30 DAS
T_7 : Jeevamrutha** + FA of Panchagavya 5 % at 15 and 30 DAS + 80 % RDN
T_8: PoP + Jeevamrutha** + FA of GSP at 15 DAS + P***
T_9: Jeevamrutha + FA of GSP at 15 DAS+ P*** +80% RDN
T_{10}: PoP + Jeevamrutha** +FA of GSP at 15 D+P****
T_{11}: PoP + Jeevamrutha** + FA of GSP at 15 and 30 DAS + P****
T_{12} : PoP + Jeevamrutha** + FA of GSP at 15, 30 and 45 DAS + Panchagavya spray 5 % at 15, 30 and 45 DAS

* Soil application of GSP at 15 & 30 DAS ** Soil application of jeevamrutha 2000 l/ac at 15, 30 and 45 DAS
*** Panchagavya spray 5% at 30 DAS **** Panchagavya spray 5% at 30 and 45 DAS
FA= Foliar application RDN= recommended dose of nitrogen DAS = Days after sowing

POP = Package of practice GSP = GMX Soil Pro Max P = Panchagavya

Table 2: Actinomycetes and nitrogen fixers population in french bean as influenced by application of jeevamrutha, panchagavya and GMX soil pro max

Treatments	Actinomycetes (No. × 10^3cfu g^{-1} of soil)			N fixer (No. × 10^3 CFU g^{-1} of soil)		
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest
T_1	12.00	16.00	13.33	11.00	13.67	12.67
T_2	13.33	16.33	16.00	12.00	15.00	13.33
T_3	15.00	19.33	19.00	14.00	17.33	15.67
T_4	13.67	17.67	17.33	13.00	16.00	14.33
T_5	16.00	19.33	20.00	15.33	18.00	17.00
T_6	17.00	23.00	23.33	18.67	19.67	19.33
T_7	16.67	21.00	22.00	17.33	18.67	17.67
T_8	20.00	24.33	25.00	21.00	22.33	21.67
T_9	19.67	22.67	23.00	20.00	20.67	21.33
T_{10}	23.33	27.67	26.33	22.67	25.67	24.67
T_{11}	24.33	29.33	27.33	24.00	28.33	27.33
T_{12}	26.33	30.67	29.67	26.33	30.33	28.00
S.Em±	1.22	1.37	1.40	1.37	1.63	1.37
C.D. at 5%	3.59	4.01	4.12	4.03	4.78	4.01

T_1 : Control T_7 : Jeevamrutha** + FA of Panchagavya 5 % at 15 and 30 DAS + 80 % RDN
T_2 :PoP + GSP* T_8: PoP + Jeevamrutha** + FA of GSP at 15 DAS + P***
T_3 :PoP + GSP* +FA of GSP at 15 and 30 DAS T_9: Jeevamrutha + FA of GSP at 15 DAS+ P*** +80% RDN
T_4 :GSP* +FA of GSP at 15 and 30 DAS + 80 % RDN T_{10}: PoP + Jeevamrutha** +FA of GSP at 15 D+P****
T_5 :PoP + Jeevamrutha** T_{11}: PoP + Jeevamrutha** + FA of GSP at 15 and 30 DAS + P****
T_6 : PoP + Jeevamrutha** + FA of P 5 % at 15 and 30 DAS T_{12} : PoP + Jeevamrutha** + FA of GSP at 15, 30 and 45 DAS + Panchagavya spray 5 % at 15, 30 and 45 DAS
Soil application of GSP at 15 & 30 DAS ** Soil application of jeevamrutha 2000 l/ac at 15, 30 and 45DAS
*** Panchagavya spray 5% at 30 DAS **** Panchagavya spray 5% at 30 and 45 DAS
FA= Foliar application RDN= recommended dose of nitrogen DAS = Days after sowing
POP = Package of practice GSP = GMX Soil Pro Max P = Panchagavya

Discussion

This could be attributed to cumulative effect of various sources of organic manures in increasing organic carbon content of soil which acted as carbon and energy source for microbes and their quick build up in the soil (Barik*et al*., 2006). Similar observations were made by Swaminathan(2005) who reported that presence of naturally occurring beneficial microorganisms predominantly bacteria, yeast, actinomycetes, photosynthetic bacteria and certain fungi were more in case of organic liquid manures.Devakumar*et al*., (2008) reported that jeevamrutha and panchagavya were rich source of beneficial microorganisms and micronutrients and also reported

that the use of handful of soil for jeevamrutha preparation serves as source of initial inoculum of bacteria, fungi, actinomycetes, N- fixers and P- solubilizers. Hence, more number of beneficial microorganisms is found in organic liquid manure formulations.

Conclusion

Organic liquid formulations are source of nutrients in considerable amount. These organic liquid formulations have direct influence on the microflora of the soil, intern N fixation, P solubalisation, plant growth promotion and yield of the crop. The studies revealed that application of organic liquid formulations have significant influence on soil microbial status, soil nutrients and yield of crop. Therefore they play a significant role in improving the soil health and sustainable production.

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Efficient method of composting for production of good quality manure from hard crop residues

Tarak Kate[1], Sonali Phate[1]

Key words: pulverization, cattle dung-urine, microbial consortium, vermi-compost

Abstract

Abundant amount of hard crop residues are generated annually from the major cash crops like cotton and pigeon. However, a large part of such biomass is burnt on the farm, thus contributing to environmental pollution, as farmers do not find any practical value in its alternative use. Due to presence of high lignin content, composting of these crop residues is difficult which may take about 9 to 12 months under natural condition. Under an innovative method developed by us, such hard biomass was pulverized to a particle size of 0.5 cm and then subjected to a pre-treatment of cattle dung + cattle urine slurry for 15 days. Thereafter, it was inoculated with a consortium of four species of fungi.One batch of the biomass was continued under this treatment for 80 to 90 days, while after 10 days, a second batch was subjected to vermi-composting for 30 days.Good quality manure was obtained after a total period of 95-105 days and 55 to 60 days under first batch and second batch, respectively.

Acknowledgments

We are thankful to Department of Science & Technology, Ministry of Science & Technology, Government of India, New Delhi for providing financial support for this research work.

Introduction

About 80 countries in the world produce cotton and occupy 27.5 million ha of cultivated area; India covers the largest land area in the world under cotton which ranges between 10.9 and 12.8 million ha (Cotton Corporation of India 2016). Similarly, India shares a largest area of 3.8 million ha out of over 4.74 million ha of land under pigeon pea cultivation in the world (ICRISAT 2016). World wise, these crops annually produce about 35.84 million tonnes of cotton stalks and 11.25 million tonnes of pigeon pea stalks as crop residues. Although such an enormous amount of agro-waste is available, it poses a great problem of degradation due to presence of high level of lignin and so, takes long period of about 9 to 12 months for decomposition under natural condition. Hence, there is a challenge to evolve an efficient method for production of good quality compost from such hard biomass in a shorter time. In this paper, we have elaborated such method successfully developed by us.

Material and methods

The freshly harvested cotton and pigeon pea stalks were shredded separately with the help of a pulveriser of 1430 rpm capacity which was powered by 3 hp electric motor and provided with a sieve with a perforation size of 0.5 cm. The shredded biomass took almost a powdered form. It was then soaked with water and subjected to a pre-treatment with 10 % cattle dung and urine slurry which was prepared by mixing 5 kg of cattle dung and 5 litres of cattle urine in 90 litres of water. The duration of pre-treatment was optimized at 15 days and during this period the biomass was covered with a thick black plastic sheet to conserve the moisture. Thereafter, the pre-treated biomass was inoculated with a mixed microbial culture. A consortium of four species of fungi namely *Pleurotus sajor caju, Trichoderma reesi, Aspergillus awamori* and *Penicillium* spp was

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used for preparation of this inoculant. The pure cultures of these fungi, obtained from the authentic research institutions in India, were sub-cultured in our laboratory, which were then developed first into mother cultures and later into mass cultures by using potato dextrose broth technique for preparation of liquid cultures (Ikechi-Nwogn and Elenwo 2012). 10 days' old liquid culture of each of the 4 types of fungi was diluted by adding 600 ml of original culture to 9 litre of distilled water and 500 ml of the diluted culture of each type of the fungus was then mixed together to form a mixed microbial consortium. The mixed microbial culture was used @ 1 litre for the inoculation of 500 kg of pre-treated biomass. During inoculation, the biomass was thoroughly mixed, moistened and then covered with the plastic sheet. After duration of 10 days, the inoculated biomass was divided into two batches. The biomass in batch I was continued to a prolonged period under the same condition which ranged from 80 days to 90 days for cotton stalks and pigeon pea stalks, respectively, while the biomass in batch II was subjected to inoculation of earthworms for a period of 30 to 35 days; earthworm species of *Eudrilus eugeniae* was used for this purpose. These procedures are summarized in Figure 1a and Figure 1b.

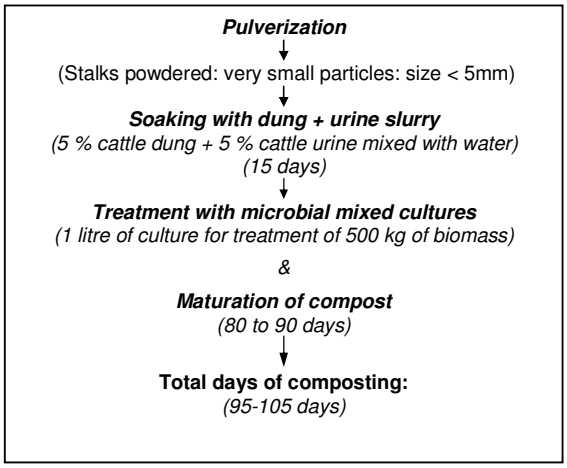

Fig. 1a: Flow chart of microbial composting

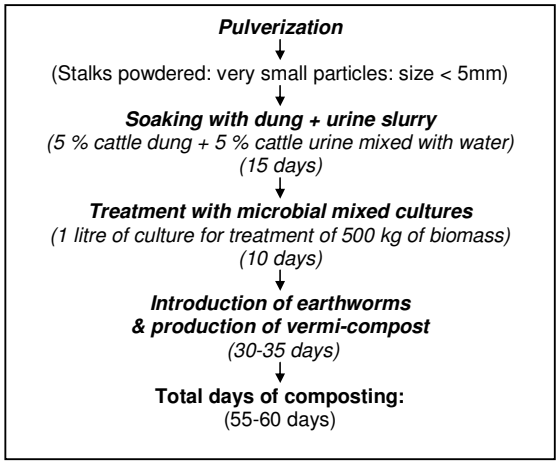

Fig. 1b: Flow chart of vermi-composting

The cotton stalks and pigeon pea stalks as well as samples of the compost from the two batches were analysed for levels of organic carbon, total nitrogen and total phosphorus present in them using standard methods (Jackson 1973).

Results

The biomass was observed to be quite softened after a period of 25 days which consisted of pre-treatment with cattle dung-cattle urine slurry followed by microbial inoculation and such softened biomass could easily be used as a feed for the earthworms. A total duration of production of compost from cotton and pigeon pea stalks under batch I was observed to be 95 days and 105 days, respectively; while for batch II, it was noted to be 55 and 60 days. This shows a substantial reduction in duration of compost production compared to that required under natural condition. However, Pan *et al.* (2012) reported a composting period of only 75 days and 90 days for rice husk and wheat straw, respectively, wherein biomass was inoculated with microbial consortium. In another investigation, pine litter was pre-treated with urea + lime + molasses + biogas slurry + cattle urine followed by inoculation with white rot fungus and the composting period was noted to be 75 days (Pal and Singh, 2002). Under the experiment carried by Sutaria *et al.* (2016), chopped cotton stalks (particle size 5-5 cm) was pre-treated with mixtures of various ingredients like urea, cow dung, rock phosphate, castor &*neem* cakes, Azotobacter and PSM cultures under different treatments and the pre-treated biomass was then subjected to a mixed inoculums of four fungal cultures; period composting period for cotton stalks pre-treated with cow dung + microbial culture

was noted to be 90 days to 120 days which is comparable to our results. But our method involving pre-treatment of cotton and pigeon pea stalks with cattle dung + cattle urine followed by microbial treatment and then by vermi-composting led to a shortest period of 55 to 60 days.

The proximate analysis of untreated cotton stalks showed the organic carbon and total nitrogen levels at 50.87 % and 0.92 %, respectively. Thus, the C:N ratio was noted to be 55.29; similar figures for untreated pigeon pea stalks were 54.06 %, 0.76 % and 71.13, respectively. The nutrient status of untreated cotton stalks and pigeon pea stalks is given in Table 1, while that of mature compost prepared under batch I and batch II (vermi-compost) is given in Table 2.

Table 1: Nutrient status of untreated cotton and pigeon pea stalks

Type of Biomass	Organic Carbon	Total Nitrogen	Total Phosphorus	C:N ratio
Cotton stalks	50.87%	0.92%	0.40%	55.29
Pigeon pea stalks	54.06%	0.76%	0.33%	71.13

Table II: Nutrient status of microbial compost, vermi-compost and FYM

Type of Biomass	C:N ratio	Total Nitrogen	Total Phosphorus
Microbial compost			
Cotton stalks	11.79	1.60%	0.41%
Pigeon pea stalks	9.60	1.98%	0.40%
Vermi-compost			
Cotton stalks	8.66	2.18%	0.46%
Pigeon pea stalks	6.68	2.91%	0.42%
FYM			
Farm waste	18.01	1.25%	0.34%

As revealed from the Table II, there has been a significant reduction in the C:N ratios in the compost in case of both the types of biomass, the reduction being more pronounced in the compost obtained using earthworm inoculation in contrast to that made with only microbial inoculation. Similarly, values of C:N ratios are comparatively lower in case of the compost made from pigeon pea stalks as compared to that from cotton stalks which are true for the compost prepared under both the batches. This may also be attributed to higher nitrogen content obtained in the compost prepared from pigeon pea stalks under both the methods. The vermi-compost prepared from both types of stalks was noted to be quite superior compared to that prepared with only microbial treatment due to significantly higher amount of nitrogen content. However, increase in the phosphorus content of compost over that in the raw biomass was extremely low; this increase was somewhat higher in the vermi-compost than that of microbial compost. These results were compared with nutrient status of the FYM obtained from the nearby farm and analysed in our laboratory. This comparison shows that nutrient content of compost made from both the types of stalks and employing two different methods is far superior to that of FYM. The compost recovery from the original biomass was noted to be 60.1 % and 52.3 % for the compost prepared under batch I and batch II methods, respectively. The lower recovery under vermi-composting indicates that there has been more carbon assimilation due to higher metabolic activity and reproductive growth

of earthworms. The colour of compost prepared under both the methods was dark black and the texture was fragile.

