Research for Organic Agriculture to tackle future challenges

ISOFAR international scientific workshops

at the 2nd International Organic Expo October 1-3, 2022

in Goesan, South Korea

Proceedings

ISOFAR
International Society of Organic Agriculture Research

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Research for Organic Agriculture to tackle future challenges

Foreword

Dear Readers,

The last decade has already been a severe challenge for the global community. Financial crises, natural and manmade calamities, weather extremes, CoVid19 as well as political crises including wars with increasing hunger, energy shortages and inflation had, have and will have global impacts. The Sustainable Development Goals of the United Nations and important international commitments become increasingly difficult to achieve. This is the case for the Paris Agreement 2015 to limit the increase in temperature below +1.5°C till 2050 and the Biodiversity Convention Declaration (BCD) from 1992 to reduce further extinction of species.

People all over the world feel and fear a future with multipolar hegemonies, increasing impacts of climate change, increasing poverty, and food and clean water insecurity. It seems to be that the future will be even worse than the last decades.

Sustainable and regional food security is an important option to tackle those risks and fears. But there was only little done in the past to design such sustainable food systems. Organic Farming is the main sustainable agro-ecological system of relevance in some regions of the world, with high appreciation and premium markets for process quality. The sustainability goals and "real world" experience and achievements of Organic Farming have pushed the approach on the political agenda. The EU, for example, is targeting 25% share of organic farmland until 2030. Nevertheless, to be a real option for future global agriculture, there is a need not only to scale-up Organic Farming, but also to improve the sustainability and productivity of the whole food system. Without research both development tracks i.e. encroachment (horizontal development) and improvement (vertical development) will be not possible.

Research for Organic Farming is necessary and needs to be strengthened to become a fair option for farmers and the food chain. The necessary discussions are the aims of the five workshops of ISOFAR over 3 days at the 2nd Expo 2022 in Goesan, South Korea. This will continue the discussions ISOFAR has started already at the 1st Expo 2015, with a considerable feedback throughout the world (Rahmann et al. 2017[1]). The next steps need to be done.

Goesan, October 1st, 2022

Gerold Rahmann
M. Reza Ardakani
Wahyudi David
Shaikh Tanveer Hossain
Jochen Mayer
Daniel Neuhoff
Amber Sciligo
Sabine Zikeli

[1] Rahmann G et al. (2017) Organic 3.0 is innovation with research. Org. Agr. (2017) 7:169–197 DOI 10.1007/s13165-016-0171

Content

Background

ISOFAR was the International partner of the 1st International Expo 2015, and is proud to be the partner of the 2nd International Expo 2022, again. ISOFAR, as global and independend network of Organic Farming scientists is organizing the scientific workshops at the IFOAM Organic conference - who is celebration their 50th anniversity with the Expo – from October 1-3, 2022 in Goesan, Korea.

The workshops will focus on scientific discussion for future needs to develop Organic agriculture to be a global option to tackle future challenges in food production and consumption. This is understood as contribution for the movement, for decision makers and scientists to design and implement healthy food systems with the support of scientific recommendations. Therefore, the participating scientists are invited to contribute to conceptional discussion for Organic Agriculture of the future: environmentally sound, efficient and enough, healthy and affortable food for everyone on the earth. Not only scientists from Organic farming research, but also from other disciplines, conventional agricultural science and inventors from private business and farms will be invited to participate and contribute. The results of the workshops will be published peer-reviewed after the event.

ISOFAR has decided to do five workshops with limited number of participants, to have high quality and deep discussion of everybody and selected and experienced scientists for the mentioned topics. The workshop language will be in english. Translation should be not necessary for participants, except for the host of the off-campus workshops on day two. That does allow significant mutual scientific inspiration and creation of future needs for Organic and the global challenges. The workshop will be part of the Organic conference and therefore linked with other scientists and participants from the global organic movement.

The Organizing Committee

ISOFAR
International Society of Organic Agriculture Research

2022 IFOAM-Goesan
International Organic EXPO +Industry Fair

Programme of the ISOFAR workshops

Oct 1st, 2022: Joint IFOAM and ISOFAR conference

09:30	Opening and welcome notes
10:00	50th IFOAM anniversity: recognitions
10:40	Keynote speech and 2 sessions
13:00	Lunch
14:00	Dialogue between the generations
16:00	Hotel
16:30	Travel to the 50th anniversity party
19:30	Back to hotel

Oct 2nd, 2022: ISOFAR Workshops

10:30 – 12:30	Session 1
12:30	Lunch
14:00 – 16:00	Session 2
16:00	Break
16:30 – 18:30	Session 3

Oct 3rd, 2022: ISOFAR world cafés and wrap-ups

09:00	ISOFAR - 5 world cafés: Open discussion and preparations for plenary
10:30	Break
10:45	ISOFAR - 5 world cafés – continue: Open discussion and preparations for plenary
12:30	Lunch
14:00	ISOFAR Wrap-up plenary session
15:30	Break
15:45	IFOAM and ISOFAR wrap-up plenary
17:00	Joint closing ceremony
17:30	Conference closure

Participants of the ISOFAR workshops

The 51 participants of the five workshops coming from 27 countries all over the world. They have been invited in recognision and value of their scientific work and experience.
All participants have prepared a paper in advance to allow all other participants to read about the research and recommendations regarding the topic of the five workshops.

The list is in alphabetic order:

- Abeysundara, Dr. Piumi De A. (Sri Lanka)
- Aksoy, Prof. Dr. Uygun (Turkiye)
- Ardakani, Prof. Dr. M. Reza (Iran)
- Auerbach, Prof. Dr. Raymond (South Africa)
- Azim, Dr. Khalid (Morocco)
- Bakar, Dr. Azizi Abu (Malaysia)
- Barberi, Prof. Dr. Paolo (Italy)
- Bügel, Prof. Dr. Susanne (Denmark)
- Chander, Dr. Mahesh (India)
- David, Dr. Wahyudi (Indonesia)
- Dussi, Prof. Dr. Claudia (Argentina)
- Farhan Saeed, Dr. Muhammad (Pakistan)
- Ferrand, Pierre (France, FAO Thailand)
- Ganesapillai, Dr. Mahesh (India)
- Grimm, Daniel (Germany)
- Hammermeister, Dr. Andrew (Canada)
- Hegde, Dr. Gurudatt M.at (India)
- Hernandez, Dr. Lorena F. (Philippines)
- Hett, Jonas (Germany)
- Hoi, Dr. Pham Van (Vietnam)
- Huque, Prof. Dr. S. M. Rafuil (Bangladesh)
- Javkhlantuya, Dr. Altansuvd (Mongolia)
- Kajitvichyanakul, Prof. Puangrat (Thailand)
- Mayer, Dr. Jochen (Switzerland)
- Melati, Dr. Maya (Indonesia)
- Migliorini, Prof. Dr. Paola (Italy)
- Mokrani, Khaoula (Tunisia)
- Mothar, Wan (Malaysia)
- Neuhoff, Dr. Daniel (Germany)
- Olowe, Prof. Dr. Victor (Nigeria)
- Rahmann, Prof. Dr. Gerold (Germany)
- Rastegary, Dr. Jalal (USA)
- Rezapanah, Dr. Mohammadreza (Iran)
- Riar, Dr. Amritbit (Switzerland)
- Sassi, Prof. Dr. Khaled (Tunisia)
- Schmutz, Prof. Dr. Ulrich (UK)
- Sciligo, Dr. Amber (USA)
- Schipanski, Dr. Megan (USA)
- Sharma, Dr. Shanti Kumar (India)
- Sonntag, Enno (Germany)
- Strassner, Prof. Dr. Carola (Germany)
- Subrahmanyeswari, Prof. Dr. B (India)
- Suknicom, Dr. Siriwan (Thailand)
- Swami, Dr. Sanjay (India)
- Taniguchi, Assoc. Prof. Dr. Yoko (Japan)
- Tashi, Prof. Dr. Sonam (Bhutan)
- Uddin, Dr. Md. Jashim (Bangladesh)
- Ugas, Prof. Dr. Roberto (Peru)
- Zanoli, Prof. Dr. Raffaele (Italy)
- Zikeli, Dr. Sabine (Germany)
- Zulkiflee, Dr. Zul Illham David (USA)

Abeysundara, Dr. Piumi De A.

(Sri Lanka)

Dr. Piumi De A. Abeysundara, is currently working as a Senior Lecturer attached to the Department of Food Science and Technology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Sri Lanka. She obtained her B.Sc. degree in Food Science and Technology, from the University of Sri Jayewardenepura, Sri Lanka and M.Sc. and Ph.D. in Food Science (Food Microbiology) from Mississippi State University, USA. Her present teaching and research interests include food safety assurance, prevalence of foodborne pathogens in food commodities, pesticide residues in food commodities, etc. She is also actively involved in knowledge dissemination and training activities related food safety and safety standard among small and medium scale food manufacturers in Sri Lanka.

Aksoy, Prof. Dr. Uygun
(Turkiye)

- Staff member at Ege University Faculty of Agriculture Department of Horticulture (1976-2016); retired on April 1, 2016
- Lectured and supervised at Bachelor, MSc. and Ph D. students
- Member of the Board at ZIDEK, Accreditation of agricultural education institutions (2022-)
- Lectured at the Mediterranean Agronomic Institute of Chania (Greece) Sustainable Agriculture (2004-2006) and at Mediterranean Agronomic Institute of Bari (Italy) Mediterranean Organic Agriculture on 'Principles and Concept of Organic Agriculture' (2000-2014)
- International Consultant on Organic Agriculture and Perennial Cropping Systems in FAO and ECO supported projects (2011-2021)
- Founder, honorary president (2010-) and current chair of the executive board of the Association of Ecological Agriculture Organization (ETO) in Turkey
- Founder and past president of the Turkish Society for Horticultural Science (1994-1998)
- International Society for Horticultural Science (ISHS) Board member (1998-2002; 2002-2006)
- Scientific coordinator of the 18th World Organic Congress 2014 (İstanbul-Turkey) and 30th World Horticultural Congress 2018 (İstanbul-Turkey)
- IFOAM (International Federation of Organic Agriculture Movements) Internal auditor (2014-2017; 2017- 2021)
- Organic Farming Innovation Award Committee member of IFOAM (International Federation of Organic Agriculture Movements) and Korea Rural Development Agency
- International Nut and Dried Fruit Council Foundation/ Scientific and Governmental Affairs Com. Member (2005-)

Awards

- International Society for Horticultural Science (ISHS) Honorary member (2008-)
- Honorary president (2010-) of the Association of Ecological Agriculture Organization in Turkey
- Science award 2011, Chamber of Agriculture Engineers in Turkey.
- Organic Heroes, IFOAM Mediterranean Regional Group (Agribiomediterraneo 25th Anniversary), 2015.

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Ardakani, Prof. Dr. M. Reza

(Iran)

Dr. M. Reza Ardakani is a Full Professor of Agroecology and Organic Farming in the Faculty of Agriculture and Natural Resources, Azad University, Karaj, Iran.

Reza has 24 years of experience with several research programs, and contributed in several training courses and scientific activities in Europe (Switzerland, Germany and Austria), Asia (Iran, India, South Korea and Philippines) and North America (Canada) which gave him extensive knowledge and experience in sustainable agricultural systems especially in organic farming and related disciplines (Scopus H-index: 17).

Reza is currently a World Board Member of International Society of Organic Agriculture Research (ISOFAR); the Director of IFOAM-IRAN (International Federation of Organic Agriculture Movements- office of Iran); Associate Editor & Advisory Board Member of a Springer Journal “Organic Agriculture”; International Advisory Board Member for Organic-PLUS Project “Pathways to phase-out contentious inputs from organic agriculture in Europe” (European Union’s Horizon 2020 research and innovation program under grant agreement No [774340 — Organic-PLUS]); and member of the Scientific Advisory Board for the EU Horizon Europe Framework Programme on "Agroecological approaches for sustainable weed management". Reza actively contributes to different international working groups of organic movements worldwide such as Advisory Group on IFOAM Strategy, Working Group on IFOAM Closing Cycle in Organic Agriculture, Action Group on IFOAM-GMOs, IFOAM Organic Food System Program and Technology Innovation Platform of IFOAM.

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Auerbach, Prof. Dr. Raymond

(South Africa)

- Raymond was a member of SASA when IFOAM was founded
- Extraordinary Professor at Centre of Excellence for Food Security, University of the Western Cape.
- Farmed organically in KwaZulu-Natal for twenty years;
- Trained organic farmers for twenty years (Rainman Landcare Foundation);
- Professor of Soil Science and Plant Production at Nelson Mandela University for ten years;
- Research into closing the yield gap between organic and conventional farming;
- Author of 4 books and 5 training manuals on organic agriculture and water use efficiency;
- Principal Researcher, Centre of Excellence for Food Security, University of the Western Cape;
- Working for African Union on policy for mainstreaming Ecological Organic Agriculture in Africa; assessing agricultural policies of 55 countries, and recommending 5 sets of policies;
- Member of the ARC Board; Director of Biological Systems Consulting & Research;
- Three adult children and two grandchildren; lives in George, Western Cape (Garden Route).

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Azim, Dr. Khalid

(Morocco)

Dr. Khalid AZIM is a horticulture engineer with a M.Sc degree in Mediterranean Organic Agriculture from the CIHEAM-Bari Italy (2003-2005). Since 2007, Khalid is in a permanent position as a researcher in "Organic Horticulture and Composting optimization" at the National Institute of Agronomic Research (INRA). He has defended his PhD thesis on "Composting optimization of organic wastes and evaluation of the compost quality and its fertilizing value" in July 2019. Khalid is mostly oriented toward research and capacity building actions. Proud to be close to farmer needs in much Research to Action projects, he has discovered the rude task of a farmer in an arid region in Morocco, and totally committed to develop organic principles, in order to bring it out from niche to a mainstream as outlined by Organic 3.0. khalid is the National Scientific Coordinator of Organic Agriculture Research Program at INRA-Morocco and coordinated 5 research project and published 23 publications, two book chapter and many oral communications and posters. He is a World Board member of ISOFAR and Associate Editor of its journal "Organic Agriculture edited by Springer (Germany).

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Bakar, Azizi Abu

(Malaysia)

Azizi Abu Bakar is a Research Officer with research experience in environmental risk assessment, kriging analysis, climate action, soil bioremediation and vermitechnology. He started his early career profession in the varsity with an international bilateral research collaboration program between Malaysia and Japan Higher Education Institutions (JSPS Asian Core Program) under the theme; Research and Education Center for The Risk Based Asian Oriented Integrated Watershed Management. His service continues with the placement at the Institute of Research Management and Services or known as IPPP for understanding research impact prior joining UM Sustainability and Living Lab Secretariat (UMSLLS) under the purview of Deputy Vice-Chancellor (Research and Innovation) in overseeing campus sustainability initiatives. He is currently in the UM Community Engagement Centre or known as UMCares for community engagement and research impact initiatives.

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Bàrberi, Prof. Dr. Paolo

(Italy)

Former Assistant Professor at the University of Tuscia, Viterbo, Italy (1996-2000), he is Professor in Agronomy and Field Crops at Center of Plant Sciences, Sant'Anna School of Advanced Studies (SSSA), Pisa, Italy, since 1 July 2000, where he leads the Agroecology research group and has coordinated the International PhD Programme in Agrobiodiversity (2013-2019). His research is focused on Functional Agrobiodiversity, Weed Ecology, Integrated Weed Management, and the design of agroecological low-input and organic cropping/farming systems. He has participated in 15 EU-funded projects (FP6, FP7, Horizon 2020, ERA-NETs) since 2007, often with leading roles. He has (co)authored >350 papers and abstracts. He is/has been external expert for the FAO (Agroecology and Ecological Weed Management), the European Commission (RTD programmes, JRC), the European Food Safety Authority (Environmental Risk Assessment of GMOs) and the Italian Ministry of Agricultural, Food and Forestry Policies (leader of the Organic Cropping Systems expert group). He has been member of the Panel for the Assessment of Biopesticides, EU Southern Zone (France, Greece, Italy and Spain) in 2015-2018. He has been Scientific Secretary, Vice-President, President and Past-President of the European Weed Research Society (2002-2015). He is former Vice-President and co-founder of Agroecology Europe (www.agroecology-europe.org). He is member of Board and co-founder of the Italian Association of Agroecology (AIDA).

Further information: www.researchgate.net/profile/Paolo_Barberi

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Bügel, Prof. Dr. Susanne

(Denmark)

Susanne Bügel graduated from University of southern Denmark in 1990 and got her Phd from the same university in 1994. SB is today professor in Human Nutrition at the Department of Nutrition, Exercise and Sports at University of Copenhagen. She works with nutrition in human health, primarily performing randomized controlled human interventions. The areas of expertise include micronutrients; vitamins and minerals for optimal health, primary food production and effects of processing. Sb has been responsible for short-term fully controlled dietary interventions aimed at determining bioavailability of primary and secondary nutrients from organic vs conventional produced foods. Currently SB is projects about health aspects of sustainable food systems and diets. SB is board member of "Food Quality and Health" (FQH) and has contributed to a number of consensus papers regarding organic foods.

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Chander, Dr. Mahesh

(India)

He is Principal Scientist, Agricultural Extension Education, with Indian Council of Agricultural Research. In career spanning over 32 years, he guided 45 Master's & PhD students as Chairman including three theses on organic farming. He completed certificate course- Organic Leadership Course (OLC) by IFOAM Academy in 2012 and Organic Master Class in 2017 (South Korea). He raised funding for organizing Pre-conference on Organic Animal Husbandry in conjunction with 19th IFOAM-OWC in 2017. He has been attending OWC since 11th IFOAM Scientific Conference held in Copenhagen, 1996. He has written several international publications on organic agriculture including a book, Organic Livestock farming, Published by ICAR in 2013, reprinted in2017. He has guided the State Government of Sikkim, especially the Sikkim Organic Mission (SCM) by developing a Roadmap for Organic animal Husbandry Development in Sikkim, published by SCM. For his outstanding work in the area of organic agriculture since 1996, he was awarded this year with Rafi Ahmed Kidwai Award by the Indian Council of Agricultural Research.

He has been a Member of International Advisory Board of EU2020 Horizon Project: Organic Plus implemented in 14 Countries. He has been member of several IFOAM Committees (like Organic Standards Committee, Organic Standard Criteria Committee, World Board Nomination Committee) & sector platforms like TIPI & Steering Committee of IFOM-IAHA. He has been World Board member of ISOFAR for three terms & Associate Editor of Springer Journal ORGANIC AGRICULTURE. He has been member of several national committees on organic Agriculture development in India.

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David, Dr. Wahyudi

(Indonesia)

More than 14 years he has been involved in organic research particularly in the processing and sensory evaluation. He serves as associate editor of Journal Organic Agriculture (section food processing) as well as Managing Editor of Asia Pacific Journal of Sustainable Agriculture Food and Energy. In 2013, together with other Universities colleagues in the region Southeast Asia, he was co-founder of Sustainable Agriculture Food and Energy (SAFE) Network that consists of 10 countries and 34 Universities in the Asia Pacific regions. His current position is head of Innovation and Business incubator at Universitas Bakrie, Indonesia

He has published more than 50 scientific papers. Most of them are in the field of organic food, dietary pattern, food culture as well as sensory evaluation (both in English as well as in Indonesian). He was awarded research grants from several funding institutions.

He is a member of the Indonesian Association of Food Technologist (IAFT) and World Board member of International Society of Organic Agriculture Research (ISOFAR) as well as member of Indonesia Society for Functional Food and Nutraceutical (ISFFN). He is a member of the technical committee for Indonesia Standard Body (BSN) for sensory evaluation standards. In 2019, He was also appointed by the IFOAM Asia as Co-chairperson Organic innovation and Technology Platform.

He obtained Doctoral degree in 2011 as Doktor der Agrarwissenschaften (Dr.agr), specifically in the field of Organic Food Quality and Food Culture as well as his master's degree from University of Kassel, Germany.

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Dussi, Prof. Dr. Claudia

(Argentina)

Dr. Maria Claudia Dussi is a Professor of Agroecology and temperate fruit physiology and culture, she leads a study group in sustainability of agroecosystems, and trains graduate students in indicators of sustainability, energy flux and efficiency and carbon footprint in agroecosystems. She is Board member of the Latin America Scientific Society of Agroecology (SOCLA), and Vice-chair ISHS Commission Agroecology and organic farming systems.

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Farhan Saeed, Assoc. Prof. Dr. Muhammad

(Pakistan)

Dr. Muhammad Farhan Saeed had earned HEC-DAAD (Higher Education Commission, Pakistan-The German Academic Exchange Service) scholarship under a scheme for M.Sc and Ph.D studies in Germany. He attained his M.Sc (International Organic Agriculture) in 2009 from University of Kassel and carried on his Doctoral research and studies in the group of Ecological Plant Protection in Witzenhausen at University of Kassel, Germany. He accomplished his Ph.D degree in May, 2013. In October 2013 he joined as an Assistant Professor in the College of Agriculture (Sub Campus Layyah) Bahauddin Zakariya University, Multan, Pakistan after completing his one-year contract of IPFP (Interim Placement of Fresh PhDs Program) of HEC he joined Department of Environmental Sciences COMSATS University Islamabad, Vehari Campus (Pakistan) on TTS as an Assistant Professor (Tenure Track System, 2014-2022). He has completed his Post- Doctorate from College of Land and Environment, Shenyang Agricultural University, China (2017-2020). He has been promoted to Tenured Associate Professor in April 2022.

He has expertise in Organic Agriculture, Ecological Plant Protection and Certification & Quality management of Organic foods moreover he has Interests in interdisciplinary and transdisciplinary research on complex and persistent problems of Environment and field crops. He has interest to explore new horizons, integration of sciences and social sciences.

His research includes Pollution, Public health, Food contamination, toxic compounds and their remediation from soil and fertility issues. He supervised research thesis of MS (Environmental Sciences) in described areas. Over the following years he presented his research work in several National and International conferences. He is co-author of book chapters with Springer. He has 40 impact factor publications. He won Research Productivity Award; 2017.

He has completed a project under the national scheme of Start-Up Research Grant Program (SRGP-2016-19). He recently led his research team as a Principal Investigator in winning the Research Grant Scheme, National Research Program for Universities (NRPU, 2022- 2024), a highly competitive national-level research grant in Pakistan.

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Ferrand, Pierre

(France, FAO Thailand)

Mr Ferrand holds a Master of Science in Agriculture, Environmental and Food sciences from ISARA in Lyon, France and a Master of Science in Tropical Agriculture Development from CNEARC in Montpellier, France.

As an agronomist, specializing in tropical agronomy and rural development, he has been working for over 18 years in implementing food and livelihood security projects in developing countries, with a strong focus on South East Asia.

He started his career with the French Research Institute for Development (IRD) in Morocco in 2004-2005 and then joined the French Non-Governmental Organization GRET, from 2006 to 2018. With GRET, he spent nearly 6 years working in rural areas of Myanmar, then joined GRET Headquarters in Paris as Project Officer in agriculture and value chains development.

In 2015, he moved to Vientiane, Lao PDR, to lead a regional project (Laos, Cambodia, Myanmar and Vietnam) promoting an agroecological transition in South East Asia. He was in charge of facilitating the emergence of, and coordinating at regional level an Agroecology Learning Alliance (ALiSEA, https://ali-sea.org), bringing together all relevant stakeholders active in the field of Agroecology (Civil Society Organizations, Research centers, Government officials, Private sector).

Since December 2018, he is working with the FAO Regional Office for Asia and the Pacific in Bangkok, Thailand, as Agriculture Officer and Regional focal point for Agroecology and the UN Decade of Family Farming. He is currently involved in the backstopping and supervision of a broad range of projects (technical assistance to governments, facilitation of policy dialogue, knowledge generation and dissemination…).

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Ganesapillai, Dr. Mahesh

(India)

Dr. Mahesh Ganesapillai acquired a MSc. in Chemical Engineering at Annamalai University and a PhD in Chemical Engineering at Anna University in Tamil Nadu, India. He is an associate professor in the School of Chemical Engineering at Vellore Institute of Technology, Vellore, India. His research focuses on closed-loop fertility cycles for sustainability in sanitation and agricultural production through the design and implementation of nutrient recovery systems. Ganesapillai is the author of over thirty eight manuscripts on resource recovery and management systems. He was awarded the Best Platform Presenter by International Water Association (Poland) in 2017, Outstanding Young Chemical Engineer from Indian Institute of Chemical Engineers, the prestigious Senior Research Fellowship award from Defense R&D Organization, Government of India.

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Grimm, Daniel

(Germany)

Daniel Grimm graduated with a MSc. in Environmental Biology at Utrecht University. He has an expertise in agroecology and fungal biology and is currently working as a PhD researcher at the Thünen Institute of Organic Farming in Germany. His research is part of the LandLessFood Project and is focused on muhroom cultivation in circular agricultural systems.

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Hammermeister, Dr. Andrew

(Canada)

Dr. Andrew Hammermeister is the Director of the Organic Agriculture Centre of Canada (OACC) and Associate Professor in the Faculty of Agriculture at Dalhousie University, Nova Scotia, Canada. After growing up on a mixed grain and beef operation in Saskatchewan he completed his B.Sc. in Agriculture (Soil Science) from the University of Saskatchewan and his MSc. in Land Reclamation and PhD in Applied Ecology at the University of Alberta. Andrew has worked with the OACC since 2002, collaborating in research on grain, vegetable and fruit cropping systems, exploring soil fertility and weed management. Most recently he has been studying, small bush fruits such as haskap, landscape biodiversity, and applications of smart technologies to organic agriculture. Andrew is the Science Director for the Organic Science Cluster, the coordinated national initiative for organic agricultural research in Canada where he leads national organic research priority setting, coordination, and impact assessment.

Andrew.Hammermeister@dal.ca

Hegde, Dr. Gurudatt M.at

(India)

I have started my professional career in the University of Agricultural Sciences, Dharwad, Karnataka, India since 2006 as Scientist. Presently working as Principal Scientist (Plant Pathology) in All India coordinated Research project on Wheat and Barley. I am the recipient of Gold Medals in M.Sc. (Agri) and Ph.D. for excellent performance. I have contributed several technologies on Organic ways of management of diseases of field and Horticulture crops both under natural and protected cultivations and applications of biopesticides. Involved in mass production, quality analysis and formulations of various biopesticides & biofertilisers and its commercialization. Published 68 research papers both in National and International journals of high impact factors. Visited Khazakistan, Israel, USA, UK, Srilanka, and Taipei to present the Research findings. Delivered invited talks, key note address in various scientific platforms. Handled various Research projects worth of Rs 1.5croes (INR). Received 5 National awards for outstanding contribution in the field of Plant Pathology/Agriculture, I am the life member of 5 National Society and editorial member of two professional Agriculture journals. Organized 10 days National capacity building programme on Organic farming, Nano-biotechnology in plant disease management to the scientific staff. I have given nearly a dozen television and radio programmes on various aspects of crop diseases for the benefit of farming community. I am closely associated with farmers in giving advisory and consultancy on various Horticulture and Agriculture crops and also popularization of bio-agents among the farmers.

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Hernandez, Dr. Lorena F.

(Philippines)

She works at the Faculty of the Central Bicol State University of Agriculture (Philippines) under the College of Agriculture and Natural Resources- Department of Landscape and Environmental Management. Her professional world evolved around Soil Science, Organic Agriculture and Educational Technology. She has been handling these courses both in the graduate and undergraduate level from 1985 to present. Dr. Hernandez served as Director of the Extension Services Division from 2019-2020, then as the Director of the University Organic Agriculture Center from 2013-2019. Prior to her involvementin the organic agriculture, she occupied the following significant positions as Associate Dean of the Undergraduate Studies (1997-2003), Compost Fungus Activator Production Center In-charge (1991-1995) and Soil and Water Laboratory In-charge (1990- 1994).

On national level recognition of her professional status, Dr. Hernandez's was an accredited organic fertilizer researcher of the Fertilizer and Pesticide Authority and the Bureau of Agriculture and Fisheries Standards (2013-2018). She was with the National Organic Agriculture Board as a Permanent Alternate of the Academic Group (2014-2017). She was a consistent partner and recipient of the Australian Government hosting seven Australian Volunteers from 2013-2019 for the advancement of the Organic Agriculture. The awards and recognition she received include: (1) Outstanding Achievement Award (2005) of the Central Luzon State University (CLSU) Alumni Association, (2) Outstanding Young Women of Naga City awarded by the Naga City "Carinosa" Jaycees (1996) (3) Presidential Awards granted by CBSUA in the years (2000), (2014) and (2019) . Being a soil scientist, organic agriculture advocate and educational technology and management practitioner, Dr. Hernandez had her doctoral degree in Educational Management (2003) from the University of Nueva Caceres, Philippines; Master in Applied Science in Farming System (1995) from the University of Western Sydney-Hawkesbury, Richmond, Australia; Master in Educational Technology from the Philippine Normal University (2007); MS Agriculture (academic requirements 1994) from the Dela Salle-Araneta University, Philippines and BSc in Agriculture major in Soil Science (1982) from the Central Luzon State University, Philippines. She was a recipient of the ATEP-EDPITAF scholarship for her MAppSci degree (1995) and Philippine Coconut Federation Inc. (COCOFED) Grant for her undergraduate course (1977-1981).

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Hett, MSc Jonas Valentin

(Germany)

Mr. Hett holds a Master of Science (*summa cum laude*) in crop science from University of Bonn (2019) with special focus on organic agriculture. He works as research assistant at INRES-AOL in the EU-project 'SIMBA' (see http://simbaproject.eu) and is responsible for the design, conduction, evaluation, and publication of diverse scientific experiments. He has profound experience in laboratory, greenhouse and field experiments and is well-familiar with different organic management practices. Further, Mr. Hett is currently preparing his PhD thesis on the topic 'Effects of microbial consortia on crop growth performance in organic agriculture'. He is member of the German Society for Agronomy and the Germany Society for Informatics in Agriculture. An overview on his research actives and publications can be found under: https://www.researchgate.net/profile/Jonas-Hett-2

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Hoi, Dr. Pham Van

(Vietnam)

He has a mixed educational background, with agronomic science at BSc education and social science at MSc level, He completed his PhD on environmental sociology at WUR, tbe Netherlands in 2010. He has been teaching agroecology for BSc course at Vietnam National University of Agriculture (VNUA) since the early 2000s, and recently with MSc course. However, he has recently intensively carried researches on applied agroecology since 2016 initiated by a small grant from ALiSEA project (GRET/AFD). Since then, he has developed several agroecological systems targeted for urban agriculture such as Chickenponics, Kitchenponics and Urban_VAC. These systems have been filmed by Vietnamese national TV. They have been also commercializing in Hanoi and Bac Giang province. He provides consultant services on agroecological projects for FAO, USAID, GRET…and involes in serveral international projects as Co-PI or research member.

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Huque, Prof. Dr. Sheikh Mohammed Rafiul

(Bangladesh)

He is professor and past Director of the Institute of Business Administration (IBA), Jahangirnagar University, Dhaka, Bangladesh. He has been involved in teaching and research activities for around twenty years in Bangladesh, Malaysia, and Japan. His research interest is organic produces, organic agriculture and marketing, agriculture supply chain management, environmental sustainability, consumer behavior, strategic cost management, quality management, and strategic & entrepreneurial issues in policymaking at the national level. Meanwhile, he published more than twenty-five peer-reviewed articles that include six book chapters on entrepreneurial and policy-making issues in education, innovation in education management, a case study in innovative organic agriculture practices in Bangladesh, and entrepreneurial education management published by IGI Global, B Press and IFOAM-Asia, Springer. Moreover, he was involved as a project leader and member of different projects related to Organic Movement, Environmental and Rural Sustainability, Community Participation and Social Livelihoods Management, and Strategic Issues related issues in Agri-businesses funded by different international organizations. He is an editorial member of the Jahangirnagar Journal of Business Research and an editorial member of Issues in Social and Environmental Accounting. Currently, he is a resource person of the Asian Productivity Organization (APO), Japan, and conducting training sessions on 'Organic Agroindustry Development Courses in Asia'. Finally, he is a reviewer of ISI and Scopus indexed journals like; the British Food Journal, Organic Agriculture, Social Responsibility Journal, Revista INNOVAR, Global Business Review, and IGI Global. For further reference please visit ORCID ID: https://orcid.org/0000-0001-7435-6251

Javkhlantuya, Dr. Altansuvd

(Mongolia)

She works as chief of the soil agrochemical laboratory of Mongolian life science of university. She is – a BS and MSc in soil science of agrochemical in Mongolia and a Ph.D. in soil science in Japan. Dr. Javkhlantuya is a senior composting expert with over 20-year work experience in research and development in the field of agriculture, sustainable natural resources management, climate change, biodiversity, soil, and its property, protection, and conservation, and land use management. Javkhlantuya is currently undertaking postdoc studies on composting of bio waste and wool pellet, and at the same time, is actively involved in the implementation of several projects on food waste recycling and composting with various clients including the Mongolian fertilizer company and Municipality of Ulaanbaatar. She is the leading composting expert in the country. Her vast work experience of 10 years in international projects started with a Japan grassroots project funded Agriculture conservation project and Tokyo University of Agriculture where she worked as a researcher since 2012. Dr. Javkhlantuya is a proven expert on a wide range of topics including bio-waste management, composting, fertilizer management, ecosystem modeling, soil acidification by nitrogen deposition, soil chemistry, soil testing analysis, climate change, and statistical data analysis. She is a team leader and active and influential team player working in a multicultural environment.