Although pre-treatment of biomass like wheat straw, leaf litter, pine needles, sugarcane waste, and cotton stalks with cattle dung + urine and / or its decomposition either with the fungal inoculation (with individual fungal strain or fungal consortium) or through vermi-composting have been tried elsewhere (Lata *el el.* 2008; Pal and Singh 2002; Pan *et el.* 2012; Pandit and Maheshwari 2012; Sutaria *et el.* 2016), we have successfully tried a novel and synergistic approach for composting of neglected hard agro-wastes, so far considered difficult for composting due to presence of high level of lignin which is in the range of 19.8 to 24. 4 % (Karunanity *et al.* 2012; Mythili and Venkatachalam 2013), by softening it with cattle dung + cattle urine mixture pre-treatment followed by its inoculation with mixed fungal consortium, and then subjecting the softened biomass to vermi-composting so as to obtain a good quality manure in a shortest span of only 55 to 60 days.

Discussion

The future challenges of global agriculture like enhancing land productivity to produce sufficient food to feed more people as well as mitigating green-house gas emissions, demand large scale recycling of farm residues and other available waste which isessential to rejuvenate the degraded or partially degraded lands and also to sustain soil health of the existing farm lands. The eco-friendly and efficient method developed by us for this purpose not only utilizes hard crop residues, but it can also be extended to environmentally hazardous bushes like *Lantana*andother forest wastes for production of good quality compost to ameliorate the soils. This is also important for most of the African countries that are endowed with availability of enormous amount of such biomass but are faced with low crop productivity due to poor soil quality in their farm lands. Our method relies on efficient use of locally available bio-resources like agrowastes, cattle dung & cattle urine and, hence, holds promise for large scale employment generation for youth in rural areas.

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Influence of different methods of rice (Oryzae sativa.l) cultivation – SRI vs NTP on microbes, soil health and grainyeild

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Key words: System of Rice Intensification (SRI), rice productivity, soil health, microbial activity

Abstract

System of Rice Intensification (SRI) developed in Madagascar, a systems approach to increasing rice productivity with less reliance on expensive external inputs, is gaining momentum all over the world including India. IIRR has conducted a long term experiments in sandy clay loam soils (2008-09 to 2010-11) to compare the organic and inorganic sources of nutrients for its productivity and soil health in SRI vs Best Management Practice (BMP) of Normal puddled Transplanted rice. The superior performance of SRI with higher microbial biomass corbon (17.2 %) coupled with higher dehydrogenase activity (ug TPFg-1soil 24h-1) with SRI (182) as compared to BMP indicating soil health improvement. SRI method with organic and inorganic nutrient application yielded 15.66 to 22.76 %mean higher grain yield in wet and dry seasons respectively as compared to BMP indicating a major factor contributing to positive SRI crop results is that its practices (young seedling, wider spacing, inter cultivation with weeder, saturation of soil use of organics) respectively taken together, create conditions in which beneficial microbes prosper due to well aeration and improves the soil health.

Introduction

Rice is the principal staple food for 65 % of the population of India cultivated in largest area 42 with a productivity of 106 m tonnes M ha (2015-16) and demand for rice is expected to rise due to increase in population (1.6 % per year), with reduced area and inputs in the next 15–20 years . The System of Rice Intensification (SRI) has been promoted for more than a decade as a set of agronomic management practices for rice cultivation that enhances yield (Senthil Kumar *et al.,* 2008), which also reduces water requirements. SRI was also found more accessible to small land holders (Stoop *et al.,* 2002) and is more honorable for the environment than conventional transplanting with its continuous flooding and leaving reliance on inorganic fertilisation (Uphoff, 2003). Increased and indiscriminate use of chemical fertilizers and pesticides since the onset of the green revolution during seventies resulted in several harmful effects on soil, water and air. This has also reduced the productivity of the soil by deteriorating soil health in terms of soil fertility and biological activity. Remarkable progress in the last 50 years in agricultural production and self-sufficiency in food of many countries including India has been attained at the cost of soil health.

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Imbalanced nutrient management and decreased soil organic matter are the key responsible factors for this decline. Therefore, emphasis should be laid on reducing the use of chemical inputs and to improve their use efficiency. Microbial-based indicators of soil quality are generally more dynamic than those of physical and chemical properties. Microbial communities are important determinants

of soil organic matter decomposition rates, and thereby the nutrient turnover and their availability in agricultural soils. Microbial soil characteristics are attaining an increased interest as sensitive indicators of soil health because of the relationships between microbial diversity, soil and plant quality and ecosystem sustainability. Although grain yield under organic farming is often lower than under conventional farming, it is feasible to have increased rice yields under the former.

The information on organic farming in rice under SRI and its comparison with Best management practices with regard biological activity and productivity of rice in Indian soils is very scanty. Hence, the present experiment was conducted to investigate growth parameters, root characters , soil microbial populations, and yield attributes and grain yield by comparing the plants grown with different crop establishment methods (SRI – organic, SRI with organic + inorganic) *vs* Best management practices (BMP with organic+ inorganic) maintained with flooded irrigation

Material and methods

The studies were conducted at Indian Institute of Rice Research Farm located at ICRISAT Patancheru (17°.53'N latitude, 78°.27'E longitude, 545 m altitude) in sandy clay loam soils (2008-09 to 2010-11) for three consecutive wet (*kharif*) and dry (*rabi*) seasons to investigate effect on grain yield by comparing the plants grown with different crop establishment methods (SRI – organic, SRI with organic and inorganic) vs Transplanted Rice (BMP with organic+ inorganic). Mean maximum and minimum temperatures there are 32°C and 20°C, respectively,and mean annual precipitation is 750 mm. Trials were managed during six seasons: *Kharif (3* wet season) 2008-10, *Rabi* (3 dry seasons) 2008–09 -2010-11, on an integrated rice agro ecosystem in an undisturbed field lay-out with permanent bunds around each plot. All the plots were surrounded by 1.5 m wide bunds to prevent lateral water seepage and nutrient diffusion between plots. Soils at the experimental site are classified as sandy clay loam, alkaline (pH 8.5–9.4), non-saline (EC 0.32 dS m^{-1}) and contained 1.01% organic carbon, 795 ppm total N, 58 ppm available phosphorus (Olsen and Sommers,1982), and 190 ppm available potassium.

The experiment was laid out in a plot size of 105 m^2 for each treatment. The three methods of crop establishment (SRI-organic, SRI-organic + inorganic, and BMP) were the main treatments done with three replications each. The rice variety Sampada with bold grain quality, which matures normally in 135 days, was tested during both *Kharif* and *Rabi* seasons. In the SRI-organic + inorganic and BMP treatments, the inputs applied were the same (50% organic + 50% inorganic), while in SRI-organic, the total nutrients were supplied through organic sources such as farm yard manure, vermicompost and green manure (*Gliricidia sepium*, a leguminous N_2-fixing tree). The recommended doses of inorganic fertilizers were given at the rate of 100–60–40 kg N_2, P_2O_5 and K_2O ha^{-1} during *Kharif* season, and 120–60–40–20 kg N_2, P_2O_5, K_2O and Zn ha^{-1} during *Rabi* season, applied through urea, single super phosphate, muriate of potash, and zinc sulphate, respectively. Nitrogen was given in three equal splits at basal, maximum tillering, and panicle initiation stages, while P, K and Zn were given as basal doses. For SRI-organic treatments, the N dose was adjusted to the recommended level based on the moisture content and total N concentration of the organic sources. The average nutrient content of the organic fertilizers that were applied is shown in Table 1 and the standard management of SRI and BMP were adopted.

Table 1: Average nutrient content of organic fertilizers

Organic source*	N (%N)	P (%P_2O_5)	K (%K_2O)

Compost	1.4	1.8	2.2
Gliricidia	2.4	0.1	1.8
Rice-straw	0.8	0.2	1.8

*Organic fertilizers incorporated one week before transplanting rice; N = nitrogen; P = phosphorous; K = potassium
SRI method and recommended management was practiced as per the standard procedure

Results

Grain yield

Grain yield was found to be significantly higher in SRI-organic + inorganic (11.72 –23.07% and 3.81–35.04 % more in *kharif* (wet) and *rabi* (dry) seasons, respectively) compared to BMP in all six tested seasons, while with the SRI-organic treatment, yield was found to be higher (4–34%) only in the *Rabi* seasons . The mean grain yield ranged between 3.39 and 9.37 t ha^{-1} for SRI-organic, and 5.24 and 10.67 t ha^{-1} for SRI-organic + inorganic as compared to 4.29–8.47 t ha^{-1} in BMP (**Table 2**). The divergence in grain yield between SRI and BMP was more attributable to differences in Harvest Index than to dry matter production.

Table 2: Grian yield of the SRI vs BMP as influenced by nutrient management in different seasons

Treatments	Grain yeild (t/ha)							
	Kharif				*Rabi*			
	2008	**2009**	**2010**	**Mean**	**2008**	**2009**	**2010**	**Mean**
SRI-Organic	3.39	3.70	5.29	4.12	5.45	8.12	9.37	7.65
SRI (Org +inorganic)	5.24	5.28	5.65	5.39	5.44	8.17	10.67	8.09
BMP	4.69	4.29	4.99	4.66	5.24	6.05	8.47	6.59
L.S.D (0.05%)	0.57	0.67	0.7	0.65	NS	0.63	0.35	0.49
Mean				4.72				7.44

In the present investigation, it was also observed that the plants grown in SRI had more open architecture, with wider spread of tillers, covering more ground area, and more erect leaves hich avoided mutual shading of leaves. With higher light interception, this would lead to more photosynthesis and higher grain yield in SRI compared to BMP. A number of previously published reports on SRI have shown enhancement in rice yield with these methods (Sato and Uphoff 2007; Thakur et al. 2009).

In the present investigation, grain yield was found higher in *Rabi* seasons 57 per cent compared to *Kharif* seasons probably due to bright sunshine and favorable weather for the crop and also less pest and disease attack. Seshu and Cady (1984) reported that the 30% higher radiation during the *Rabi* season over *Kharif* season on the rice crop correlated positively with economic yield. This increase could also be attributed in part to soils during *Rabi* being less saturated (less hypoxic), which would favor larger concentrations of more beneficial aerobic soil organisms in the rhizosphere.

Nutrient, biological and microbiological properties of the rhizosphere soil from SRI vs BMP

The total N and %OC were found to be significantly higher in SRI-organic (16–22% and 12–20%, respectively) and SRI-organic + inorganic (3–13% and 5–10%, respectively) treatments over BMP (Table 3). Not much difference in total P was observed, however, in either SRI-organic or SRI-organic + inorganic treatments compared to BMP (Table 3). Soil dehydrogenase and microbial

biomass carbon (MBC) were also found to be significantly higher in SRI-organic (11–18% and 34–38%, respectively) and SRI-organic + inorganic (9–50% and 6–34%, respectively) treatments over BMP in all seasons.

Table.3. Comparison of soil biological activity and nutrient status as influenced by SRI-organic, SRI-organic + inorganic and best management practices (BMP)

Season	Treatment	Dehydrogenase ($\mu g\ g^{-1}$+soil $24\ h^{-1}$)	MBC ($\mu g\ g^{-1}$+soil $24\ h^{-1}$)	Total N (ppm)	Total P (ppm)	%OC	
Kharif season (2008)	SRI-org	188.0	672.0	*	108.0	1.14	
	SRI-org + inorg	186.0	643.0	*	96.0	1.15	
	BMP	170.0	500.0	*	93.0	1.13	
	LSD (5%)	13.6	120.7		12.5	0.02	
Kharif season (2009)	SRI-org	97.0	623.0	1674.0	94.0	1.38	
	SRI-org + inorg	110.0	605.0	1549.0	91.0	1.27	
	BMP	82.0	450.0	1375.0	91.0	1.15	
	LSD (5%)	14.8	151.0	73.2	3.0	0.01	
Rabi season (2008–09)	SRI-org	*	*	*	*	*	*
	SRI-org + inorg	326.0	1218.0	1103.0	134.0	1.20	
	BMP	267.0	1153.0	1083.0	130.0	1.19	
	LSD (5%)	26.2	19.5	2.6	1.8	0.02	
Rabi season (2009–10)	SRI-org	*	*	1497.0	122.0	1.25	
	SRI-org + inorg	274.0	781.0	1328.0	122.0	1.17	
	BMP	183.0	706.0	1287.0	120.0	1.12	
	LSD (5%)	89.5	4.3	206.6	2.4	0.07	

MBC – microbial biomass carbon; N = nitrogen; P = phosphorous; OC = organic carbon; ppm = parts per million; org = organic; inorg = inorganic; * = not analyzed; LSD = least significant difference

The microbial populations (total bacteria, fungi and actinomycetes) were found to be always higher in SRI-organic and SRI-organic + inorganic treatments over BMP (Table 4). It should be noted, however, that the approach of quantifying microbial population through plate-count techniques estimate probably less than 10% of the total microflora in the soil (Nannipieri et al. 1994). Therefore, molecular quantification (a more reliable method) needs to be done in future studies.

Table 4: Comparison of microbial population as influenced by SRI-organic, SRI-organic + inorganic and best management practices (BMP)

Year	Treatment	Total bacteria	Total actinomycetes	Total fungi
Kharif season (2008)	SRI-org	5.79	4.60	5.59
	SRI-org + inorg	5.79	4.66	5.71
	BMP	5.77	4.41	5.42
	LSD (5%)	0.01	0.11	0.10

Kharif	SRI-org	5.97	5.00	3.81
season	SRI-org + inorg	6.08	4.90	3.81
(2009)	BMP	5.80	4.73	3.78
	LSD (5%)	0.08	0.200	0.02
Rabi season	SRI-org	*	*	*
(2008–09)	SRI-org + inorg	6.94	5.56	5.72
	BMP	6.81	5.52	5.59
	LSD (5%)	0.16	0.10	0.13
Rabi season	SRI-org	6.88	6.04	4.88
(2009–10)	SRI-org + inorg	6.76	5.84	4.99
	BMP	6.76	5.69	4.68
	LSD (5%)	0.01	0.13	0.04

org = organic; inorg = inorganic; * = not analyzed;
LSD = least significant difference; Microbial populations were expressed in Log_{10} values

Discussion

In the present investigation, revealed that the grain yield found to be significantly higher in the SRI-organic + inorganic trials, as compared to BMP. Grain yield was found to be significantly higher in SRI-organic + inorganic (11.72 −23.07% and 3.81−35.04 % more in *Kharif* and *Rabi* seasons, respectively) compared to BMP in all six tested seasons, while with the SRI-organic treatment, yield was found to be higher (4−34%) only in the *Rabi* seasons. This is clear evidence that SRI management is not only a seed-saving (5kg /ha over 30 kg /ha) method but also enhances the productivity of the rice.

It can be concluded that SRI practices create conditions for beneficial soil microbes to prosper and for increasing grain yield. The role of soil microbes in enhancing rice plant productivity, even affecting the expression of genetic potentials, is just beginning to be studied (Chi et al., 2010). Further, long-term research studies at different locations will be useful to quantify each component of SRI, for enhancing resource conservation, wide-scale adoptability, and molecular assessment of microbial populations in the soil and the effects of symbiotic endophytes to assess positive soil–plant–microbial interactions.

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Application of beneficial soil microbial inoculants to pigeon pea and finger millet crops reveals the potential to reduce fertilizer input without reduction in grain yields

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Key words: bio-inoculants, bio-irrigation, pigeon pea, finger millet, arbuscular mycorrhizal fungi, plant-growth promoting rhizobacteria

Abstract

Arbuscular mycorrhizal fungi (AMF) and plant growth-promoting rhizobacteria (PGPR) are among the most important rhizosphere microorganism well-known for improving plant nutrient uptake. Identifying and scientific evaluation of effective microbes for each crop remain the biggest challenge which needs multi-year and multi-location field trials. We found that combined application of pre-selected AMF and PGPR strains improve pigeon pea and finger millet crop yield under rain fed agroecosystem in India. Our study indicates the potential to reduce fertilizer input by about 50% without jeopardizing the grain yields, and to increase yields of crops amended by farmyard manure (FYM) solely.

Acknowledgments

Indo-Swiss Collaboration in Biotechnology (ISCB), Department of Biotechnology (DBT), India, Swiss Development Agency (SDC), Switzerland.

Introduction

With rapid decline in agriculturally important natural resources such as P stocks and fossil resources, search for alternate but sustainable inputs to improve crop production remains a great challenge. There is increasing evidence that through the use of beneficial soil microbes, particularly the combined inoculation of AMF and PGPR have the potential to substantially reduce mineral fertilizer input. This holds true mainly for marginal soils with low inherent soil fertility in rain fed conditions. Under the umbrella of the Indo-Swiss Collaboration of Biotechnology, a multi-stakeholder platform which includes research collaboration between India and Switzerland, we performed replicated field trials for two consecutive seasons at two sites in South India planting pigeon pea and finger millet. Our major goal was to find whether the bio-inoculants pre-selected for pigeon pea and finger millet would be able to improve the crop yield under reduced chemical fertilizer input, and to evaluate if they were effective when FYM alone is applied.

Material and methods

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Field trials were conducted at two field sites in South India, one at Bangalore and another in the Kolli Hills, during two seasons 2014-15 and 2015-16. Each field trial comprised three cropping systems: (i) finger millet mono-cropping (FM); (ii) pigeon pea mono-cropping (PP) and (iii) finger millet and pigeon pea inter-copping system (FM+PP), each tested at four levels of microbial inoculantion: (i) no inoculants (No); (ii) AMF alone; (iii) PGPR alone and (iv) AMF and PGPR combined (AMF+PGPR). Farmyard manure (FYM) at a dose of 7.5 t ha^{-1} was applied to each experimental plot. Factorial combination of crop and microbial inoculants results in 12 treatments tested at 50% level of recommended mineral fertilizer dose (RDF). In order to explore whether microbial inoculants have the potential to replace the expected yield gap at 50% RDF we included a treatment where 100% RDF without microbial inoculants under all three cropping systems. Additionally, we included two treatments without mineral fertilizer, but with farmyard manure alone in combination with AMF+PGPR tested only in the mixed cropping system (FM+PP). The total 15 treatments (12+3+2) were laid out in a randomised block design with each treatment replicated four times resulting in total 68 plots (6.6 m length x 3.9 m width). In each plot the crops were row wise planted with 22 rows of FM, 11 rows of PP in the monoculture and 16 rows FM plus 4 rows PP in the intercropping system.

Results and Discussion

At both sites and in both years FM and PP grain yields at 50% RDF inoculated with AMF+PGPR were on par with the 100% RDF without any inoculation. Dual inoculation by AMF and PGPR was more effective than inoculation by AMF or PGPR alone. Inoculation also increased grain yield of FM and PP in the plots amended only by FYM to a level achieved by 50% RDF without inoculation. Our data revealed that the combined inoculation of AMF+PGPR in general promotes grain yields of finger millet and pigeon pea with consistent results obtained for two cropping seasons and sites. Interestingly AMF+PGPR in both the crops, particularly in finger millet, shows in mean a yield increase that is on par with 100% RDF indicating potential to reduce mineral fertilizers without reduction in yields. Our results also indicate that in plots which received FYM alone there is great potential to improve the yield through microbial inoculants, what is relevant in particular in organic farming. To conclude bio-inoculants can reduce the amount of mineral fertilizers and thereby safeguard fertilizer P stocks and fossil fuels. In organic farming bio-fertilizers have the capacity to minimise yield gap to high input conventional farming. Detailed results on yields and yield components of the multi-site and multi-year experiments will be presented at the conference.

Organic Rice farming – A viable option for sustaining productivity, grain quality, soil health and economic returns

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Key words: Organic rice, yield, soil health, grain quality, economics

Abstract

Considering the importance and growing demand for organically produced foods, field experiment was conducted to study the influence of organic farming on super fine rice varieties. During wet season, grain yields with chemical fertilisers were superior to organics by 15-20 % in the first 2 years which improved with organics in the later years. However, during dry season, inorganics were superior for 4 years and organics recorded equal yields in the 5th year. Though grain quality parameters were not influenced significantly, moderate improvement in nutritional quality was observed with organics, especially, in brown rice. A significant improvement in soil properties with organics improved the soil quality and sustainability indices. Benefit:cost ratio was less with organics in the first year which improved over inorganics by fifth year. Thus, organic farming needs some time to stabilize productivity, improve grain/soil quality and economic returns depending on the season.

Introduction

Introduction of high yielding rice varieties has led to the indiscriminate use of chemical fertilisers and pesticides that reduced the productivity of soils and resulted in soil, water and atmospheric pollution. Several long-term field experiments indicated a declining trend in grain yield under intensified rice cropping system with constant and high fertilizer inputs (Cassman and Pingali, 1995). Therefore, emphasis should be laid on reducing the use of chemical inputs. Organic farming has been considered as one of the best options for protecting/sustaining soil health and is gaining lot of importance in present day agriculture in most parts of the world. There is very limited comprehensive research on organic rice farming in India and to generate scientific research data, the present study was undertaken to assess crop growth, productivity, grain quality, pesticide residues, soil health parameters and economics of rice as influenced by organic and inorganic systems of production.

Material and Methods

Field experiments were conducted spread over five years (2004-05 to 2009-10) covering ten rice cropping seasons [five wet (WS, *kharif*) and five dry (DS, *rabi*)] on a deep black clayey vertisol (Typic pellustert) at the Indian Institute of Rice Research (IIRR) farm, Rajendranagar, Hyderabad to compare the influence of organic and conventional farming systems on productivity of super fine rice varieties, BPT 5204 (WS) and Vasumati (DS), pest dynamics, grain quality and soil health. The experimental soil characteristics were:

slightly alkaline (pH 8.2); non-saline (EC 0.7l dS/m); calcareous (free $CaCO_3$ 5.01%); with CEC 44.1 C mol (p+)/kg soil and medium soil organic carbon (0.69%) content. Soil available N was low (228 kg/ha); available phosphorus was high (105 kg P_2O_5 /ha); available potassium was high (530 kg K_2O /ha) and available zinc was also high (12.5 ppm). The treatments consisted of protected and

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unprotected crop in main plots and four sub plot treatments: control (T1); 100% inorganic fertilisers (T2); 100% organics (T3) and 50% inorganics+50% organics (T4, INM) arranged in split plot design with three replications. The organic sources used were: green manure, dhaincha (*Sesbaniaaculeata*) + paddy straw during wet seasons (WS) and poultry manure + paddy straw during dry seasons (DS). The local recommended dose of inorganic fertilizers were given to conventional system @ 100-40-40 kg N, P_2O_5, K_2O/ha during WS and 120-40-40-10 kg N, P_2O_5, K_2O and Zn /ha during DS through urea, single super phosphate, muriate of potash and Zinc sulphate, respectively. Nitrogen was applied in three equal splits at basal, maximum tillering and panicle initiation stages while P, K and Zn were applied as basal doses only. Through organics, N dose was adjusted to recommended level based on their moisture content and 'N' concentration on dry weight basis. Organic fertilizers were incorporated one day before transplanting rice.Organic fertilizers were incorporated one day before transplanting rice. Chemical plant protection measures were given to protected plots (PP) only and irrigation and weeding operations were done according to normal practice and uniformly for all the treatments.

Results

The results pertaining to grain yield trends, partial nutrient balance, grain quality parameters, pest incidence and parasitism, soil quality parameters, pesticide residue analysis and economics of the study are presented and discussed here.

Grain yield and partial Nutrient balance

During *kharif*, grain yields in the fertilizer applied and INM plots were near stable ranging from 5.2-5.5 and 4.7-5.2 t/ha, respectively. These were superior to organics during the first two years by 15-20 % which improved with organics (4.8-5.2 t/ha) in the later years to comparable levels with inorganics. During *rabi*, however, inorganics and INM were superior to organics for four consecutive years and organics recorded yields on par with inorganics and INM in the fifth year only. Yield difference between protected and unprotected blocks during most part of the study was only marginal/negligible due to very low pest incidence (Table 1).

Table 1. Grain yield (t/ha) as influenced by nutrient sources

Year	*Kharif (WS)*		*Rabi (DS)*		*Kharif (WS)*			*Rabi (DS)*		
	NPP	PP	NPP	PP	Inorganics	Organics	INM	Inorganics	Organics	INM
2004-05	4.50	4.8	3.38	3.43	5.47a	4.68b	5.00ab	3.79a	3.52b	4.28a
2005-06	4.31b	4.91a	3.08	3.26	5.35a	4.59b	5.15a	3.74a	3.10b	3.62a
2006-07	4.28b	4.84a	3.00	3.60	5.20a	4.85a	5.03a	3.81a	3.14b	3.77a
2008-09	4.49	5.01	3.27	3.17	5.33a	5.23a	5.12a	3.76a	3.27b	3.86a
2009-10	4.70	4.73	3.57	3.63	5.23a	5.36a	5.08a	4.18a	3.98a	4.13a

Figures within the same row with different letters in a particular season differ significantly (p=0.05)

With regard to partial nutrient balance after four years, cumulative N and P balance was higher with organics by 41.5&11.3% and with INM by 15.1&6.1%, respectively, over inorganic fertilizers alone. In case of partial K balance, it was positive only with organics (252 kg/ha) and negative with inorganics (-329 kg/ha) and INM (-31 kg/ha).

Grain quality parameters

Physical grain quality parameters- milling%, hulling%, head rice recovery (HRR), L/B ratio; cooking quality parameters- amylose content and elongation ratio were not influenced by the nutrient sources even after 5 years of study. However, in the fifth year, there was an improvement in HRR by 9.5% with organics over inorganics. Similarly, there was an improvement in elongation ratio by 4.1% with organics over inorganics. Whereas, moderate improvement in nutritional quality parameters such as protein, phosphorus and potassium contents was recorded with organics

compared to inorganics and brown rice recorded higher values (by 5-16%) than polished rice (by 1-6%).

Soil quality parameters

Changes in soil quality parameters were monitored at the end of every year and the results indicated a significant improvement in soil physical (bulk density and penetration resistance), fertility (organic carbon and available N, P and K) and biological properties (soil respiration and enzyme activities viz., glucosidase, phosphatase and dehydrogenase) with organics compared to inorganic fertilisers. Compared to inorganics, there was an increase in soil organic carbon (SOC), available N, P and K by 59-65, 3-10, 10-27 and 8-25 % with organics, respectively, at the end of five years.

Soil quality, as measured by different indices viz., nutrient index (NI), microbial index (MI) and crop index (CI) indicated maximum nutrient (1.10) and microbial (1.19) indices with organics and inorganics recorded 0.97 & 0.95 NI & MI values, respectively (Figure 1). Whereas, the crop index was maximum with inorganics (1.12) compared to organics (1.08). The sustainability index (SI) of the soil system, measured from above three indices was maximum with organics (1.63) and inorganics recorded 1.33, which was just above the minimum sustainability index of 1.30

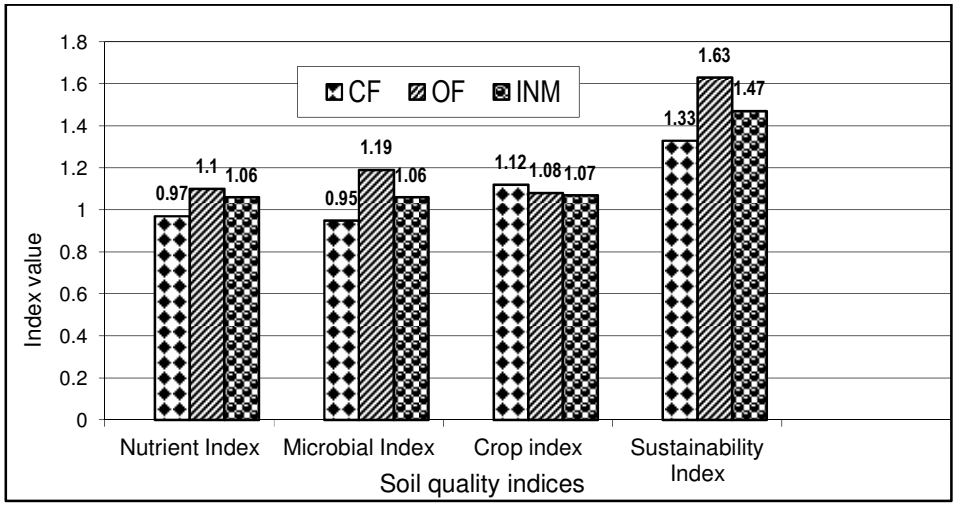

Figure 1: Soil quality and sustainability indices after five years

Pesticide residue analysis

Pesticide residue analysis was done in a few *grain*, straw, brown rice, polished rice and soilsamples. Most of the residues were below detectable limits (BDL) in grain, brown rice and white rice with an exception in a few samples where BHC (CHC compound), dimethioate and chlorpyriphos (OP compounds), butachlor (herbicide) were detected. But, all these residues were below permissible limits. Whole grain and brown rice detected more residues and polished rice has negligible and BDL values as most of them are removed during processing. No clear-cut differences were noticed in pesticide residue accumulation between organic and inorganic production systems. Very low levels of residues are recorded mainly as drift from conventional farming and from the persistent chemicals used over the past few decades.