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Kajitvichyanukul, Prof. Dr. Puangrat (Thailand)

Dr. Puangrat Kajitvichyanukul is a Professor of Environmental Engineering, Faculty of Engineering, Chiang Mai University, Thailand. She has her B.Eng. degree in Industrial Engineering from Chiang Mai University, Thailand, in 1990, her M. Eng. degree in Environmental Engineering from Chulalongkorn University, Thailand, in 1994, and her Ph.D. degree in Civil and Environmental Engineering from the University of Texas in 2002.

Dr. Kajitvichyanukul has been the principal investigator of several research projects, funded by competitive research grants. Her current research is involving the impact of micro-pollutants (mainly on pesticides and heavy metals) on environmental and ecosystems. Her research works also focus on the technology research and development to remove the micro-pollutants from the contaminated environment especially soil and water. She has approximately 300,000 – 400,000 $US research grant won each year supported from Thailand government agencies and international grants such as International Foundation for Science (Sweden), Newton Fund-Royal Academy of Engineering (UK) and collaborative support from ERAMUS+, United Nations Institute for Training and Research (UNITAR), National Science Foundation (NSF) and U.S. Department of Energy.

Dr. Kajitvichyanukul is the author of chapters and lead Editor of 12 books in Environmental Engineering published in well-known publishers such as International Water Association (IWA) publishing, Taylor & Francis publishing, HUMANA Press, Inderscience Publishers. She was Associate Editor for Handbook of Environment and Waste Management, World Scientific Publishing Co., Singapore. She was Editor and Guest Editor for many journals such as Water Science and Technology (WS&T), International Journal of Environmental and Hazardous Waste Management (IJEWM) and International Journal of Environmental Engineering (IJEE). She has also more than 80 refereed journal articles and 100 refereed conference proceedings.

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Mayer, Dr. Jochen

(Switzerland)

Jochen Mayer is agronomist and leads the Substance Flows research team at Agroscope in Switzerland. After a practical education at two organic farms in Germany he studied agricultural science at Technical University of Berlin and University of Hohenheim, Germany. His scientific career led him to the Universities of BOKU in Vienna, Austria and University of Kassel, Germany. Since 2002 he works as senior scientist at Agroscope in Switzerland and leads the research team Substance Flows. He is the responsible scientific coordinator for the internationally well-recognized DOK long-term experiment comparing organic and conventional cropping systems in Switzerland and published more than 50 research papers. His research interests are soil-root interactions, long term cropping system sustainability and nitrogen dynamics in cropping systems. He teaches organic cropping at Zurich Applied University and ETH Zurich. As member of several policy advisory boards, he supports legislation in Switzerland. Since 2021 he is member of the Board of Directors of ISOFAR.

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Melati, Dr. Maya

(Indonesia)

She was motivated to be more concerned with sustainability for the environment when she attended a master's degree in the Human Ecology program at the Vrije Universiteit Brussels, Belgium in 1993-1995. This inspired her to develop organic farming. As a lecturer at the Department of Agronomy and Horticulture, Faculty of Agriculture at Bogor Agricultural University (IPB University), organic cultivation insights are passed on to students, including research topics for undergraduate and postgraduate students since 2005. Food plants, vegetable crops, medicinal plants, and vegetable plants function as the object of research. The idea of organic cultivation for research equips students to continue their research activities both in their field of work and for further studies. More than 60 articles have been published in Indonesian or International Journal, more than half of them are related to plant cultivation in organic way. She completed her doctoral degree in 2002 from the University of New England, Armidale-NSW-Australia in Agronomy and Soil Science. She is a member of the Indonesian Association of Agronomy (PERAGI), Indonesian Association of Horticulture (PERHORTI), Indonesian Association of Natural Drugs Researcher (PERHIPBA), International Society for Southeast Asian Agricultural Sciences (ISSAAS) and once as a member of International Society of Organic Farming Research (ISOFAR).

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Migliorini, Assoc. Prof. Dr. Paola

(Italy)

Associate Professor in Agronomy and Crops at the University of Gastronomic Sciences, Pollenzo, Italy, (https://www.unisg.it/docenti/paola-migliorini/), holds courses in agroecology, organic farming, sustainable agriculture and agrobiodiversity at the bachelor's, master's and PhD level. She is coordinator of the Master in Agroecology and Food Sovereignty and author of over 100 scientific & technical publications. She coordinates several EU, national and regional research projects on agroecology, agrobiodiversity, action research, sustainable education, local agri-food systems, indicators of sustainability and ecosystem services.

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Mohtar, Dr. Wan Abd Al Qadr Imad Wan

(Malaysia)

He acquired a BSc. in Microbiology and a MSc. in Food Technology at Universiti Putra Malaysia, before graduating as a PhD on Fermentation Technology at Strathclyde University in Glasgow, Scotland. He now works and teaches as an associate professor at the University of Malaya in Kuala Lumpur. His research focuses on liquid fermentation, using a range of fungal species, on recycling waste resources and on producing animal feed and food from mycelium.

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Mokrani, Dr. Khaoula

(Tunisia)

My name is Khaoula Mokrani. I am a Doctor in “Agronomic Sciences” speciality “Biotechnology and Plant Production”. I am currently the Regional Knowledge Manager in the global project “Knowledge Center for Organic Agriculture in Africa “KCOA”, within the Technical Center for Organic Agriculture in Tunisia (CTAB). My main role is to collect, validate and prepare traditional and scientific knowledge in Organic Agriculture, in particular, the production, processing and marketing of organic products and also to participate in the creation of a digital knowledge platform relates to North Africa and to ensure its sustainable and continuous supply by complete, reliable and up-to-date knowledge products useful for multipliers in their mission of knowledge dissemination. Here, I precisely, focused on collecting and preparing knowledge affiliated with the main needs of knowledge multipliers like pest and disease management, financing, marketing options, organic certification and soil health. Thus, I successfully collaborate with other Knowledge hubs in order to guarantee the connectivity and the synchronization of our missions while respecting the specificities of each region. Through this projects we want to engage more with influential decision-makers and thought leaders in international public policy. We are open to challenges, conversations, and an exchange of ideas from the top players in the Organic Agriculture sector.

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Neuhoff, Dr. Daniel Bernhard

(Germany)

Dr. Neuhoff has a DAA (Diplôme d'Agronomie Approfondie of the Ecole Nationale Supérieure Agronomique de Toulouse (1993) and a Diploma (Dipl. Ing. Agr.) of the University of Bonn (1994). He graduated to Dr. agr. at the Institute of Organic Agriculture, University of Bonn, in 2000 about organic potato production. Dr. Neuhoff is initiator, coordinator or PI of various research projects in the area of organic farming including nutrient management, crop protection and special crops (see https://www.aol.uni-bonn.de/en/forschung-en). He teaches organic agriculture at the University of Bonn and is guest lecturer a.o. at CIHEAM Bari. He is Editor of various ISOFAR conference proceedings and Associate Editor of the Springer journal ‚Organic Agriculture'. Since 2005 Dr. Neuhoff is member of the Advisory Board for Sustainable Agriculture of the Federal Office for Consumer Protection and Food Safety (BVL). He is E-Board member of ISOFAR since 2021 and member of the German Society for Agronomy. An overview on his publication activities can be found under: https://scholar.google.com/citations?user=upaZE8YAAAAJ&hl=de.

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Olowe, Prof. Dr.Victor Idowu

(Nigeria)

Victor Olowe started his research carrier as a Senior Research Fellow in 1990 at the National Cereals Research Institute, Badeggi, Nigeria under Oilseeds Research Programme. He later transferred his service to the Research and Development Centre (RESDEC) now Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR), Federal University of Agriculture Abeokuta as Research Fellow I/Lecturer I in 1993. He rose through the ranks and was promoted to the rank of Research Professor in 2008. In his over 30 years in academics, he has acquired relevant experience in project conception, execution, monitoring, research methodologies, impact assessment and recently organic agriculture. He is very vast in multi-disciplinary research and a very good team player. He has participated in local, regional and international research projects on organic agriculture and funded by national and international donor agencies. Professor Olowe's main area of research interest is agronomy of tropical oilseeds and has contributed several publications as articles in learned journals, refereed conference proceedings, technical reports, chapters in books, and papers read at conferences to learning in his field. He is currently a World Board Member of the International Society for Organic Agriculture Research (ISOFAR) and immediate past President, Association of Organic Agriculture Practitioners of Nigeria.

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Rahmann, Prof. Dr. Gerold

(Germany)

In 1962, Gerold Rahmann was born on a dairy farm in East Frisia, Germany. The childhood formed his identity to be a farmer, tries to be a good farmer and loves to be a good organic farmer and scientist. Gerold has studied Agricultural Economics, made his PhD in Rural Development and Habilitation in Agroecology. Gerold is founding Director of the German Federal Research Thünen-Institute for Organic Farming and Professor at the Faculty of Organic Agricultural Science at the University of Kassel, Germany. He has work many years in other countries, was 7 years world board member of IFOAM, is more than 9 years president of ISOFAR, board member of FiBL Germany and many other organisations in the Organic world. He has worked many years in other countries, mainly in southern and eastern Africa, was many years editor-in-chief or scientific journals and has published 47 peer reviewed and 340 non-peer reviewed papers.

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Rastegary, Dr. Jalal

(USA)

Dr. Jalal Rastegary is working as a Research Scientist for the College of Engineering, New Mexico State University. Jalal has been working on different aspects of renewable energy, new bioenergy, and sustainable management of integrated water and energy use for more than 25 years. Since 2014, Jalal has been Co-PI for the Pollution Prevention (P2) Program funded by the EPA. He is providing technical assistance to small business and provide on-site technical assistance in the areas of Pollution Prevention and Energy Efficiency; he assesses the client's operations focusing on environmental and P2 performance with the goal of providing recommendations for improvements and related cost-savings in dealing with their pollution. Jalal also has been PI and Co-PI of several Grants funded by the Bureau of Reclamation (BOR), United State Department of Agriculture (USDA), and the Economic Development Department (EDA). With his expansive knowledge of plants, soils, water, and energy, Jalal has published more than 40 journal and conference papers. He is a reviewer for the following programs and journals: The Food Science and Nutrition topic area of the U.S. Department of Agriculture's (USDA) Small Business Innovation Research (SBIR) program; the USDA's biofuel program; the African Journal of Environmental Science and Technology (AJEST); and the Basic Research Journal of Agricultural Science Review (BRJASR).

Rezapanah, Assoc. Prof. Dr. Mohammadreza

(Iran)

Mohammadreza Rezapanah, Associate professor of Iranian Research Institute of Plant Protection (IRIPP/AREEO), is an insect pathologist with a key interest on insect viruses, biological control agents (BCAs) & organic agriculture (OA). He served the joint FAO/IAEA program of UN/Vienna (2018-2019), the International Organization of Biological Control (IOBC/WPRS) as an auditing committee member for a decade (2001-2011) and as TIPI council member since 2014. He was head of BC Department at IRIPP about a decade. He is Head and board member of CEOA (Center of Excellence for Organic Agriculture) since 2011 and Council member of Iranian Network for Research in Viral Diseases since July 2019, while is teaching MSc & PhD courses on BC & OA Since 2007.

He has more than 230 publications including 70 peer-reviewed articles mostly access able via ResearchGate. He is president of AIPPSS (Association of Iranian Plant Protection Scientific Societies, http://aippss.areeo.ac.ir) since 2019.

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Riar, Dr. Amribtir

(Switzerland)

Dr. Amritbir Riar is a Senior Scientist at FiBL, where he leads 'Resilient Cropping Systems' group in the Department of International Cooperation. He is a farming systems research and development expert. His expertise is well recognized in participatory research, Agrobiodiversity, agronomy, plant breeding and rural farming sociology. Current research activities are focused on the interphase of agriculture, environment and society using participatory and agroecological approaches. Transdisciplinary is an inherent feature in all ongoing projects, engaging with multiple stakeholders including farmers, farm workers, consumers, traders, agri-value chains, industry, trainers, extensionists, researchers and policymakers.His contribution to the field of agriculture research and development is well recognized. Australian prestigious award 'John Allwright Research Fellow' for his doctoral work on N and water co-limitation", '2019 SFIAR Team Award' and 'SHIFT Prize 2021: Award for Transformative Agroecological Research' for Long-term farming systems comparisons in the tropics (SysCom) project and 'Distinguished Scientist Award 2020' and '2021 SFIAR Team Award' for his contribution to participatory plant breeding in India. Based upon his contribution to the organic cotton field, a policy brief entitled "Long-term sustainability of cotton-based farming systems in India: An evidence-based objective brief for policy interventions." was released during a pre-conference of IFOAM 19th Organic World Congress, 9-11 November 2017 in New Delhi, India.

Sassi, Dr. Khaled

(Tunisia)

He is a Professor in sustainable agriculture at the National Agronomic Institute of Tunisia (INAT). He's a PhD graduate in Crop Production Sciences from the INAT since 2008. He also has a postgraduate degree in agronomic sciences and bioengineering from the Gembloux Agricultural University (Belgium).

In 2015/2016, he successfully participated in the Organic Leadership Course (OLC) that was organized by IFOAM - Organics International. After this training, in April 2017, he was selected to be part of the first OLC Master Class that took place in South Korea. In 2019, he served as a trainer in the OLC course of the OM4D project in Togo.

Presently, for three years now, he's the General Manager of the Technical Center of Organic Agriculture (CTAB). With his CTAB team, he leads the national technical coordination of the organic sector in Tunisia. During the Organic World Congress 2021, he was re-elected in Rennes (France) as Member of the new ISOFAR World Board for the tenure 2021 to 2024. He is also an ambassador of IFOAM Organics International and he has coordinated several international projects funded by GIZ, USAID, AFD, mainly in agroecology.

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Sciligo, Dr. Amber

(USA)

Dr. Amber Sciligo is the director of science programs at The Organic Center where she directs projects associated with communicating and conducting research related to organic agriculture. During her tenure at The Organic Center, Dr. Sciligo has worked closely with researchers, industry, farmers, and policymakers to identify organic research needs, and she has collaborated on a diverse range of research programs with her most recent collaborations including projects aimed at:

- Mitigating climate change
- Increasing the accessibility of equitable agricultural technology aimed at supporting the organic supply chain
- Reducing incongruities in National Organic Program standards and third party food safety requirements
- Tackling challenges associated with inadvertent pesticide contamination across the organic supply chain
- Incorporating livestock into vegetable cropping systems

Dr. Sciligo heads The Organic Center's grant writing program and FFAR funding partnership which offers organic research funding and prizes for outstanding organic extension efforts. She also leads the center's signature conference event, Organic Confluences, which brings together policy makers, researchers, farmers, industry members, and other non-profits to address and overcome challenges faced by the organic sector. Dr. Sciligo brings the organic voice to communities at international, national, and local levels by serving on boards and advisory committees for ISOFAR, FFAR and the Organic Association of Kentucky, the state in which she resides.

Dr. Sciligo received her PhD at Lincoln University, New Zealand in ecology and evolution with a specialty in plant/insect interactions, specifically pollination services to plants. Her extensive postdoctoral work at UC Berkeley included several interdisciplinary projects related to the impacts of farm diversification within the organic system on a range of ecosystem services from biodiversity, pollination, natural pest control, soil health, and climate change mitigation, as well as the livelihoods of farmers. The main goals of her work have been to inform research and policies to include the needs of agroecological farmers so that their businesses can thrive, while preserving the land for future farming.

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Schipanski, Dr. Meagan

(USA)

Dr. Meagan Schipanski is an Associate Professor in the Department of Soil and Crop Sciences at Colorado State University, USA. Her research group applies systems-based approaches to improving the resilience of cropping systems, including topics of crop diversity, soil health, nutrient and water management, and climate adaptation strategies. She received her BA in Biology from Oberlin College and her PhD in Horticulture from Cornell University. Prior to her graduate studies, she managed field operations on an organic, diversified vegetable farm. Most of her research continues to be on working farms and in collaboration with innovative producers.

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Schmutz, Prof. Dr. Ulrich

(United Kingdom)

Ulrich is a professor at Coventry University in England, United Kingdom. He is a co-founder of the university's research centres on Agroecology (CAFS, CAWR) based at Ryton Organic Gardens. Ulrich is an agricultural and horticultural engineer/economist by training and has 30 years experience in organic horticulture, food and farming research.

Ulrich has been working in multi-actor EU projects since framework-5, being task-, workpackage-leader, and coordinator in framework-8 (Horizon). The research is co-designed with innovative ecological food and farming businesses of any size and complexity (e.g. community supported agriculture). In his academic work Ulrich has specialised in organic horticulture, agroecology and ecological economics, taking a broader view of this social science. Urban agroecology, agroforestry, vegan organic, bio-dynamic, social farming, and the environmental, social and governance issues of just food systems from the bottom-up are important. In addition, Ulrich has long expertise in modelling farm, environmental and policy/economics data sets. Example projects: EU-Rotate-N, Foodmetres, BioGreenhouse, Waste Few-ULL, Organic-PLUS, Agromix, Agroecology for Europe, FooDivers.

Prior to the establishment of the Agroecology centre, Ulrich has worked as a Horticultural Economist for Garden Organic/HDRA at Ryton, and as visiting professor for Organic Agriculture at the Free University of Bozen-Bolzano, Italy. His PhD was in a project with Israel and Philippines on salinity in mango rootstocks at Humboldt University Berlin. Non-academic professional work is as organic farm inspector and farm business consultant during the transition in East Germany. Ulrich has an agricultural engineering/economic diploma/MSc and a BSc in Philosophy from Bonn and Munich Universities, Germany.

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Sharma, Dr. Shanti K.

(India)

Dr. Shanti did his PhD from Indian Agricultural Research Institute, New Delhi with Jawahar Lal Nehru Young Scientist Award in 2001 by ICAR, New Delhi and MSc from Rajasthan Agricultural University (1994) Bikaner, Rajasthan India with gold medal.

He graduated from Rajasthan Agricultural University (1991) Bikaner, Rajasthan India. Dr. Shanti is initiator, coordinator and PI of various research projects in the area of organic farming of crops and vegetables, nutrient management, integrated farming system and organic input characterization. He teaches organic agriculture at Maharana Pratap University of Agriculture & Technology, Udaipur, India and he is guest speaker in National and International conference on organic farming. He authored first National Level Distance Education Course on Organic Farming in 2007 for creating awareness about human face of environmental conservation. He wrote e-learning course on Agro-meteorology sponsored by Ministry of Human Resource and Development, New Delhi. He developed 46 technologies and Package of Practices of organic farming being adopted at State and National level. He is Director of ICAR Centre for Advance Faculty Training on Organic Farming and has implemented 32 Research and Development projects and Vocational Certificate Course in organic and sustainable agriculture. He is Joint Secretary and Vice President of Indian Society of Agronomy, New Delhi, India. He is Vice President of Indian Society of Dryland Agriculture, Hyderabad, India. He is member of Board of management and Academic Council in Agricultural universities.

An overview on his publication activities can be found under:
https://www.scopus.com/authid/detail.uri?authorId=57211423209
https://scholar.google.com/citations?user=UfFxq58AAAAJ&hl=en&authuser=1
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Sonntag, Enno

(Germany)

Enno Sonntag gradutated with a MSc. in Agricultural Development from the University of Copenhagen. He has expertise in agroecology and sustainable food systems and is currently working as a PhD researcher at the Thünen Institute of Organic Farming in Germany. There he is investigating the potential of vermiculture (= earthworm rearing) as a sustainable protein source for human nutrition as part of the circular LandLessFood system

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Strassner, Prof. Dr. Carola

(Germany)

Dr. Carola Strassner is fulltime tenured Professor at FH Münster University of Applied Sciences in Westphalia, Germany. There she is vice dean of the Department of Food, Nutrition & Facilities and programme director for the M.Sc. Sustainability in Service Management and Food Industries. Her fields of research and teaching are Sustainable Food Systems and Nutrition Ecology, especially alternative food systems and the out-of-home (horeca) context; she works specifically with the organic food system and with systems of institutional catering, including school meals. Carola is coordinator and steering committee member of the Organic Food System Programme (OFSP), a Core initiative of the UN 10YFP Sustainable Food System Programme. The scope is to identify, understand and describe transformation processes towards sustainable food systems and make lessons learned available. She serves as chairwoman of the OFSP founding member, FQH – the International Research Network for Organic Food Quality and Health. Currently Carola is working on SYSORG - which studies organic agrofood systems in Europe and Northern Africa to identify how pathways to increase sustainable food production and consumption can be successfully designed – and INSUM – which identifies indicators for the assessment of health effects in Eco Regions. Recent research includes the CORE Organic Cofund project ProOrg - Developing a Code of Practice for organic food processing, particularly the market survey analyses and consumer research. Past CORE Organic involvement was as partner in iPOPY - Innovative Public Organic Food for Youth. In addition, Carola is managing partner of the business company a'verdis – Sustainable Foodservice Solutions.

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Subrahmanyeswari, Prof. Dr. Bodapati

(India)

Dr. Bodapati Subrahmanyeswari is Professor of Veterinary & AH Extension in Sri Venkateswara Veterinary University, Andhra Pradesh, one of the Southern States of India. Carried out doctoral research work with registered organic farmers of Uttarakhand Organic Commodity Board India during 2005-07. Attended 16th Organic World Congress and 2nd ISOFAR scientific research track– cultivating the future based on science at Modena, Italy, 2008. Presented paper during the IAHA Pre-Conference on Organic Animal Husbandry, Organic World Congress of IFOAM in India, 2017. Having 40 national and international publications research publications, 15 technical papers, books and booklets at credit. Co-author of technical manual and information system on 'organic livestock farming', also ICAR book on 'Organic livestock farming'. Delivered informative and persuasive talks through Radio & Television programmes for bringing wider awareness in the innovative farming i.e. organic livestock farming. Guided post-graduate student in the area of organic dairy farming and involved in capacity building programmes of Veterinarians and livestock farmers especially women with focussed attention on organic livestock farming. Carrying out orientation programmes at farmers fields on recommended ethnoveterinary practices for applicability in organic livestock production systems. Attended training in the area of Accreditation Evaluation and Surveillance Procedures of Certification bodies under NPOP, Govt. of India organised by APEDA and member of Evaluation Committee of certification bodies of organic production and products, APEDA, Govt. of India, New Delhi. Completed ALGOA Organic Foundation course, 2021 and presented paper during the 4th Organic Asia Congress held at Jakarta, Indonesia, 2021 through virtual platform.

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Suknicom, Dr. Siriwan

(Thailand)

She graduated with a doctoral degree in food technology from Chulalongkorn University in 2021. She is interested in research on food hydrocolloids, konjac glucomannan, emulsion technique microencapsulation and food law of Thailand. Within the last 10 years, she has published more than 10 scientific papers. Most of them are in the field of food hydrocolloids, food chemistry, as well as nutrition (both in English as well as in Thai). Nowadays, she is a lecturer at the department of food science and technology, faculty of Agricultural Technology and Agro-Indutry, Rajamangala University of Technology Suvarnabhumi, Thailand. She is also working on GMP and GAP standards for community products (in Thailand call ONE TAMBON ONE PRODUCT, OTOP). In addition, she works with the Food and Drug Administration (Thai FDA) to take care of Thailand's food safety.

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Swami, Dr. Sanjay

(India)

He obtained Ph.D. in the field of Soil Science from CCS Haryana Agricultural University, Hisar, India. After Ph.D., he took up a research position at ICAR-CSSRI, Karnal and then served SKUAST-Jammu as Assistant Professor and subsequently as Senior Scientist & Head of Krishi Vigyan Kendra. Presently, Dr. Swami is Professor in Soil Science and Agricultural Chemistry at School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, Barapani, Meghalaya under Central Agricultural University, Imphal. Apart from teaching, he is an active researcher in the field of conservation and management of natural resources, especially in the Indian Himalayan Region for more than 18 years. He handled 7 externally funded projects and contributed over 150 research papers in various journals of international repute. He has also to his credit 18 standard books and more than 50 book chapters. He has guided/guiding 5 Ph.D. and 13 M.Sc. scholars, attended more than 25 international conferences, presented research papers and won many prestigious awards *viz.* SCSI Gold Medal Award, SCSI Leadership Award, Young Scientist Award, Distinguished Scientist Award, Outstanding Achievement Award, Global Scientist Award, Outstanding Eminent Scientist Award, Established Teacher in Soil Science Award, etc. The Grassroots Institute, Canada and the Soil Conservation Society of India conferred upon him the Senior Global Fellow Award and the National Fellow Award, respectively. He has wide international exposure. He is editor, associate editor, consulting editor and reviewer of many national and international journals.

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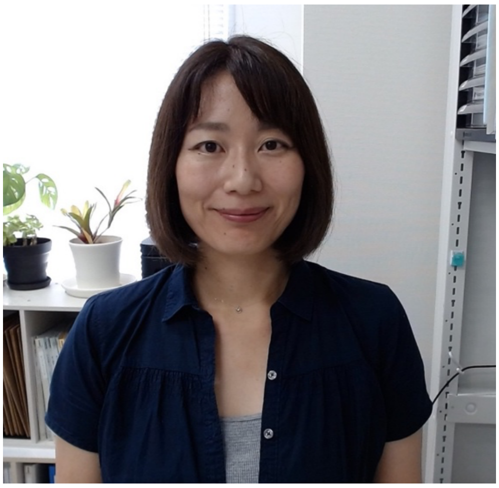

Taniguchi, Assoc. Prof. Dr. Yoko

(Japan)

Yoko Taniguchi is a researcher with more than 20 years of experience in working organic food marketing research. She specializes in agricultural economics and is responsible for teaching basic issues in organic agriculture, as well as some social scientific theories, including statistics and marketing. Her research topics include: 1) How to improve quality, quantity, and international comparability of organic food market data; 2) Basic Human Values and behavioral characteristics of organic food buyers; and 3) Values, images, and brand personality associated with organic food products and its implications. Her current research interest centers around the difficulty in forming healthy community and industry development of organic sector due to the “collective” nature of organic brand, in which act of individual players affect the entire reputation of the industry or the consumers’ willingness to pay for organic products.

In addition to her research and educational activities, she has closely worked with local organic farmers to promote consumer awareness towards organic food and agriculture. She has organized online promotional campaigns, launched in-restaurant lecture series, and helped running organic farmers market. She now seeks ways to build up a data platform of organic market in Japan.

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Tashi, Assoc. Prof. Dr. Sonam

(Bhutan)

He currently serves as a Dean of Research and Industrial Linkages at the College of Natural Resources, Royal University of Bhutan. Prior to his current position, Dr. Tashi also served as the Dean of Academic Affairs.

Before joining the University in 2008, Dr. Tashi served in various capacities in the Ministry of Agriculture and Forests, including as the Deputy Chief of Horticulture and General Manager in Druk Seed Corporation.

Dr. Tashi is an editor of the *International Journal of Environment* and *Bhutan Journal of Natural Resources Development*. In July 2022, after about eight years, Dr. Tashi resigned as an assoc. editor of the *Organic Agriculture Journal* of the International Society of the Organic Agriculture Research. Besides authoring several peer-reviewed articles on organic agriculture, Dr. Tashi is a regular reviewer of national and international journals. Amongst several initiatives in organic agriculture sector, he also introduced BSc in Organic Agriculture in the College of Natural Resources in 2019.

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Workshop 1: How to scale-up Organic farming in Korea?

Acronym: Up-scaling

Moderator: Dr. Shaikh Tanveer Hossain (Bangladesh)
Rapporteur: Dr. Piumi Abeysundara (Sri Lanka)
Date: Oct 2nd, 2022

Oct 2nd, 2022	Impuls presentations by:
10:30 – 12:30	**Session 1:** • Sanjay Swami (India) • Javkhlantuya Altansuvd (Mongolia) • Khaled Sassi (Tunisia) • YokoTaniguchi (Japan)
14:00 – 16:00	**Session 2:** • Sheikh Md Rafiul Hoque (Bangladesh) • Gurudatta M. Hegde (India) • Hoi Pham Van (Vietnam) • Pierre Ferrand (France) (online)
16:00 – 18:00	**Session 3:** • Mohammadreza Rezapanah (Iran) • Piumi Abeysundara (Sri Lanka) • Uddin Md Jashim (Bangladesh) • Puangrat Kajitvichyanukul (Thailand) (online)

Organic Farming in South Korea has developed incredibly in recent decades. It is one of the emerging countries in the global organic sector in terms of movement, consumer awareness, and government supports. Some good organic programs and practices are already highlighted, such as local governments initiatives, school meal programs, research and development such as organic seed production and seedling techniques, organic fertilizer & biopesticides, multi-functionality of organic agriculture, bio-engineering, organic cooperatives, and consumer organization in the high level of a global perspective. The environment-friendly (organic plus pesticide-free) products sales reached around 1.13 billion euro in 2020 (Korea Rural Economics Institute, KREI). Despite these achievements, Korea most recently reported around 38,000 hectares of certified organically managed land. The country's overall organic coverage is about only 1% of the cultivated land. Climate change adaptation, carbon neutrality, organic breeding programs, animal husbandry, consumer outreach, producers' socio-economical aspects could get more attention and focus on rice with other high-value crops for improving the organic sector. The workshop will showcase and discuss successful organic farming models and technologies developed and practiced in different countries and way forward to diseminate in other places. It will also discuss how to improve the current continuous progress and possible ways to improve the productivity and profitability of the organic agriculture of Korea in the coming years.

A novel approach for phosphorus estimation in organically managed acidic soils, Meghalaya, India

SANJAY SWAMI [1]

Key words: Phosphorus, pools, extractants, acidic soil, organic farming, soil testing protocol.

Abstract

Organic farming systems possess somewhat different nature of nutrient pools as compared to the conventional farming systems. Besides the solution phosphorus (P) pool, the organic as well as insoluble inorganic P pools are quite significant as far as the phosphorus nutrition of the plants is concerned. The dynamic fraction of P, which is considered in conventional soil testing, cannot explain the correct status of phosphorus in soils under organic production systems as the conventional soil testing protocols do not take into account the potentially available P pools. Proper interpretation of these pools is very important to suggest a balanced manuring plan for a sustainable and successful organic production system. Hence, a different extractant which can extract such potentially available P pools in an acidic soil under organic production system is highly required. The extraction, mineralization and solubilization of the potentially available P pool by various organic acids produced by the beneficial soil microorganisms can serve this purpose. Therefore, the present investigation was carried out to identify the best suitable P extractant(s) to extract such potentially available P pools. Under this investigation, 40 random soil samples were collected from each of the five selected sites viz. two conventional farms: CPGS-AS farm, Umiam; a farm of Palwi village, and three organic farms: ICAR organic farm, Umiam; a farm of Krydem village, and a virgin forest farm of CPGS-AS, Krydemkulai. The soils were acidic with low available P content. Further, five organic acid extractants viz., 2% citric acid extractant; double lactate extractant (0.02 M Ca-lactate + 0.05 M lactic acid at pH 4.1); 2, keto-glutaric acid extractant (0.05 M 2 keto-glutaric acid + 0.02 M HCl at pH 4.0); acetic acid extractant (0.54 N acetic acid + 0.7 N sodium acetate at pH 4.8) and lactic acid extractant (0.02 M Ca-lactate + 0.02 M HCl at pH 3.7) were employed to obtain different sizes of potentially available P pools which were compared with the conventional Bray 1 extractant (check). Multiple linear regression models were obtained for each of the extractants taking total P as the dependent variable, organic carbon and the extractants as independent variables. Result revealed that in comparison to the conventional Bray 1 extractant, 2% citric acid and double lactate extractants, among 6 different tested extractants were found to strongly define the variation of total P in organic soils. Hence, 2% citric acid and double lactate extractants may be proclaimed as the promising extractants which can best estimate the potentially available phosphorus pools in organic farms of Meghalaya and the soil must be tested with these extractants to march towards a successful organic cultivation.