Economics of the study

Total cost of cultivation, gross returns, net returns and Benefit: cost ratio were calculated at the end of first and fifth years of study under inorganic and organic production systems. In the first year, net returns were calculated without price premium for the organic rice. Benefit cost ratio was less with organics (1.09:1) compared to inorganics (1.37:1) in the first year which improved with organics (1.85:1) over inorganics (1.52:1) by fifth year.

Discussion

Thus, slow and gradual release of nutrients from organics during the initial years of conversion to organic farming could not result in increased yields. But, repeated application of organics over the years may build up sufficient soil fertility by improving soil biological activity. Organic rice production can be sustainable and economical/remunerative over a period of time, once the soil fertility is built up due to continuous use of organic nutrient sources that release the nutrients to the plant in a balanced way, for a longer period. Hence, organic farming can be practiced using easily available local natural resources, with a view to protect/preserve/safe guard our own environment for a fertile soil, healthy crop and quality food, and let our future generations enjoy the benefits of non-chemical agriculture. Given the same profitability, organic farming is more advantageous than conventional farming, considering its contribution to health, environment, and sustainability.

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Yield and yield attributes of organic frenchbean (Phaseolus vulgaris L.) as influenced by farm yard manure and liquid manures

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Key words: Jeevamrutha, Panchagavya, Organic frenchbean, pod yield and yield attributes

Abstract

Field experiments on organic farming were conducted during kharif 2014 and 2015 to study the influence of different levels of N through farm yard manure (FYM), panchagavya and jeevamrutha on organic frenchbean production. There were 12 treatment combinations comprising of three levels of FYM (100, 150 and 200% recommended N equivalent through FYM),two levels of each jeevamrutha (0 and 1000 l ha^{-1}) and panchagavya (0 and 3 %). The experiment was laid out in factorial randomised complete block design with three replications. Among different FYM levels, significantly higher pod yieldof 135.2 and 168.5 q ha^{-1}, number of pods (15.3 and 17.35) and pod weight (78.45 and 93.97 g $plant^{-1}$) were recorded in treatments with FYM equivalent to recommended 200 per cent N during 2014 and 2015.Maximum podyield of 141.7 and 168.5 q ha-1, number of pods(15.9 and 17.76) and pod weight (81.68 and 93.46 g $plant^{-1}$)were recorded with application of jeevamrutha1000 l ha^{-1}during 2014 and 2015. Similarly,panchagavya3 per cent application recorded higher pod yield of 138.7 and 164.7 q ha^{-1},number of pods (15.3 and 17.23) and pod weight (79.42 and 90.73 g $plant^{-1}$) during both the years respectively.

Introduction

Organic agriculture is not a new concept to India and traditionally Indian farmers were organic. In organic agriculture nutrients are supplied throughFYM, Compost, Vermicompostetc. and micronutrients and growth promoting substances were provided through panchagavya and jeevamrutha and other liquid formulations. Higher levels of N through FYM was selected to study the impact of FYM levels on microbial load, which acts as source of energy for microbial growth and to know the nutrient availability to next season crop. It acts as media for beneficial microbes, higher the N through FYM higher will be the microbial load, results in higher mineralization, nutrient availability, PGPR effect on plant growth and yield. To know the interaction effect of N levels with J& P and their enhancement effect on growth and yield .Panchagavya(P) and jeevamrutha(J) are eco-friendly organic preparations prepared from cow products. They contain macro nutrients, essential micro nutrients, vitamins, essential amino acids, growth promoting factors like indoleacetic acid (IAA), gibberellic acid (GA) and beneficial microorganisms (Devakumaret al., 2008 and 2014).Farmyard manure is a rich source of nutrients having inherent ability to improve the soil health and aeration, water holding capacity and substrate for beneficial microbial population.Frenchbeanis an important pulse-cum-vegetable crop of India, cultivated for its tender and mature pods, seeds and fodder. With this in view, an attempt was made to study the effect of FYM, jeevamrutha and panchagavya levels on yield and yield attributes of frenchbean.

Material and methods

Field experiments were conducted at Organic Farming Research Centre (OFRC), University of Agricultural Sciences, Bengaluru, India, under protective irrigation during *kharif* 2014 and 2015 (July to September). The soils are sandy loam with medium organic carbon content of 0.46 per cent, medium in available nitrogen,phosphorus and potassium (328,36 and 258 kg ha^{-1},respectively). The experiment consisted with three factors *viz.,*three fertility levels(F) (100, 150 and 200% of

recommended Nitrogen equivalent through FYM), with and without panchagavya (0 and 3 %) andjeevamrutha levels (0 and 1000 l ha^{-1}), Experiment was laid out on factorial randomized block design with 12 treatment combinations and three replications.The treatment combinations are: $F_1J_0P_0$, $F_1J_0P_1$, $F_1J_1P_0$, $F_1J_1P_1$, $F_2J_0P_0$, $F_2J_0P_1$, $F_2J_1P_0$, $F_2J_1P_1$, $F_3J_0P_0$, $F_3J_0P_1$, $F_3J_1P_0$and$F_3J_1P_1$.

Preparation of Panchagavya and Jeevamrutha

Panchagavyawas prepared by mixing 7 kg fresh cow dung and 1 kg ghee and incubated in a container for 2 days and it was mixed daily once. On third day, 10 litres cow urine and 10 litres water were added, mixed thoroughly and incubated for fermentation for 13 days. Then, 3 litres milk, 2 litres curd, 3 litres tender coconut water, 3 kg jaggary and 12 well ripened Cavendish banana were added and contents were incubated for 6 days. The mixture was stirred thoroughly thrice a day at morning, afternoon and evening. Plastic drum was kept in shade and it was covered with wet jute bag. After 21 days of fermentation mixture was filtered through a cotton cloth and used for spraying. Three litres of filtrate was taken and diluted to 100 litres using water and sprayed to the crop during the 15, 30 and 45day after sowing when the soil is moist.

Jeevamrutha was prepared by mixing 10 kg of cow dung, 10 litre of cow urine, 2 kg of jaggery, 2 kg of pigeon pea flour and hand full of soil collected from farm. All these were put in 200 litre plastic drum and mixed thoroughly and volume was made up to 200 litres by adding water. The mixture was stirred well in clock wise direction thrice a day plastic drum was kept shade covered with wet jute bag. Jeevamrutha was fermented for 10 days and applied to the plants manually at of 15, 30 and 45 days after sowing (DAS) as per treatments.

Results

Pod yield and yield attributes of frenchbean varied significantly due to different FYM levels, panchagavya and jeevamrutha application (Table 1). During both the years among N equivalent FYM levels, FYM at 200 per cent recorded significantly higher pod yield of 135.2 and 168.5 q ha^{-1},fresh weight of pods $plant^{-1}$ (78.45 and 93.67 g)and maximum number of pods (15.3 and 17.35) during 2014 and 2015 respectively. However, it was on par with the 150 per cent of N equivalent through FYM*i.e.,*pod yield of 132.5 and 158.8 q ha^{-1}, pod weight (75.16 and 84.47 g $plant^{-1}$) and number of pods $plant^{-1}$ (14.7 and 16.50) during 2014 and 2015. This was followed by 100 per cent of N equivalent through FYM*i.e.,* pod yield of 120.3 and 134.4 q ha^{-1}, pod weight (69.86 and 77.71 g $plant^{-1}$) and number of pods $plant^{-1}$ (13.6 and 14.95) during both the years respectively. While, there was no significant difference between the 150 and 200 per cent of N equivalent through FYM application.

Application of jeevamrutha and panchagavya recorded significantly higher pod yield and yield attributes as compared to without application. Application of jeevamrutha recorded higher pod yield of 141.7 and 168.3 q ha^{-1}, fresh weight of pods $plant^{-1}$ (81.68 and 93.46 g$plant^{-1}$) and more number of pods $plant^{-1}$(15.9 and 17.76$plant^{-1}$) as compared to without application of jeevamruthai*.e.,*pod yield of 117 and 139.5 q ha^{-1}, fresh weight of pods $plant^{-1}$ (67.30 and 77.10 g $plant^{-1}$) and number of pods (13.20 and 14.77)during 2014 and 2015, respectively.

Significantlyhigher pod yield of 138.7 and 164.7 q ha^{-1},fresh weight of pods $plant^{-1}$ (79.42 and 90.73 g$plant^{-1}$) and number of pods $plant^{-1}$ (15.4 and 17.23 $plant^{-1}$)recorded in panchagavya (3 %) spray as compared to without panchagavya application *i.e.,* pod yield of 120 and 143.1 q ha^{-1}, fresh weight of pods $plant^{-1}$ (69.56 and 79.84 g$plant^{-1}$) and number of pods (13.70 and 13.30)during *kharif*2014 and 2015. Combined application of FYM 200 per cent, jeevamrutha 1000 litre ha^{-1} and panchagavya at 3 per cent recorded higher pod yield of 151.7 and 170.5 q ha^{-1} during both the

seasons and the yield attributes*viz.,*number of pods (17.2 and 19.44), fresh weight of pods per plant (88.75 and 105.84) during both the years even though statistically non-significant.

Table 1: Yield and yield attributes of organic frenchbean as influenced by FYM, Jeevamrutha and Panchagavya applications during 2014-2015

Treatments	Pod Yield (q ha^{-1})		Pod weight (g plant^{-1})		No. of Pods plant^{-1}	
	2014	2015	2014	2015	2014	2015
FYM Levels						
F_1	120.3	134.4	69.86	77.71	13.6	14.95
F_2	32.5	158.8	75.16	84.47	14.7	16.50
F_3	135.2	168.5	78.45	93.97	15.3	17.35
S.Em ±	2.57	3.41	1.39	2.00	0.35	0.36
C.D.	7.52	10.0	4.09	5.88	1.04	1.06
Jeevamrutha						
J_0	117.0	139.5	67.30	77.10	13.20	14.77
J_1	141.7	168.3	81.68	93.46	15.90	17.76
S.Em ±	2.09	2.78	1.14	1.64	0.29	0.30
C.D. at 5%	6.14	8.16	3.34	4.80	0.85	0.87
Panchagavya						
P_0	120.0	143.1	69.56	79.84	13.70	15.30
P_1	138.7	164.7	79.42	90.73	15.40	17.23
S.Em±	2.09	2.78	1.14	1.64	0.29	0.30
C.D. at 5%	6.14	8.16	3.34	4.80	0.85	0.87
Interactions						
$F_1J_0P_0$	79.7	84.9	52.91	59.80	10.30	11.41
$F_1J_0P_1$	125.3	132.4	68.61	76.06	13.40	14.77
$F_1J_1P_0$	131.7	139.2	74.07	81.71	14.50	15.89
$F_1J_1P_1$	144.7	153.0	83.87	93.26	16.10	17.71
$F_2J_0P_0$	116.3	127.8	66.67	74.52	13.10	14.49
$F_2J_0P_1$	130.0	142.8	70.79	79.28	13.80	15.55
$F_2J_1P_0$	135.5	148.9	76.49	86.97	15.20	16.98
$F_2J_1P_1$	148.3	163.2	86.69	97.12	16.70	18.76
$F_3J_0P_0$	118.3	133.3	67.00	80.14	13.30	15.05
$F_3J_0P_1$	132.0	148.3	77.82	92.82	15.20	17.14
$F_3J_1P_0$	138.3	155.4	80.21	95.88	15.70	17.78
$F_3J_1P_1$	151.7	170.5	88.75	105.84	17.20	19.44
S.Em±	5.13	4.72	2.79	4.01	0.71	0.72
C.D. at 5%	NS*	NS*	NS*	NS*	NS*	NS*

* Non significant at P<0.05

Discussion

Application of higher levels of the FYM increased the availability of major and micro nutrients to plants whereas as application of jeevamrutha and panchagavya spray increased the yield and yield attributes of the organic frenchbean. This might be due to the fact that jeevamrutha and panchagavya are rich source of beneficial microorganisms and contains growth promoting substances such as auxins, gibberlins, cytokinins apart from having lower concentration of both macro and micro nutrients. Results of the present study were in conformity with the results of

Shashidhara, (2000), Kattimani, (2004), Sanjutha et al. (2008), Kondapa Naidu *et al*. (2009) and Premsekhar and Rajashree, (2009). Increased yield due to increasing sink potential as indicated by higher number of pods. The increase in pod yield with increased FYM in present investigation was also in accordance with Umamaheswari and Haripriya, (2008) and Bhriguvanshi, (1988) who have also reported higher yield levels with increased levels of FYM and vermicompost in wheat and capsicum.

Conclusion

Higher frenchbean yields could be obtained by applying higher amount of FYM, jeevamrutha and panchagavya application. Liquid organic manures like panchagavya and jeevamrutha could be prepared locally by farmers themselves and obtain increased yield levels. Such practices would pave way to reduce use of external inputs and increase sustainability among organic farmers in the developing countries.

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Effect of various sources of Zinc with particular reference to Nano Zinc carrier on Growth and Yield parameters in Rice (*Oryza sativa.L*)

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Key words: Rice, Nano, Zinc, soil and foliar application, growth and yield parameters

Abstract

A field experiment was conducted during kharif , 2015 at College Farm, College of Agriculture, PJTSAU. Experiment was laid out in Randomized Block Design with 12 treatments and 3 replications. The treatments were viz., T1-Control(no fertilizers were applied), T2- RDF@ N,P_2O_5,K_2O@120:60:40 kg ha^{-1},T3-RDF+Soil application of $ZnSO_4$@25kgha^{-1} at transplanting, T4 and T5- RDF +Soil application of nano Zn @10 kg $ha^{-1}$and 15 kg ha^{-1},T6 and T7- RDF +Soil application of bio Zn @15 kg $ha^{-1}$and 30 kg ha^{-1} at transplanting , T8-RDF +foliar application of 0.2 % as $ZnSO_4$ at tillering and panicle emergence stage, T9 and T10-RDF +foliar application of 1 ml l^{-1} and 2 ml l^{-1} as nano zinc at tillering and panicle emergence stage, T11 and T12 -RDF +foliar application of 1.5ml l^{-1} and 3ml l^{-1} as bio zinc at tillering and panicle emergence stage. The nano zinc soil and foliar formulation had Zn content of 40 mg kg^{-1} and bio zinc soil and foliar formulation contains 3% Zn. The results revealed that application of bio zinc and nano zinc fertilizers both as soil and foliar application have resulted in obtaining the yields and are on par with the conventional zinc application@ 25kgha^{-1}.RDF+ soil application of Bio zinc@30kgha^{-1} increased crop growth and yield as evidenced by increased plant height, number of tillers, number of panicles per m^2 and number of filled grains per panicle.