Introduction

Phosphorus (P) plays a major role in growth and development of the plants and significantly contributes in energy storage and transfer. Depending upon the soil pH, different orthophosphate forms are present in the soil solution. Proper replenishment of the soil solution P is must to meet the plant P demand. Besides the soil solution P pool, the organic as well as insoluble inorganic P pools are quite significant as far as the phosphorus nutrition of the plants is concerned because both these pools contribute high amount of available phosphorus for plant uptake through mineralization and solubilization processes. More than 50 % of the total P is contributed by organic P with the range varying from 15 % to 80 %. Inositol phosphate, phospholipids, nucleic acids, nucleotides and sugar phosphates are the important organic pools of P out of which the inositol phosphate, phospholipids and nucleic acids are the major contributors of the organic P with inositol phosphate consisting of 35 % or more of the total organic P, phospholipids consisting of 1-5 % of the total organic P and nucleic acids consisting of around 0.2 to

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2.4 % of the total organic P in soil (Das 1996). The most common phosphate ester, inositol hexaphosphate, contributes around 50 % of total soil organic P. The nucleic acids and most of the inositol phosphates in soils are the products of microbial degradation of the plant residues. Nucleic acids (RNA and DNA) are also rapidly degraded by soil microbes and they also contribute a portion towards total soil P. Phospholipids, which are derivatives of glycerol, are also readily degraded by soil microorganisms. The remaining percentage of soil organic P also originate from the soil microbial activities, where, the cell walls of bacteria contain a significant amount of stable P esters. This emphasizes the significance of microorganisms in their contribution towards the organic P pool.

Organic farming systems possess different nature of nutrient pools as compared to conventional farming systems. The dynamic fraction of P which is considered in conventional soil testing cannot explain the correct status of phosphorus in soils under organic production systems because the conventional soil test protocols for P do not take into account the potentially available inorganic P pools under organic production system which is otherwise a very important contributor in P nutrition, resulting in improper fertilizer recommendation that fails to attend the expected yields (Saha and Mandal 2011). Thus, through the conventional methods of P extraction, one cannot know about the amount of P which is available in an organic farm. Hence, a different extractant which can extract such potentially available P in an acidic soil under organic production system is highly required.

The mineralization and solubilization of the organic P and the insoluble inorganic P present in the soil is mainly catalyzed by the enzymes and organic acids released by various soil microorganisms, plant roots and decomposing organic matters. Phosphatase enzymes have the capability of mineralizing or dephosphorylating all known organic phosphates of plant origin (Das 1996). Also, several of the released organic acids have the ability to complex Al, Fe, Ca, Mg, Mn, and Zn by ion-exchange, surface adsorption, coagulation and peptization reactions and, therefore, play an important role in the mobilization of such metals in soil-water systems. These complexation reactions may lead to the release of P from P-bearing minerals (Kpomblekou-Ademawou and Tabatabai 1994). For extracting or estimating these potentially available P pools under organic farming, generally organic acids are recommended.

The soils of North-Eastern Hill (NEH) region of India are generally organic in nature. Meghalaya, one of the states in NEH region, is also by default organic and the farmers of this region are mainly organic producers. Further, out of 21 million hectares (m ha) acidic soil of NEH region of India, Meghalaya covers 2.24 m ha acidic soils (Singh and Sanjay-Swami 2020). These soils are deficient in phosphorus mainly due to leaching of bases through high rainfall and fixation of phosphate in the iron and aluminium oxides and hydroxides. Therefore, proper study and access of the organic P and inorganic insoluble P pools in acidic soils has its importance in suggesting a balanced manuring plan to the farmers for a sustainable and successful organic production system. Therefore, the present investigation was carried out to test the tailed five organic acid P extractants keeping Bray 1 as check and develop a unique soil testing protocol for phosphorus estimation in organically managed acidic soils of Meghalaya, India.

Materials and methods

Meghalaya is predominantly hilly and geographically known as "Meghalaya Plateau". For the present study, five sites were selected representing two conventional production systems (1) CPGS-AS Research Farm, Umiam and (2) Palwi Village, Bhoirymbong, and three organic production systems, (3) ICAR Research Farm, Umiam, (4) Krydem Village, Bhoirymbong and (5) CPGS-AS Research Farm, Krydemkulai. Forty (40) random soil samples from the plough layer i.e., 0-15 cm depth were collected in a zig-zag manner throughout the each selected five sites. The soil samples were well composited and six composite samples of 1 kg each were derived from each of the sites. The composite soil samples were brought to the laboratory and processed for estimation of soil organic carbon (SOC) by the rapid dichromate wet digestion method (Walkley and Black 1934) and total phosphorus (Total P) by the digestion method with perchloric acid at 130 °C (Jackson 1958). The soil samples were subjected to five different tailored organic acid extractants *viz.,* acetic acid extractant (0.54 N Acetic acid + 0.7 N Sodium acetate at pH 4.8), citric acid extractant (2 % Citric acid), lactic acid extractant (0.02 M Ca-lactate + 0.02 M HCl at pH 3.7), double lactate extractant (0.02 M Ca-lactate + 0.05 M Lactic acid at pH 4.1) and 2, keto-glutaric acid extractant (0.05 M 2 keto-glutaric acid + 0.02 M HCl at pH 4.0) and their combinations, along with conventional Bray 1 extractant for acidic soil as check to determine the respective extractant soluble P_2O_5 pools in the selected sites.

The data obtained were statistically analyzed and the means of each of the parameters were compared using Duncan's Multiple Range Test (DMRT) and significance of differences between the parameters means was tested with critical difference (C.D.) value at 1 % level of probability as described by Gomez and Gomez (1984). Further, multiple linear regression analysis was performed with total P as dependent goal variable to find out the suitable extractant/s which can best define the variability of total P in organic soils.

Results

Organic soils have significantly higher organic carbon than that of conventional soils. The highest organic carbon was recorded in the virgin forest soils of CPGS-AS farm, Krydemkulai with a value of 2.53 % and the lowest value was recorded in the CPGS-AS farm, Umiam i.e., 1.13 % (Table 1). Total P differed significantly in the soils of selected sites. It was higher in the organic soils than that of conventional soils. Highest total P was recorded in the organically managed soil of the ICAR farm, Umiam (1933.35 kg/ha) whereas the conventionally managed farm of CPGS-AS, Umiam recorded the lowest total P (1321.58 kg/ha) as depicted in Table 1.

Table 1: Soil organic carbon and total P of the selected sites under conventional and organic production system

Site	Production system	SOC (%)	Total P (kg/ha)
1	Conventional	1.13±0.06c	1321.58±13.57e
2	Conventional	1.20±0.07c	1542.12±6.59d
3	Organic	1.81±0.14b	1933.35±4.30a
4	Organic	1.65±0.10b	1748.18±3.60b
5	Organic	2.53±0.13a	1645.67±4.44c

*Means not sharing the same letters in the same column differs significantly (at $p<0.01$) by DMRT

Quantification of potentially available P pools by organic acid extractants

The amount of P_2O_5 solubilized by five different organic acid extractants showed 2, keto-glutaric acid as the highest contributing P pool in acidic soils under organic production system (Table 2). The outcome revealed that this pool demonstrated a gradual increase in the sizes of soluble P_2O_5 from 60.413 kg/ha to 63.344 kg/ha up to 68.120 kg/ha in the organically managed soils of the ICAR farm, Umiam, Krydem village, Bhoirymbong block and the farm of CPGS-AS, Krydemkulai, respectively. Significantly lower values of 29.631 kg/ha and 25.257 kg/ha were recorded in the conventional soils in the farm of CPGS-AS, Umiam and the farm of Palwi village of Bhoirymbong block, respectively.

Table 2: Organic acid extractants soluble P_2O_5 pools in the soil of the selected sites under conventional and organic production system

Site	Production system	Acetic acid soluble P_2O_5 (kg/ha)	Citric acid soluble P_2O_5 (kg/ha)	Lactic acid soluble P_2O_5 (kg/ha)	Double lactate soluble P_2O_5 (kg/ha)	2, keto-glutaric acid soluble P_2O_5 (kg/ha)
1	Conventional	4.227±0.41b	12.220±0.90d	18.790±0.75a	33.180±1.00c	29.631±1.06c
2	Conventional	3.520±0.41b	5.630±0.46e	17.983±0.68ab	27.137±1.06d	25.257±1.00c
3	Organic	6.427±0.37a	45.365±0.75a	16.340±1.00abc	47.590±1.03a	60.413±1.06b
4	Organic	6.599±0.29a	32.231±0.90b	14.990±0.60c	43.736±1.29ab	63.344±1.49ab
5	Organic	6.827±0.63a	24.027±1.28c	15.693±0.62bc	42.517±1.28b	68.120±1.71a

*Means not sharing the same letters in the same column differs significantly (at $p<0.01$) by DMRT

Developing a ready-to-use soil testing protocol

The data obtained were subjected to multiple linear regression analysis considering all the possible combinations of extractants with total P as dependent variable revealed that both citric acid extractant and double lactate extractant were able to strongly define the variation of total P content in organic soils with the highest R^2 value of 0.93 i.e., 93 % of the variability in total P could be explained by running this model (Table 3). This is followed by the combination of citric acid and acetic acid extractants as well as the citric acid and lactic acid extractants which were statistically at par with R^2 values of 0.81 for both the models. The combinations of citric acid and 2, keto-glutaric acid extractants, acetic acid and lactic acid extractants, acetic acid and double lactate extractants, acetic acid and 2, keto-glutaric acid extractants, lactic acid and double lactate extractants, lactic acid and 2, keto-glutaric acid extractants and double lactate and 2, keto-glutaric acid extractants resulted in the R^2 values of 0.78, 0.59, 0.64, 0.69, 0.69, 0.60 and 0.63, respectively. The detailed relationships of the variation of total P with the independent variables as described by the ten equations (1-10) are presented in Table 3. Hence, the citric acid and double lactate extractants could be claimed as suitable extractants to explore the potentially available phosphorus in acidic soils under organic production system.

Table 3: Regression equations of different combination of extractants

S. No.	Equation	R^2
1.	Total P= 1458.90 + 183.74 OC% + 17.26 (Citric acid-P) – 97.61 (Acetic acid-P)	0.81
2.	Total P= 2218.66 – 29.06 OC% + 10.00 (Citric acid-P) – 46.01 (Lactic acid-P)	0.81
3.	Total P= 2566.36 + 268.41 OC% + 37.75 (Citric acid-P) – 58.63 (Double lactate-P)	0.93
4.	Total P= 1282.57 + 94.66 OC% 13.70 (Citric acid-P) – 2.62 (2, keto glutaric acid-P)	0.78
5.	Total P= 2768.57 – 97.39 OC% + 62.94 (Acetic acid-P) – 78.51 (Lactic acid-P)	0.59
6.	Total P= 699.23 + 73.20 OC% – 97.68 (Acetic acid-P) + 34.93 (Double lactate-P)	0.64
7.	Total P= 2474.78 – 363.82 OC% – 591.26 (Acetic acid-P) + 61.45 (2, keto glutaric acid-P)	0.69
8.	Total P= 2248.48 – 85.40 OC% – 64.39 (Lactic acid-P) + 15.73 (Double lactate-P)	0.69
9.	Total P= 2287.97 – 155.83 OC% – 48.26 (Lactic acid-P) + 8.48 (2, keto glutaric acid-P)	0.60
10.	Total P= 927.90 – 75.19 OC% + 17.05 (Double lactate-P) + 3.51 (2, keto glutaric acid-P)	0.63

Discussion

The higher amounts of SOC in organic soils might be because of the incorporation of the crop residues, and organic manures into the soils and better root growth under organic production system. Similar results have been reported by Karishma and Prasad (2015). Similarly, higher value of total P in organic soils than the conventional soils might be due to accumulation of P from the crop residues as well as from the organic matter residues at the surface as highlighted by Scheiner and Lavado (1998). The amount of P_2O_5 solubilized by five organic acid extractants was found to be in the order in organically managed soils: 2, ketoglutaric acid soluble P_2O_5 > double lactate soluble P_2O_5 > citric acid soluble P_2O_5 > lactic acid soluble P_2O_5 > acetic acid soluble P_2O_5 (kg/ha). The reason behind the large size of 2, keto-glutaric acid extractant soluble P_2O_5 might be because 2, keto-glutaric acid has a keto functional group along with two carboxyl group in its structure which resulted in its tremendous chelating property. The findings of Dey et al. (2019) supports the findings of present investigation with respect to 2, keto-glutaric acid extracted P_2O_5. Whereas, the overall contribution of acetic acid extractant soluble P_2O_5 towards P nutrition was relatively smaller as compared to the contributable sizes solubilized by the other extractants. This might be because acetic acid is a monobasic acid with one carboxyl functional group which triggered lesser extent of chelation of the predominant iron and aluminium ions. Similar results were obtained by Korndorfer et al. (1995) while using water, Mehlich 1, and 0.5 M acetic acid as P extractants. Further, the multiple linear regression analysis targeting all possible combinations of extractants with total P as dependent variable revealed that both citric acid extractant and double lactate extractant were able to strongly define the variation of total P content in organic soils with the highest R^2 value of 0.93. Therefore, it may be advised to test organically managed acidic soils for potentially available phosphorus through citric acid and double lactate extractants, and accordingly recommend P manorial plan for successful organic cultivation.

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Determine the use of organic sheep wool fertilizer for Gobi soils in Mongolia

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Key words: Organic fertilizer, wool pellet, Gobi soil, nutrient, organic material

Abstract

The purpose of this study is to determine the dosage of sheep wool fertilizer in the Gobi soil and how it affects the eroded soil. Nitrogen content in Mongolian sheep's wool fertilizer is 8-9%, but the research and use of wool fertilizer is not currently practiced and is not widely known to farmers due to the scarcity of research in our country. Wool fertilizers at a rate of a) 2 tons, b) 5tonn, c) 10 tons, d) 20 tons, and e) wool fertilizer mixed with mineral fertilizers were applied to low-yielding light loamy and sandy soils of the Gobi with three types of perennials in 6 variants. The control was installed for comparison. Soil organic matter, nutrient contents, and plant growth attributes were estimated. The results suggest that sheep wool can be used successfully as wool fertilizers increased soil nitrogen and organic matter contents and vegetation cover, but decreased soil mineral contents. Both soil nutrient indices and plant growth were statistically significant when 2 tons, 5 tons, and 11 tons of wool fertilizers were applied for biological restoration in mining sites and it is economical to fertilize wool with 2 tons of fertilizer. Before the experiment, the vegetation cover of our experimental area was less than 1%, but as a consequence wool fertilizer application, the vegetation cover increased to 50-60% and the plant species increased by 40% compared to the natural state. Our conclusion as wool fertilizers were more effective than mineral fertilizers in the biological restoration of mining sites.

Introduction

The purpose of this study is to determine the dosage and use of Mongolian wool pellet fertilizer and its affect on soil fertility. In our country, wool pellet is produced by Mon pellet company. The company has been conducting research since 2017, producing fertilizers since 2020, and selling them on the market from 2021. However, due to the lack of detailed research on the dosage to be used in our country, consumers do not know it well. In some EU countries, wool compost has been studied since 2008 and is used in agricultural and mining rehabilitation. The advantages of wool fertilizer are as follows

- ecological multi-functional fertilizer with long-term effect (up to 10 months)
- 100% renewable, without extraneous additives and chemicals
- soil loosening by swelling effect and water storage (up to 3.5 times of its own weight) in the soil
- good manageability through point by point and low-loss dosage under or around the root balls
- fertilizing function in combination with humification
- profound maintenance of soil biology through a continuous nutrient and moisture regime
- remedy against acidification trends in soils

Based on research works done in foreign countries, we need to re-introduce our country's sheep wool into agricultural and pasture soils. This is because our country is a livestock country, and there is an opportunity to use a lot of valuable resources to improve soil nutrients. Dundgovi aimag, where experimental work has been performed is a natural zone with a predominantly steppe zone in the north

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and a desert steppe zone in the south. Dundgovi aimag is a natural zone with a steppe zone in the north and a desert steppe zone in the south. The same as for the rest of Mongolia, it has a harsh continental climate, but it is relatively warm. Winters are warm and sparsely snowy, summers are relatively long, hot and sparsely rainy, with heavy storms in spring and autumn, and are hot and dry. Therefore, we compared the effect of pellet fertilizers made of sheep's wool with mineral fertilizers on soil nutrients and sought to establish appropriate doses for Mongolian pasture soils.
Experimental variations

When sowing in the experimental area, 3 parts of the selected area was manually cultivated to a depth of 0-20 cm, and the seed norm was 70 g per 1 m2 area and planted between June 10-15, 2021. Plant biometric measurements were made 4 times during the growth with 30-day interval period. Six variants of the test site were selected for a total of 36 plots or 300m2 with 3 repetitions, and 4 types of perennials were selected as rehabilitation cultivar. An experimental scheme is shown (Table 1).

Table 1. Allocation of test site

Variations	1	2	3	4	5	6
Field 1	WP:P:K	WP:2 tn	Con	WP:11 tn	P+K	WP:5 tn
Field 2	WP:P:K	Con	WP: 2 tn	WP: 11 tn	WP:5 tn	P+K
Field 3	P+K	WP:P:K	WP: 5 tn	Con	WP:11 tn	WP:2 tn

Result

In order to study the effect of sheep wool fertilizer on soil fertility, soil samples were taken from each variant in a sampling bag before sowing and during plant growth for the laboratory analysis. Soil analysis were done following related standards MNS 3310:1991, MNS ISO 11466:2007, MNS ISO 22036:2014 and the results of the analysis are compared and shown in the tables and graphs below.

Table 2. Statistical probability test results

	Test Statistics a,b							
	pH	EC	Salt	NO3	CaMg	Ca	Mg	Total N
Chi-Square	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
df	2	2	2	2	2	2	2	2
Asymp. Sig.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

a. Kruskal Wallis Test, b. Grouping Variable

According to the results of the analysis, the soils of the three sites selected in the experimental scenario did not differ from each other in terms of basic chemical parameters (P = <1.0000). In terms of total soil nitrogen content, the maximum increase was 8.3 ± 6.0 for the 11 ton variant of wool fertilizer, and the mixed version for organic fertilizers and mineral fertilizers was higher than for the single mineral version (f = 257.0, p <0.0001). In terms of field moisture, the moisture content increased statistically significantly in July-September, specifically by 11 ton and 5 ton variations (f = 5.1, p <0.0001) (Graph 1). Soil moisture content was not significantly affected by mineral fertilizer alone or the P-K fertilizer option.

Table 2. Soil moisture changes

Months	WP:P:K		WP:2 tn		Con		WP:11 tn		P+K		WP: 5 tn		Average	
	Moist, %	S. D	Moist, %	S. D	Moist, %	S. D	Moist, %	S. D	Moist, %	S. D	Moist, %	S. D		
July	8.0	5.7	18.1	17.0	2.5	1.4	**3.6**	0.3	5.6	7.4	**4.2**	3.1	6.5	8.2
Aug	8.8	6.5	7.5	1.9	6.5	2.4	**13.7**	11.7	9.2	1.9	**6.6**	3.1	8.4	5.6
Sep	1.2	0.2	1.4	0.1	1.6	0.2	**1.1**	0.4	1.7	0.4	**1.3**	0.3	1.4	0.4
	f=10.5, p=0.003		f=8.2, p=0.019		f=29.5, p=0.000		f=9.77, p=0.012		f=10.6, p=0.004		f=35.1, p=0.000		**f=46.1, *****	
	f = 5.1, p<0.0001													

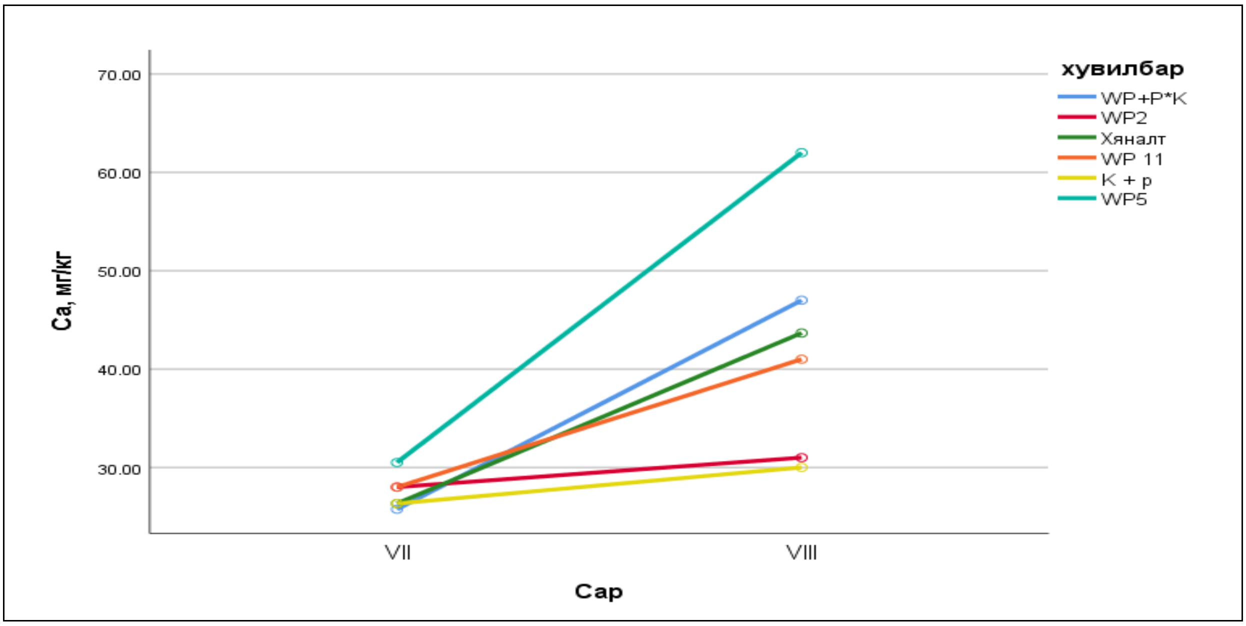

Figure 1. Calcium content changes in the soil

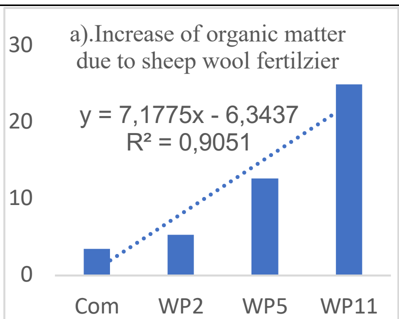	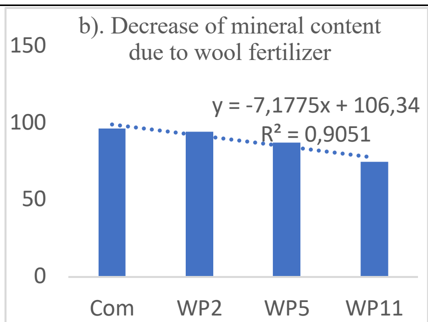	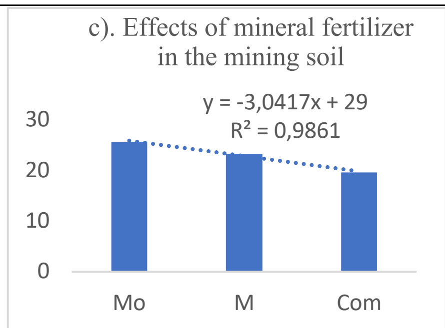
The content of organic matter increases statistically depending on the doseage of wool fertilizer.	Depending on the dose of wool fertilizer, the content of minerals against organic matter decreases.	Wool fertilizers have a better effect on soil fertility than mineral fertilizers R=0.9, P<0.005

Figure 2. Correlation between fertilizers applied in the experiment

Wool fertilizer effect on plant growth

The table below shows that in the first month of the growing season of perennials, in July, no effect of fertilizer was observed on the growth of *Onobrychis sibirica (Sir.) Turcz.* ex grossh. and *Agropyron cristatum (L.) P. B.,* and it is effective on *Elymus dahuricus Turcz. ex griseb.* In the middle and last months of the growing season, the effect of fertilizer is observed on both three types of perennials.

Wool fertilizers have a positive effect on plant growth. In July, there was little statistical impact on *Elymus dahuricus Turcz. ex griseb* and *Onobrychis sibirica (Sir.) Turcz. ex grossh*. From the values shown in the table, values of $P \leq 0.4$ and less are considered significant.

Conclusion

In our study, when 2 tons, 5 tons, and 11 tons of wool fertilizers were applied for biological rehabilitation in mining sites, both soil nutrient parameters and plant growth were statistically significant $p < 0.0001$. (It is economical to fertilize wool with 2 tons of fertilizer). The vegetation cover of our experimental area was less than 1 percent before the experiment, but as a result of our study, the vegetation cover increased to 50-60 percent and the plant species increased by 40 percent compared to the natural condition. In biological rehabilitation of mining sites, wool fertilizers were more effective than mineral fertilizers.

Table 3. The effects of fertilizer on each variation

	Э+O		WP 2		Con		WP 5		Э		WP 11		
O.s	Avrag	SD	Avrag	SD	Avrag	SD	Avrag	SD	Avrag	SD	Avrag	SD	P
VI	2.81	1.83	3.92	1.43	3.21	1.73	4.00	0.67	3.69	1.20	3.44	2.28	0.403
VII	4.80	3.25	6.60	1.60	5.17	3.98	7.15	1.47	6.53	1.70	4.58	3.03	**0.078**
VIII	3.00	7.42	21.95	16.06	17.20	18.53	23.50	4.70	1.10	16.95	13.80	16.37	0.531
IX	7.24	8.00	15.63	7.68	14.64	5.63	20.13	7.91	5.47	3.70	15.02	5.69	**0.322**
f=67.56,		P=0.0001											
E.d													
VI	5.48	1.18	6.54	1.81	5.24	1.66	5.45	1.86	6.03	1.95	5.11	1.85	**0.273**
VII	1.00	3.63	11.55	1.92	11.40	2.92	11.45	1.67	11.53	3.50	10.73	3.57	0.966
VIII	2.68	6.92	22.25	9.19	17.40	7.69	28.40	10.47	19.43	5.85	20.85	7.60	**0.028**
IX	5.22	6.30	32.17	14.10	26.40	10.22	35.74	12.92	30.02	11.36	27.86	8.24	**0.101**
f=292.156		P=0.0001											
A.c													
VI	8.85	2.30	10.08	2.89	7.21	3.19	11.45	3.70	8.63	5.33	9.20	2.61	**0.073**
VII	12.88	1.29	17.00	10.1	12.43	10.26	23.30	7.23	19.60	8.31	6.65	9.82	**0.000**
VIII	24.85	8.71	22.50	9.74	18.73	6.96	27.70	9.73	24.33	5.25	24.13	7.71	**0.117**
IX	20.81	6.03	19.69	11.1	19.97	7.90	27.33	9.43	23.13	5.37	24.67	8.91	**0.130**
f=92.78	P=0.0001												

O.s; Onobrychis sibirica (Sir.) Turcz. ex grossh-Хуцэнгэ, E.d; Elymus dahuricus Turcz. ex griseb-Дагуур өлөнгө A.c; Agropyron cristatum (L.) P. B-Саман ерхөг.

Discussion

Sheep wool organic fertilizer is a high quality fertilizer containing high amount of nitrogen and potassium. Nitrogen is an important element in plant cells (cytoplasm) and green tissue, which are important for plant nutrition and protein production. Potassium helps plant cells to grow, enlarge, and build up pressure. Due to the high nitrogen content of sheep wool fertilizer, it is suitable to apply 5 tons on sandy soils and 2 tons on light loamy soils. It is suitable to be used as a basic fertilizer before planting and sprayed before tillage.

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African Knowledge Hubs approach as an innovative applicable model to promote organic farming in Korea

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Key words: Knowledge, Gap, Collection, Validation, Dissemination, Network.

Abstract

The knowledge gap refers to a disparity in access to information; it is also related to a lack of recognized dissemination channels adapted to different information seekers including farmers. With regard to this situation, the GIZ project « Knowledge Centre for Organic Agriculture in Africa (KCOA) » together with African partners is establishing knowledge hubs in North, East, West, Center and Southern Africa for the collection, validation and dissemination of relevant knowledge. The main goal of the project is to facilitate access to knowledge and to enable organic farmers to contribute in, which mean particular measures toward guaranteeing participation and transparency. In the coming sections, we will emphasize: the knowledge management strategy going from collection to dissemination and the importance of stakeholders' involvement in these processes for the purpose of explaining how the KCOA approach could be a concrete model to boost organic farming in Korea.

Introduction

Organic agriculture plays a crucial role in overcoming hunger faced by large communities around the world. Sustaining organic agriculture provides permanent nutritive resources for future generations to feed a growing world population. To this end, Knowledge Hubs for Organic Agriculture in Africa has been conceived to become an innovative network for promoting organic farming. The KCOA project is financed by the German Federal Ministry for Economic Cooperation and Development (BMZ) and implemented by the German Corporation for International Cooperation (GIZ) GmbH and fits under the special initiative "ONE WORLD No Hunger". The overall goal of Knowledge hubs is to provide important knowledge on organic agriculture for all people along the value chain. With this innovative concept, Knowledge hubs are successfully implementing and achieving its goal of boosting the sector around the continent and could be an applicable model to promote organic farming in Korea and many other countries.

Results

1. Visions of the Knowledge Center for Organic Agriculture in Africa "KCOA"

The overall goal of the Knowledge Center of Organic Agriculture in Africa is: Knowledge hubs as an innovative concept for the promotion of organic farming with actors in the regions of North, West, East Africa and Southern Africa are being successfully implemented.

The project strategy is based on collection, verification and dissemination of relevant knowledge on organic farming and agroecology which is a discipline, seen as a subset of ecology or biology that addressed the relations and interactions between organisms and their environment in ecosystems managed for agricultural purposes. It is an alternative model for developing agriculture. The model is based on each farm being an integrated ecosystem, in which crops, plants and animals interact to create favourable conditions for cultivation (Lund University, 2018). It is also a social movement that links

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producers to consumers, and criticizes the effects of industrialization and the economic framework of the globalized food market. Hilbeck et al (2015) write that "agroecology is neither a defined system of production nor a production technique. It is a set of principles and practices intended to enhance the sustainability of a farming system, and it is a movement that seeks a new way of food production. Currently, agroecology incorporates a threefold dimension: it starts as a scientific discipline (from scientists), it has also evolved into a set of agricultural practices (from farmers), as well as a movement that incorporates social justice, food sovereignty and the preservation of cultural identities (from society) (Barberi et al., 2017).

This holistic vision derives also from the Organic Agriculture. In fact, both concepts (organic agriculture and agroecology) diverge towards the sustainability and the rational use of natural resources and inputs, and take into account biodiversity conservation. Apart of this, Organic Agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. Therefore, Organic farming should be strengthened as a practical and certified approach of agroecological farming.

2. KCOA main objectives and goals

The objective goal of the KCOA project is to facilitate access to knowledge and to enable organic farmers all around Africa to participate in and to contribute to the knowledge management and dissemination which mean particular measures toward guaranteeing participation and transparency. This will be achieved by means of the KCOA Digital Knowledge Platform founded for the purpose to provide a "Home" for users, a space for exchange, networking and self-promotion, as well as, a database for relevant and reliable knowledge.

This model show that if the knowledge hub is operational and if key constraints in production, processing, trading and consumption are addressed, growth will take place in the domestic and export organic trade, which will have positive effects on the environmental, the economic, the social and the cultural spheres. To achieve these aforementioned objectives, the project is based on well-defined axes including collection, validation and dissemination of organic knowledge, as well as, liaison of the stakeholders in the organic sectors in order to improve their conditions. An integrated approach is proposed to address this knowledge gap which include an intervention strategy based on the fact that Hubs firstly collects knowledge and creates a database out of knowledge including in factsheet, videos, podcasts, social media posts etc. This knowledge is verified and validated. Secondly, knowledge is published and promoted to a Multipliers Network (platform) in which the knowledge database will be integrated. This network space is the backbone of the intervention strategy, hence it is carefully built and coached. A participation in the network manifests itself by regestry to the virtual knowledge platform. Users get regular information and access to knowledge sharing opportunities such as posting own content, contribution to knowledge collection, participation in virtual for a and events or eligibility to knowledge hub awards. Selected multipliers are trained to implement micro-interventions in their communities to disseminate the knowledge. Thirdly, the hub builds networks into the whole value chain and to governments in order to promote sector knowledge flow to increase trade and development in an improving policy environment.

3. Knowledge development and dissemination structures

Knowledge is defined as the set of concepts, meanings, skills and routines developed over time by individuals and groups through processing of information. Once the knowledge is acquired, it also brings about changes in overt behavior such as adoption. Knowledge level of farmers refers to the information they posses in respect of organic farming practices (Sahu et al., 2010). Putting organic agriculture into practice requires an in-depth understanding of the complex interrelationships of ecological issues and extensive knowledge of how organic products are produced, processed and marketed locally. This knowledge is, however, often very limited (BMZ, 2020), starting from this situation of "Knowledge Gap" characterized by a deficit of accessible and recognized dissemination channels adapted to different information seekers including farmers and other key players in agricultural production, processing and marketing who do not have contextual expertise to implement and disseminate organic farming practices. The project hubs members established the knowledge management strategy going from collection to dissemination, the dissemination channels including the Digital Knowledge Platform, social media, face to face contact, along with, print material, specific knowledge needs for Organic Agriculture, the knowledge validation process and the importance of the involvement of stakeholders in these processes.

Knowledge management within the context of African Knowledge Hubs is the process of creating, collecting, verifying, validating storing, disseminating, sharing, using and managing knowledge and information. It is a core concept of a knowledge hub and deserves special attention.
The African organic knowledge hubs organize knowledge for operators and multipliers including but not limited to farmers, processors, traders, service providers, government and consumers. It aims at a lively flow of knowledge with the purpose of continuous learning from each other.

3.1. Elements of the knowledge management system

The knowledge management strategy relies on eight elements that are interconnected in three platforms. There are virtual, training and application platforms where knowledge is used. Multipliers are at the heart of these activities and are the key agents of knowledge distribution. They are part of a "multiplier network" and get training from the trainers and apply the knowledge through "micro-interventions". Virtual platform includes the virtual knowledge bank, a social platform for multipliers of knowledge, a network of multiplier of knowledge (multipliers).

The Hub firstly collects knowledge and creates a database out of pieces of knowledge including in texts, videos, podcasts, social media posts etc. This knowledge is verified by staff and – in more complicated cases – by a verification committee and well organized on a virtual platform and in demonstration sites of the hub. Secondly, knowledge is published and promoted to a network of multipliers. This network of the multipliers is the backbone of the intervention strategy, hence it is carefully built and coached. A participation in the network manifests itself by subscription to the virtual knowledge platform. Subscribers get regular information and access to knowledge sharing opportunities such as posting own content, contribution to knowledge collection, participation in virtual fora and events or eligibility to knowledge hub awards.

3.2. Social multiplier platform

The social platform unites all associates of the knowledge hub. Access comes with a simple subscription based on which staff starts an interactive dialog with interesting information and with debates relevant for organic farming (e.g. GMO legislation trends, latest research findings, seed access opportunities, demo plot news, organic events, donor project opportunities etc.). Staff issues regular short information newsletter with the opportunity to comment and discuss items. The platform provides the opportunity for associates to publish their posts and news and to present and promote themselves and their activities. The platform positions itself as the center of a network of multipliers and rural service providers and communicates with that target group in mind. The main language is Arabic. Content and the language level chosen is simple and relevant and attractive to the target group.

The knowledge bank is an integrated part and a key service of the social platform. Again, the social platform starts temporary until the continental infrastructure is ready. While the temporary platform is very basic, we anticipate that the continental platform includes attractive features such as highlighting activities, feedback and voting features or special promotion.

3.3. Multiplier network

All associates of the social platform form the network of the multipliers also called rural service providers. The strength of this network in the three countries and segregated by gender is a key indicator of the knowledge hub development. This includes the number of associates (subscribers) and the intensity of interactions.
Apart from the Internet based activities, the network also organizes face to face events.

The network is mainly used for knowledge promotion and for knowledge interactions in order to make knowledge alive and disseminated. This includes basic knowledge and understanding but also promoting of good practice (including for production and consumption) or information about opportunities (e.g. market partner that need supply or new certification bodies that enter the market).
It can however also be used for promotion of values, for advocacy (e.g. organic framework conditions such as organic law further development) and for the promotion of events (e.g. an annual event of the organic movement). The network is also beneficial for having a participation option e.g. in consultation of national action plans or innovative ideas e.g. in promotion to consumers or in organizing petitions.

3.4. Multipliers

Multipliers are individuals who want to be part of the community and that the hub tries to mobilize. Their profile are women and men that are well rooted in agricultural communities (rural or urban) in their everyday life. They enjoy the trust of their communities and they have the ambition and motivation to contribute to the sustainable development (economically, socially, ecologically and culturally) of their communities promoting agriculture and value chain innovations. They seek contact to likeminded people and are open to receive inspiration, information and opportunities. They have an Internet access e.g. through a smartphone.

Multipliers disseminate the knowledge to farmers, farmer associations and processors. They may be farmers, traders, teachers, intellectuals and returning university graduates, government representatives (e.g. extension agents for agriculture or health), advisors or seeker of an individual business. They can also be from producer organizations, value chain operators or ICS representatives. The definition of multipliers is wide and can include model farms, individual farmers, members of organizations, trainers, trainers of trainers, leaders within farmer associations / processing / marketing units, nutritionists (e.g. in local health care centers), video performers (farmer to farmer videos, Access Agriculture), young digitals using apps, chat groups, blogs, etc. - basically whoever is able to take the knowledge to the farmers, processors, marketers and consumers.

The hub offers them a community with values and a vision, engagement opportunities (including economic opportunities and profiling opportunities), innovative knowledge and training.

3.5. Micro-interventions

Micro interventions are multiplier activities (among other guided by principles of the “Ecole Paysanne”) to introduce knowledge in the communities of the multipliers. Micro-interventions have to follow certain criteria and volume but are mostly determined by the priorities of the community and the multipliers. The service of the implementation of a micro-intervention according to criteria is remunerated from the hub budget.

Discussion

Numerous studies conclude that more knowledge would be key to boost sustainability in farming. Conventional farmers, established companies and institutions often not only lack the knowledge but also the access to knowledge about organic farming. In many cases, only a small impulse is needed to start something big. This is true for every part of the value chain.Therefore, we are working hard to collect, verify and spread organic knowledge. The Hubs is strictly impartial towards stakeholders and is directed to achieve the overall objective. Our knowledge management system is based on various interconnected elements rely in the participation of interested parties. Thus, Knowledge Hub could present potential opportunities for promoting organic agriculture in Korea. Those opportunities can be enhanced through an adaptative intervention strategy based on collection and dissemination of knowledge and identifing key stakeholders that could play the role of a supporter and provider of needs.

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Does "go-getters" image of organic consumers affect organic consumption?

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Key words: go-getters, organic consumers, image of organic foods, brand personality, self-image congruity

Abstract

In this paper, we examined 1) the presence of "go-getters" image toward organic consumers, 2) the characteristics of people who possess such idea, and 3) the impact of having the idea on their own consumption of organic foods. We found that organic foods and consumers both hold good image in general, while small but certain percentage of respondents agrees with several negative image. All personality aspects that are incorporated to grasp the existence of "go-getters" image of organic consumers were sympathized by more than 30 % of respondents, suggesting the existence of certain volume of population who hold such belief. The results of cluster analyses showed that people who are likely to have "go-getters" image on organic consumers, tend to be middle aged, have job, and have higher income, than at least one of the other groups. Their understanding on organic farming is not necessarily poor, and they do not show consistent tendency in the level of consumption of organic foods. We could not find the clear evidence that having "go-getters" image on organic consumers negatively affects their own consumption of organic foods.

Introduction

In Japan, there has been a trend of mocking people who are "go-getters," or "*Ishiki-takai-kei*" in Japanese, and it has been rumoured that some people use the word describe a person who purchase organic foods. If people perceive organic consumers being "go-getters," and consider organic foods as merely the tools of shallow self-branding, it possibly forms negative peer pressure to convince people not to buy organic foods. Consumer theory suggests that the image of typical users of the brand affects the image of the brand itself, so-called "brand personality," and consumers tend to purchase the brand that matches their own self-concept or ideals and the brand personality (Sirgy 1982). Therefore, if people perceive typical buyers of organic foods are "go-getters," and thus organic brands have "go-getters" image, it provides a disincentive for people to associate themselves with organic brands. Therefore, in this paper, we will find out what kind of images people perceives on organic foods and organic consumers, and grasp the presence of people who might consider organic consumers as "go-getters." In addition, we will examine what are the characteristics of the people who holds such idea, and whether it negatively affects their consumption of organic foods.

Material and methods

In this study, an online questionnaire survey was conducted in March 2019 to examine the characteristics of people who think organic consumers as "go-getters." Some 441 samples were collected from the resident of 7 prefectures in Tokyo metropolitan area, with age ranging from 20s to 60s, of which 418 were valid samples. The sample contains younger (those in 20s and 30s) and older (60s and above) age group in less proportion than in the actual population, but the author considered this does not construct a serious problem for this preliminary analysis. However, some samples were randomly removed so that the gender ratio will be 50:50 for each age group and for the entire samples, leaving 314 samples usable for the analysis.

According to Furuya (2017) and Tsunemi (2012), the word "*Ishiki-takai-kei* (go-getters)" has increasingly been used in recent years to describe a person who seek approval more than his/ her actual capacity, show off his/her fulfilling private life, and make unauthentic, superficial efforts. So in the

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survey, five personality aspects, namely, "approval seeker," "acting superior," "ambitious," "crowd follower," and "deceptive" were arbitrarily picked for rating whether each words fits his/ her image on organic consumers. Including these negative personality aspects, a total of 10 aspects are included for rating whether they fit the image of organic consumers or not, all by 6-point Licket Scale. In the same way, respondents were asked to rate a total of 30 adjectives whether they fit the image of organic foods. Questions regarding their demographic information, their level of understanding the word "organic farming," and their consumption level of organic foods were also included.

To capture the characteristics of people with different beliefs in organic consumers' image, respondents were divided into three groups using cluster analysis, of which one cluster represents the people who consider organic consumers as "go-getters," and then, cross analysis was applied to examine the difference from each other. In addition, to see if the "organic consumers are go-getters" belief negatively affects the consumption of organic foods, a regression analysis was applied on the ratio of organic in all vegetables consumed as dependent variable, and the latent variable gained through confirmatory factor analysis as independent variable. Statistical analyses conducted in this study used IBM SPSS Statistics Base ver. 27 and IBM SPSS Amos ver. 27.

Results

a) Perception towards organic foods and organic consumers

The study revealed that in general, people embrace positive image toward organic foods (Table 1). More than 70 % of respondents positively evaluated quality and functional properties of organic foods, such as "good for health," "safe," "good for environment," "high quality," "nutritious," and "tasty." Also, more sensory and abstract properties such as "likable," "intrinsic," "sophisticated," "happy," "advanced," "individualistic," and "pretty," gained affirmative responses from more than 60 % of respondents. While 95 % considered organic food being "expensive" and more than 50 % agreed "troublesome" and "elitist," other negative images received less supporters. However, it is worth noting that more than 20 % of respondents considered organic foods being "superficial," "deceptive," "closed," and "foolish."

Table 1: Image of organic foods[a]

Items	%	Items	%	Items	%
Expensive	96	Happy	63	Exciting	39
Good for health	92	Advanced	61	Traditional	38
Safe	90	Individualistic	60	Superficial	33
Good for environment	89	Pretty	57	Western	27
High quality	87	Neat	56	Deceptive	27
Nutritious	82	Fair	56	Closed	26
Likable	76	Troublesome	54	Interesting	25
Tasty	76	Elitist	52	Foolish	23
intrinsic	69	Fashionable	51	Empty	17
Sophisticated	64	Liberating	51	Unpleasant	14

[a] The figures in the table show the ratio of the sum of the affirmative evaluations out of all evaluations by 6-point Lickert scale, of which three (4, 5 and 6) are affirmative evaluations, and the remaining three (1, 2 and 3) are negative evaluations.

Likewise, organic consumers received good reputation in general (Table 2). More than 60 % of respondents consider the purchasers of organic foods as being "sophisticated," "likable," "hardworking," and "successful." However, some 40 to 50 % of respondents affirmed that organic consumers being "approval seeker," "acting superior," and "didactic." Other negative properties such as "ambitious," "crowd follower," and "deceptive" had less, but more than 30 % of affirmative response. From these results, we can assume that, at non-negligible proportion, there exist people who think that organic consumers are "go-getters."

Table 2: Image of organic consumers[a]

Items	%
Sophisticated	71
Likable	70
Hardworking	63
Successful	59
Approval seeker	54
Acting superior	44
Didactic	39
Ambitious	37
Crowd follower	35
Deceptive	34

[a] The figures in the table show the ratio of the sum of the affirmative evaluations out of all evaluations by 6-point Lickert scale, of which three (4, 5 and 6) are affirmative evaluations, and the remaining three (1, 2 and 3) are negative evaluations.

b) Characteristics of people who make "go-getters" claim on organic consumers

To find out the characteristics of the people who believe that organic consumers are go-getters, a cluster analysis was conducted to divide the respondents into three groups. Before performing cluster analysis, factor analysis was applied to 10 variables related to the perception toward organic consumers. Two factors were extracted, one representing positive personality aspects such as "likable" and "successful" and the other representing negative personality aspects such as "acting superior" and "crowd follower." Then, K-means cluster analysis was performed using these two factors, yielding three clusters: "favourable," "mixed," and "unfavourable" (Table 3). Respondents in "favourable" group are those who possess good image on organic consumers, clearly denying the negative personality aspects while admitting positive aspects. Respondents in "mixed" group have mixed image on organic consumers, making affirmative evaluation on both negative and positive personality aspects of organic consumers. Respondents in "unfavourable" group do not have good image on organic consumers, clearing denying positive personality aspects of organic consumers. As respondents who have "go-getters" image on organic consumers can be identified only with the negative personality aspects, it turned out that they exist only in "mixed" group. To grasp the characteristics of each cluster group, cross-analyses with demographic and other variables were conducted.

Table 3: Clusters according to the perception on organic consumers[a]

	Clusters		
	1	2	3
Factor 1 (negative personality aspects)	-.80885	.79203	-.00605
Factor 2 (positive personality aspects)	.49810	.45123	-1.00034
Cluster name	"favorable"	"mixed"	"unfavorable"

[a] The figures in the table show the final cluster centers obtained as a result of K-means cluster analysis (k=3).

Demographic characteristics

The results of cross-analyses with demographic variables are summarised in Table 4. No significant difference was observed in gender. As for the age, those in "Mixed" cluster had the highest percentage of middle age groups (40s and 50s), and the lowest percentage of people in 20s and 60s. No significant difference was observed for occupation, except that "Mixed" group had lower ratio of unemployed or retired people compared to "Unfavourable" group. As for the educational record, "Unfavourable" group had higher ratio of those who graduated vocational college than "Favourable" group. For both "Favourable" and "Mixed" groups, the largest income level category was "4 million – 6 million JPY", which is higher than the mode of "Unfavourable" group. The median income of those in "Unfavourable" group could be lower, considering the fact that more than 20% of the respondents in "Unfavourable" group either did not know the household income level or chose not to answer this question.

Table 4: Demographic characteristics for each cluster group

		clusters					
		Favourable (n=105)		Mixed (n=108)		Unfavourable (n=101)	
		n	%	n	%	n	%
gender	Male	46	43.8	55	50.9	56	55.4
	Female	59	56.2	53	49.1	45	44.6
Age group	20s and 30s	28	26.7	23	21.3	26	24.8
	40s and 50s	58*	55.2	76*	70.4	60	59.4
	60s	19*	18.1	9*	8.3	16	15.8
Occupation[a]	Unemployed or retired	8	7.6	5*	4.6	15*	14.9
Educational record[a]	Vocational college	12*	11.4	15	13.9	23*	22.8
Household income[a]	4 million – 6 million JPY	28*	26.7	26	24.1	15*	14.9
	Don't know or refuse to answer	13*	12.4	17	15.7	23*	22.8

* significant difference with at least one of other clusters at P<0.05
a Only the options with statistically significant difference (P<0.05) between at least two clusters are shown.

Table 5: Characteristics regarding understanding and consumption of organic food [a]

		clusters					
		Favourable (n=105)		Mixed (n=108)		Unfavourable (n=101)	
		n	%	n	%	n	%
Understanding of organic farming	High	28	26.7	30	27.8	23	22.8
	Middle	64	61.0	60	55.6	50	49.5
	Low	13*	12.4	18	16.7	28*	27.7
Frequency of purchasing organic food	Never	15*	14.3	12*	11.1	40*	39.6
	Hardly ever	10*	9.5	22*	20.4	24*	23.8
	Rarely	18	17.1	17	15.7	14	13.9
	Occasionally	20	19.0	24*	22.2	10*	9.9

	Sometimes	22*	21.0	18	16.7	10*	9.9
	Often	13*	12.4	11*	10.2	1*	1.0
	Regularly	7	6.7	4	3.7	2	2.0
Ratio of organic in total vegetable consumption	Less than 10%	60*	57.1	72	66.7	74*	73.3
	10% - 35%	27	25.7	17	15.7	16	15.8
	35% - 65%	11	10.5	17*	15.7	7*	6.9
	65% - 90%	6	5.7	1	0.9	2	2.0
	90% or more	1	1.0	1	0.9	2	2.0

* significant difference with at least one of the other clusters at P<0.05

Characteristics regarding understanding and consumption of organic food

The results of the cross-analyses with variables regarding understanding and consumption level of organic food are summarised in Table 5. The group with the poorest understanding of organic farming was "Unfavourable" group, having the largest proportion categorized into "Low" understanding. Among the three clusters, "Favourable" group purchase organic foods most frequently, while "Unfavourable" group do so at the least frequency. "Mixed" group does not show a consistent tendency; both occasional buyers and non-buyers showing certain presence. Similar tendency was seen in the ratio of organic vegetables in total vegetable consumption. While "Favourable" group has the higher, and "Unfavourable" group has the lower level of organic ratio in vegetable consumption, "Mixed" group had the highest share in moderate consumption level (35-65%).

c) **The effect of "go-getters" image of organic consumers on the consumption of organic foods**

To see if holding "go-getters" image on organic consumers affect the consumption of organic foods, a regression analysis was conducted using the share of organic in total vegetable consumption as dependent variable and the latent variable obtained through confirmatory factor analysis as independent variable (Figure 1). Goodness of fit indicators of the model such as CMIN, GFI, and RMSEA all suggested the model fits the data very well. However, the causal relationship between the latent variable and the ratio of organic vegetables were not significant. In other words, no statistically significant impact of the "go-getters" image on their own consumption level of organic vegetables were found. This is consistent with what were observed in cross analyses above, which showed "Mixed" group are not necessarily the non-buyers of organic foods; rather, the group included occasional and regular buyers of organic foods with similar intensity with "Favourable" group.

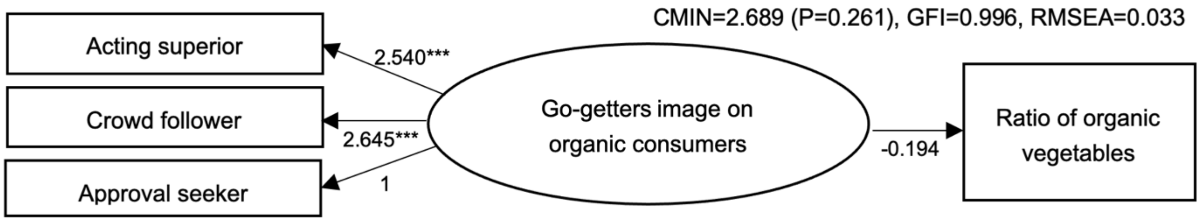

Figure 1. Regression analysis on the effect of go-getters image of organic consumers

Conclusion and Discussion

In this paper, three kinds of analyses are conducted to examine 1) the presence of "go-getters" image toward organic consumers, 2) the characteristics of people who possess such idea, and 3) the impact of having the idea on their own consumption of organic foods. By looking at the simple summary of the survey, we found that organic foods and consumers both hold good image in general, while small but certain percentage of respondents agrees with several negative image. All personality aspects that are incorporated to grasp the existence of "go-getters" image of organic consumers were sympathized by more than 30 % of respondents, suggesting the existence of certain volume of population who hold such belief. The results of cluster analyses showed that people in "Mixed" group, which is more likely to have "go-getters" image on organic consumers, tend to be middle aged, have job, and have higher income, than at least one of the other groups. Their understanding on organic farming is not necessarily poor, and they do not show consistent tendency in the level of consumption of organic foods: there are some volumes in both frequent and infrequent buyers. From the third analysis, we could not find the clear evidence that having "go-getters" image on organic consumers negatively affects their own consumption of organic foods. Based on the result of this study, we can say that "go-getters" image is a part of the brand personality of organic foods in Japan, although it is not widely shared idea. People who perceive "go-getters" image on organic consumers are not necessarily poorly informed about organic food and farming, and they are possibly the occasional buyers of organic foods. It is important for organic industry to seek the causes of forming such negative brand-user image of organic foods, despite the fact such image holders do have some knowledge and experience in purchasing organic foods.

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Utilization of urban bio-waste for rooftop gardening

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Key words: recycling platform, rooftop gardening, solid waste, vermicompost, waste management,

Abstract

In Dhaka city, solid was generated in 1999 was 3500 tonnes/day, which might increase to 10,952 tonnes/day by the year 2025. Around 40-60% of waste generated in the city remains uncollected, and the rest of them goes to dumping fields and virtually causes pollution to water and air. Among these wastes, 80% contain organic matters that can be converted into organic fertilizer. Vermicomposting uses earthworms in the organic waste to transform organic matters into soil-healthy compost. GARBAGEMAN LIMITED is a Dhaka-based organization that successfully collected solid kitchen waste from corporate houses with a win-win mechanism, and organic vermicomposting is one of their successful products. A comparative study reveals that the quality vermicompost, Regen, is filled with high nutrients required for plant growth. They have a unique online 'recycling platform' by which can effectively reach interested the organic urban gardeners.

Introduction

In Bangladesh, the volume of waste generated was 1100 thousand tonnes in 1970 and increased to 1.48 million tonnes in 2012 (Ashikuzzaman and Hawlader 2020, Shams et al. 2017). The amount of solid waste generated in Dhaka city was 3,500 tonnes/day in 1999, which might increase to 10,952 tonnes/day by the year 2025 (CEPS 2014, Hasan et al. 2019). Studies revealed that around 40-60% of the waste generated in Dhaka city remains uncollected and not disposed of safely causing air pollution (Ahsan et al. 2014). These wastes contain 80% organic matter (Prodhan and Kaesan 2020). The air quality index (AQI) was recorded at 184 on 5 March at 8:48 AM in 2022, and AQI between 150 and 200 is considered 'Unhealthy' (The Daily Star 5 March 2022, Oklahoma Environmental Quality 2022). Vermicomposting from urban waste is a good source of organic fertilizer. This paper highlighted a commercial vermicomposting model that aims to minimize urban waste to promote organic farming on urban premises.

Material and Methods

GARBAGEMAN LIMITED (GML) strives to work for the betterment of both the environment and the socio-economic status of waste-pickers and scrap dealers in Bangladesh by introducing modern and formalized approaches to the waste management system. This initiative reduces the usage of landfills by converting organic and inorganic wastes into resources. GML first started its journey in 2018 and has three service lines: 'Recycle Platform'; 'Subscription-based Collection'; 'Zero Waste Consultancy'; and one line product 'Regen Vermicompost'. This section will explain the relevant services of the organization, which are closely related to vermicomposting and the uniqueness of GML.

'Recycling Platform' is an incentive-based service line catering to the household needs of disposing of recyclable wastes. With the help of a simple sign-up form on the online platform, individual households can schedule the collection service with GML once every month, where collectors from the company collect the inorganic recyclables from the subscriber's doorstep (Figure 1). These recyclables are sorted into categories and sent to compliant recyclers instead of throwing them into landfills, where they take

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decades to decompose while emitting harmful toxins in the air and groundwater. Starting from August 2020, GML has conducted 35 collection drives for up to 400 individual households and 40 scrap dealers from 14 areas of Dhaka city and collected around 45 tons of plastic waste, which were redirected to two compliant recyclers for recycling purposes.

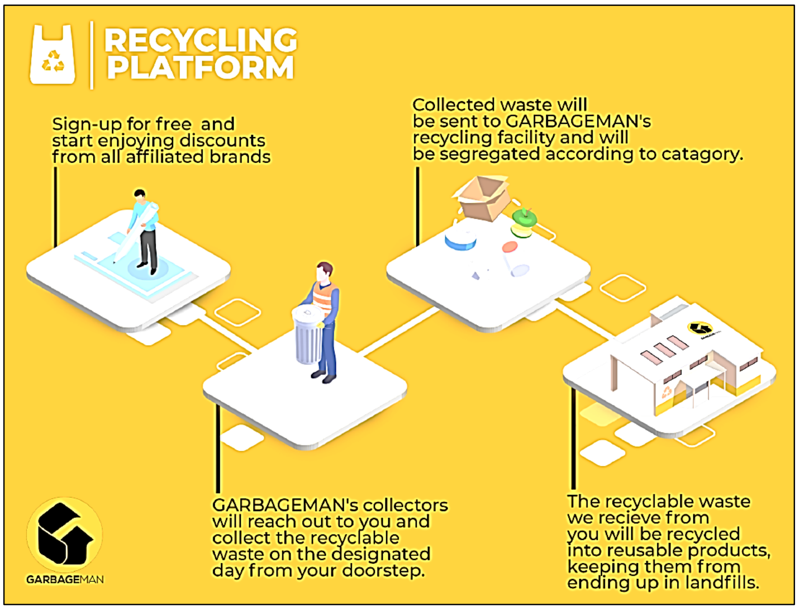

Figure 1. Recycling flowchart of 'Recycling Platform' of GML

'Subscription-Based Collection' service mainly caters to the waste management and disposal needs of corporate organizations that produce organic and inorganic waste in bulk weights daily or weekly. Till now, GML is engaged with large corporates located in Dhaka city and working with them to collect solid waste. GML provides a daily collection service of the kitchen waste which is afterward converted into organic vermicompost in their production factory (Figure 2).

'Regen Vermicompost' is the organic fertilizer that GML produces from kitchen waste collected from the Subscription-Based Collection service mechanism. This fertilizer is potent food for rooftop gardening particularly. GML started selling vermicompost to rooftop gardeners first and built a brand value among individuals. The main reason for targeting rooftop gardeners was to encourage city dwellers for gardening in their leisure time to increase the greenery on the urban premises. It is a unique fertilizer for plants that are solely made of recycled organic wastes. It retains soil moisture and boosts plant health while providing necessary nutrients to grow them faster.

The vermicompost contains 60 micronutrients while tracing calcium, magnesium, nitrogen, phosphate, and potash. Vermicomposting uses earthworms in the organic waste to transform organic matters into soil healthy compost (Dominguez 2004). The worms (E. eugeniae, E. fetida, E. andrei, and P. excavatus) swallow and break the organic matter, simultaneously airing and mixing them by moving through the organic substrate. In this process, the organic matter decomposes optimally with the help of micro-organisms and also enhanced the microbial decomposition rate. Vermicompost provides stimulants necessary for plant growth and contains growth-promoting substances like as; auxin and cytokinin (Krishnamoorthy & Vijranabhaiah 1986).

GML aims to reduce urban waste starting from the corporate level. Corporate social responsibility is the obligation of large corporate organizations, and they need to spend funds for that purpose. Moreover, it is comparatively more accessible for an organization to operate with larger bodies than on a small-scale household level with a small setup. GML has an online city-based 'Recycling Platform' at the household level for collecting inorganic household items. The hybrid nature of the waste management initiative helps GML to reach the customer end with their final organic vermicompost, Regen, for the households interested in rooftop gardening in their urban premises.

Results and Discussion

Vermicomposting is one of the major initiatives of GML to minimize urban waste and source organic fertilizer for urban gardeners. However, the organization did a lab test of their vermicompost product, Regen, which is evaluated in Table 1 for further comparison. The results indicate that GML is producing high quality vermicompost in its production process. The pH level is 7.07, and pH 7.0 means neutral like pure water. Moreover, the high level (19.11%) of organic carbon (OC) presence indicates that soil texture would be improved after using GML's vermicompost.

Moreover, a significantly high percentage (4.56%) of nitrogen (N) level ensures good plant growth, which is also being advocated by the users. Sabah R Haque, an architect & urban gardener, remarks, "My aloe era plant grew so fast and big within a month that I had to put them into different tubs".

Table 1: Results of the chemical analysis of vermicompost (Regen) after 40 days with worms

Parameters	Vermicompost (Regen)	Vermicompost*
pH	7.07	7.59
Organic Carbon OC (%)	19.11	10.48
Total Nitrogen N (%)	4.56	1.67
Total Calcium Ca (%)	1.92	2.83
Total Magnesium Mg (%)	0.28	0.40

* Chaudhury et al. 2000

Nilufar Ahmed, a balcony gardener, comments, "The leaves of lemon and green chili plants became green and fresh after using GML vermicompost". The above remarks indicate the presence of high nutrient contents, especially nitrogen (N) in the GML vermicompost.

Table 2: Cost-benefit comparison of GML vermicompost vs. Competitors' vermicompost

	Cost in Taka** (Tk.)/Kg.	GBL Price Regen/Kg.	Competitor* Price/Kg.	Profit/Kg.
GML	Tk. 45/Kg.	Tk. 65/Kg		Tk. 20/Kg.
Competitor	Tk. 20/Kg.		Tk. 100/Kg.	Tk. 80/Kg.

* Competitors are collecting vermicompost based on a contract farming approach from rural farmers rather than focusing on an urban waste management approach

** 1USD=87.90 (Bangladesh Bank 30 May 2022)

GML solely focuses on urban waste, and competitors collect vermicompost from contract growers residing in rural areas which have been producing vermicompost mostly from cow dung and agriculture waste which has less impact on urban waste minimization and minimizing air pollution. A baseline study reveals that the average space for gardening in Dhaka city was around 1593 sq. feet (150 m^2), and the number of buildings in Dhaka city is approximately 360 thousand. In that case, the effective space for gardening would be approximately 54 Km^2 (Jamaluddin, 2016). If the vermicomposting model is directly linked with urban solid waste and urban gardening, there would be a great probability of reducing waste in the urban area, which may improve the air quality significantly.

However, GBL faces major challenges in renting waste processing premises that might force the organization to keep themselves stuck only to collecting waste from the large corporates based on 'Subscription-based Collection'. They need to transport the collected waste to renowned vermicompost organizations situated outside Dhaka to minimize their operating cost until they are getting support from the government or development organization to subsidize some of their initiatives to stay alive in the fiercely competitive business environment. However, unmonitored or unethical price competition and significant profit loss may put a successful urban waste management-based organic vermicomposting organization to extinction. GML will be an example if no significant strategic initiative is being taken by the policymakers in Bangladesh.

Conclusion

Urban solid waste management is a major challenge for developing countries, especially for densely populated cities, like Dhaka. Vermicomposting from urban waste may be a good source of organic fertilizer that produces low odor, saves space, and requires little effort. GML provides a unique solution for urban-based waste management systems. They concentrated on large waste-generating sources to minimize their handling cost and financial obligations of those corporations for their financial reporting purpose. GML also has an online recycling platform by which they have integrated their quality vermicompost product, Regen, at the doorstep of the urban gardeners. The initiative GML enhances the urban solid waste management slogan and same time, encourages the organic gardening movement. Finally, the movement helps to improve the environmental quality of a city whose air quality index level is unhealthy.

Figure 2. Vermicomposting Process of GML

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Innovation in Bio-pesticides Application for Effective Disease Management of Major Agriculture, Horticulture, and Forest Crops

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Key words: Biopesticides, formulation,microbial consortia, protected cultivation, diseases

Abstract

The minimum terminal disease severity for fungal foliar diseases of ground nut was recorded in sequential application of bioagents (Trichoderma harzianum –Pseudomonas fluorescens – Bacillus subtilis) and has significantly enhanced the plant growth and yield parameters, highest B:C ratio and maximum enzymatic activities. Field experiments revealed that minimum disease severity (24.69 %) was recorded in treatment (seed treatment with canola oil-based formulation of Pseudomonas fluorescens @10ml/kg - spray of canola oil-based formulation @ 0.5 %) which was significantly superior over the other treatments in reducing the spot blotch of wheat crop. The combination sprays of Pseudomonas fluorescens and Bacillus subtilis @ 5 g per litre three times at an interval of 15 days recorded highest reduction of powdery and downy mildews of cucumber and increased the yields, increase in plant height under protected cultivation with maximum net returns and benefit-cost ratio. The seed treatment with Bacillus subtilis and Pseudomonas fluorescens @ 5 g/kg followed by seedling dip with B. subtilis and Pseudomonas fluorescens @10 g/l followed by spray with B. subtilis and Pseudomonas fluorescens 4 times at 15 days interval has considerable reduced the early blight, septoria leafspot and powdery mildew diseases of tomato under protected cultivation with highest net returns. The talc based microbial consortia (Trichoderma harzianum+ Pseudomonas fluorescens + Bacillus subtilis + Neofusicoccumpurvum) was found promising in the management of foot rot of wheat.Management of leaf spot disease of mappiafoetidacaused by Cylindrosporiummappiarevealed the significant effect of use of fungal antagonist and bacterial antagonists in reducing the pathogen growth under laboratory conditions.