Introduction

Micronutrients are essential for crop production and their deficiency affects growth, metabolism and reproductive phase of crop plants, animals and human beings. Among the micronutrients, zinc deficiency in plants and soils has been reported across the world Alloway (2008).The critical limit of available zinc in the soil suitable for rice growth is 0.3 mg kg^{-1} .The plant available zinc in Indian soils extracted with DTPA is less than 1% of total zinc (Takkar and Mann, 1975).Hence, application of zinc fertilizers is essential in keeping sufficient amount of available zinc in soil solution, maintaining adequate zinc transport to seeds to increase the crop yield. Hence it is essential to minimize the nutrient losses in fertilizer application, increase the crop yield through the exploitation of new applications with the help of nano technology and nano meterials. The nano fertilizers or nano encapsulated nutrients might have the properties that are effective to crops, release the nutrients on demand, controlled release of chemical fertilizers that regulate the plant growth and enhanced target activity (Raliya *et al*., 2013).Owing to the high surface to volume ratio, the efficacy of nano fertilizers may surpass the most innovative polymer coated conventional fertilizers which have seen little improvement in the past decade. Thus nanotechnology could provide devices and mechanisms for release of zinc when it is stable, there by releasing the nutrients on demand, by preventing them from getting converted to unavailable form (DeRosa *et al.,* 2010). The efficiency of applied zinc through conventional $ZnSO_4$ application is only 2-4%, hence there is a need to improve the efficiency of these costly inputs. Therefore the present investigation was taken up to explore the possibility of improving the zinc nutrition of rice through nano zinc application.

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Material and methods

A field experiment was conducted during *kharif* , 2015 at College Farm, College of Agriculture, PJTSAU. The soil of experimental site was low in organic carbon, available nitrogen, high in P_2O_5 and K_2O.The DTPA extractable zinc was below the critical limit. The soil was slightly alkaline and non saline in nature.

Experiment was laid out in Randomized Block Design with 12 treatments and 3 replications. The treatments were viz., T1-Control(no fertilizers were applied), T2- RDF@ N,P_2O_5,K_2O@120:60:40 kg ha^{-1},T3-RDF+Soil application of $ZnSO_4$@25kgha^{-1} at transplanting, T4 and T5- RDF +Soil application of nano Zn @10 kg $ha^{-1}$and 15 kg ha^{-1},T6 and T7- RDF +Soil application of bio Zn @15 kg $ha^{-1}$and 30 kg ha^{-1} at transplanting , T8-RDF +foliar application of 0.2 % as $ZnSO_4$ at tillering and panicle emergence stage, T9 and T10-RDF +foliar application of 1 ml l^{-1} and 2 ml l^{-1} as nano zinc at tillering and panicle emergence stage, T11 and T12 -RDF +foliar application of 1.5ml l^{-1} and 3ml l^{-1} as bio zinc at tillering and panicle emergence stage.

The products i.e., nano zinc and bio zinc formulations were obtained from M/S.Prathishta industries, Alwal, Secunderabad. These are being manufactured by the firm. Both the nano zinc as soil application and foliar application and bio zinc as soil application and foliar application were used in the study.

Bio zinc formulations

The products of bio formulations were obtained by treating the insoluble ZnO with substances like gluconates and lactates and mixed with vegetable protein of maize in water. This process is allowed to undergo hydrolysis, after the hydrolysis the suspension is filtered and the mixture was again enriched with lactates and gluconates and mixed with zinc solubulizing bacteria. This was found to contain 3% zinc and 16% organic carbon, for liquid bio formulations this formulation is used. For obtaining the solid formulation of bio zinc the required quantity of liquid formulation is mixed with the inert carrier material like bentonite ,talc etc and the formulation is recommended at the rate of 15 kg ha^{-1}.

Nano zinc formulations

Nano zinc formulations are of very recent origin wherein the nano zinc particle are obtained by microbial synthesis using *Rhizoctonia bataticola* in the artificial medium TFR-6PD. The mycelia mat is cultured and released into double distilled water and mixed with ZnO suspension. This broth medium with zinc suspension was induced with *Bacillus subtilis* and is centrifuged. The product obtained is used as it is as liquid formulation. The liquid formulation of nano zinc contains 40 ppm Zn. For production of nano zinc granules the liquid formulation obtained by the above method is impregnated on the surface of carrier material like bentonite, talc etc and sold as nano zinc impregnated granules.

The observations were recorded on Plant height (cm), Number of tillers m^{-2},Number of filled grains panicle $^{-1}$,1000 grain weight (g) and Grain and straw yield (kg ha^{-1}).

Results and Discussion

The data pertaining to the effect of zinc treatments on growth and yield parameters is presented in table 1.The The plant height (100.6cm), number of tillers m^{-2}(440.0 tillers m^{-2}),number of panicles m^{-2}(446.6 panicles m^{-2}),grain yield (5355 kg ha^{-1}) and straw yield (6347kg ha^{-1}) was recorded and these parameters found to be highest in the treatment receiving RDF+ soil application of Bio zinc@30kgha^{-1}.This treatment is found to be onpar with RDF +foliar application of 0.2 % $ZnSO_4$,RDF +Foliar spray of nano zinc @ 1ml l^{-1} and soil application of $ZnSO_4$ @25Kg ha^{-1}.One of the reasons that could be attributed in bio zinc which is encapsulated in the organic compounds i.e.,

either gluconates or lactates might have prevented the leaching losses of the zinc and made it available to the growth of the crop at the time of its requirement by the crop. Further the use of microorganism and organic matter (16%) which might have contributed to increased microbial activity in the soil by being a source of organic carbon .In addition, use of bio zinc might contribute to the increased organic carbon status of soil in long run.

Table 1: Effect of various sources of zinc on growth and yield components

S. No	Treatment	No of tillers m^{-2}	No of panicles m^{-2}	Filled grain $panicle^{-1}$	Test weight	Grain yield	Straw yield
T1	Control (no fertilizers were applied)	315.8	348.8	84.0	17.0	2604	3324
T2	Recommended dose of $N:P_20_5:K_2O$ @120:60:40 Kg ha^{-1}	341.0	365.5	94.0	20.0	3768	4621
T3	RDF +Soil application of $ZnSO_4$ @25Kg ha^{-1} at transplanting	398.3	434.5	116.9	21.3	4807	5855
T4	RDF +Soil application of nano zinc as impregnated granules @10kg ha^{-1} at transplanting	363.0	370.6	97.6	20.2	3942	4806
T5	RDF +Soil application of nano zinc as impregnated granules @15kg ha^{-1} at transplanting	356.4	376.9	94.3	20.3	4043	4963
T6	RDF +Soil application of bio zinc@15 kg ha^{-1} at transplanting	374.0	400.4	109.0	20.6	4623	5531
T7	RDF +Soil application of bio zinc @30 kg ha^{-1} at transplanting.	440.0	446.6	133.3	21.8	5355	6347
T8	RDF +foliar spray of 0.2% as $ZnSO_4$	433.4	444.0	123.6	21.7	5268	6258
T9	RDF +foliar spray of 1ml l^{-1} as nano zinc	426.8	442.1	121.3	21.5	5247	6189
T 10	RDF +foliar spray of 2ml l^{-1} as nano zinc	365.0	389.9	106.0	20.3	4370	5306
T 11	RDF +foliar spray of 1.5ml l^{-1} as bio zinc	392.6	411.7	114.6	21.1	4740	5740
T 12	RDF +foliar spray of 3ml l^{-1} as bio zinc	383.8	405.9	109.3	20.9	4625	5603
	SE(m) ±	5.7	11.6	2.3	0.4	71.5	70.8
	CD (P=0.05)	17.0	34.5	7.0	NS	209.7	207.8

Conclusion

From the above results and discussion it is clearly evident that the application of zinc brings about an improvement in the yield of rice. The results have clearly brought out the fact that application of bio zinc and nano zinc fertilizers both as soil and foliar application have resulted in obtaining the yields and on par with the conventional zinc application as $ZnSO_4$ @25 kg ha^{-1} and foliar application of 0.2% $ZnSO_4$.The effect of bio zinc applied as soil application@30kg/ha resulted in a significant effect on all the parameters studied which are comparable to the conventional $ZnSO_4$.

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Dry matter accumulation and nutrient content in frenchbean (*Phaseolus vulgaris* L.) as influenced by organic liquid formulations

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Key words: Frenchbean, Panchagavya, Jeevamrutha, GMX soil pro max, Drymatter accumulation, Nutrients.

Abstract

A study on effect of organic liquid formulations ondry matter accumulation and nutrient content offrenchbean was conducted at red sandy loam soil in Research Institute on Organic Farming (RIOF), UAS, GKVK, Bengaluru in summer 2016 withTwelve different treatment combinations and three replications in randomized complete block design concept. Results revealed that treatment T_{12}recorded significantly higher dry matter (15.47 g) and nutrient content (4.32 % N, 0.38 % P and 4.31 % K) and it was on par with treatment T_{11}(14.88 g, 4.30 % N, 0.37 % P and 4.26 % k) and T_{10}(14.05 g, 4.28 % N, 0.37 % P and 4.22 % k) compared to control (11.28 g,4.09 % N, 0.30 % P and 3.74 % K) at harvesting stage. Control recorded lower nutrient content and dry matter accumulation. The results indicated that the organic liquid manures i.e.,jeevamrutha, panchagavyaand GMX soil pro max have increased the dry matter accumulation and nutrient content of frenchbean crop..

Introduction

Organic agriculture is now finding a place in main stream of agricultural development.Organic systems relay on management of organic matter to enhance the soil fertility and productivity. Organic farming gives major emphasis on recovery and maintenance of soil fertility for sustainable yield. It is also considered as storehouse of many nutrients (Anon, 2008). General acceptance of organic farming is not only due to the greater demand for pollution-free food but also due to natural advantage of organic farming in supporting the sustainability in agriculture. The natural inputs used in organic farming are locally available, releases nutrients slowly, supplies macro and micro nutrients and provides favorable soil environment for microbial population (Devakumar *et al*., 2011). Frenchbean is an important vegetable crop of our country. With this view, an experiment was undertaken to study the effect of organic liquid formulations on dry matter accumulation and nutrient content in frenchbean.

Material and methods

A field experiment was conducted at research and demonstration blocks of research institute on organic farming (RIOF) University of Agricultural Sciences, Bengaluru in Karnataka, India.Soil of the experimental site was red sandy loam (*Alfisols)*. Organic carbon (0.512 %), available nitrogen (340 kg/ ha), phosphorus (40.5 kg/ ha) and potassium (239 kg/ ha) content of the soil were medium. The experiment was laid out on randomized complete block design having three replications and twelve treatmentsT_1 - Control - Recommended package of practice (63:100:75 kg NPK/ha and 25 t/ha FYM), T_2 – Package of practice (PoP) + soil applicationof GMX soil pro max (GSP) at 15 and 30 DAS, T3 - PoP + soil application of GSP at 15 and 30 DAS + foliar application of GSP at 15 and 30 DAS,T_4- Soil application of GSP at 15 and 30 DAS + foliar application of GSP at 15 and 30 DAS + 80 % recommended N,T_5-PoP + Jeevamrutha 2000 l/ac at 15, 30 and 45 DAS,T_6 - PoP + Jeevamrutha 2000 l/ac at 15, 30 and 45 DAS +Panchagavya 5 % at 15 and 30 DAS, T_7-Jeevamrutha of 2000 l/ac at 15, 30 and 45 DAS + Panchagavya 5 % at 15 and 30 DAS + 80 % recommended N, T_8 - PoP + Jeevamrutha 2000 l/ac at 15, 30 and 45 DAS + foliar application of GSP at 15 DAS +

Panchagavya 5 % at 30DAS, T_9 - Jeevamrutha 2000 l/ac at 15, 30 and 45 DAS + foliar application of GSP at 15 DAS + Panchagavya 5 % at 30 DAS + 80 % recommended N, T_{10} - PoP + Jeevamrutha 2000 l/ac at 15, 30 and 45 DAS + foliar application of GSP at 15 DAS + Panchagavya 5 % at 30 and 45 DAS,T_{11} - PoP + Jeevamrutha 2000 l/ac at 15, 30 and 45 DAS + foliar application of GSP at 15 and 30 DAS + Panchagavya 5 % at 30 and 45 DAS and T_{12}- PoP + Jeevamrutha 2000 l/ac at 15, 30 and 45 DAS + foliar application of GSP at 15, 30 and 45 DAS + Panchagavya 5 % at 15, 30 and 45 DAS. The experiment comprised of three different organic liquid formulations. Jeevamrutha was applied through soil and while Panchagavya was applied as foliar spray and GMX soil pro max applied through soil and foliar spray. Organic liquid manures – Jeevamrutha, GMX soil pro max and Panchagavya were applied to frenchbean crop at 15, 30 and 45 days after sowing and were prepared using standard procedures. Farmyard manure was applied to the plots three weeks before sowing at 25 t ha^{-1} and it was incorporated into the soil. The entire quantity of recommended dose of nitrogen 63 kg ha^{-1} was applied through FYM along with basal dose. Short duration (65-70 days) variety of frenchbean was used for the field experiment. Frenchbean crop was sown on 1st February 2016 with seed rate of 60 kg ha^{-1} and seeds were sown at spacing of 45cm and seed to seed spacing of 15 cm (45 cm X 15 cm). Irrigation was provided at 10-15 days interval depending on the stage of crop and soil condition. Necessary aftercare operations were followed as per the recommendations. No major pest and disease incidences were noticed during crop growth. Observations on growth parameters were recorded at regular intervals – 20, 40 days after sowing and at harvest. Experimental data collected was subjected to statistical analysis by adopting Fisher's method of Analysis of Variance (ANOVA) as outlined by Gomez and Gomez (1984). Critical Difference (CD) values were calculated whenever the 'F' test was found significant at 5 per cent level.