Introduction

Plant diseases are among the main constraints affecting the production and productivity of crops both in terms of quality and quantity. Biological control is more relevant today than it has been. Stand alone bio-control agents and products are now available for management of various field, horticulture and forest crop diseases. The development and use of natural antagonists to combat plant diseases has emerged as a promising alternative to chemical pesticides. Liquid bioformulation are microbial cultures or suspensions amended with compatible substances to improve viability, stickiness, stability, surfactant and dispersal ability. The microbial consortia are getting paramount importance in crop production and protection. Application of bioagents as a consortium may improve efficacy, reliability and consistency of the bioagents even under diverse soil conditions. The protected cultivation of crops enhances the success of biological control agents with greater precision than the field crops. Hence, there exists scope for growing organic vegetables under protected structures by use of bio inoculants for pest and disease management.

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Material and Methods

Management of fungal foliar diseases of groundnut through bioagents

Different bioagents were evaluated for their efficacy to manage the three major fungal foliar diseases of groundnut. Three sprays were given to manage the fungal foliar diseases. First spray was given immediately after the disease appearance and subsequent at fifteen days interval. A common seed treatment with *Trichoderma harzianum* @ 10 g/kg seed was given to all the treatments except the untreated control. Observations on disease severity were taken at weekly intervals for all the three diseases. The plant growth parameters and yield parameters and enzymatic activity were analysed by using standard procedures.

Effect of oil-basedPseudomonas fluorescen sagainst Bipolaris sorokoniana causing spot blotch of wheat

The three oil based formulations along with three checks *viz.,* talc based formulation, chemical check, were evaluated against spot blotch of wheat under field condition: Observations on disease severity was recorded before spray and after sprays. Ten plants in each treatment plot were selected randomly to record disease rating and disease rating was done using double digit (DD, 00-99) scale.

Efficacy of Microbial consortia against mildews of Cucumber under polyhouse conditions

Under polyhouse conditions powdery mildew and downy mildew diseases were managed through application of 2kgs each of *Trichoderma harzianum, Pseudomonas fluorescens, Bacillus subtilis ,Paecilomyceslilacius and Metarhiziumansoplia* along with soil test based organic manures (Farm yard manuare, Vermicompost, Rock phosphate and neem cake) at 2:1:0.5:0.5 ratio. The rizwan (indetereiminate) seeds of cucumber were used for the experiment. Seeds were sown in small trays containing coco pits for up to 25 days. Later the seedlings were drenched with *Trichoderma harzianum* @10g/l. Liquid organic manure such as panchagavya and verimiwash was used along with the drip at weekly intervals as a source of nutrition and imparting resistance against attack by pests and diseases. For managing the sucking pests a mycoinsecticide *Lecanicilliumlecanii* and for fruit borer *Nomurearelyi* was used common to all the treatments.

Efficacy of biopesticides against fungal foliar diseases of Tomato under polyhouse conditions

The experiment consists of 8 treatments, viz., T1 (ST with *T. harzianum* @ 5 g kg-1 followed by (Fb) seedling dip with *T. harzianum* 10 g l^{-1} spray with *T. harzianum* 4 times at 15 days interval), T2 (ST with *B. subtilis* @ 5 g kg^{-1} Fb seedling dip spray with *B. subtilis* 4 times 10 g l^{-1} at 15 days interval), T3 (ST with *P.fluorescens* @ 5 g kg^{-1} Fb seedling dip, spray with *P. fluorescens* 10 g l^{-1} four times at 15 days interval), T4 (ST with *T. harzianum* @ 10 g l^{-1} Fb spray with *T. harzianum* @ 10 g l^{-1} four times), T5 (ST with *T. harzianum*@ 5 g kg^{-1} Fb spray with *B. subtilis* @ 10 g l-1 four times), T6 (ST with *T. harzianum*@ 5 g kg^{-1} Fb spray with *P. fluorescens* @ 10 g l^{-1} four times), T7 (Recom. Check (Sulphur) @ 3 g l^{-1}) and T8 (Untreated Control). A split-plot with three replications with a plot size of 2.5m x 1m and 45cm x 60 cm spacing at a distance of 45 cm between the rows and 60 cm within a row on a one-meter wide bed was followed. The diseases like early blight were recorded on a 5-point scale, while powdery mildew and septoria leaf spot were recorded on a 10-point

Pot culture studies on Microbial consortia against foot rot of wheat pathogen

The plastic pots were filled with two kilograms of sieved sterile soil. The sick soil was created by mixing 30 days old growing inoculum of the pathogen at the rate of four percent of soil weight.The seeds were first surface sterilized with sodium hypochlorite (0.1%) and were then treated with talc formulations of fungal and bacterial bio control agents (alone and in combination) at the rate of 10g/kg of seeds. In case of consortia, equal amount of talc formulations of bioagents were mixed (two combination of bioagents were mixed at 5g + 5g per kg of seeds, three combinations of bioagents were mixed at 3.33g + 3.33g

+3.33g per kg of seeds and four combination of bioagents were mixed at 2.5g + 2.5g + 2.5g + 2.5g per kg of seeds) and then air dried. In each pot ten treated seeds were sown and watering was given at regular intervals. After 20 days of sowing, second set of pots were drenched with talc formulations of fungal and bacterial bio control agents (alone and in combination) at 10g/ litre of water and (Carboxin 37.5 % + Thiram 37.5 %)WP at 2g/ litre of water was used as standard chemical check. Each pots were drenched with 50ml of bioagents suspension. In case of consortia, equal amount of talc formulations of bioagents were mixed (two combination of bioagents were mixed at 5g + 5g per litre of water, three combination of bioagents were mixed at 3.33g + 3.33g + 3.33g per litre of water and four combination of bioagents were mixed at 2.5g + 2.5g + 2.5g + 2.5g per litre of water).

Biocontrol agents against *Cylindrosporiummappiacausingleaf* spot disease of mappia

The fungal antagonists *Trichoderma sps* and bacterial antagonists *Pseudomonas fluorescens* and *Bacillus subtilis* were used under *invitro* conditions to manage*Cylindrosporiummappia.* The fungal culture was inoculated at the centre of the petri dish and two 5 mm discs of antagonistic fungi was inoculated on either side of test fungus. Freshly sub cultured bacterial antagonists were streaked at the centre of the petri dish. At two points on either side of the bacterium, 5 mm disc of test fungus *Cylindrosporiummappiae* was inoculated.Observations were recorded on the zone of inhibition produced by the antagonistic organisms.

Results

Biopesticidesin management of fungal foliar diseases of Ground nut

The minimum terminal disease severity for fungal foliar diseases was recorded in sequential application of bioagents (*Trichoderma harzianum –Pseudomonas fluorescens – Bacillus subtilis*) which was found to be on par with wettable sulphur. The sequential application of bioagents significantly enhanced the plant growth and yield parameters (Figure 1).

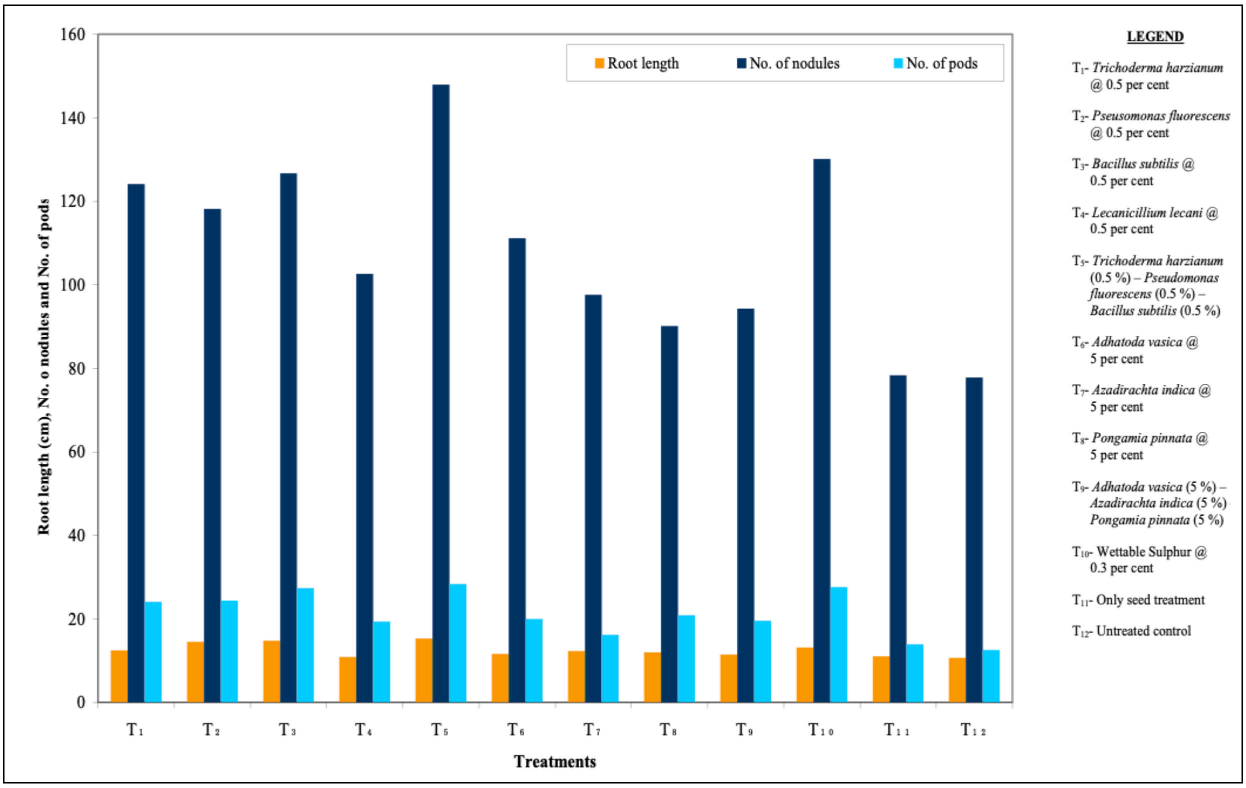

Figure 1. Influence of PGPR on plant growth parameters in ground nut

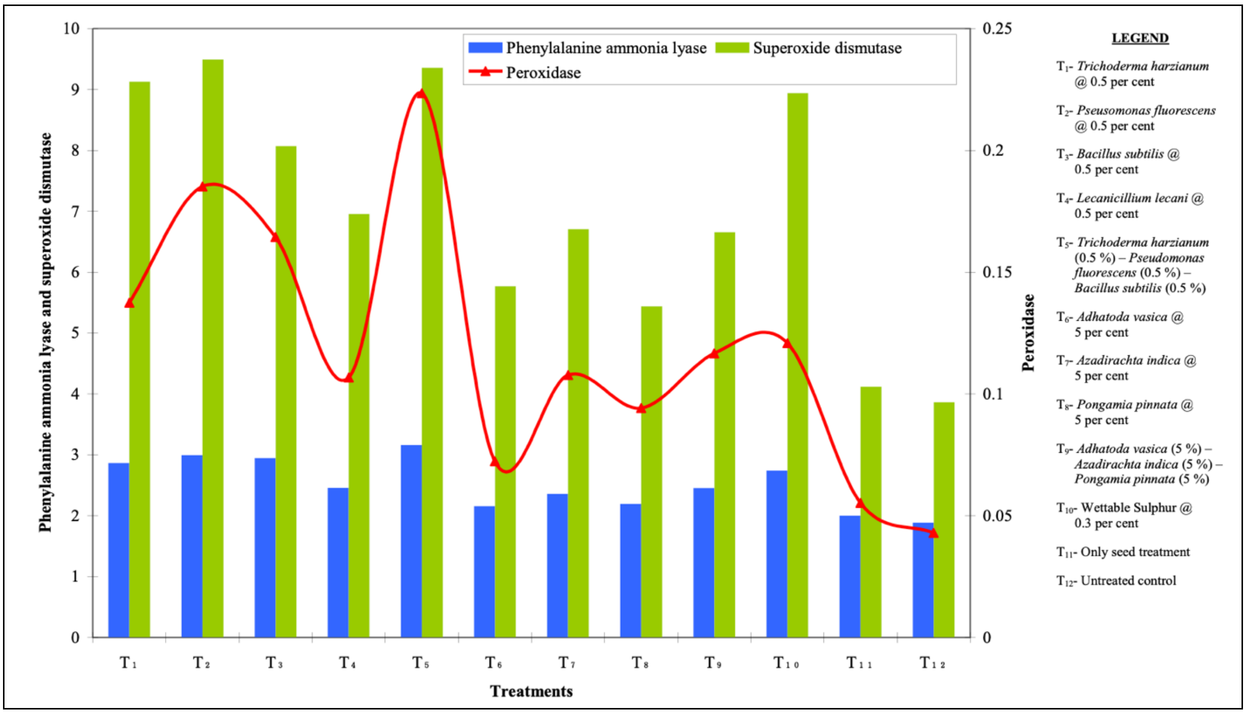

Figure 2. Influence of PGPR on enzymatic activities of Ground nut

Phenylalanine Ammonia Lyase (PAL): The maximum activity of PAL was recorded in sequential application of bioagents (3.161 U/mg protein) followed by *Pseudomonas fluorescens* (2.994 U/mg protein). Peroxidase (POX): Amongst all the treatments, maximum activity of POX was recorded in sequential application of bioagents (0.223 U/mg protein) followed by *P. fluorescens* (0.185 U/mg protein). Superoxide dismutase (SOD): Amongst all the treatments, maximum activity of SOD was recorded in *Pseudomonas fluorescens* (9.492 U/mg protein) followed by sequential application of bioagents (9.356 U/mg protein) (Figure 2).

Oil-based formulations of *Pseudomonas fluorescens* on spot blotch of wheat

Field experiments revealed that minimum disease severity (24.69 %) was recorded in treatment (seed treatment with canola oil-based formulation @10ml/kg - spray of canola oil-based formulation @ 0.5 %) which was significantly superior over the other treatments involving different oil-based formulations, talc based formulation and untreated control. Plant height, yield and quality parameters of wheat grain were significantly enhanced in all the treatments containing *P. fluorescens* formulation compared to untreated control. The highest yield (11.29 q/ha), B:C ratio (1:1.34), GPC (11.44 %), WGC (33.16 %) and GI (92.64 %) were recorded in the canola oil-based formulation (Figure3).

Biopesticides in the management of fungal foliar diseases of Cucumber and Tomato under polyhouse conditions

Spray with suspensions of bioagents significantly reduced severity of both mildews as well as increased fruit yields of cucumber. The combination sprays of Pseudomonas fluorescens and Bacillus subtilis @5g per litre three times at an interval of 15 days recorded highest reduction of both the mildews, increased the yields and also has shown increase in plant height as compared to sole applications. The combined spray of Pseudomonas fluorescens and Bacillus subtilis hasalso resulted in highest net returns and benefit-cost.

In tomato experiment the results showed that seed treatment with *B. subtilis* at 5 g l-1 followed by a seedling dip with *B. subtilis* at 10 g l-1 and spray with *B. subtilis* at 10 g l-1 four times at 15 days intervals significantly ($p<0.05$) reduced the tomato diseases early blight, septoria leaf spot, and powdery mildew. These results were comparable to seed treatment with *P. fluorescens* at 5 g l-1 followed by a seedling dip with *P. fluorescens* at 10 g l-1 and spray with *P. fluorescens* at 10g l-1 four times at 15-day intervals. Except for T1, plant parameters, yields, net returns, and benefits were significantly higher ($p<0.05$).

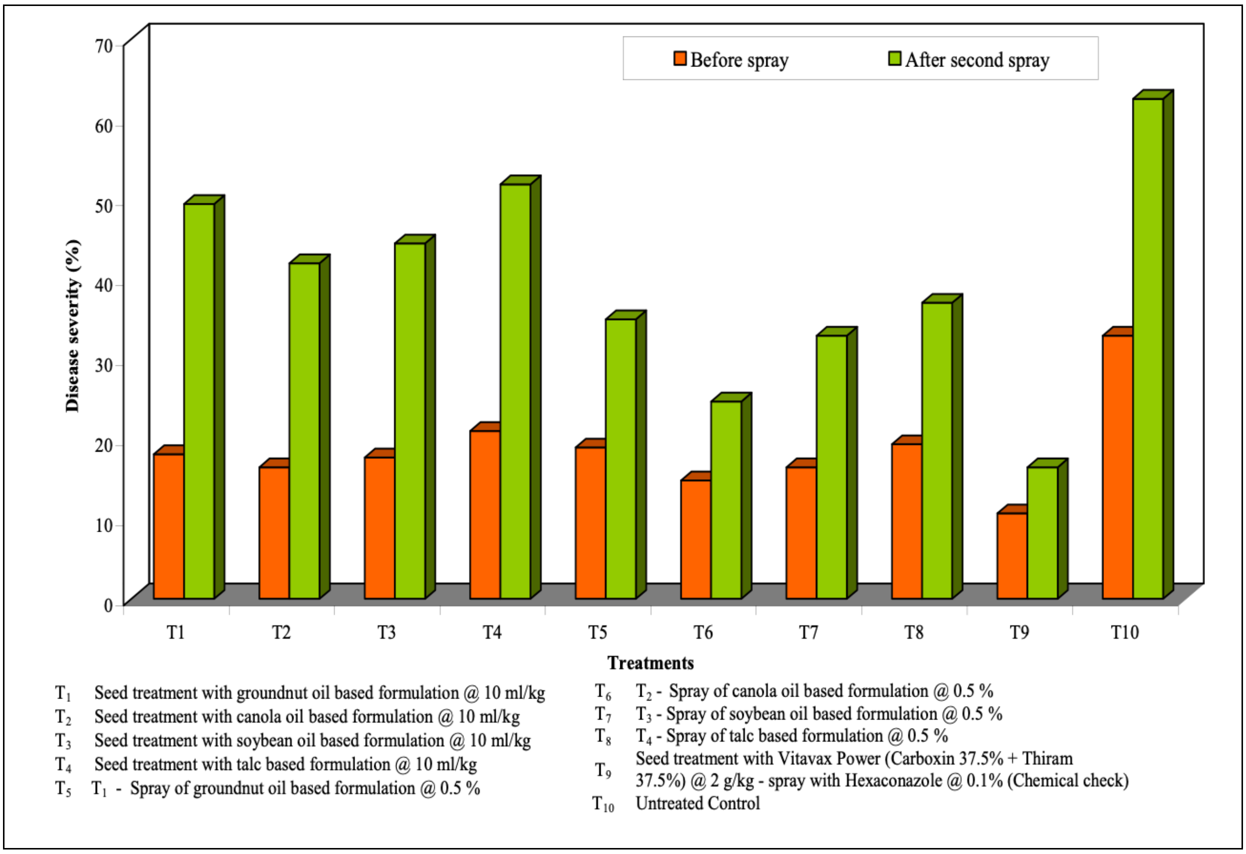

Figure 3. Evaluation of oil-based formulations of *Pseudomonas fluorescens* on spot blotch of wheat

Wheat foot rot management using microbial consortia

The highest disease reduction and maximum plant growth parameters (root length, shoot length and number of leaves) were recorded in microbial consortia treated with seed treatment followed by soil drenching. The minimum disease incidence was found in consortium of T. harzianum + P. fluorescens + B. subtilis + N. parvum (26.67%) compared to all other treatments and maximum disease incidence was recorded in P. fluorescens (63.33%) in seed treatment followed by soil drenched pots. The pots treated with seed treatment alone has shown minimum disease incidence of 16.67 per cent in consortium of T. harzianum + P. fluorescens + B. subtilis + N. parvum and maximum disease incidence was found in P. fluorescens (66.67%). While 96.67 per cent of foot rot disease incidence(Figure4).

Fungal and Bacterial antagonists to manage leaf spot of *Mappiafoetida* an anticancer drug yielding tree.

Among the different fungal bio agents *Trichoderma harzianum*, IOF strain has exhibited maximum zone of inhibition (99.81 %), followed by Trichoderma viride, which has exhibited 89.97 per cent and found on par with *Trichoderma koengii*, which inhibited 88.59 per cent The least growth of inhibition of 84.03 per cent was recorded in *Trichoderma harzianum*, (Local strain) that has inhibited 84.03 per cent. The bacterial biocontrol agent *Pseudomonas fluorescens*, IOF strain has shown maximum growth inhibition of 70.74 per cent and *Bacillus subtilus* (IOF strain) which has recorded 51.48 per cent.

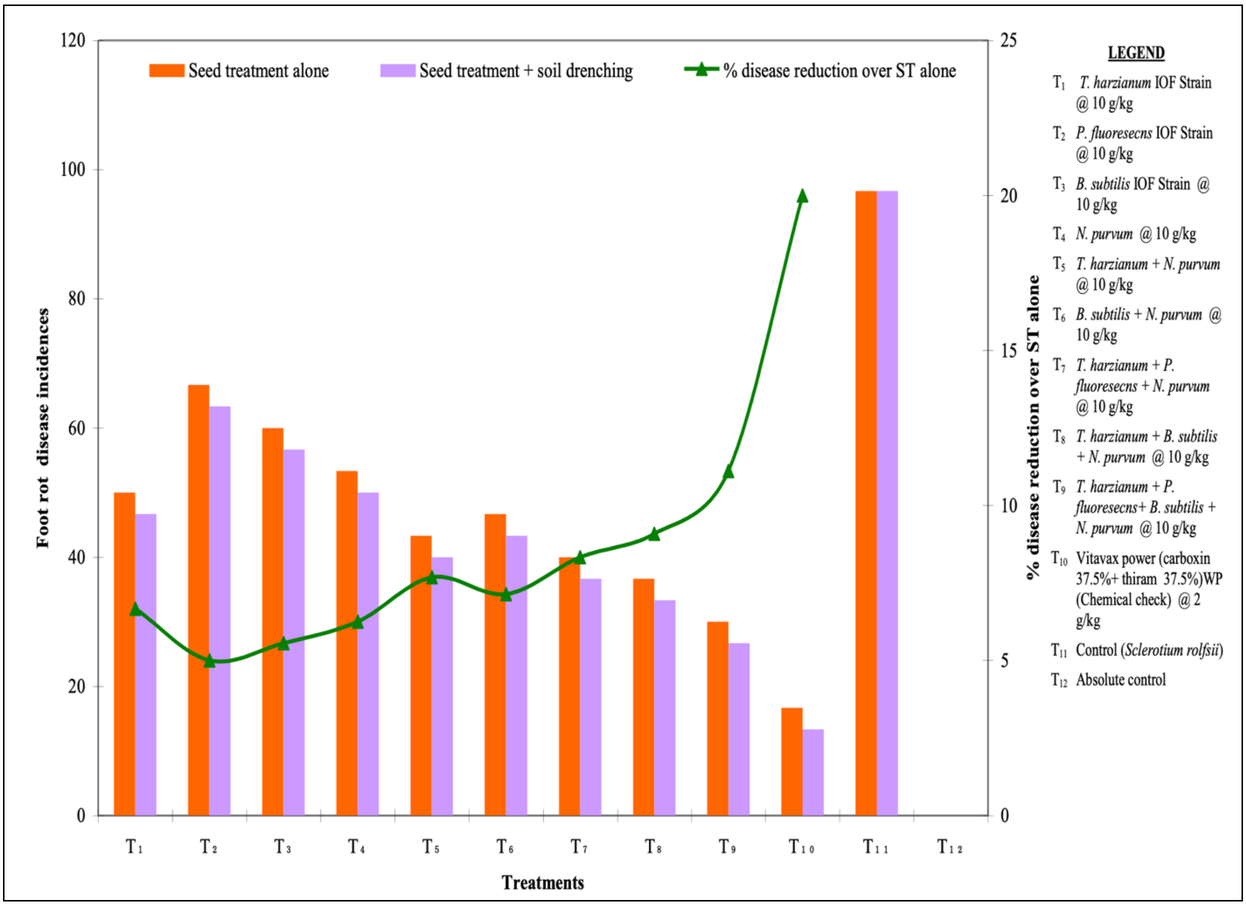

Figure 4: Evaluation of microbial consortia against *Sclerotium rolfsii* Sacc. under pot experiments

Discussion

The possible role of growth inhibition of phytopathogens by bioagents is attributed by different mechanism of actions such as production of antibiotics, hydrogen cyanide, siderophore, secretion of lytic enzymes, competition for the space and nutrients (Intana et al., 2008). PGPR has direct role in activating defence genes encoding chitinase, glucanase, peroxidase and synthesis of phytoalexins (Meena and Marimuthu 2012).The growth promotion activity of *Pseudomonas fluorescens* as PGPR has been well proved by, Sindhushree and Hegde (2019. The efficacy of consortial application in reducing the diseases may be attributed to the production of HCN, siderophore and chitinase enzyme which will influence the plant resistance mechanism to various biotic and abiotic mechanisms (Ghazy, N. and El-Nahrawy, S., 2021 and Karagi,V. B., 2020). *Pseudomonas fluorescens* is able to induce the growth hormones in plants such as IAA (indole acetic acid), which acts to stimulate plant growth parameters. Hahlbrock and Scheel (1989) reported that, Phenylalanine ammonia-lyase (PAL) is the first enzyme that is produced in the phenylpropanoid pathway and leads to the biosynthesis of a variety of phenols, leading to the synthesis of many defence-related compounds such as antimicrobial phytoalexins and lignin that helps in arresting the growth of the pathogens. Aryanatha and Guest (2006) observed antibiosis as the main mode of action although mycoparasitism, indicated by parallel hyphal growth, hyphal coiling, appresorium formation and direct penetration of biological agents. Thus, the use of biological control agents either individually or in combination can be of great use in successful management of the diseases of Agriculture, Horticulture and Forest crops for sustainable crop production and diversity.

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Better knowledge of agroecological principles to improve organic vegetable production in Vietnam

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Key words: PGS, vegetable, soil, ecosystem, Vietnam

Abstract

Participatory guarantee systems (PGS) are intended to provide an affordable means for smallholder farmers to gain organic certification. PGS vegetables have been promoted in Vietnam for the last 10 years and the value chain has been relatively well functioning with an effective coordination and quality monitoring system. However, the number of PGS certified vegetable farmers in Vietnam is not growing as expected. This contribution is a qualitative assessment on PGS vegetable performance in Vietnam; looking through the agroecological lens, and based on interviews with farmers and direct farm observation. The results suggest that a shortage of agroecological awareness and innovation, at all PGS promotion and implementation levels is an important constraint because the lack of knowledge hinders PGS farming efficiency, self-sustainability, and overall farmer's income. Although there is a degree of subjectivity in our views and discussion, the arguments and conclusions could contribute to refinement of the existing PGS farming development strategy of organic promotion agencies, including IFOAM.

Introduction

Participatory Guarantee Systems (PGS) are local quality assurance schemes that provide an affordable alternative to third party certification. PGS producers receive certification in a system that is built on trust, social networks, and knowledge exchange and in which controlling is based on active participation of stakeholders, including consumers (Home et al., 2017). In Vietnam, although the market share of PGS organic vegetable products is still relatively small, PGS production and marketing channels can be considered as a flagship value chain for raising Vietnamese public awareness on food safety, food consumption, environmental protection, and sustainability. Promotion of PGS organic vegetable production in Vietnam has been centrally organised since 2008 when "PGS Vietnam" was founded in a collaboration between Agricultural Development Denmark Asia (ADDA) and the Vietnam Farmer's Union (VNFU) (IFOAM, 2022). In 2019, the Vietnamese government issued technical standards for organic agriculture with the intention of further motivating adoption and expansion of organic vegetable production in Vietnam.

Vietnamese PGS and organic certified vegetable production has been mainly adopted in Hanoi and some surrounding provinces such as Hoa Binh and Ha Nam. PGS organic vegetable produce is mainly supplied to safe vegetable retail chains, such as Bac Tom, Soi Bien, and Big Dream, and to other shops/supermarkets and individual city households. However, despite the active promotion by PGS Vietnam and the Vietnamese Government, the number of PGS certified vegetable farmers in Hanoi and nearby provinces has fallen from around 500 in 2016-2017 to around 300 in 2021 (Nhung, Vietnam PGS chair. Personal interview in Jun, 2021). Although there is some fluctuation, it appears that PGS Vietnam has not yet created steady ground for the development of PGS vegetable production. Recent research, in PGS vegetable groups in Hanoi, Ha Nam and Hoa Binh provinces, has found a range of hindering factors that, unless addressed, could even further challenge development of the sector in the future. These include low income, the intensive demand for labour in production, and aging farmers due to decreasing interest of the youth in agriculture. These challenges are not unique to Vietnam, but are exacerbated by poor existing farming practices, sub-optimal implementation of optimisation measures

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and/or actions taken by farmers, and to some extent, insufficient awareness by PGS development stakeholders (Mich, 2022).

The aim of this contribution is to identify concrete actions that might be implemented to remedy these hindering factors and thereby reduce the barriers faced by farmers to PGS certified organic vegetable production. To address this aim, we use a combination of field observations and qualitative interviews with PGS vegetable farmers in Hanoi. Hanam and Hoabinh province in May 2022. Although there is a degree of subjectivity in this qualitative approach, the arguments and conclusions could contribute to refinement of the existing PGS farming development strategy. Throughout the results section, direct quotes from respondents are shown in "…".

Results

Certification and seasonal constraints

One cause of poor farming practices was insufficient bottom-up innovation by PGS farmers who "have been very much looking for external supports at the expense of internal efforts for development and innovation". The reason for the lack of innovation was nominated as the overdependence, for the last 10 years, on the technical and facility support from NGOs and local governments. For example, the head of a PGS vegetable group in Hanam province, with over a decade of experience working on PGS vegetables, reported that: "there have been no technical innovations/changes discovered and adopted by farmers since 2013". The support structures have achieved considerable successes, such as building a well-functioning PGS coordination and monitoring system, including market actors to make PGS into a unique vegetable value chain, lobbying for organic standards that have been officially institutionalized in Vietnam, making PGS Vietnam one of several PGS countries accredited by IFOAM. However, they have been overly general and insufficiently responsive to local and individual needs, which means they have not been able to motivate innovation at the farm level.

A major barrier to economically sustainable PGS vegetable production is related to seasonal price fluctuations and the inability of the PGS farmers to devise an amelioration strategy. The participating farmers reported that their vegetable harvests are easy to sell at a fair price in the hot and rainy summer season because almost the entire vegetable harvests are bought by retailers. However, in the easily productive winter season, there is typically a surplus of vegetable harvest and supply, which means that only 50-60% of the vegetable harvests are bought by retailers, with the rest is sold in local markets at the same price as conventional vegetables, or just fed to animals. Meanwhile, a strategy for "soil-rehabilitation" in PGS groups is to plant low-value crops such as legumes, maize, and cassava, which participating farmers report as growing very well without the addition of manures. These fluctuations lead to loss of income for the farmers, and contribute to farming being a less attractive career choice for young people.

The increasing offer of better paying, off-farm jobs in the industrial and service sectors in provinces have attracted the younger labour force away from agriculture. Organic standards have been successfully applied and monitored within the PGS system, which means that substitution of labour with synthetic inputs is not allowed during the production of PGS vegetables. Therefore, farmers are heavily dependent on physical labour; especially for composting and applying manures, weeding, and controlling insects, which means that the decreasing supply of younger workers is particularly strongly felt in the labour-intensive PGS vegetable production. For example, one PGS farm group leader reported that weed control (by hands) is the most labour consuming activity for her group during vegetable production in summer - the rainy and hot season. In response, farmers attempt to reduce labour demands, such as by increasingly applying direct seeding for most crops: even for common crops such as gourds, Basella alba, nalta jute, rather than sourcing seedlings though nursery practices. This practice appears to be false economy and is likely causing farmers multiple downstream problems, although they may not be aware of them.

Firstly, direct seeding requires thorough soil preparation to support seed germination, which causes heavy physical soil disturbance, including compaction and degradation (see figures 1 and 2) and weed explosion: especially those multiplied by stems. Once soil has been compacted, there are lot of negative consequences such as reduced water permeability, reduced holding capacity for water and nutrients, and an overall reduction in soil ecosystem functioning.

Secondly, in contrast to well-prepared and cared-for nursery conditions, normal fields do not provide a good environment for young plants to develop, which can lead to low germination rates and unhealthy seedlings with possible unequal size and quality of vegetables at harvesting time.

Figure 1. Regular soil preparation that harm soil ecosystem and productivity

Figure 2. Soil compaction at a field that has adopted PGS since 2013.

Thirdly, control of weeds, which negatively affect young plant development during the period of early plant growth, is difficult because the prepared fields, with no competition, offer favourable conditions for weeds that germinate more quickly than the crop plants. In response, farmers choose to increase planting density (see figures 3 and 4) with the aim of shortening the time of full crop canopy development, with the side benefit of generating quick harvests shortly after seeding. This farming practice however, causes plant stems in important crops, such as Morning Glory and Bassella, to remain small, which ultimately requires more labour for harvesting and sorting, and thereby reduces overall efficiency in production. Reflecting lessons can be learnt from other crops and animals. For instance, lowering rice planting density in SRI or low shrimp density in Ecuador have proved to achieve higher farming productivity as compared to conventional high planting density (cf. VGP, 2017).

Figure 3. High density planting integrated with cassava, maize (as soil rehabilitation crops) in summer season

Figure 4. High planting density: vegetables growing under guava canopy.
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Agroecological constraints

In addition to the certification constraints that cause more work for farmers, and lower their crop productivity and yield (Reganold and Wachter, 2016), we observed that farmers' lack of ecological knowledge leads them to unconsciously harm their own soil. For example, one responding farmer expressed the opinion that "earthworms are harmful because they eat the manure […] and plant roots so they harm the crops". The common practice in the production of PGS vegetables in Vietnam is to use composted manures alone, combined with technical measures, such as diversification, integration, and rotation. However, even with increasing the quantity of composted manures above the amounts that are commonly applied is insufficient to successfully enrich or regenerate the soil environment. Soil quality remains a troublesome issue for farmers, with compacted soils commonly subject to waterlogging in the hot and rainy cropping season, which makes vegetable production both more risky and costly. One PGS farm group leader expressed exasperation that their soil "still remains compacted after almost 10 years of PGS practices with lot of, and continuous, manuring, with no chemicals applied".

The results showed that few PGS stakeholders, including PGS/organic promoters and farmers, were aware of the concept of self-sustaining PGS farming systems and therefore focussed their attention elsewhere. For example, several respondents reported that they consider availability of good, but externally sourced, composted manure at a reasonable price will be the most important driver for PGS vegetable development in Vietnam. The responding farmers reported that imported chicken manure (apparently from Japan) is available and is being marketed for PGS and organic farmers in Vietnam at a price of 9,000 to 12,000VND/kg, which is approximately equal to the price of low quality rice. This price is beyond the prices that farmers can pay for fertiliser, but rather than thinking of overall farming ecosystem functions in the mid- to long- term, they understand that the "application of more composted manures is the solution for boosting PGS vegetables".

In reality, organic agriculture in Vietnam is not necessarily less productive than conventional, chemical agriculture based on synthetic inputs, but is rather dependent on the way the farm is managed in terms of nutrient provision. However, lack of ecological knowledge, such as knowledge of land ecosystems, and nutrient diversification and balance, often leads farmers to rely on (composted) chicken manure, which is readily available in localities, but which also condenses nutrient more than cow or buffalo manure. Regular application of composted chicken manure and regular physical disturbance continue to degrade the soil. Responding PGS farmers reported that vegetable growing became easier and more productive in the early years following PGS certification, but the vegetables are now easily damaged by heavy rain in the summer hot season, and are less productive to the point that "vegetables grow slower with harder stems, so are less preferred by consumers".

Conclusions

At the farm level, soil is the basic determinant of farming success, efficiency, and sustainability. Soil retains its decisive role in sustainable agriculture, serving as buffer for mitigating increasing risks in farming practices related to climate change and the increased price of different types of inputs including labour. Agroecological awareness could motivate the development of more circular farming systems that help free farmers from dependence on external (compost) inputs. However, lack of agroecological awareness has impeded farmers from realizing that alternative practices exist, which means they don't seek ways to make their soil better, which could reduce labour, increase local resource use efficiency, and deliver overall farming benefits.

For example, the combination of less production needed in winter, when vegetables are oversupplied and prices are low, and the strategy of planting low-value crops as a soil rehabilitation strategy leads us to the conclusion that these crops should be grown in the winter season when the market cannot absorb the entire PGS vegetable harvest. Using an ecological manure strategy for these crops would quickly boost soil rehabilitation and fertilization for vegetables in the following cropping seasons when prices are high. Furthermore, a change in farming practices by sourcing seedlings from nurseries could not only help to improve plant health and final crop productivity, but also increase the efficiency of land-use, minimise soil physical disturbance, and control weeds (through crop competition).

Without better knowledge of agroecology that could help farmers adopt sustainable farming practices and agricultural innovation, farmers will continue to be trapped in farming practices that are both ecologically damaging and economically inefficient. Their soil fertility and ecosystem management, which is considered as the most important driver in contributing to farming success and sustainability, can only improve if farmers are aware that there is a better way. This allows the conclusion that lack of ecological knowledge, in both farmers and those who promote the development of the organic sector, is the most important constraint for PGS farmers in pursuing more sustainable farming practices as well as possible farming innovation. The concept of a self-sustaining system is largely absent from the discourse on PGS vegetable systems and farmers appear locked into buying external (organic) inputs that are damaging to the soil and which they can't afford. Overall, more agroecological awareness and knowledge should be delivered to stakeholders involved into PGS vegetable development: especially farmers for whom any agroecological innovations taken will have direct impacts on their farming efficiency, living quality, and sustainability.

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Lessons learnt from the application of the Tool for Agroecology Performance Evaluation (TAPE) in four Asian countries

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Key words: TAPE, Agroecology, Performance Assessment, Asia

Abstract

Agroecology has a high potential for transforming our agrifood systems, influencing all dimensions of sustainability. But its pluralistic nature raises specific challenges for its wider adoption, particularly in terms of consolidation of knowledge and innovation, policy processes and connections between countries and between partners. To answer the need for global and harmonized evidence on the multidimensional performance of agroecology, FAO has facilitated the elaboration of the Tool for Agroecology Performance Evaluation (TAPE). It was piloted in four countries (Cambodia, China, Laos and Vietnam) across different territorial realities and using different implementation modalities. Through its application in collaboration with a broad diversity of stakeholders, it was shown that TAPE is relevant to help understanding the importance of the different dimensions of agroecological transition, and the identification of the strengths and weaknesses of the actual farmers' practices, linking theory and the level of practice. However, most pilots have highlighted a challenge for partners to fully analyze the data produced by the tool. This may limit both the dissemination of the tool and the ability to use the information produced out of the processed data for technical and policy recommendations. Thus, development of partnerships between Family Farmers Organizations, government agencies and Universities (Higher Education Institutions) in country should be fostered in order to build capacities and overcome the challenges in data processing and analysis for TAPE.

Introduction

Agroecology is based on a complex interplay of practices, technologies, innovations, policies, incentives, social dynamics, investments, and governance. Agroecological systems can significantly contribute to the production of healthy diets, gender-equality, climate change mitigation and adaption, natural resources management (including conservation of biodiversity) and attract youth and create employment. Agroecology goes beyond technical solutions and innovations based on incremental changes and can drive genuine transformative change in food and agricultural systems by moving towards socio-ecological systems that place people (farmers and consumers) at the center. Defined simultaneously as a science, a movement and a practice (Wezel et al., 2009), agroecology differs from other approaches and has a high potential for transforming our agrifood systems, influencing all dimensions of sustainability. But this pluralistic nature also raises specific challenges for its wider adoption, particularly in terms of consolidation of knowledge and innovation, policy processes and connections between countries and between partners.

To answer the need for global and harmonized evidence on the multidimensional performance of agroecology to inform the policy making process, FAO has facilitated the elaboration of the Tool for Agroecology Performance Evaluation (TAPE)[5]. At the heart of this tool is the question of "How do we assess performance in agriculture?" that moves beyond fractured evidence (often production driven) that is often siloed by discipline and that generates coherent, consistent and robust information that can help policy makers, producers, researchers, consumers, civil society and a multitude of other actors make better decisions, leading to sustainable food and agricultural systems. Thus, the general objective of

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[5] The need for harmonized evidence on agroecology was a systematic recommendation from the various global and regional consultations on agroecology organized by FAO between 2014 and 2018, and specifically requested by FAO governing bodies in 2018 (COAG 26 / C 2019/21 Rev.1 , Para. 15 a).

TAPE is to produce evidence on the performance of agroecological systems across all the dimensions of sustainability to support agroecological transitions at different scales, in different locations, through different timeframes and to support context-specific policy making on agroecology. In simplified words, the TAPE analytical framework aims at providing a multidimensional diagnostic of agricultural performance to move beyond standard measures of productivity (e.g. yield/ha) and better represent the benefits and trade-offs of different (alternative) agricultural systems.

TAPE was first presented to several key stakeholders of the ASEAN (+China) Region in a regional workshop organized by FAO Regional Office of Asia and the Pacific (FAO RAP) in Bangkok in September 2019 with the objective to be fine-tuned, contextualized, and confirm partners for the field–testing of TAPE. Following this regional workshop in Bangkok, four pilots were developed and implemented at country level to test TAPE across different territorial realities and using different implementation modalities.

This paper will first present the four different contexts and implementation modalities. Then, it will explore the common TAPE methodology applied and present some of the key findings. It will also share some lessons learnt and limits from the pilots before providing recommendations for the future.

Material and methods

TAPE is a result of a long participatory and inclusive multi-stakeholder process which included the review of existing assessment frameworks, the prioritization of over 70 existing indicators by more than 450 participants and an international in-person workshop with 70 participants from academia, non-profit, government, social movement, private sector, and from international organizations. After this workshop, a technical working group of 16 people was formed, including scientists and civil society representatives working on agroecology in different parts of the world. Twenty founding principles were agreed upon during the participatory process of TAPE's development (see Annex 1). Based on those founding principles, TAPE follows a stepwise approach which has been broadly described in several publications (in particular, Mottet et al., 2020). Drawing from this, it can be summarized as follows (a more detailed presentation of the steps can be found in Annex 2).

TAPE data analysis is based on two central steps (1 and 2) that consist of assessing the level of agroecological transitions and quantifying impacts of those transitions on the core criteria of performance. Step 1 (Characterization of Agroecological Transition, CAET), based on the 10 Elements of Agroecology (FAO, 2018), provides a diagnostic of a system and its transition toward agroecology. Step 2 measures in semi-quantitative terms the impact of agroecological systems on the various dimensions of sustainability. This duality is a response to one of the basic principles identified during the consultation phase leading to the elaboration of TAPE. The two core steps are complemented by a preliminary description of the context (Step 0), with the facultative inclusion of a typology of transitions (Step 1 bis), and a final analysis and participatory interpretation of the results and opportunity for discussion of next steps (Step 3). The 2 core steps (Step 1 and 2) can be undertaken with an digital survey form, using KoBo, a suite of free and open source tools for field data collection specially developed for humanitarian work and challenging environments[1]. This tool directly populates a secure central database. The questionnaire used for TAPE can be translated in any local languages and uploaded directly to Kobo which can work offline. Step 1 and Step 2 can be undertaken simultaneously in the field, but they can also be carried out in separate visits.

Up to now, TAPE has been used in over 30 countries and 5,000 farms or households. In particular, four pilots have been carried out in the region to test TAPE in different contexts and through a broad diversity of partners (detailed information can be found in Annex 3).

In Cambodia, the international NGO Louvain Cooperation in collaboration with 9 other partners (local and International CSOs, University and Government agencies) have assessed 260 farms from 4 different agroecological zones.

[1] https://www.kobotoolbox.org/

In China, the Community Supported Agriculture (CSA) Alliance for Social Ecological Agriculture, with the support of the Ecological Agriculture Development Association of Shunyi District of Beijing and the China Agricultural University, have assessed 37 CSA farms in 19 provinces and municipalities.

In Laos, the Department of Technical Extension and Agro-Processing (DTEAP) of the Ministry of Agriculture and Forestry, with the support of an expert from the National Agriculture and Forestry Research Institute (NAFRI), have assessed 93 farms in 3 villages of Khoun district, Xiengkhouang province.

In Vietnam, the Vietnam Agriculture Academy of Science (VAAS), in collaboration with an expert from the Vietnam National University of Agriculture have assessed 64 farms from 3 communes of Soc Son district (Hanoi Province) and Moc Chau district (Son La province).

Results

Cambodia:

The TAPE survey was well adapted to highlight and evaluate the differences between two different agroecological practices at the organization level. Well-defined agroecological techniques and practices and standard monitoring and procedures seemed to be the main reason that some particular farms performed better than the other farms in the agroecological transition. Most farms in the TAPE survey grow a mixture of crops and used varying levels of agroecological practices. Some farms properly applied agroecological techniques while other farms did not. Thus, it is important to effectively measure the level of agroecology among farms with mixtures of crops. Overall, the relationship between CAET and Step 2 revealed a significant relationship between animal revenue and agricultural biodiversity with increasing agroecology transition. The input expenditure per hectare was negatively correlated with the CAET score. Hence, the higher the overall agroecological score, the higher the animal revenue and agricultural biodiversity, and the less households spend on input expenses. While looking by territory, in the Tonle Sap Plain (lowland), the increase of animal revenue, agriculture biodiversity, and high score of pesticide indicator (i.e. lower synthetic pesticide usage and integrated management of pests) are associated with a higher overall CAET score. A positive correlation was also found between pesticide score, dietary diversity, crop revenue and women's empowerment and the overall CAET score in the Tonle Sap Plain (upland). In the Plateau (upland) territory, there was a positive relationship between increasing CAET and integrated management of pests. Women's involvement in decision making in households and farming activities, access to resources, decision on use of income and women's participation and leadership activities (training, religious and/or political group) were associated with the increases in the CAET score. It was found that the training opportunities led by the partner organizations which aimed to support a transition to agroecological practice contributed to the promotion of women's empowerment.

Vietnam:

The pilot took place in 2 very different farming contexts. In Hanoi, farms were small with a diversity of annual crops (rice and vegetable), moderate animal raising level (especially cattle) and closely connected to large food markets in Hanoi. In Son La, farms were larger, working more on perennial crops such as plum, apricot,and avocado and with much reduced animal raising (especially cattle). The two sites are also different in terms of ethnic composition and climate conditions. Overall, more than half of the farmers in the two provinces had CAET score of less than 50. A small percentage (7%) of households had CAET scores greater than 60. In comparison between the two provinces, Son La farmers are outperforming in some elements of agroecology as compared to those in Hanoi. With regard to Step 2 and the criteria of performance, Hanoi farmers earn more from crop production, especially from fruit crops whereas Son La farmers are getting more income from animal production, especially cattle. However, an inverse trend is found in nutrition intakes: generally, Hanoi farmers have better food intake as compared to Son La farmers. The survey highlighted that households at higher levels of agroecological transition have more food self-sufficiency, raise more animals, use less agrochemicals, and have better soil health. Higher maize productivity is likely associated with better soils and increased ecosystem services, including higher natural pollination associated with high levels of agroecological transition. From an economic perspective, results showed that farms more advanced in the agroecological transition have better and more diversified sources of revenue.

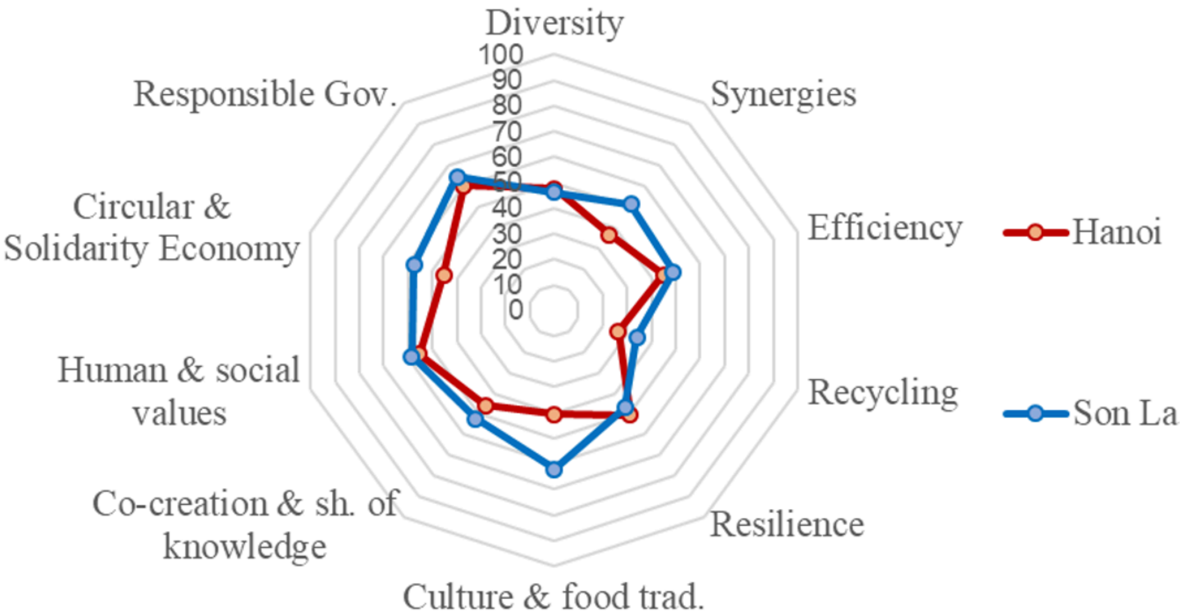

Figure 1: TAET Vietnam

<u>Laos:</u>

In terms of the average CAET score, more than 60% of the total of 93 farms evaluated were relatively advanced in terms of their transition to agroecology (with a CAET score over 51). The mean of farms for individual CAET score was highest for Culture & Food Traditions (72.94), while the lowest was for Recycling (44.09), Synergy (45.30) and Diversity (45.56). Therefore, these 3 elements could be entry points for the development of policy and activity to enhance agroecology. 75% of farmers in the intervention villages (LURAS project area) had a score higher than 50, while 50% of farms in control village had a score below 50. The overall mean of CAET scores of farmers in the intervention villages was a bit better (60) than in the control village (50). It is possible that activities that the LURAS project implemented in the intervention villages have influenced the CAET score, especially in regard to Co-creation and sharing of knowledge and Circular and solidarity economy. The mean of revenue of farmers in the intervention villages was lower than in the control village, but the source of income from crops was higher in the intervention villages, while the sale of non-timber forest products (NTFPs) was higher in the control village. This suggests that farmers from the villages in the LURAS project area earn more from their cash crops, while farmers from the control village earn more from NTFPs. The nutrition score is slightly higher among households in the intervention villages, particularly in regard to consumption of other fruits, grains, pulses, and dairy. This is likely because of the availability of food and nutrition knowledge as well as different eating habit of farmers in the intervention villages from the project.

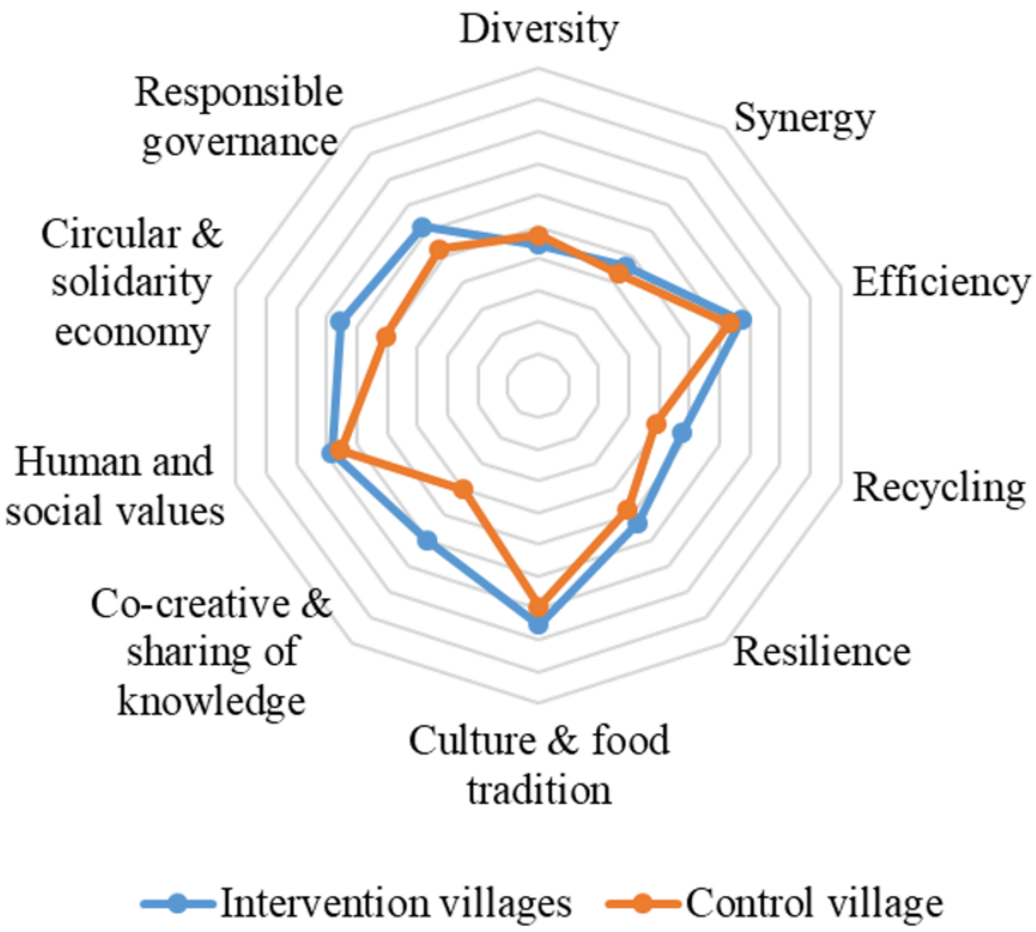

Figure 2: CAET Laos

<u>China:</u>

Among the farms surveyed, most of the farm managers were of middle age (average age is 43), and most of them received higher education, which can help guide scientific agricultural activities. According to the TAPE survey, most ecological farms have high CAET scores (mean CAET scores of 68). The overall performance for all the 37 farms shows that CSA farms in China are in an advanced level of the transition to agroecology. The farms reflect the characteristics of large scale, complete management system, industrial chain formation, and mature transition. By comparing the CAET scores of "crop growing" farms and "crop-livestock integration" farms, the second type shows higher mean CAET scores (72) than the first one (61). In terms of diversity, the existence of animals in farms has greatly improved the diversity score of farms. This indicates that animals can play a vital role in ecological agriculture and should be integrated into the ecological cycle system of agriculture. Through the CAET analysis, the transition of farms in both the national market and the provincial market were relatively mature with the average CAET score greater than 70 and the agricultural products sold were relatively diversified. The poor performance of the agricultural ecological transition of local market farms is related to China's economic development and the concentration of consumer markets in first-tier cities. However, from the perspective of community-supported agriculture, the role of the development of local agriculture will become more obvious, which has been reflected in the time during COVID-19 (Urgenci, 2020).

The element of Responsible Governance achieved high scores in most of the surveyed farms (mean of 82). This may provide indications of the existence of laws, policies, and programs at the national level which reward agricultural management and that are conducive to improving biodiversity and ecosystem service provision. The performance of three elements of Efficiency (75), Human & Social Values (71), Culture & Food Traditions (71) followed closely, all scoring greater than 70. Human & Social Values and Culture & Food Traditions are important context features of agroecology. Efficiency shows that the farms reduce dependence on external resources and enhances producers' autonomy and resilience to natural or economic shocks by empowering them. The five specific elements of Co-Creation & Sharing of Knowledge, Diversity, Resilience, Synergies, and Recycling compose the common characteristics of the agricultural ecosystem, basic practices and innovation methods. Across farms, their individual scores were less than 70; which shows that the ecological and technical issues on farms are at different levels of agroecological transition, but could be improved in the near future.

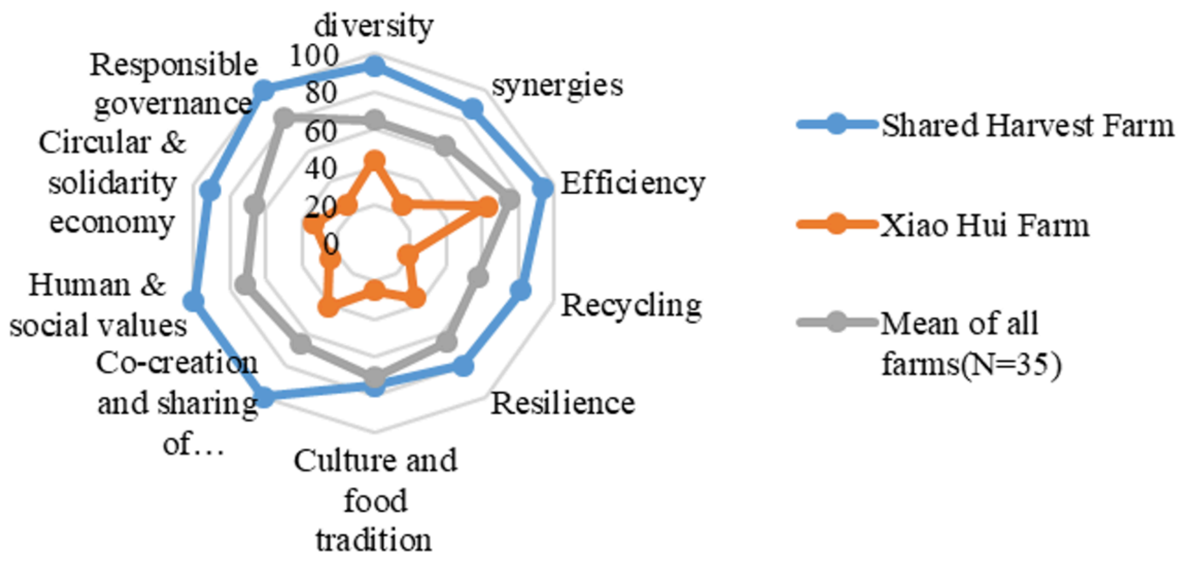

Figure 3: CAET China (Focus on 2 farms: Shared Harvest and Xiao Hui)

Compared with the average level of transition of all farms, 3 elements (Diversity, Efficiency, Circular & Solidarity Economy) of the Shared Harvest Farm are close to 100 and three elements (Co-Creation and Sharing of Knowledge, Human & Social Values, and Responsible Governance) had the scores of 100. There are 40 fixed workers and 10 temporary workers on the farms with a farm area of 33.33 hectares. The farm's business scope ranges from planting to processing and livestock and poultry breeding. It has formed a complete material circulation and industrial chain system, while Xiaohui Farm has only one labor force and the farm area is 0.53 hectares. The farm's business only focuses on vegetable cultivation, and the products are relatively simple.

Key lessons learnt & limitations

Some lessons learnt

Through its application in collaboration with a broad diversity of stakeholders ranging from local organizations (CSOs, Farmers Organizations…) to academia and government agencies, it has been pointed out that TAPE is relevant to help understanding the importance of the different dimensions of agroecological transition, and the identification of the strengths and weaknesses of the actual farmers' practices, linking theory and the level of practice. However, it is important to point out that each pilot had different sample strategies which can have an impact on the representativeness of each sample. Thus, for example, the farms in China were not selected randomly and were already well engaged in agroecology (not representing average farms in the country).

TAPE can produce a good image of the current level of agroecological transition of productive systems. Broader analyses at territorial levels based on performance of Step 2 can also be produced, but a good sample strategy and sample size is key for this purpose.

One major interest of TAPE by users is that the tool addresses different dimensions (productivity, economic, youth or gender) but also at different scales (plot, farm, and community) in an integrated manner. TAPE is a comprehensive tool used to investigate the transition to agroecology. It provides the opportunity to observe the position of farmers in relation to the sustainable practices that they implement and to analyze their context-specific knowledge and utilization of agroecology. TAPE helps in understanding the gap between the theory and the actual practice of agroecology among farmers. Elements with lower average scores can be considered as entry points for interventions from R&D projects and/or policy interventions.

TAPE can capture the level of transition to agroecology of farms at a determined time. In order to produce a dynamic analysis that includes changes and transformations that might be taken by farmers in a certain period of time, a second round of data collection is needed, thereby using TAPE as a monitoring and evaluation tool by collecting repeated measures in time.

TAPE (using Kobo) allows users to save time for interviews and provides data security. It also allows better survey quality management through rigorous data quality control (as compared with conventional paper-based survey). However, a successful TAPE implementation needs well-trained enumerators, not only for approaching and interviewing skills, but also some knowledge of agroecology and rural extension, since some parts of the assessment need to be undertaken during the interview, especially for Step 1.

TAPE has been designed to harmonize assessments from all countries but its methodology is flexible and adaptable enough to integrate context-specific features into the tool. Therefore, Step 0 needs to provide clear background information about the context to be integrated in the following analysis and to explain the results of the criteria of performance.

Some limitations and recommendations to move forward

The assessment of a farm with TAPE is quite time consuming (although shorter than other global multi-criteria methodologies), ranging from 1h to 4h depending on the size of the system to asses and on how familiar enumerators are with the tool. Although TAPE can provide good information about the level of agroecological transition at farm level and identify areas where support could be provided, it has been found that there is still limited incentive for farmers to dedicate time to the assessment. To overcome this “lack of interest”, stronger linkages should be anticipated between the result of the TAPE assessment and the need for specific technical assistance to support the agroecological transition. Here is where the historic and future relationships with the farmers via the implementing partners is key.

The translation of the TAPE questionnaire into the local language and the contextualization of the different questions is critical for enabling both enumerators and farmers to fully understand the tool and for guaranteeing consistency in the data collection. Well-trained enumerators are also necessary to ensure consistent data collection and therefore, statistical robustness. In addition, context differences and sensitivity in Step 2 requires flexibility and adaptation. Sometimes, obtaining data over the last 12 months can be a bit challenging since farmers may not recall everything (for example, when it comes to the quantity and type of pesticides used, their revenues and expenditures). Here is an entry point for actors to help in this realm.

If the data collection is rather “easy” once the enumerators are well trained and the questionnaire is translated into local language and well explained, the data analysis requires basic statistical analysis skills, ranging from correlations to PCA and may require involvement of research and academia partners. Most of the pilots, although very diverse in terms of implementation modalities, have led to a somewhat basic description of simple statistical analysis without deeper understanding of the link between step 1 and step 2 and even less inter-connection with findings and information from Step 0. This is a serious limitation in both the dissemination of the tool and more importantly in the ability to use for technical and policy recommendations the information produced out of the processed data. However, the TAPE team, through extensive piloting, has been made aware of this limitation and is enhancing statistical analysis, interpretation, and next steps (Step 3) support to the diverse actors using TAPE.

Lastly, the pilots have also shown that the participatory validation of the findings (in step 3) very seldom occurs, mostly because of lack of resources. Due to the challenges in processing the date mentioned above, local partners often have difficulties to “own” the findings from TAPE and would struggle if they had to present them at a local level and have them validated through a participatory process.

To address some of the limitations mentioned above, one could recommend the following:

- Develop a set of guidance questions for TAPE users to facilitate the interviews with farmers
- Ensure well-trained and continuous practice of enumerators on the use of Kobo Toolbox
- Ending subsection with blank cell for enumerators to include possible lessons learnt or to add voice function (if available in Kobo) so that enumerators can save time for sharing their lessons/other relevant info they learn from farmers
- Develop partnerships between Family Farmers Organizations, government agencies and Universities (Higher Education Institutions) in country to build capacities and overcome the challenges in data processing and analysis for TAPE but also beyond TAPE. This could also contribute to better use of TAPE in informing SDG monitoring (since all data produced are connected to specific SDGs and their indicators) and future data collection for whatever tool is of interest.

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A comparative investigation on organic rice farming in North of Iran

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Key words: biological control, organic production, rice, fish, duck

Abstract

Variation in organic rice production (ORP) categorized in an investigation based on different using combination of duck, fish, other biological control agents (BCAs) and biological fertilizers (BFs) in North of Iran. The main types of continuous ORP were recognized and their harvested paddy average compared in MANOVA and meta-analysis. It was 4416±227 kg/ha in the rice fields after clover or bean culture in autumn and winter, with fish and duckling production in 2011-2013. It increased till 5785 kg paddy/ha after BFs introducing to the farmers and when Participatory Guaranty System (PGS) started among farmers. The other main organic fields looking for higher price via 3rd party certification usually don't use fish or duckling herds, while they use BCAs and BFs based on the appropriate regulations, so 300 Kg/ha white-rice less than conventional fields reimburse via appropriate higher price by consumers. It seems the PGSs are suitable for development of ORPs nationally and regionally without tensions of higher-price expectation and with economic and social benefits of duck herds and fish productions, of course via a synchronized data recording, monitoring, R&D on inputs and outputs in environmental impact assessments and a nexus approach.