Results

Significant variation in dry matter production and its accumulation in plant at 20 DAS, 40 DAS and at harvest observed, treatments supplemented with all organic liquid manures at three times application i.e treatment T_{12}recorded significantly higher dry matterproduction (3.26 g $plant^{-1}$ at 20 DAS, 10.17 g $plant^{-1}$ at 40 DAS and 15.47 g $plant^{-1}$ at harvest) it was on par with other organic manurial treatments *i.e*treatment T_{11} (2.97 g $plant^{-1}$ at 20 DAS, 9.04 g $plant^{-1}$ at 40 DAS and 14.88 g $plant^{-1}$ at harvest) and T_{10} (2.94 g $plant^{-1}$ at 20 DAS, 8.92 g $plant^{-1}$ at 40 DAS and 14.05 g $plant^{-1}$ at harvest). Lower dry matter production (2.02 g $plant^{-1}$ at 20 DAS, 6.10 g $plant^{-1}$ at 40 DAS and 11.28 g $plant^{-1}$ at harvest) was recorded with control.

Nutrient content of frenchbean differed significantlydue to treatments effect. Nitrogen content at different crop growth stages was higher were treatment T_{12}(3.33 % at 20 DAS, 2.23 % at 40 DAS and 4.32 % at harvest) over other treatments. Which were on par with the other treatments i.e T_{11} (3.31 % at 20 DAS, 2.22 % at 40 DAS and 4.30 % at harvest) and treatment T_{10}(3.29 % at 20 DAS, 2.20 % at 40 DAS and 4.30 % at harvest) Further, the content of nitrogen in frenchbean with these treatments were comparable with that of control, control recorded lower nitrogen content (3.10 % at 20 DAS, 2.09 % at 40 DAS and 4.09 % at harvest).

Content of phosphorus at different crop growth stages was significantly higher with treatment T_{12} (0.36 % at 20 DAS, 0.36 % at 40 DAS and 0.38 % at harvest) over other treatments. Which were on par with the other organic manurial treatment T_{11} (0.34 % at 20 DAS, 0.34 % at 40 DAS and 0.37 % at harvest) and treatment T_{10}(0.34 % at 20 DAS, 0.33 % at 40 DAS and 0.37 % at harvest).Lower content of phosphorus was recorded with the control treatment (0.28 % at 20 DAS, 0.27 % at 40 DAS and 0.30 % at harvest).

Table 1: Plant dry matter production at different growth stages of frenchbean as influenced by organic liquid formulations.

Treatments	Dry matter (g plant^{-1})		
	20 DAS	40 DAS	At harvest
T_1 : Control	2.02	6.10	11.28
T_2 : PoP + GSP*	2.13	6.25	11.73
T_3 : PoP + GSP* + FA of GSP at 15 and 30 DAS	2.39	6.73	12.43
T_4 : GSP* + FA of GSP at 15 and 30 DAS + 80 % RDN	2.28	6.54	11.98
T_5 : PoP + Jeevamrutha**	2.50	6.92	12.70
T_6 : PoP + Jeevamrutha** + FA of P 5 % at 15 and 30 DAS	2.64	7.34	13.16
T_7 : Jeevamrutha** + FA of Panchagavya 5 % at 15 and 30 DAS + 80 % RDN	2.48	7.14	12.95
T_8 : PoP + Jeevamrutha** + FA of GSP at 15 DAS + P***	2.85	8.59	13.61
T_9 : Jeevamrutha + FA of GSP at 15 DAS + P*** + 80 % RDN	2.77	7.63	13.46
T_{10}: PoP + Jeevamrutha** +FA of GSP at 15 DAS + P****	2.94	8.92	14.05
T_{11}: PoP + Jeevamrutha** + FA of GSP at 15 and 30 DAS + P****	2.97	9.04	14.88
T_{12} : PoP + Jeevamrutha** + FA of GSP at 15, 30 and 45 DAS + Panchagavya spray 5 % at 15, 30 and 45 DAS	3.26	10.17	15.47
S.Em±	0.13	0.39	0.56
C.D. at 5%	0.38	1.14	1.65

* Soil application of GSP at 15 & 30 DAS
** Soil application of jeevamrutha of 2000 l/ac at 15, 30 and 45 DAS
*** Panchagavya spray 5% at 30 DAS
**** Panchagavya spray 5% at 30 and 45 DAS
FA= Foliar applicationRDN= recommended dose of nitrogenDAS = Days after sowing
POP = Package of practiceGSP = GMX Soil Pro MaxP = Panchagavya

Potassium content in frenchbean differed significantly due to different organic liquid formulations. Significantly higher potassium content was recorded in treatment T_{12}(3.18 % at 20 DAS, 2.63 % at 40 DAS and 4.31 % at harvest) which was on par with the treatment T_{11}(3.16 % at 20 DAS, 2.59 % at 40 DAS and 4.26 % at harvest) and treatment T_{10}(3.14 % at 20 DAS, 2.59 % at 40 DAS and 4.22 % at harvest). Significantly lower content of potassium was recorded with the control (2.93 % at 20 DAS, 2.36 % at 40 DAS and 3.74 % at harvest).

Discussion

Enhanced dry matter accumulation and nutrient content of frenchbeandue to interaction of jeevamrutha, panchagavya and GMX soil pro max. There might be synergistic effect of *Rhizobacteria*with Panchagavya spray and soil application of Jeevamrutha and GMX soil pro max. Which helped translocation of carbohydrates to developing plant parts andIncreasedallocation of food materials in turn enhancesaccumulation of dry matter and nutrient content in plant.The higher accumulation of assimilates in these treatments reflected in higher dry matter accumulation and higher nitrogen, phosphorus and potassiumcontent, thus indicating theirsuperiority.These results were in agreement with those of Thomas Abraham and Lal (2003). Rajkhowa*et al.* observed that application of vermicompost showed significant positive effect on nutrient content obtained with

Increase in the doses of vermicompost from 2.5 to 5.0 t ha^{-1} also significantly increased the plant nutrients.

Table 2: Nutrient content of frenchbean as influenced by organic liquid formulations

Treatments	Nitrogen content(%)			Phosphorus content (%)			Potassium content (%)		
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest
T_1	3.10	2.09	4.09	0.28	0.27	0.30	2.93	2.36	3.74
T_2	3.13	2.13	4.11	0.29	0.29	0.31	2.95	2.39	3.81
T_3	3.17	2.16	4.15	0.31	0.31	0.33	3.00	2.44	3.96
T_4	3.14	2.14	4.14	0.32	0.30	0.33	2.98	2.41	3.92
T_5	3.20	2.17	4.17	0.32	0.31	0.34	3.04	2.48	4.03
T_6	3.24	2.18	4.22	0.33	0.32	0.35	3.10	2.53	4.10
T_7	3.22	2.17	4.19	0.33	0.31	0.34	3.05	2.49	4.07
T_8	3.26	2.19	4.25	0.33	0.32	0.36	3.12	2.56	4.17
T_9	3.25	2.18	4.23	0.33	0.31	0.35	3.09	2.52	4.14
T_{10}	3.29	2.20	4.28	0.34	0.33	0.37	3.14	2.59	4.22
T_{11}	3.31	2.22	4.30	0.34	0.34	0.37	3.16	2.59	4.26
T_{12}	3.33	2.23	4.32	0.36	0.36	0.38	3.18	2.63	4.31
S.Em±	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.04
C.D. at 5%	0.04	0.03	0.04	0.02	0.03	0.03	0.04	0.06	0.13

T1 : ControlT7 : Jeevamrutha** + FA of Panchagavya 5 % at 15 and 30 DAS + 80 % RDN
T2 :PoP + GSP*T8: PoP + Jeevamrutha** + FA of GSP at 15 DAS + P***
T3 :PoP + GSP* +FA of GSP at 15 and 30 DAST9: Jeevamrutha + FA of GSP at 15 DAS+ P*** +80% RDN
T4 :GSP* +FA of GSP at 15 and 30 DAS + 80 % RDN T10: PoP + Jeevamrutha** +FA of GSP at 15 D+P****
T5 :PoP + Jeevamrutha**T11: PoP + Jeevamrutha** + FA of GSP at 15 and 30 DAS + P****
T6 : PoP + Jeevamrutha** + FA of P 5 % at 15 and 30 DAST12 : PoP + Jeevamrutha** + FA of GSP at 15, 30 and 45 DAS + Panchagavya spray 5 % at 15, 30 and 45 DAS
* Soil application of GSP at 15 & 30 DAS** Soil application of jeevamrutha2000 l/ac at 15, 30 and 45 DAS
*** Panchagavya spray 5% at 30 DAS **** Panchagavya spray 5% at 30 and 45 DAS
FA= Foliar application RDN= recommended dose of nitrogen DAS = Days after sowing
POP = Package of practice GSP = GMX Soil Pro Max P = Panchagavya

Conclusion

Application of Jeevamrutha, Panchagavya and GMX soil pro max have increased the dry matter accumulation and nutrient content in frenchbean. The organic liquid formulations have favorable effect on soil beneficial microflora, nutrient content, major and minor nutrients and yield. These formulations have great role in improving soil properties and sustainability.

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Participatory non-GM cotton breeding to safeguard organic cotton production in India

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Key words: cotton, breeding, local adaptation, genetic diversity, farmer participation

Abstract

Due to fast spread of genetically modified (GM) Bt-cotton, organic farmers in India were suddenly exposed to a severe shortage of non-GM seed threatening the organic cotton production. Therefore, organic cotton grower organisations got engaged in decentralized participatory cotton breeding to develop their own locally adapted cultivars and to reintroduce the traditional more robust Desi cotton species. By engaging and training advisors and farmers using participatory methods, they became researchers and breeders. The close collaboration with the textile industry ensures that the market demand is also met. Training of male and female farmers in cultivar selection and seed propagation made them independent from global seed companies. Participatory breeding is an important tool to get prepared for future challenges like climate change and at the same time strengthens the relationship along the value chain. The project can serve as a successful model for other organisations and crops.

Acknowledgments

This project is supported by Mercator Foundation Switzerland, bioRe Foundation Switzerland, Corymbo Foundation, Coop Sustainability Fund, and C&A foundation.

Introduction

Up to 80% of world's organic cotton has been produced in India in 2010, but dropped dramatically due to shortage on non-GM cotton seed. Genetically modified F1 hybrids of the tetraploid upland cotton (*Gossypium hirsutum*) carrying a gene from Bacillus thuringiensis (Bt cotton) account for more than 95% of the cotton area in India. The non-GM cotton seed market became completely eroded (Nemes, 2010; Marty 2013) and locally adapted diploid Desi cotton (*G. arboreum, G. herbaceum*) almost disappeared. Fast action was needed to re-establish non-GM cotton seed supply chains and breeding programs to support organic and low input cotton farmers in India. Participatory plant breeding (PPB) offers a great opportunity for developing locally adapted cultivars as well as for maintaining and increasing genetic diversity (Lancon et al. 2004; Ceccarelli et al. 2009). The main aim of the project was to (i) foster collaboration among stakeholders, (ii) introduce participatory breeding approaches for organic cotton, (iii) evaluate improved cotton cultivars in smallholders' organic cotton fields, and (iv) gain information about the suitability of different types of cotton species and cultivars for organic and low input farming in India.

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Material and methods

The participatory cotton breeding project was initiated in 2011 and has been driven by two local organic cotton producer organisations bioRe Association in Madhya Pradesh and Chetna Organic in Odisha. Cotton germplasm and guidance on cotton breeding was provided by Prof. S.S. Patil heading the cotton breeding department of the University of Agricultural Science (UAS) Dharwad, Karnataka. FiBL coordinated the transdisciplinary project and provided training in participatory methods. To initiate the process a two day national workshop was organized to develop a common vision and roadmap towards safeguarding the heritage of Indian Desi cotton, maintaining genetic diversity, avoiding GM contamination and supporting the organic farmers with suitable cultivars (Dharwad declaration 2011). Based on the commitment of the stakeholders to join forces for re-establishing the seed supply chain we started cotton cultivar evaluation and participatory cotton breeding in 2011 and 2013, respectively. Five activity strains were followed in parallel or sequential: (i) replicated on-station field trials (mother trials) and replicated multi location trials (year 4-6), (ii) unreplicated on-farm trials (baby trials) in year 1 to 6, (iii) pilot cultivation in year 4 to 6, (iv) new crosses in year 3, and (v) single plant selection in segregating populations in year 4-6. This was accompanied by capacity building at local level including training of trainers, farmer workshops on cultivar ideotypes, farmers' trainings for cultivar evaluation, crossings, single plant selection and seed multiplication. Networking and awareness rising was done on local level in India, and Switzerland as well as on international level.

Based on the workshop with farmers we identified the most distinct cotton farming systems per region: (i) summer sown (May-June) cotton on fertile soil with irrigation and (ii) monsoon sown (June – July) cotton on shallow or light soils in Madhya Pradesh and (iii) shallow red soil and (iv) black fertile soil and both under rainfed conditions in Odisha. Black soil is characterized by deep soil with high clay content (>40%), whereas light or red soils are shallow soils with high sand content (>50%) and low water holding capacity. Annual precipitation (mainly during monsoon: June till September) at field sites in Khargone district in Madhya Pradesh and at sites in Kalahandi district in Odisha, ranged between 760 and 937mm and between 1372 till 1855mm, respectively, during project years (2013-2016). Highest average temperature was reached in May with 38°C in Madhya Pradesh and 33°C in Odisha. On-station trials: each year 50 to 90 non-GM cultivars and breeding lines of different cultivar types (*G. hirsutum* hybrids, *G. hirsutum* varietal lines, *G. arboreum* varietal lines) were tested against commercial F1 hybrids under the different growing conditions with two replications in a randomized complete block design. Promising cultivars were selected for further testing, while the others were discarded and replaced by new entries. Plant spacing was first 1 x 1 m and later reduced to 1 x 0.3 m for summer sown cotton and 0.6 x 0.3 m for rainfed conditions for varietal lines and 1 x 0.6 m or 0.6 x 06 m for F1 hybrids, respectively. The 4 row plots (4 x 7 m) were always separated by other species (millet) or by morphologically distinct *G. arboreum* lines to avoid any mixture during picking time. Cotton was picked two up to three times (October till January) depending on soil fertility and irrigation. The best 10 cultivars based on two years data were tested with three replication under 2-4 organically managed farms (multi location trials). Germination, vegetative growth, plant morphology, susceptibility to bollworm, sucking pests and diseases as well as seed cotton yield per plant and hectar were assessed for the different pickings. Male and female farmers visited the on-station trials and make a ranking of cultivars during picking period, independent from the rating of the breeder and the research team. Ginning output and fiber quality parameters (fibre length as Upper half mean Length UhmL (mm), fibre finesse (micronaire), fibre strength (g/tex), Maturity Index (MI), Uniformity Index (UI) and Short Fibre Index (SFI)) were assessed for the bulk of the first two picking and the last picking.

In addition, on-farm cultivar evaluation trials were conducted with a set of the five most promising cultivars and one common standard (in two replications) by farmers in their own fields after training by the research team. In total 4 sets of cultivars were tested on either heavy or light soil aiming for 6

farmers per set, resulting in total of 24 on-farm trials per region and year. Due to small fields only 100 plants per cultivar were tested, allowing the farmer to identify the different characteristics of the cultivars. Seed cotton was picked per cultivar by colour coding and sent for fiber quality analysis. Farmers made a ranking of the genotypes with detailed explanations. After 3 year successful testing in on-station and on-farm trials, seed of candidate cultivars were distributed among farmer for pilot cultivation to be grown on 400 to 1000 m2 next to their standard cultivar. Yield and fiber quality of both cultivars was assessed.

In 2013 we started with new crosses of tetraploid *G. hirsutum* lines and diploid *G. arboreum* lines to start participatory selection under organic production in the target environment (heavy soil and light soil) at both regions. The homogeneous F1 generation was multiplied and the obtained F2 progenies were provided to the two organic cotton growers organisations. The F2 plants were independently selected by the breeder, research team and farmer at each location. Phenotypic selection by farmers was compared with selection by researchers and experienced cotton breeders. Selected single plants (5 – 10%) were harvested to determine seed cotton yield, fiber length and micronair. Only those plants with satisfying fibre quality were selected and grown as one-row plot in the F3 generation. This process was repeated till F5 or F6 generation, afterwards the lines will enter the cultivar evaluation trials. In parallel the farmers have been continuously trained in all aspects of plant breeding, seed multiplication and GM testing to obtain a "farmer's breeder curriculum". Female farmers are especially encouraged to participate together with their husbands or in separate groups. Local partners have organized or attended national meetings and workshops to exchange with other organic cotton growers, breeders, seed companies, and stakeholders of the value chain. The importance of securing non-GM cotton seed was also forwarded to the international Organic Cotton Round Table of Textile Exchange, organizing yearly meetings of the Seed & Soil Task Force, to obtain attention and engagement of the textile brands.

Results

Summer sowing in fertile soil with irrigation resulted in much higher yield (2.0 t ha-1) than monsoon sowing in sandy soil (1.2 t ha-1) and we obtained different rankings of the cultivars for heavy soil and light soil trials. Delayed sowing can cause further yield reduction. Pest attack of bollworms was very severe under fertile conditions (67%) with two crops per season compared to the low bollworm pressure under rainfed conditions (7%) with only one major crop per year. While *G. arboreum* is more tolerant against sucking pests, the susceptibility against bollworm is similar to F1 *G. hirsutum* hybrids. *G. hirsutum* varietal lines show higher susceptibility to bollworm which might be attributed to their delayed fruiting compared to F1 hybrids. *G. arboreum* showed high yield potential and yield stability both on light and heavy soil in Madhya Pradesh, however the fiber length is often not fitting the textile industry (fiber length > 28mm). A few *G. arboreum* introgression lines had consistently long fiber, while others show strong environmental effects. In Odisha the performance of existing *G. arboreum* cultivars was not satisfactory, due to late boll opening. Here early genotypes need to be selected. For female farmers boll opening and easy picking is of great importance, while male farmers are interested in boll size, plant height and germination. In general, cotton growth under rainfed conditions is reduced and therefore, a higher plant density should be implemented to increase productivity per ha. Under less fertile conditions *G. hirsutum* varietal lines can outperform F1 hybrids, which cannot realize their yield potential under rainfed conditions. We observed on average higher yield level in on-station trials compared to on-farm trials. However, there is a huge variation for yield between the different farmers, indicating the great scope for yield improvement if the cotton management is done properly. Yield potential of the best cultivars can only be reached if the crop management is also optimized with respect to fertilization, timely weed control, and preventive pest control. Single plant selection under organic conditions was very successful, as new developed lines showed high yield potential under fertile

and less fertile management. Final data will be presented at the conference. It was possible to set up cotton cultivar evaluation trials under organic conditions to identify and multiply cultivars that are suited for organic cotton farmers and meet the demand of the textile industry to close the seed gap in the short term (4-6 years). We could identify in Madhya Pradesh and Odisha ten and three promising non-GM cotton cultivars that have a high yield potential and yield stability and meet the expectation of the textile industry. Comparing the different cultivar types it became obvious that F1 hybrids can outyield varietal lines only under very favourable growing conditions, and that *G. arboreum* were very resilient against various stresses like water logging, drought or sucking pests.

Discussion

The organic sector has to take responsibility for its own seed supply and breeding, which need to be done under organic conditions. Priorities for optimal traits are quite different between breeders, farmers, also between female vs. male farmers, and the textile industry. To be successful all aspects must be considered. Under low fertility and rainfed conditions traditional G. arboreum have much higher yield than *G. hirsutum*. A limited number of *G. arboreum* show good fiber quality, but picking time is increased. Inbred lines can outyield hybrids under less favorable conditions. A broad range of genotypes is needed to cover the different growing systems, soil types and demands of textile industry. Continuous breeding is indispensable to cope with climate change and new pest & diseases evolving. Cultivation (e.g. plant density) need to be adjusted to each cultivar, therefore breeding must go hand in hand with improvement of plant management and anticipated future trends like mechanical harvest.

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Soil health response to organic nutrient management in vertisols under aerobic rice (*Oryza sativa* l.) cultivation

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Key words: Aerobic rice, Organic carbon, Organic manures, microbial population, enzymatic activity

Abstract

A field experiment was conducted at Main Agricultural Research Station, Dharwad, during kharif, 2013 and 2014 to study the influence of organic and inorganic nutrient management practices on soil health of aerobic rice (Oryza sativa L.) in northern transition zone of Karnataka. The experiment consisted of twenty four treatment combinations comprising of six main plots (manurial practices) and four sub plots (liquid organic manures) which were replicated thrice. Two years pooled data on nutrient management revealed that, Integrated application of FYM (1/3)+ vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM (5 t ha^{-1})+ microbial consortium with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS) recorded significantly higher organic carbon (5.97 g kg^{-1}) available soil nitrogen (310.46 kg ha^{-1}) phosphorus (30.90 kg ha^{-1}), potassium (328.16kg ha^{-1}), sulphur (15.16 ppm), N fixers (39.83 x10^3 cfu g^{-1} soil), PSB (41.83 x10^4 cfu g^{-1} soil), Azospirillum spp. population(0.80 x10^6 cfu g^{-1} soil), higher dehydrogenase (14.27 μg TPF g^{-1} soil day^{-1}) and phosphatase (28.66 μg pNP g^{-1} soil h^{-1}) at harvest.

Acknowledgments

The Authors are extremely thankful to the Department of Agronomy and Department of Agricultural Microbiology, College of Agriculture, University of Agricultural Sciences, Dharwad for the laboratory facilities provided for the research.

Introduction

In order to meet the food and fiber needs of the increasing population on a sustained manner, the strategies involving addition of carbon from organic soil amendments like farm yard manure, compost, vermicompost in combination with liquid organic manures like cattle urine, bio-digested liquid manure, jeevamrut *etc.* deserves priority for sustained production and better on farm resource recycling and utilization (Babalad *et al.* 2009). Soil microbes mediate the biochemical transformations of organic matter that underpin essential ecosystem functions, including decomposition, mineralization of plant available nutrients, and nutrient retention (Jackson *et al.* 2012). The quantity and quality of Soil Organic Matter (SOM) and carbon (C) and nitrogen (N) inputs are the overriding controls on soil microbial biomass and activity (Kallenbach and Grandy 2011).The enzymatic activities of a soil catalyzes the biochemical activities performed by bacteria and thereby indicates the potential of the soil for maintaining soil fertility. Organic management increases overall enzyme activity, but activities of specific enzymes may change depending on the composition of the amendments and the relative availability of nutrients. In aerobic rice (*Oryza sativa* L.) among the various practices, optimizing the use of manures and fertilizers is one of the important strategies for increasing productivity of rice. In this direction, integrated management of

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solid and liquid organic manures needs priority. Organic farming minimizes the use of external inputs and aims to optimization of crop productivity rather than its maximization through renewal and strengthening of ecological processes and functions of farm ecosystem (Shukla *et al.,* 2011). On going through the above facts, a study was conducted to find out the impact of various nutrient management practices on soil health under prevailing conditions in aerobic rice cultivation during *kharif,* 2013 and 2014.

Material and methods

A field experiment was conducted at Main Agricultural Research Station, UAS, Dharwad, Karnataka during *kharif,* 2013 and 2014 to study the effect of organic and inorganic nutrient sources on soil health of aerobic rice. The experiment was laid out in a split plot design with three replications. The main-plot treatments comprised of six manurial combinations as M_1- Recommended dose of chemical fertilizer (RDF) (100:50:50 kg N, P_2O_5, K_2O ha^{-1}), M_2- RDF + Farm yard manure (5 t ha^{-1}) + microbial consortium (*Azospirillum* + Phosphate solubilizing bacteria) (MC), M_3- FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN, M_4-FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN + microbial consortium, M_5- FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM (5 t ha^{-1}), M_6- FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium. The subplot treatments consisted of four liquid organic manure treatments L_1: Soil application of jeevamrut @ 500 l ha^{-1} at 30, 60 and 90 DAS, L_2: Foliar application of cow urine @ 500 l ha^{-1} at 30, 60 and 90 DAS, L_3: Soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS, L_4: Control (no liquid manure application). Organic manures equivalent to RDN (100 kg N ha^{-1}) through FYM, vermicompost and green leaf manure (*Gliricidia spp.*)were applied 15 days before sowing as per the treatments. The soil of the experimental site was clay, having low carbon (4.90 g kg^{-1}) and available N P K (263.42; 23.30 and 285.60 NPK kg ha^{-1} respectively). The seeds of variety MAS-26 developed specifically for aerobic rice production from UAS, Bengaluru were used and sown at 30 cm x15 cm spacing on 4th July, 2013 and 16th July, 2014 during 2013-14 and 2014-15 respectively. Liquid organic manures were applied as per schedule to the respective treatments. Spraying of neem oil, *Metarrhizium* and *Pseudomonas fluroscence* was done to manage the insect pests and diseases in organic nutrient management treatments. The crop was harvested on 13th November, 2013 during first year and 21st November, 2014 during the second year. Soil physical and physico-chemical properties were estimated by standard procedures at harvest. The population of free living N fixtures – Azotobacter, Phosphate solubilizing bacteria (PSB) were estimated by standard serial dilution plate count method.To enumerate Azospirillum sp. in soil, the most probable number (MPN) method was followed with semi solid Dobreiner medium. The tubes which have turned blue and have developed typical white sub-surface pellicle counted as +ve or –ve and considered for the purpose of calculation by referring to statistical tables of Cochran (1950) and expressed as MPN per gram of soil. The dehydrogenase activity in the soil samples was determined by following the procedure described by Casida *et al.*(1964). The Phosphatase activity in the soil samples was determined by following the procedure described by Evasi and Tabatabai (1979).The experimental data obtained were subjected to statistical analysis by adopting Fisher's method of analysis of variance as outlined by Gomez and Gomez (1984).The level of significance used in 'F' test was at 5 per cent. The mean values of main plot, sub plot and interaction were separately subjected to Duncan' multiple range test using the corresponding error mean sum of squares and degrees of freedom values. Values indicated with same alphabet do not differ significantly.

Results

Application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium (M_6) recorded significantly higher organic carbon

(5.71 g kg^{-1}), nitrogen (302.62 kg ha^{-1}), phosphorus (29.10 kg ha^{-1}), potassium (316.12kg ha^{-1}), sulphur (14.48 ppm), N fixers (37.42 $x10^3$ cfu g^{-1} soil), PSB (40.25 $x10^4$ cfu g^{-1} soil), *Azospirillum* spp. population(0.51 $x10^6$ cfu g^{-1} soil), dehydrogenase (13.10 µg TPF g^{-1} soil day^{-1}) and phosphatase (27.27 µg pNP g^{-1} soil h^{-1}) activity at harvest on pooled basis than other manurial treatments (Table 1.). Among the liquid organic manures, soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (L_3) recorded significantly higher organic carbon (5.65 g kg^{-1}), available nitrogen(297.92 kg ha^{-1}), phosphorus (29.73 kg ha^{-1}), potassium (312.57kg ha^{-1}), sulphur (14.49 ppm), N fixers (31.61 $x10^3$ cfu g^{-1} soil) PSB (28.33 $x10^4$ cfu g^{-1} soil), *Azospirillum* sp. population(0.31 $x10^6$ cfu g^{-1} soil), dehydrogenase (12.39 µg TPF g^{-1} soil day^{-1}) and phosphatase (25.74 µg pNP g^{-1} soil h^{-1}) at harvest. Integrated application of FYM (1/3) + vermicompost (1/3) + green leaf manure (1/3) equivalent to RDN with recommended FYM + microbial consortium with soil application of biodigester @ 2500 l ha^{-1} at 30, 60 and 90 DAS (M_6L_3) recorded significantly higher organic carbon (5.97 g kg^{-1}) available soil nitrogen (310.46 kg ha^{-1}) phosphorus (30.90 kg ha^{-1}), potassium (328.16kg ha^{-1}), sulphur (15.16 ppm), N fixers (39.83 $x10^3$ cfu g^{-1} soil), PSB (41.83 $x10^4$ cfu g^{-1} soil), *Azospirillum* spp. population(0.80 $x10^6$ cfu g^{-1} soil), higher dehydrogenase (14.27 µg TPF g^{-1} soil day^{-1}) and phosphatase (28.66 µg pNP g^{-1} soil h^{-1}) at harvest.