Introduction

The major methods of rice establishment in the world are transplanted rice (TPR) production systems and direct-seeded rice production systems. Rice fields in Iran reaches to 623000 ha. Most of rice fields in North of Iran are in TPR system, but due to water shortage and climate change, direct-seeded rice production system is in progress as well as conservation agriculture (CA) in Golestan province. The impact of a decade long of capacity building and R&D on BCAs and BFs via the national project, Chemical Use Reduction Policy (CURP), indicates some improving trend in organic production since 2000 (Rezapanah 2018); When we may refer to a rather limited 57 hectares of land recorded for organic rosewater production in Kerman. This is while, Kerman province is well-known for its organic production capacities rooted in its more than ten millennia of animal domestication and a Qanat heritage extending more than thirty centuries back in history and for its production of cashmere from Raeini goats by nomad pastoralists (Ansari-Renani and Rezapanah 2017). The farmer groups experiences in rice fields of 3 provinces as well as scientists' innovations on BCAs and BFs (ShahdiKumleh, 2019) prepare a diverse condition for ORP boosting that should be studied and compared with other organic experiences (Rezapanah et al. 2015) nationally, regionally and internationally.

Material and methods

The organic rice fields in North of Iran (between mountains and Caspian Sea in 3 provinces) were recognized, visited and/or re-recorded via related local authorities. Their plant protection activities

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against pests, diseases and weeds such as using duck, fish and other BCAs re-recorded. Situation of manure, fertilizers, BFs, land quality, 2nd culture and clover or bean culture in autumn and winter were recorded too. The main types of continuous ORPs were compared in MANOVA and meta-analysis in average, maximum and minimum of the harvested paddy per hectare of TaromHashemi (Dadpour-Moghanloo et al. 2011).

- The “1st type of the organic rice fields” recognized as “rice+fish” production fields. About 800-1000/ha local carp fish, Cyprinidae were realised in the paddy field. The fishes (20-30 gr) will get weight to even more than 1500 gr in the rice field. They have social and economic benefits for the fields and farmers. Such fields should support with a simple or equipped fish pool inside or beside the field naturally or professionally. This type of production has been tested in research stations of Rasht (personal communication with Dr. Rezaei) and Amol (personal communication with Dr. Khosravi and Mr. Dariabari) several times. It followed up in Baiekola and Daboodasht’s PGSs (Daokola and korsikola) continuously. The villages with duck herds have opportunity to grazing 1-3 duckling herds/year (150-230 ducklings 7-10 days’ age) in the organic rice field. The perfect fields of 1st type include clover or bean culture in autumn and winter and/or appropriate use of manure, vermicompost and BFs. More than a decade, organic activities should be divided to 2011-2013 before introducing BFs to farmers, 2014-2016 and 2017-2021 when farmers starting professional network for organic boosting via PGSs.

- The 2nd type, with 3rd party certification in the fields, mostly without biological control via fish and duck, while they use BCAs and BFs based on the appropriate regulations that certifiers looking for (personal communication with S Shokrollahpour 2022).

- Other types of the fields that studied in this investigation: for research, R&D, non-private, by default organic and the fields with partial experience of organic or in conversion period and/or non-continuous organic activities (Such as activities in Anzali in 2018) in transplanted rice (TPR) production systems and direct-seeded rice production systems.

Results

The maximum of the harvested paddy is still an index of success not only among farmers, but also related officers. Of course, the other social and environmental issues should be considered in future. The average of the harvested paddy (Table 1) was 4416±227 kg/ha in the rice fields after clover or bean culture in autumn and winter with fish and ducklings’ production in Daeokola, Daboodasht, Amol in 2011-2013. The production increasingly (with decrease in 2013 and 2019) reached to 5785 kg paddy/ha, after BFs introducing to the farmers and when Participatory Guaranty System (PGS) started among farmers (presented in farmer session of organic world congress 2017).

The other main organic fields looking for higher price via organic certification usually don’t use fish or duckling herds, while they use BCAs and BFs based on the appropriate regulations harvested maximum 4550 Kg/ha and in worse case about 50% of this amount in the 1st try a decade before, so 300 Kg/ha white rice less than conventional fields reimburse via appropriate higher price by consumers. Significant differences were found among comparable treatments (Table 1).

The harvested paddy of other types of the fields for research and R&D purposes in non-private field expressed the significant differences of fish and duck production. The average of the harvested paddy 5277±323 kg/ha was two times more in the rice fields after clover or bean culture in autumn and winter with fish and ducklings’ production in Daeokola, Daboodasht, Amol in 2014-2021 against 2550 Kg/ha in Baiekola research station field. Also, against usual conventional field (#4500 Kg/ha) showed the significant positive effects of fish and duckling herds production too. The organic seed screening in a decade, after continuous organic production will boost ORP (even in 2nd culture) as by product of ORPs. In this investigation, the fields with partial experience of organic were not compare as well as in conversion period by-default organic field, and/or non-continuous organic activities (Such as activities in Anzali in 2018) in transplanted rice (TPR) production systems and direct-seeded rice production systems.

Table 1: Harvested paddy and white-rice of different organic rice (TaromHashemi) fields

	White-rice (Kg/ha)			Harvested paddy (Kg/ha)				
	Median	Min.	Max.	Median	Min.	Max.		
Rice+fish+duck-herds+BFs Daokola' PGS since 2017		3700	4050		5300	5785	**	Consider other benefits
Rice+fish+duck-herds+BFs Daokola 2014-2016		3360	3655		4800	5221	*	
Rice+fish+duck-herds Daokola 2011-2013	3040	2964	3130	4342	4235	4671		
Certified organic rice in Babol since 2011	2800	1500	3200	4000	2150	4550		
Certified 10 ha Rice Baiekola Research Station 2017-2020		1250	1800		1800	2550		Consider as non-private
conventional		2700	3200		3850	4500		

* Significant at $P<0.05$ and ** significant at $P<0.01$

Discussion

After 3 decades' extensive biological control of rice stem borer in North of Iran based on a decade budget law support of the national project (Rezapanah 2011), Chemical Use Reduction Policy (CURP); Organic rice production is boosting via different combination of using duck, fish, other biological control agents (BCAs) and biological fertilizers (BFs). Of course, the land-fertility quality (between mountains and Caspian Sea in 3 provinces) are different as variation as quality of variety, number of culture in the year, possibility of clover or bean culture in Autumn and Winter, treat severity of pests, diseases and weeds. The main types of continuous organic rice production were recognized and compared. The harvested paddy average expressed that in the rice fields after clover or bean culture in autumn and winter, with fish and ducklings (1-3 herd (150-230)/ha/year) production should be encouraged in PGS as well as organic certification by 3rd party even without fish or duckling herds with higher price. The appropriate combination of rice, fish and duck herds in PGSs are suitable for development of organic agriculture (OA) in North of Iran and the region. Not only economic benefits of duck herds and fish productions, but also physiological effects and control of higher-price expectation tension should be considering in further investigations via a synchronized data recording, monitoring, R&D on inputs and outputs in environmental impact assessments and a nexus approach.

The nexus approach (Personal communication with Dr. B Taheri) is an emerging approach which internalizes the complex interconnections within natural and social systems. The nexus approach encompasses the linkages of multiple resource (Katyaini et al. 2021). We suggest a robust nexus analysis approach to food sector problems with a starting focus on the positive nexus impacts of a robust organic food system (Niggli et al. 2016 and Rezapanah 2015).

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Assessment of the impact of socio-economic factors and consumer behaviour on food waste generation in Sri Lankan households

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Key words: food waste, socio-economic factors, consumer behaviour, Sri Lankan households

Abstract

To achieve the goal of sustainable consumption, sustainable solutions are required for reducing food waste. This study focused on assessing the impact of socio-economic factors and consumer behaviour on household food waste generation of seventy-five volunteer households in Alpitiya Grama Niladhari division, Sri Lanka. Responses were collected from the persons who are actually involved in food preparation and food purchasing at the household level. Household food waste was measured by introducing waste collecting bins. The amount of food waste generated within one household per day was measured for three consecutive days. The mean avoidable food waste and unavoidable food waste generated within one household per day were 0.2625 ± 0.2070 Kg (mean ± SD) and 0.3687 ± 0.1417 Kg respectively. Therefore, the total food wastage (avoidable food waste + unavoidable food waste) within one household per day was 0.6312 ± 0.2864 Kg. Results of the multiple linear regression analysis indicated, total household food waste generated was significantly different according to the income level, the number of family members, the age of the participants ($p < 0.05$). Similarly, total food waste generated within one household was significantly different across two groups; whether they prepare a shopping list or not ($p < 0.05$). The study suggests practices like preparation of a food shopping list, reduction of fruits and vegetable purchasing frequency and adhering to proper meal planning as effective behaviours to reduce household food waste generation.

Introduction

Food wastage is a serious issue faced by countries globally. The Food and Agriculture Organization recently reported that one-third of food produced for human consumption globally is lost or wasted which is about 1.3 billion tons per year (FAO, 2011). According to the data from UN, 854 million people, worldwide are estimated to be undernourished, and another 100 million estimated to be faced with poverty and hunger due to high food prices (UN, 2009). Food wastage is significantly high in developed countries compared to developing and under-developed countries (World Bank, 2014). Food waste generation in Sri Lanka has received much attention due to rapid expansion of the food industry, urbanization, and rising population. A recent study pointed out; the total solid waste generated in Sri Lanka to be around 7 000 tons per day. This solid waste majorly constitutes perishable organic material (65 – 66%) by weight and the total food waste generated in Sri Lanka estimated to be about 3 955 tons per day (Aheeyar et al. 2020). A study conducted by Thirumarpan and Lanka, (2015) in Eravur urban council area, Batticaloa district showed that every household generates an average of 2.06 kg of food waste per day contributing 79% of the total waste generated in the area out of an estimated 20 metric tons of solid waste generated. Therefore, the present study aims to find a reliable method to measure food waste within households in Alpitiya Grama Niladhari division, Sri Lanka and to trace factors influencing over its generation.

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Material and methods

The study was conducted in Alpitiya Grama Niladhari (GN) Division in Warakapola Divisional Secretariat, Kegalle, Sri Lanka, which had 221 households. Based on the convenience sampling approach, 75 households were selected out of 221, to carry out the survey. Data were collected using a researcher-administered questionnaire which contained 19 close-ended questions on two basic areas; participants' socio-economic factors and their behavioural characteristics. Responses were collected from the persons who are actually involved in food preparation and food purchasing in each household.

Household food waste generated was measured by introducing a waste collecting bin (Figure 1), which consisted of eight separate chambers namely: avoidable raw fruits and vegetable food waste (A1), unavoidable raw fruits and vegetable food waste (A2), avoidable cooked fruits and vegetable food waste (B1), unavoidable cooked fruits and vegetable food waste (B2), avoidable cereals, grain / flour-based and tuber food waste (C1), unavoidable cereals, grain / flour-based and tuber food waste (C2), avoidable animal-derived food waste (D1) and unavoidable animal-derived food waste (D2). Finally, participants were advised to fill the given collecting bin containing coded chambers with food waste. The amount of food waste generated within one household per day was measured for three consecutive days (Figure 2). The reasons for generating avoidable food waste were collected from each household and noted daily. The data were entered into excel data sheets and test statistics were conducted using R- studio. Multiple linear regression analysis was carried out to develop a model for total food wastage (including both avoidable and unavoidable food waste) based on socio-economic and consumer behaviour factors (independent variables) under 95% confidence level.

Figure 1. Waste collecting bin with eight separate chambers

Figure 2. Measuring the generated food waste

Results

Socio-economic and behavioural factors of the respondents

Majority of the respondents were females (91%). This may be due to the fact that they are more likely to involve in food preparation and food purchasing at the household level. The most of the participants were between the age of 31 and 40 years (30.6%). The mean household size was 4, which ranged from 2 to7 family members. Majority of the respondents (44.0%) represented the income level of Rs 50001-75000. Moreover, with regard to occupation, 49% of the respondents were unemployed. In addition, 41.3% of families did not have children under the age of 18 years. By concerning respondent behaviour characteristics, it was found that about 58.7% of the participants prepare a food shopping list by considering already available food at home while 41.3% participants do not prepare such thing.

When food purchasing behaviour of the respondents were analysed, majority of the participants, purchased fruits and vegetables (58.6%), as well as meat and fish (50.6%) weekly. The respondents' dry foods purchasing frequency was reported as monthly by about 49.3% of the participants.

As a percentage, 85.3% of participants used a refrigerator to store foods and all participants who own a refrigerator store fresh foods in the refrigerator. However, only 4.7% of participants store leftovers of cooked foods. When the spending on food for a month is considered, majority of the respondents belonged to the spending range of more than Rs 25000, which was 26.6%.

The average weight of different categories of food waste generated within one household are shown in Table 1. Based on above measurements, calculated mean avoidable food waste and unavoidable food waste generated within one household per day were 0.2625 ± 0.2070 Kg (mean ± SD) and 0.3687 ± 0.1417Kg respectively. Therefore, the total food wastage (avoidable food waste + unavoidable food waste) generated within one household per day was 0.6312 ± 0.2864 Kg. Most frequent wasted food (avoidable) was cereals, tubers and grain / flour-based food waste, while animal derived food waste was among the category that has subjected to minimum wasting. Our finding is somewhat different from previous studies, (Schott et al. 2013; Langen et al. 2015; Edjabou et al. 2016; Elimelech et al. 2018) where they have reported vegetables and fruit products as the most wasted food category. This difference may be mainly due to differences in eating habits as Sri Lankans consume rice, tubers and cereal-based food products as their staple food. The main reason for cereals, tubers and grain / flour-based food waste generation was rated as over preparing by majority (81.5%) of the participants.

Table 1: The average weight of food waste for each group

Food waste category	Mean (g)	Median (g)	Standard deviation (SD)
Avoidable raw (unprocessed) fruits and vegetable food waste (A1)	86.5	60.0	91.2
unavoidable raw (unprocessed) fruits and vegetable food waste (A2)	304.5	296.3	116.8
avoidable cooked (processed) fruits and vegetable food waste (B1)	40.1	21.3	54.1
unavoidable cooked (processed) fruits and vegetable food waste (B2)	13.8	8.3	18.4
avoidable cereals and tubers and grain / flour-based food waste (C1)	128.4	85.3	139.4
unavoidable cereals and tubers and grain / flour-based food waste (C2)	33.6	11.6	44.7
avoidable animal-derived (meat, fish and eggs) waste (D1)	7.5	0	12.7
unavoidable animal-derived (meat, fish and eggs) waste (D2)	16.6	13.3	11.2

The regression model developed for this study: Total Food waste = 544.24 -165.94 (Shopping list preparation – Yes) + 335.04(Income 75001-100000) -331.16 (Age 31-40) -312.45(Age 51-60) +77.27(Number of family members)

Impact of socio-economic factors and consumer behaviour on food waste generation

The summary of the regression model for the total food waste generation is shown in Table (2). The results indicated that 40.23% (adjusted R^2 =0.4023) of the variance of the food waste generation in one household per day can be explained by independent variables included in the model. Moreover, the p value of the model suggest that the estimated model is significant ($p<0.05$, p=4.147e-06).

Table 2: Model summary of total food waste generation

Variable	Coefficients			
	Estimate Std.	Error	t value	Pr (>|t|)
(Intercept)	544.24	139.52	3.901	0.000235 ***
Shopping list preparation - Yes	-165.94	55.98	-2.964	0.004277 **
Income 50001-75000	78.58	65.24	1.205	0.232881
Income 75001-100000	335.04	87.04	3.849	0.000279 ***
Income less than 25000	127.22	168.77	0.754	0.453774
Income more than 100000	107.92	133.93	0.806	0.423380
Age 31-40	-331.16	114.68	-2.888	0.005312 **
Age 41-50	-62.25	124.02	-0.502	0.617445
Age 51-60	-312.45	120.29	-2.598	0.011674 *
Age 61-70	-229.39	119.42	-1.921	0.059282.
Age more than 70	-215.11	192.71	-1.116	0.268846
Number of family member	77.27	28.90	2.674	0.009547 **

Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 221.4 on 63 degrees of freedom

Results suggested that the total food waste generated was significantly different according to the income level, the number of family members, age of participants ($p < 0.05$). Similarly, the total food waste generated within one household per day was significantly different across two groups; whether they prepare a shopping list or not ($p < 0.05$). Similar findings were observed in previous studies also (Baker et al. 2009; Bernstad et al. 2013; Edjabou et al. 2016; Akerele et al. 2017; Yildirim et al. 2016). The expected food waste generation for a household/person who has 25000-50000 (LKR) income level, two family members and age between 20-30, with no previously prepared shopping list, was 544.24g. While holding other factors constant, if one family member is added to the family, food waste is expected to increase by 77.27g. whilst, the food waste is expected to decrease by 165.94 g if a person/household prepares a shopping list. Also, the food waste is expected to increase by 335.04 g if a person/household has 75000 – 100000 (LKR) income level compared with the reference group. The food waste generated is expected to decrease by 331.6g if a persons' age is between 31-40 and decrease by 312.45g if a persons' age is between 51-60 compared to reference group.

Discussion

The results indicated that cereals, tubers and grain / flour-based food wasted more than any other food group, and is mostly wasted as left-over due to over preparation. Thus, the study recommends that households should properly plan the quantity of food for consumption before cooking, and re-use left-overs as a way of reducing food waste. Further the findings suggest that the preparation of a food shopping list, reduction of fruits and vegetable purchasing frequency and adhering to proper meal planning practices as effective strategies to reduce household food waste generation. Since, the total food waste produced within one household is impacted by different variables like the income level of the family, age of participant (who are actually involved in food preparation and food purchasing), the number of family members, the effect of aforementioned factors can be successfully controlled in minimizing the amount of food waste generated in households of the tested population.

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Climate Smart Approaches to Enhance Carbon Sequestration in the Coastal Ecosystems of Bangladesh

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Key words: Climate Smart Approaches, Soil Organic Carbon Sequestration, Coastal Ecosystems

Abstract

A study was conducted in the coastal ecosystems of Bangladesh regarding climate smart approaches to assess soil organic carbon (SOC) stock and their sequestration in the mangrove and salt marsh habitats. Fifty soil samples of 10 soil profiles up to 1 m soil depths were collected. Bulk density and SOC level are the two prerequisites for estimating SOC stock. SOC stock was estimated following standard methodology. In the salt marsh sites, SOC ranged from 13.1 to 45.7 g/kg with a mean value of 27.5 g/kg. In the mangrove sites, SOC varied from 14.1 to 46.3 g/kg with a mean value 26.4 g/kg. The study revealed that both of these ecosystems sequester more carbon than the threshold level (20.0 g/kg). The analytical results also revealed that mangrove and salt marsh ecosystems store and sequester 57.68 kg/m^2 and 83.78 kg/m^2 in the above-ground and 100.56 kg/m^2 and 121.11 kg/m^2, respectively in the below-ground compartments. So, deeper soil horizons sequester more carbon than the subsoil horizons. It is suggested to make a management policy to restore the carbon in the mangrove and salt marsh habitats.

Introduction

The coastal region of Bangladesh covers 710 kilometer coastline covering three distinct geographical parts: western, central and eastern. This lies between 21˚30′ to 22˚30′ north latitudes and 88˚01′ to 92˚00′ east longitudes. It comprises the most active portion of Ganges-Brahmaputra-Meghna River system in Bangladesh. Scientists reported that about 2.4 billion tons/year sediments flows in the Bay of Bengal through the major River channels (Coleman 1969; Anwar 1989). As a result, erosion and accretion games are common phenomenon in the coastal regions and coast line movement towards the Bay of Bengal (Uddin *et al.* 2019). The impact of climate change aggravates the situation of sediment transportation and deposition in a serious turn. To mitigate climate change and enhance blue economy, soil carbon sequestration strategies are getting priority in developing and formulating delta plan 2100. Knowledge of SOC dynamics in deeper soil profiles is essential to understand the SOC sequestration rate (Simo *et al.* 2019). For this reason, a study was initiated to understand how climate smart approaches can enhance carbon sequestration to tackle natural calamities. It is thus important to conserve mangrove forest, sea grass, and the saltmarsh ecosystems etc. to reduce atmospheric CO_2 and mitigate global climate change. It is evident that coastal vegetation sequesters carbon far more effectively and permanently than the terrestrial ecosystem which is often referred to as 'blue carbon' (Howard *et al.* 2014). Authors have noticed the potentials of carbon storage in coastal ecosystems (Hopkinson *et al.* 2012) that covers only 2.5% of total land surface of the world, but their net global carbon storage is estimated to be 25 Pg (Duarte *et al*. 2013). It was estimated that carbon accumulation rate per unit area is 30–50 times higher in coastal wetlands than that of terrestrial forest ecosystems (Ouyang and Lee 2013), highlighting their importance with respect to the global carbon cycle. Chmura *et al.* (2003) reported an annual carbon sequestration rate of ~ 44.6Tg C for soils of mangroves and salt marshes habitats.

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Materials and Methods

Total 50 soil samples from 10 soil profiles at different soil depths up to 100 cm (0-20cm, 20-40cm, 40-60cm, 60-80cm, 80-100cm) were collected covering the mangrove and salt marsh coastal eco-zones of Bangladesh. During soil sampling, soil bulk density for the individual depths were measured which were used in the estimation of SOC dynamics and stocks. The collected soil samples were processed and preserved in plastic bottles for subsequent laboratory analysis.

Soil organic carbon was determined by the wet oxidation method of Walkley and Black (1934) as described by Nelson and Sommers (1982). Bulk density was measured by core method as described by Blake and Hartge (1986). The total soil organic carbon (TSOC) stock or storage was calculated using the equations of Batjes (1996), Chen et al. (2007), Zhang et al. (2013). It may be noted that the bulk density and SOC contens are the two prerequisites for estimating SOC stock or storage. Thus, the soil organic carbon storage was calculated using the following equations:

$$\text{Soil Organic Carbon (TSOC)} = SOC_i \times B_i \times D_i$$

Where, SOCi is the SOC content on the i^{th} layer (g/kg);

B_i is the bulk density of the i^{th} layer (g/cc), and D_i is the depth of the i^{th} layer (cm).

At first, the area of the mangrove and salt marsh eco-zones were visually delineated using the International Union for the Conservation of Nature (IUCN) resources map and the shape files were extracted and digitized in Google Earth Pro. Secondly, the shape files were geo-referenced, projected and subsequently the areas were calculated using the respective polygon attribute tables (PAT) in ARC/GIS 10.3.

Results

In the salt marsh sites, SOC ranged from 13.1 to 45.7 g/kg with a mean value of 27.5 g/kg (Table 1). On the other hand, SOC storage in the salt marsh sites ranged from 19.01 to 61.53 kg/m^2 with a mean value of 41.53 kg/ m^2.

Table 1: Soil Organic Carbon (SOC) Storage (kg/m^2) in the Salt Marsh Sites at 100 cm Depths in the Coastal Areas of Bangladesh

Salt Marsh Sites	Geo-Coordinates & Elevation (m)	SOC (g/kg)	Areas (ha)	SOC storage (kg/ m^2)
Char Kukri Mukri, Bhola	21˚ 55′ 51.5″ N; 90˚ 40′ 062″ E E= -1m	19.8	272	30.77
Reju Khal, Cox's Bazar	21˚ 17′ 52.2″ N; 92˚ 03′ 16.1″ E E= -2m	13.1	239`	19.01
Bakkhali Estuary -1	21˚ 28′ 16.68″ N; 91˚ 58′ 21 88″E E= 2 m	27.2	106	42.92
Bakkhali Estuary -2	21˚ 28′ 54.01″ N; 91˚ 58′ 44.59″ E E= 5 m	31.9	108	50.70
Rangi Khali Khal, Teknaf, Cox's Bazar	21˚ 00′ 11.6″ N; 92˚ 15′ 48.6″ E E= 8 m	45.7	281	61.53
Mean SOC	-	27.5 g/kg	1006	41.53

In the mangrove sites, soil organic carbon (SOC) varied from 14.1 to 46.3 g/kg with a mean value 26.4 percent (Table 2). On the other hand, SOC storage varied from 18.85 to 46.76 Kg/m^2 with a mean value of 31.64 kg/ m^2.

Table 2: Soil Organic Carbon (SOC) Storage (kg/m^2) in the Mangrove Sites at 100 cm Depths in Coastal Areas of Bangladesh

Mangrove Sites	Geo-Coordinates & Elevation (m)	SOC (g/kg)	Areas (ha)	SOC storage (kg/m^2)
Munshiganj, Shyamnagar, Satkhira	22˚ 15′ 85.8″ N; 89˚ 11′ 69.4″ E E= 7 m	18.4	8,000	24.46
Magurkhali, Dumuria, Satkhira	22˚ 41′ 69.8″ N; 89˚ 21′ 59.4″ E E= 5 m	46.3	19	38.76
Char Kukri Mukri, Bhola	21˚ 55′ 67.6″ N; 90˚ 39′ 54.3″ E E= 8m	14.1	2763	18.85
Reju Khal, Cox's Bazar	21˚ 17′ 62.4″ N; 92˚ 03′ 17.2″ E E= -2m	20.0	376	29.41
Boroitoli, Teknaf, Cox's Bazar	20˚ 53′ 29.3″ N; 92˚ 17′ 44.7″ E E= 9m	33.6	535	46.76
Mean SOC	-	26.4 g/kg	11,693	31.64

From the above datasets, it was found that salt marsh sites sequester more SOC than the mangrove sites.

Discussion

The above study revealed that the spatial variability of soil organic carbon (SOC) differs depending on the local hydro morphological conditions where salt marsh habitat carries diverse vegetation with higher level of SOC stock. Benner *et al.* (1991) reported that salt marsh soils are rich in organic carbon derived from dead plant material, and thus contain more carbon than tidal flat soils and getting accumulated in the deeper soil horizons. Byun *et al.* (2019) noted that the mean carbon storage per unit area of coastal wetlands sinks four times higher than terrestrial ecosystems in South Korea. Soil carbon storage in South Korea in the pristine mud flat was also higher than that of other ecosystems (Byun et al., 2019). The analytical results revealed that mangrove and salt marsh ecosystems store and sequester 57.68 kg/m^2 and 83.78 kg/m^2 in the above-ground and 100.56 kg/m^2 and 121.11 kg/m^2, respectively in the below-ground compartments. So, deeper soil horizons sequester more carbon than the subsoil horizons. It was also reported that mangrove ecosystems store and sequester significant quantities of carbon (Kauffman *et al.* 2014).The global mean SOC concentration of mangroves is 22 g C kg^{-1} (Kristensen *et al.* 2008) where it is higher value of C (26.4 to 27.5 g/kg) in the study sites than the stated value. Weiss *et al.* (2016) reported that SOC stocks in mangrove ecosystem vary from 27.1 to 57.2 Kg C m^2 which is consistent with the present study. It is evident that SOC threshold for sustaining soil quality is widely suggested to be about 20 g/kg (Patrick *et al.* 2013), below which deterioration in soil quality occurs. It is found that both mangrove and salt marsh habitats sequester more carbon beyond the threshold level. There is no alternative to protect and regenerate mangrove and salt marsh habitat in the coastal ecosystem to tackle climate change and other often disasters. It is the high time to formulate a management policy of zoning mangrove and salt marsh ecosystem and to conserve wetland bio-resources and their carbon storage.

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Biochar-facilitated water remediation of residual pesticides for sustainable agriculture and the environment

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Key words: Biochar sorbent; Pesticide removal; Pollutant adsorption; Surface chemistry

Abstract

This study demonstrated the adsorption capability of biochar in removing pesticides (atrazine, 2,4-D, dichlorvos, and pymetrozine) from water. The characteristics of biochars were analysed by SEM, BET, and FTIR. The adsorption isotherms for all pesticides were followed the Langmuir isotherm with the maximum adsorption capacities were 16.6,41.7,29.9, and 39.3 mg g^{-1} for atrazine, 2,4-D, dichlorvos, and pymetrozine, respectively. The chemical bonding (π-π electron donor–acceptor interaction, hydrogen bonding, and hydrophobic interaction) between biochar and pesticides was the major mechanisms for biochar-facilitated water remediation of all investigated pesticides.

Introduction

Pesticides are natural synthetic chemicals that are used in various activities of agriculture in order to maintain traditional agricultural practices. Though there is no doubt that the application of pesticides has a large contribution to increased yields of crops and reduced insect-borne disease, it has prompted concerns regarding to their long-term impact on human health and ecology safety. The accompanying environmental consequences are mostly owing to the pesticides persistent and pervasive qualities through agricultural runoff (Sharma et al. 2019). The small concentrations of these pesticides that accumulate in water can be amplified by the food chain and penetrate in aquatic species that are harmful to humans (Rasool et al. 2022). In this context, it is of great importance to develop efficient methods for simultaneously eliminating the pollution of pesticides from the agricultural use.

Biochar is a carbonaceous solid material derived from pyrolysis of biomass. To date, much of attention has been focused on controlling pesticides by using biochar because it is rich in carbon, porous structure, and contains multiple functional groups (El-Naggar et al. 2019). Likewise, biochar has the advantages of low-cost (El-Naggar et al., 2020), environment friendliness (An et al. 2021), easy operation, wide adaptability, easy recyclability, and high possibilities for industrial-scale applications (Wang et al., 2020). In general, adsorption process of biochar is known as a very efficient technique to reduce organic and heavy metal pollutants (Tan et al. 2015). Concerning the adsorption economy, pyrolysis, gasification, or combustion process has been used to transform agricultural waste to biomass (Inyang et al. 2015), resulting in high porosity and surface area of the residual product. However, different temperatures and burning conditions significantly influence the distinctive properties of a biowaste sorbent, leading to different pollutant removal efficiency. Moreover, the physico-chemical property of biochar is one of the crucial factors affected the performance of pesticides removal process. Therefore, the aim of this study was to (i) determine the effect of burning conditions on corn cob biochar (CB) characteristics, (ii) evaluate the effect of CB properties on pesticides (atrazine, 2,4-D, dichlorvos, and pymetrozine) adsorption, and (iii) identify pesticide removal mechanisms by CB.

Material and methods

Synthesis and modification of biochar

The corn cob biomass was chopped to be approximately 1 cm^3 in size and dried under the sun for 7 days to exclude the moisture. The biomass was further dried in the hot air oven at 105 °C for 4 h to achieve a constant weight. Subseqeuntly, the biomass was pyrolyzed in a muffle furnace (Nabertherm, Germany) under oxygen-limited conditions at 400-600 °C during specified burning period of 2-6 h. The

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temperature in the furnace was controlled and rose slowly at 3 °C/min. Biomass product was pyrolyzed at different temperatures (400, 500, and 600 °C) for 6 h, while the heating periods were varied at 2, 4, and 6 h when the temperature was fixed at 600 °C. The obtained biochar were modified by 0.1 M HCl acid as described by Uchimiya et al. (2012) prior use. All data obtained from the duplicate experiments. Samples were analysed by scanning electron microscope (SEM) (model LEO 1455 VP, Carl Zeiss Microscopy GmbH, Germany). The surface area and total pore volume of CBS were evaluated using a BET-N2 surface area analyzer (model TriStar II 3020, Micromeritics Instrument Corporation, USA). The functional groups on biochar surfaces were assessed using the Fourier Transform Infrared (FT-IR) spectrometer (Frontier, PerkinElmer, USA).

Pesticide removal by biochar

The stock solution of different pesticides (atrazine, 2,4-D, dichlorvos, and pymetrozine) was prepared with deionized water. The CB loading was 1.5 g/L. The adsorption of pesticides was conducted for 6 h under dark conditions. Throughout the adsorption process, the residual concentrations of atrazine, 2,4-D, dichlorvos, and pymetrozine were examined during a specific time interval. The separation of the biochar and pesticides solutions was done by filter paper (Whatman No. 42) prior concentration analysis. The UV–Vis spectrometer (Genesys 10S UV-Vis spectrophotometer, Thermo Scientific, USA) was employed for the analysis of pesticides concentrations at the wavelength of 229, 235, 210, and 299.2 nm, respectively. All experiments were performed in triplicate.

Results and Discussion

Corn cob biochar characteristics

The morphological structures of the CB were investigated. SEM micrographs revealed that the physical appearance of the biochar differed, owing to the effect of pyrolysis conditions (Fig. 1a-b).