Discussion

Incorporation of organic amendments resulted in increased organic carbon status (Kumari *et al.,* 2011). Addition of organics enhanced the available nutrient status of soil considerably due to mineralization of native soil and unavailable forms of nutrients in addition to applied nutrients. Iswandi *et al.* (2011) reported that the rice root exudates containing some organic compounds as source of nutrition for microorganisms and encourages colonization in the population of *Azospirillum* spp. and PSB. This might be due to leachates of biodigester which has helped to improve the soil physical, chemical and biological properties leading to overall improvement in soil health in the long run. Jeevamrutha was able to improve the microbial population when supplied on N basis. These observations indicate that repeated use of liquid organic manures would help in enhanced bacterial activity and ultimately in improved soil fertility. Further continuous use of liquid organic manures with organic manures can improve microbial activity in soil and these improving the fertility in short run and have not indicated yield advantage (Kasbe *et al.,* 2009). The higher dehydrogenase activity after addition of organic manure could be due to increased microbial population, which is known to stimulate the dehydrogenase activity in soil (Watts *et al.,* 2010; Tejada *et al.*2010). Dehydrogenase activity is also impacted by the changes in soil organic carbon as higher level of organic carbon stimulated microbial activity and therefore, enzyme synthesis (Meena *et al.* 2014). Incorporation of green manures enhanced soil enzyme activity. The maximum phosphatase activity in soil under organic nutrient management practice due to incorporation of organic manures that increase decomposition process thereby increase the microbial activity. Addition of organic amendments and adoption of management practices that increase soil organic matter lead to increased enzyme activity. Plant roots stimulate enzyme activity because of their positive effect on microbial activity and production of exudates rich in substrates acted on by enzymes. Sriramachandrasekharan and Ravichandran (2011) reported that the addition of organic substances to the soil served as a carbon source that enhanced microbial biomass and phosphatase activity, showing that these enzymes are of microbiological origin.

Conclusions

Addition of organics to nutrient management system sequesters carbon into soils and help in improving soil health of microbial dynamics viz., N fixers, PSB, *Azospirillum* spp. population and

soil enzymes such as dehydrogenase and phosphatase activity with enhanced nutrient availability in vertisols under aerobic rice cultivation.

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Table 1: Effect of organic and inorganic sources of nutrients on soil properties at harvest

Treatments	Organic Carbon (g kg^{-1})	Available nutrients (kg ha^{-1})				Microbial population			Soil enzymes	
		N	P	K	S	N fixures (x10^3 cfu g^{-1} soil)	PSB (x10^4 cfu g^{-1} soil)	Azospirillum (x 10^6 cfu g^{-1} soil)	Dehydrogenase (µg TPF g^{-1} soil day^{-1})	Phosphatase (µg pNP g^{-1} soil h^{-1})
Manurial practices (M)										
M_1-RDF (100:50:50 kg N, P_2O_5, K_2O ha^{-1})	5.11 f	264.99 e	27.01 e	299.6 c	13.09 d	20.42 f	15.00f	0.03d	9.50d	20.87d
M_2-RDF+FYM+MC	5.25 e	277.54 d	27.81 d	301.28 c	13.36 cd	24.58 e	29.21c	0.19c	10.40 c	22.53c
M_3-FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN	5.32 d	288.51 c	28.25 c	303.8 bc	13.72 bc	29.17 d	19.67e	0.05d	11.50b	24.43b
M_4-FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+MC	5.49 c	293.22 b	28.79 b	304.92 bc	13.98 ab	31.17 c	34.17b	0.37b	11.82b	24.75b
M_5-FYM (1/3) +VC (1/3) +GLM (1/3) equi.RDN+FYM	5.56 b	294.78 b	28.38 c	310.8 ab	14.18 ab	35.17 b	21.79d	0.08d	12.66a	26.88a
M_6-FYM (1/3) +VC (1/3) +GLM (1/3) qui.RDN+FYM+MC	5.71 a	302.62 a	29.10 a	316.12 a	14.48 a	37.42 a	40.25a	0.51a	13.10a	27.27a
S.Em±	0.02	1.00	0.08	2.39	0.56	0.29	0.38	0.03	0.19	0.14
Liquid organic manures (L)										
L_1-Jeevamrut @ 500 litres ha^{-1} at 30, 60 and 90 DAS	5.47 b	291.65 b	28.96 b	307.35 ab	14.01 b	30.28 b	27.11b	0.23b	11.81b	25.10b
L_2-Cow urine @ 500 litres ha^{-1} at 30, 60and 90 DAS	5.36 c	282.24 c	28.33 c	304.55 bc	13.59 b	28.89 c	26.22c	0.17c	11.08c	23.79c
L_3-Bio digester @ 2500 litres ha^{-1} at 30, 60 and 90 DAS	5.65 a	297.92 a	29.73 a	312.57 a	14.49 a	31.61 a	28.33a	0.31a	12.39a	25.74a
L_4-Control (no liquid manure application)	5.14 d	275.97 d	25.86 d	299.88 c	13.11 c	27.83 d	25.06d	0.11d	10.71d	23.20d
S.Em±	0.03	1.17	0.13	2.01	0.16	0.20	0.18	0.01	0.09	0.09
Interactions- (M X L)										
M_1L_1	5.15 gh	279.10 ef	27.28 fg	299.6 de	13.28 d-h	20.83 o	15.33p	0.03jk	9.66kl	21.49h
M_1L_2	5.07 gh	254.02 g	26.77 gh	298.48 de	12.96 f-h	19.50 op	14.67p	0.02k	9.24lm	20.18i
M_1L_3	5.22 f-h	285.38 de	28.39 de	302.96 c-e	13.87 a-g	22.83 n	16.67o	0.04jk	10.19jk	22.15h
M_1L_4	5.00 h	241.47 h	25.58 i	297.36 e	12.27 h	18.50 p	13.33q	0.02k	8.93m	19.67i
M_2L_1	5.30 e-g	279.10 ef	28.27 d-f	301.28 c-e	13.55 b-h	25.50 m	30.00g	0.21ef	10.72ij	23.16g
M_2L_2	5.15 gh	272.83 f	27.78 e-g	300.16 de	13.15 e-h	23.50 n	28.50h	0.16e-h	9.92kl	21.94h
M_2L_3	5.52 c-e	285.38 de	29.51 bc	304.6 b-e	14.07 a-f	26.83 lm	30.83g	0.24de	11.25g-i	23.56fg
M_2L_4	5.02 h	272.83 f	25.67 i	299.04 de	12.66 gh	22.50 n	27.50h	0.14f-i	9.71kl	21.48h
M_3L_1	5.37 d-f	291.65 cd	29.35 b-d	304.08 c-e	13.95 a-g	29.83 ij	19.83lm	0.06i-k	11.79e-h	25.05e
M_3L_2	5.17 f-h	285.38 de	27.95 ef	301.8 c-e	13.46 c-h	28.50 jk	19.33mn	0.05jk	11.03hi	23.59fg
M_3L_3	5.60 b-d	297.92 bc	29.56 bc	308.5 b-e	14.37 a-e	30.83 hi	21.33jk	0.07i-k	12.38c-e	25.96cd
M_3L_4	5.15 gh	279.10 ef	26.15 hi	300.7 de	13.09 e-h	27.50 kl	18.17n	0.04jk	10.81ij	23.14g
M_4L_1	5.52 c-e	297.92 bc	29.86 a-c	305.7 b-e	14.15 a-f	31.83 gh	34.50e	0.40 c	12.14d-f	25.43de
M_4L_2	5.45 d-f	291.65 cd	29.16 b-d	303.52 c-e	13.76 b-g	30.83 hi	33.83e	0.30d	11.32g-i	24.04f
M_4L_3	5.75 bc	304.19 ab	30.08 ab	310.2 b-e	14.65 a-d	32.50 fg	35.83d	0.60b	12.63cd	25.99cd
M_4L_4	5.22 f-h	279.10 ef	26.06 hi	300.1 de	13.35 d-h	29.50 ij	32.50f	0.19e-g	11.21hi	23.55fg
M_5L_1	5.67 bc	297.92 bc	29.21 b-d	315.2 a-d	14.36 a-e	35.83 cd	22.17j	0.09h-k	13.01bc	27.54b
M_5L_2	5.52 c-e	291.65 cd	28.72 c-e	308.5 b-e	13.95 a-g	34.50 de	21.17j-l	0.08h-k	12.41c-e	26.48c
M_5L_3	5.82 ab	304.19 ab	29.94 ab	320.88 ab	14.86 ab	36.83 bc	23.50i	0.11g-j	13.62ab	28.15ab
M_5L_4	5.22 f-h	285.38 de	25.62 i	298.48 de	13.57 b-h	33.50 ef	20.33k-m	0.06i-k	11.62f-h	25.37de
M_6L_1	5.82 ab	304.19 ab	29.81 bc	318.0 a-c	14.75 a-c	37.83 b	40.83ab	0.60b	13.55b	27.94b
M_6L_2	5.82 ab	297.92 bc	29.60 bc	314.7 a-d	14.25 a-f	36.50 bc	39.83b	0.40 c	12.60 cd	26.50 c
M_6L_3	5.97 a	310.46 a	30.90 a	328.16 a	15.16 a	39.83 a	41.83a	0.80a	14.27a	28.66a
M_6L_4	5.22 f-h	297.92 bc	26.09 hi	303.52 c-e	13.77 b-g	35.50 cd	38.50 c	0.23de	11.99d-g	26.00 cd
S.Em±	0.08	2.87	0.34	4.94	0.40	0.51	0.45	0.02	0.23	0.23
Initial	4.90	263.42	23.30	285.6	12.06	16.67	12.67	0.01	7.68	17.23

Thünen Report

Bereits in dieser Reihe erschienene Hefte – *Volumes already published in this series*

1 - 32	siehe http://www.thuenen.de/de/infothek/publikationen/thuenen-report/
33	Anja-Kristina Techen, Elke Ries, Annett Steinführer **Evaluierung der Gewässerschutzberatung in Hessen im Kontext der EU-Wasserrahmenrichtlinie: Auswirkungen auf Wissen und Handeln von Landwirten**
34	Jan T. Benthien, Sabrina Heldner, Martin Ohlmeyer, Christian Bähnisch, Jörg Hasener, Clemens Seidl, Alfred Pfemeter, Christian Kathmann **Untersuchung der Faserqualität von TMP für die MDF-Produktion –** Abschlussbericht zum FNR-Vorhaben „Fiber-Impact“ (FKZ: 22013211)
35	Andreas Tietz **Überregional aktive Kapitaleigentümer in ostdeutschen Agrarunternehmen: Bestandsaufnahme und Entwicklung**
36	Nicole Wellbrock, Erik Grüneberg, Daniel Ziche, Nadine Eickenscheidt, Marieanna Holzhausen, Juliane Höhle, Rainer Gemballa, Henning Andreae **Entwicklung einer Methodik zur stichprobengestützten Erfassung und Regionalisierung von Zustandseigenschaften der Waldstandorte**
37	Andrea Ackermann, Claudia Heidecke, Ulrike Hirt, Peter Kreins, Petra Kuhr, Ralf Kunkel, Judith Mahnkopf, Michael Schott, Björn Tetzlaff, Markus Venohr und Frank Wendland **Der Modellverbund AGRUM als Instrument zum landesweiten Nährstoffmanagement in Niedersachsen**
38	Hermann Achenbach und Sebastian Rüter **Ökobilanz-Daten für die Erstellung von Fertighäusern in Holzbauweise**
39	Hans-Dieter Haenel, Claus Rösemann, Ulrich Dämmgen, Annette Freibauer, Ulrike Döring, Sebastian Wulf, Brigitte Eurich-Menden, Helmut Döhler, Carsten Schreiner, Bernhard Osterburg **Calculations of gaseous and particulate emissions from German agriculture 1990 - 2014** **Berechnung von gas- und partikelförmigen Emissionen aus der deutschen Landwirtschaft 1990 – 2014**
40	Frank Offermann, Martin Banse, Claus Deblitz, Alexander Gocht, Aida Gonzalez-Mellado, Peter Kreins, Sandra Marquardt, Bernhard Osterburg, Janine Pelikan, Claus Rösemann, Petra Salamon, Jürn Sanders **Thünen-Baseline 2015 – 2025: Agrarökonomische Projektionen für Deutschland**
41	Stefan Kundolf, Patrick Küpper, Anne Margarian und Christian Wandinger **Koordination, Lernen und Innovation zur Entwicklung peripherer ländlicher Regionen** **Phase II der Begleitforschung zum Modellvorhaben *LandZukunft***
42	Sebastian Rüter, Frank Werner, Nicklas Forsell, Christopher Prins, Estelle Vial, Anne-Laure Levet **ClimWood2030 ‘Climate benefits of material substitution by forest biomass and harvested wood products: Perspective 2030’ Final Report**
43	Nicole Wellbrock, Andreas Bolte, Heinz Flessa (eds) **Dynamik und räumliche Muster forstlicher Standorte in Deutschland – Ergebnisse der Bodenzustandserhebung im Wald 2006 bis 2008**

44	Walter Dirksmeyer, Michael Schulte und Ludwig Theuvsen (eds) **Aktuelle Forschung in der Gartenbauökonomie – Nachhaltigkeit und Regionalität – Chancen und Herausforderungen für den Gartenbau** – Tagungsband zum 2. Symposium für Ökonomie im Gartenbau
45	Mirko Liesebach (ed) **Forstgenetik und Naturschutz – 5. Tagung der Sektion Forstgenetik/Forstpflanzenzüchtung am 15./16. Juni 2016 in Chorin – Tagungsband**
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48	Markus Ehrmann **Modellgestützte Analyse von Einkommens- und Umweltwirkungen auf Basis von Testbetriebsdaten**
49	Mirko Liesebach, Wolfgang Ahrenhövel, Alwin Janßen, Manuel Karopka, Hans-Martin Rau, Bernd Rose, Randolf Schirmer, Dagmar Schneck, Volker Schneck, Wilfried Steiner, Silvio Schüler, Heino Wolf **Planung, Anlage und Betreuung von Versuchsflächen der Forstpflanzenzüchtung** **Handbuch für die Versuchsanstellung**
50	Tobias Mettenberger **Jugendliche Zukunftsorientierungen in ländlichen Mittelstädten** Zur Rolle des alltäglichen (sozial-)räumlichen Kontexts beim Übergang von der Hauptschule in den weiteren Ausbildungsweg
51	Stefan Neumeier **Modellvorhaben chance.natur – Endbericht der Begleitforschung –**
52	Andreas Tietz **Überregional aktive Kapitaleigentümer in ostdeutschen Agrarunternehmen: Entwicklungen bis 2017**
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THÜNEN

Thünen Report 54 - Volume 1

Herausgeber/Redaktionsanschrift

Johann Heinrich von Thünen-Institut
Bundesallee 50
38116 Braunschweig
Germany

www.thuenen.de