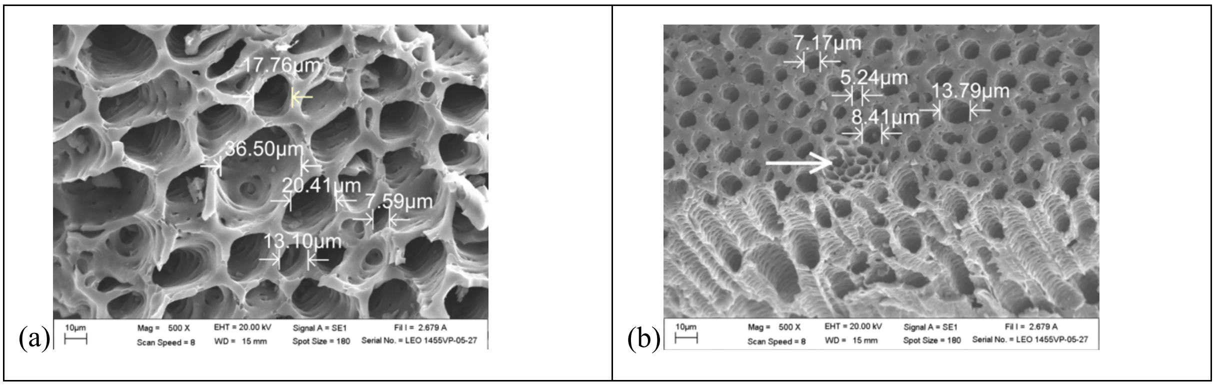

Figure 1. Morphology and pore sizes of CB from (a) 400 °C-6h and (b) 600 °C-4h

The CB have high porosity with numerous longitudinal pores in the range of 4.0 – 36.5 μm diameters. With the increasing of pyrolysis temperature from 400 °C to 600 °C in 6 h, the BET surface area of CB changed from 6.10 to 303.36 m^2/g, respectively (Table 1). When the holding times are considered, it could be seen that the CB600 °C-4 h had a surface area higher than the SSA of CB600 °C-6 h and CB600 °C-2 h, respectively. In adition, the small pores in the hive forms with approximately 4-5 μm in diameter were also found in sample of CB600 °C-4 h. In CB analysis, pore volume distributions in pore sizes of micropores (<2 nm) and narrow mesopores (2-20 nm) were detected in the range of the 13.69 - 28.57% and 47.25 - 68.18%, respectively.

Eight functional groups, mainly the unsaturated hydrocarbon such as which are ketone, carbonyl, and aromatic organic molecules, are dominated on the surfaces of the CB as shown in the FTIR spectra (Fig. 2). The FT-IR spectra showing the functional group of CB before and after adsorption are compared in Fig. 2a-d. The change of peak area in FT-IR spectra at 1046-1015 cm^{-1}, 1230-1203 cm^{-1}, 1736-1696 cm^{-1}, 2325-2311 cm^{-1}, and 3600-3000 and 3787 cm^{-1} was observed. The adsorption isotherms of pesticides and CB are shown in Table 2.

Table 1: Pore size and diameter of corn cob biochar

Pyrolyzed condition	BET surface area (m^2/g)	Total pore volume (cm^3/g)	Average pore diameter (μm)	pore size (μm)
600 °C-2h	280.67	0.1079	7.00	4.00 – 16.97
600 °C-4h	350.22	0.1335	6.76	5.24 – 13.79
600 °C-6h	303.36	0.1131	10.55	7.45 - 15.59
400 °C-6h	6.10	0.0019	18.82	7.59 - 36.50
500 °C-6h	109.84	0.0436	11.06	5.10 - 18.76

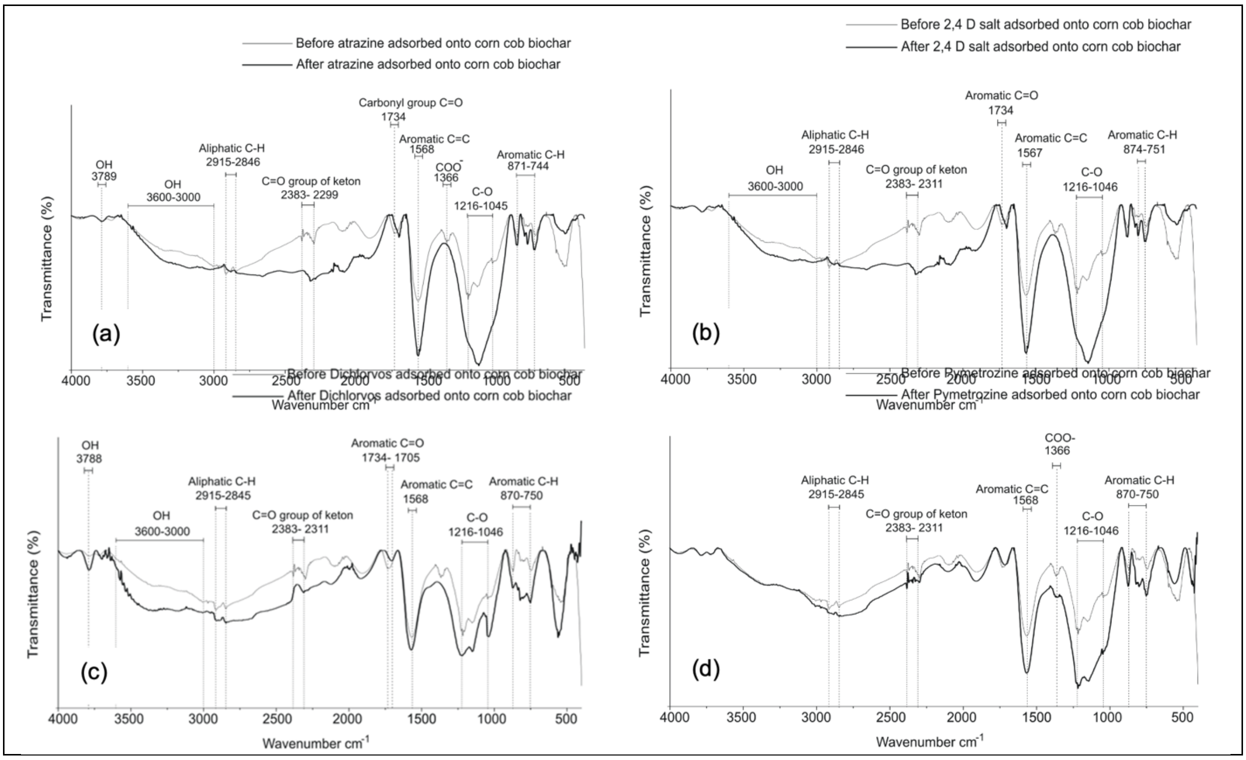

Figure 2. FTIR of corn cob biochar for both before and after adsorbed pesticides (a) atrazine, (b) 2,4-D, (c) dichlorvos, and (d) pymetorzine.

The calculated parameters for both Langmuir and Freundlich adsorption isotherms are shown in Table 2. From the Langmuir isotherm, the capacities of the maximum monolayer coverage, Q_o, were 16.6, 41.7, 29.9, and 39.3 mg g^{-1} for atrazine, 2,4-D, dichlorvos, and pymetrozine, respectively. From the Freundlich isotherm, the adsorption capacities as illustrated by K_f were 8.54, 14.21, 7.07, and 12.38 (mg/g)$(mg/L)^{-n}$ where 1/n was 0.40 for atrazine, 0.40 for 2,4-D, 0.66 for dichlovos, and 0.66 for pymetrozine, respectively. The R^2 of the Langmuir model and the Freundlich model of CB was in the range of 0.992-0.997 and 0.922-0.998, respectively. However, the R_L value of CB synthesised was in the range of 0.0010-0.0024.

Discussion

The surfaces of CB synthesized at 600 °C for 2, 4, and 6 h formed many small rough pores. Interestingly, the improvement of porosity was occurred from the dissolution of the remaining volatile matter in the CB at 600 °C. Some destoyed pores which were observed in CB600 °C-6 h could be ascribed by the effect of long residence time during the pyrolysis process at a high temperature. The volume and size of the pores and surface area may affect the uptake of pesticides and it played an important role in the pore-filling adsorption (Wang et al. 2018). In some cases, the functional groups on the biochar surface benefit pesticide adsorption (Thue et al. 2017). The results showed that the Langmuir model very well explained the adsorption behaviour of all pesticides, except dichlovos, when compared to the Freundlich model.

This means the monolayer adsorption of atrazine, 2,4-D, and pymetrozine tended to occur on the surface of the CB. In the case of dichlovos, it seems both monolayer adsorbtion as well as multilayers and heterogeneous adsorption could be found on the surface of CB. The monolayer adsorption of dichlorvos on activated carbon derived from the nut shells was reported by Ogwuche et al. (2015). Moreover, the R_L value of CB also demonstrated the favourability of the CB for all pesticides adsorption.

Table 2: Adsorption of pesticides (Atrazaine, 2,4-D, Dichlorvos, and Pymetrozine) by biochar.

Models	Adsorption parameters	Adsorbed pesticides			
		Atrazine	2,4-D	Dichlorvos	Pymetrozine
Langmuir	Q_0 (mg/g)	16.6	41.7	29.9	38.3
	K_L (L/mg)	1.12	0.46	0.32	0.51
	R_L	0.0024	0.0010	0.0013	0.0010
	R^2	0.993	0.993	0.992	0.997
Freundlich	K_F (mg/g) (mg/L) $^{-n}$	8.54	14.21	7.07	12.38
	1/n	0.40	0.40	0.66	0.66
	R^2	0.964	0.922	0.998	0.982

The change of peak area in FT-IR spectra at 1046-1015 cm^{-1}, 1230-1203 cm^{-1}, 1736-1696 cm^{-1}, 2325-2311 cm^{-1}, and 3600-3000 and 3787 cm^{-1} were ascribed to type of C-O stretching of alcohol, C-O stretching of phenolic hydroxyl, C=O of carbonyl group, C=O of ketone group, O-H of alcohol, phenol, and carboxyl, respectively. The shifts of these peaks indicated that oxygen and hydrogen in the CB functional groups are involved in H-bonding interactions. The H-bonding interaction can also occur from the interaction between the oxygen containing functional group of these pesticides and the hydrogen in the carboxylic acid, and the phenolic groups of CB. In this study, the CB hydrogen atoms are possibly bonded to some chemical groups of these pesticides, and carried the positive charge. In addition, the H-bonding interactions in the pesticide adsorption processes were also possible through the oxygen from the phenolic, carbonyl, and carboxyl groups of CBS and hydrogen from pesticides. The results of this study are comparable to the results obtained in similar studies (Sun et al. 2010). When the π- π EDA interaction between these pesticides and the aromatic compound on the CB surface is considered, the peaks were changed to 1585-1569 cm^{-1} which indicated the aromatic C=C. The π- π EDA interaction can occur from the aromatics ring of CB which has high electron density (π^-) and, consequently, can provide an electron for this interaction (Liao et al. 2008). The electron-withdrawing group can lead to the positive charge (π^+) for the π- π EDA interaction (Tan et al. 2016) to accept electron from the CB surface. The hydrophobic interactions were also linked between the alkyl side chains of pesticides and the alkyl groups of CB. The peaks at 2851-2823 cm^{-1}, assigned to the alkyl group, were shifted after pesticides adsorption. As the alkyl side chains of pesticides are significantly nonpolar, it is assigned to the hydrophobic properties (Lerch et al. 1997). However, from FTIR spectra, CB also had the alkyl groups. During the adsorption of pesticides onto CB, the hydrophobic interactions occurred between the alkyl side chains of pesticides and the alkyl groups of CB.

Conclusion

The biochar-facilitated water remediation from pesticide contamination was achieved in this work. The predominant changes in intensity of the carbonyl, ketone, alcohol, phenol, carboxylic acid groups occurred on the CB surface after pesticides adsorption. These groups were proposed for H-bonding interactions. The overall intensity changes of these groups were higher than the intensity changes of the groups that were involved in the hydrophobic interactions and the π- π EDA interactions. Apparently, the key chemical interaction in the adsorption mechanism of the CB and pesticides was the H-bonding interaction.

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Workshop 2: From farm to fork - healthy Organic food systems?

Acronym: Healthy food systems

Moderator: Assoc. Prof. Dr. Wahyudi David (Indonesia)
Rapporteur: Dr. Maya Melati (Indonesia)
Date: Oct 2nd, 2022

Oct 2nd, 2022	Impuls presentations by:
10:30 – 12:30	**Session 1:** • Wahyudi David (Indonesia) • Raymond Auerbach (South Africa) • Mahesh Chander (India)
14:00 – 16:00	**Session 2:** • Maya Melati (Indonesia) • Lorena Fernandez (Philippines) • Siriwan Siknocom (Thailand)
16:00 – 18:00	**Session 3:** • Muhammad Farhan (Pakistan) • Tashi, Sonam (Bhutan) • Susanne Bügel (Denmark) (online)

The global food system is complex and facing a wide range of social, cultural, political, economic, health and environmental challenges. Therefore, there is the need for models and frameworks that contribute to solving these problems and which indicate how to establish a sustainable food system that integrates sustainability in all its dimensions. Before investigating to what degree organic food systems may be used as such models, a model for organic food and farming as a system is needed. Thus, we consider organic food and farming through a food system lens and describe organic food system elements such as boundaries, actors, and sub-systems as part of an aggregated model. The workshop will discuss about how organic food/agriculture as a system contribute as a pilot model and living laboratory for sustainable food systems. The model would demonstrate drivers of sustainable food consumption and to link this to real-world examples of sustainable production and consumption. It is important to understand that the organic food system as a kind of window for exploration but not as the exclusive solution.

Organic food system model: quality perspective on organic rice

WAHYUDI DAVID [1]

Key words: knowledge, consumer, farmer, processor, organic rice quality

Abstract

In recent years, the demand for organic rice has increased along with the increasing consumer awareness of it. However, information or knowledge systems regarding consumer expectations of the quality of organic rice have not been well developed. For this reason, this study aims to describe gaps in information or knowledge systems throughout the supply chain which is the strategy for developing the quality of organic rice. Focus group discussions were conducted with farmers, processors, and consumers, from which key information or knowledge was coded and weighted to describe which was the dominant factor for quality development. The study found that the definition of organic rice quality differs among farmers, processors, and consumers. The farmers tend to define the quality based on environmental context, but processors consider the attributes of the product, while consumers tend to focus on both the attributes of the product and the process

Introduction

Consumer knowledge of the latest products is an important point in the discourse of service innovation. In this case, common knowledge becomes a bridge to improve the relationship between two parties, especially between consumers and producers (Salunke et al., 2019). While achieving common knowledge means that both parties 'acknowledge' and 'agree' on common terms and procedures, the level of consumer knowledge and characteristics of a product have become point of interest (Singh et al., 2021). This shows that the process by which common knowledge is formed is highly dependent on how consumers experience, feel, and use the product.

Since the level of knowledge can be a reference to accelerate the achievement of common knowledge, both consumers and producers must create a dialectical situation – this suggests that common knowledge is developed by the process of synthesis done by both (Nonaka and Toyama, 2015). Producers and consumers may have different or similar views about a product – the level of knowledge of a product leaves 'room' for different points of view. From both sides, the internalization of knowledge will continue to occur, and tacit knowledge is the reason for the formulation of common knowledge. However, common knowledge in product development is majorly driven by the customer perception of the product (Stolzenbach et al., 2013). In addition, knowledge acquisition between both parties is urgently needed to drive the adoption of 'new' products in terms of both usability and social trends (Risselada et al., 2014). Consequently, the term 'consumer power' reinforced by the digital revolution has changed the way consumers interpret a product, and this has left an impact on the way producers capture consumer knowledge (Labrecque et al., 2014).

In many ways, mastery of knowledge of a product has an impact on the development of technological products and daily needs; this may refer to products developed to meet needs (that evolve over time) or products that are cultural-based and whose processing is not eroded over time. In Indonesia, certain food products have been manufactured and consumed for generations, but not many consumers understand why they should choose one product in place of another. For organic foods, organic rice is the second-highest demanded organic product in Indonesia (David and Ardiansyah, 2017a). Since 2010, the Indonesian government has been supporting organic food production. The enthusiasm to practise organic agriculture and to consume organic products was pushed by the Department of Agriculture with the slogan 'Go Organic 2010' (Dalmiyatun et al., 2018). Currently, organic food production has been increasing. Organic products in Indonesia represent 0.03% of global demand, with a per capita

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expenditure of US$0.06 in 2021. With a growing number of consumers interested in organic products and the emerging economy in Indonesia, the potential for organic products seems positive when considered in the long term, with a forecast value CAGR of 6.1% for the period of 2021 to 2026 (Euromonitor International, 2022).The demand for organic food has been a steady increase not only in Indonesia but also in the global market, as well as in developed and developing countries due to increasing consumer awareness of health and environmental issues (Joshi et al., 2019).

Because the organic farming approach follows some basic principles such as health, ecology, fairness and care, it is considered an efficient agricultural practice for environmental sustainability (Dhiman, 2020). A healthy and eco-friendly lifestyle enabled by consuming organic food becomes a thing of value and a symbol of green identity and a global green movement in the broader culture called green consumerism (Wilujeng, 2021). Today, consumers and producers around the world have become more conscious of the danger of using synthetic chemicals in farming, which may have negative effects on human health and may equally cause environmental damage. Consumers need assurance that the food they consume is safe and contains a high nutritional value (Export News Indonesia, 2017).

According to David and Ardiansyah (2017b) on consumer perception of organic rice, health concerns and less pesticide residue were important factors that influenced the purchase of the product by the consumers. However, what consumers did not know is that when the organic rice is polished, like the conventional one, then the nutritional content of both will be similar (David et al., 2019; David et al., 2020). Meanwhile, the consumer spends more on the nutritional quality of organic rice compared to the conventional one. The selling price of organic rice ranges from 1.5 USD to 4 USD. The wide price range is assumed to be asymmetric information along with the milling process.

The dilemma between the degree of milling and the nutritional properties of rice cannot be reflected in the price. Consumer perception of brown rice is lower where the nutritional properties are high. Meanwhile, for both farmers and processors, the highest degree of milling reflects an increase in the price. In the area of organic food, consumers and their purchasing behaviour have been the subject of several studies, even though there is still a lack of consistent findings and clear description of consumers' perception of organic food quality, in terms of its health benefits, safety, and environmental sustainability, as well as in terms of the determinants of perceived quality (Lamonaca et al., 2022). Food quality is commonly associated with nutritional and sensory aspects, especially taste. In the case of organic products, the notion that organic food is more nutritious than conventionally produced foodstuffs is still debatable and the conclusion is not clear yet. Moreover, some people may be able to differentiate the taste of organic and non-organic food, but others may find no difference. Various factors influence food quality besides the farming process, such as harvesting time, post-harvest process, storage condition, including room temperature and packaging material, and the cooking practice.

Given the above situation, this study aims to analyse the common knowledge of organic rice quality by its consumers and producers, and how they develop a consensus of information. The study further identifies which knowledge/information is not fully understood by these stakeholders as well as the one that can be understood by both of them.

Material and methods

To examine how the discourse of shared knowledge is formed between producers and consumers, we approached groups of stakeholders in organic rice in Indonesia. The stakeholders consisted of a group of farmers (n=13), a group of processors/intermediaries (n=10), and a group of consumers (n=18). We collected data by focus group discussion (FGD) which was performed in three groups of separate sections. The Group of Farmers (GF) is an organic rice grower who has been practising organic agriculture for about ten years. The GF were between 36 and 58 years old and all of them were males. The Group of Processors (GP) is a processor of rice milling as well as a middleman trader who has been practising for more than 15 years and also doing conventional and organic rice milling. The Group of Consumers (GC) is a consumer of organic rice with an age range of 25–50 years. An FGD was conducted for about 90 minutes under one facilitator. Data was collected and documented.

Data from the FGD was collected using an affinity diagram and was weighted according to the expert panel. The expert panel consisted of consumers, farmers, and processors. Data was coded and weighted to describe which key knowledge was the main gap/barrier. Data was translated from Indonesian into English, and all actors were asked what their expectation of organic rice was and what was yet to be accomplished.

Five key questions were addressed to all actors (farmers = F) (Processor = P) and (consumer = C). The question is 1) Are you satisfied with organic rice information/knowledge? (Yes/No) 2) Do you consider the milling degree to be the problem? (Yes/No/Don't Know) 3) How do you rate the current quality of organic rice? (1= low, 5= best) 4) Is the quality/price ratio satisfactory? (Yes/No) 6) Do all actors think the quality should be improved? (Yes/No/Don't know)

The qualitative data was computed to Xlstate (R) Base Version 2021. The Audio analysis was carried out using f4 software developed by Marburg University, Germany. After importing, editing, and formatting, content analysis was done. Data was analysed using Multiple Correspondence Analysis (MCA) which was performed by Xlstat Base Version 2021. Correspondence Analysis aimed to represent as much of the inertia on the first principal axis as possible, with a maximum of the residual inertia on the second principal axis and so on until all the total inertia was represented in the space of the principal axes.

Results

The comparison of key information among the actors can be seen in table 2. The GF understood that the quality of organic rice guaranteed by the information that no fertilizer or pesticide was used in its growth implied that there would be no additional chemical residue on their yield. The farmers agreed that when they practised organic farming, they gained a high yield and received a better selling price. They believed that organic farming could be beneficial to the environment. However, they still assumed that organic rice should be milled like conventional rice as the more the degree of milling, the better the appearance of the rice. Consumers define organic rice quality based on its sensory and non-sensory attributes. The taste of organic rice is an important attribute. David et al. (2020) confirmed that aroma and taste are the attributes which consumers appreciate before buying an organic rice product. However, the dilemma is that the better the taste the higher the degree of milling, with the consequence that lower nutritional content is found in the organic rice. In addition, consumers rarely consider the freshness of organic products, whereas freshness has a great impact on food product taste and nutritional value. During processing, transporting or storage, some chemical change which contributes to sensory change and some loss of certain nutrition may occur. Furthermore, some organic products are still being produced on a limited scale, and thus not as widely available as other products. In such cases, the organic product may be transported for quite a long distance, and it may stay on the market longer before it is sold and consumed. Further, a study showed that the physicochemical properties of rice are changed during storage at various temperatures. Milled rice stored at higher temperatures contains higher fat acidity than the one at low temperatures. Storing milled rice above room temperature increases cohesiveness and hardness. Moreover, after 1 month of storage at 30 oC and 40 oC, there will begin a significant decrease in all sensory values (Park et al., 2012). Even though the consumer is still willing to buy the organic rice in such condition, the current price is expensive for some people; however, those who understood the organic rice benefit, still agree that the product has value for the money spent on it.

As shown in Table 2, the results of the study show that the differences in general knowledge about organic products between actors are quite prominent. We highlight three factors to explain how these differences occur, and they include personal preferences, social values, and breadth of literacy. Personal preference influences the actors' usage and consumption choice of organic products. This factor creates a gap among the actors since each of them has their way of describing the term 'organic'. When the actors were asked their definitions of the quality of organic rice, all gave three different answers. The GF replied that organic rice is processed with fewer pesticides and no chemicals. The processors said that organic rice has to do with whiteness. The consumers replied that organic rice is a product of rice that is healthy and tasty. Using a definition of knowledge as a 'highly valued state in which a person is in cognitive contact with reality' (Zagzebski, 2017, p. 92), personal preference is highly related to the cognitive aspect of actors towards the product. When the actors were asked about the expectation of organic rice, all of them replied from two different points of view. Farmers and processors have their knowledge as the 'sellers' while consumers have theirs as the 'buyers'. This describes the variation in the answers provided by these three types of institutional actors. They respectively expressed their views on organic food based on their norms, values, social statuses and professional backgrounds. The practices and norms upheld by the actors are developed based on their institutional practices (Thornton and Ocasio, 2010). When the actors were asked their motivation for producing organic rice, their three different answers suggested a variation in knowledge regarding such rice. The GF was motivated by the fact that growing organic rice is good for the environment, while the consumers thought that organic rice is healthy. Lastly, we pointed out that the ability to acquire external knowledge on organic products is related to the literacy of the actors. The question regarding the opinion on the degree of milling shows the breadth of their literacy. Having a high level of literacy is needed to expand knowledge of organic products.

Figure 1 explained: in the Upper Right Quadrant (URQ), farmers' and processors' response is that the quality/price ratio of appropriate and current quality is reflected in range 4, which means that both farmers and processors are satisfied with the current quality/price as well as current quality. Conversely, in the Upper Left Quadrant (ULQ), most of the consumers' response shows the lowest current quality as well as their not being satisfied with the information/ knowledge about the organic rice. If we refer to Table 2, most of the consumers think that the definition of the taste, is organic, healthy and nutritional, but they do not get this information correctly, therefore they are not satisfied with the product. This condition is positively correlated with the importance of the degree of milling which also has been studied in the previous research (David et al., 2019).

Moreover, in the Lower Right Quadrant (LRQ), the farmer and processor respond that they are satisfied with the quality when the ranges of the quality are between three and five. This condition may be because of the Indonesian National Standard for rice (SNI 6218 2020) which has grouped the quality of rice into three different classes. The Lower Left Quadrant (LLQ) belongs to the group that thinks there is no satisfaction of the quality/price and to which the degree of milling is not that important.

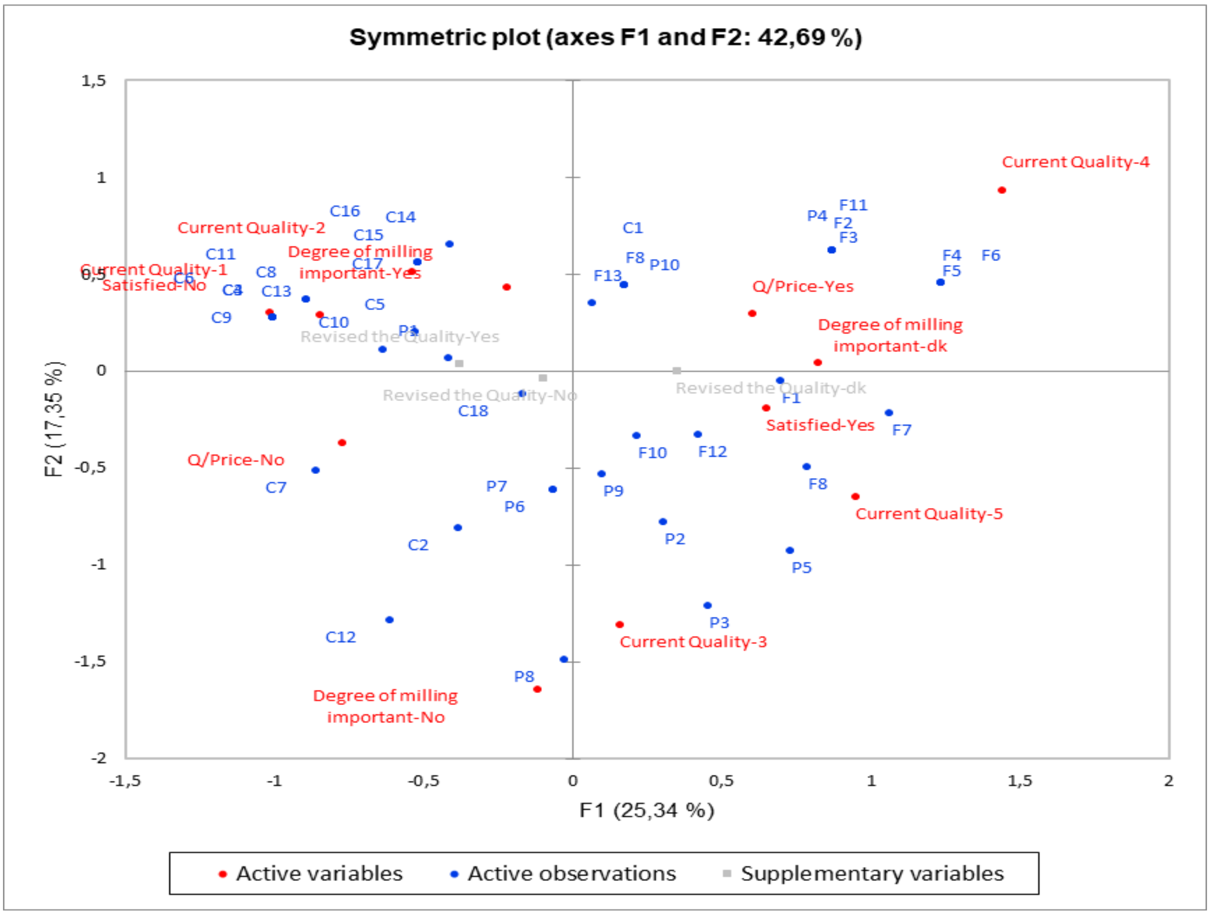

Figure 1. Distribution of knowledge of all actors regarding the five keys information/knowledge

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African Leaders Adopt Ecological Organic Agriculture: Research results and policy process

RAYMOND MICHAEL AUERBACH [1]

Key words: organic food systems, comparative research, farming systems, just transitions.

Abstract

The Mandela Organic Farming Systems Research Trials compared organic and conventional farming with cabbages, sweet potatoes and cowpeas in rotation and also with mono-cropped cabbages. In the first two years, soil life improved and soil acidity decreased in the organic treatments; however, the yield gap was larger after the second year (organic 31% lower yields) than the first (20%). Low available soil phosphate was then addressed using rock phosphate before planting the third cycle of crops. The yield gap was closed after the third year, with organic crops out-yielding conventional. A wide range of soil improvements was measured, including soil micro-organisms (diversity and quantity), soil organic carbon, soil water content and soil chemistry. Soil water content was consistently better in the organic farming system, as was soil organic matter and soil acidity. In the fourth year, crop rotation yields were significantly better than mono-cropped cabbage yields. The results contributed to a system for promoting Ecological Organic Agriculture in the African Union and to a typology which was developed, together with monitoring and evaluation criteria.

Introduction

Ecological Organic Agriculture is a term used in Africa to combine agroecology and organic farming; farming systems are not really organic if they do not respect ecological principles! Similarly, the discerning consumer wants assurance that the farmer did not use poisons, synthetic fertilisers or genetic engineering, so the formal standards adopted by the organic sector are also important in promoting alternatives which produce healthy food while caring for the environment, whether the produce is certified organic or not.

The paper reports on 25 years of research on organic food systems in southern Africa, much of which has been published recently (Auerbach 2020), and on policy work for the African Union (Auerbach 2021). Methods and details of approaches are described in the two open access works cited; findings and implications are summarised in this paper.

Comparative Farming Systems Research and Extension (FSRE) field trials

The Mandela Organic Farming Systems Research Trials compared organic (compost, mulch, biological pest and disease control) and conventional farming (synthetic fertiliser, agrochemicals for pest and disease control) with cabbages, sweet potatoes and cowpeas in rotation and also with mono-cropped cabbages. In the first two years, soil life improved and soil acidity decreased in the organic treatments; however, the yield gap was larger after the second year (organic 31% lower yields) than the first (20%). Low available soil phosphate was then addressed using rock phosphate before planting the third cycle of crops. The yield gap was closed in the third year, with organic crops out-yielding conventional.

A wide range of soil improvements was measured, including soil micro-organisms (functional diversity using whole-community substrate utilisation profiles, and quantity including Shannon-Weaver substrate diversity and evenness), as well as enzymatic activity and nematode dynamics, soil organic carbon, soil water content and soil chemistry. Soil water content was consistently better in the organic farming

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system, as was soil organic matter and soil acidity. In the fourth year, crop rotation yields were significantly better than mono-cropped cabbage yields

South African research and organic sector development

South African Organic Sector Organisation (SAOSO); food systems approach; Participatory Guarantee Systems Association of SA (PGS-SA); bottom up; Mandela Trials findings and their implications; science based policy development; Avaclim two sites – preliminary results (Brazil, India, Africa x5 = 7 countries) & also TAFS recommendations: Facilitating a Just Transition; international collaboration; Southern African OKH & IFOAM Southern African Network (ISAN); regional integration.

Mainstreaming EOA in Africa – Assessment for African Union and Policy Briefs (2021)

Factors hindering EOA; ideas for EOA promotion.
The idea of identifying levers of change for scaling up (Woltering).

According to an exhaustive policy analysis carried out in 2021 by Auerbach *et al.,* of the 55 countries in North, West, Central, East and Southern Africa, only four (Morocco, Tunisia, Madagascar and Uganda) have an EOA policy, organic production standards, strong government support for EOA and well-developed National Organic Agriculture Movements (NOAM) or farmers' organisations. Eleven countries have some government support with a policy underway and strong NOAMs. Another ten countries have strong civil society organisations, significant EOA production including some export, but little government support. A further twelve countries have some civil society capacity to manage farmer organisation, production and marketing, no organic guidelines, little or no export and not much government support. Finally, there are eighteen countries with very little institutional capacity, no government support and no exports.

Currently, much of Africa's agricultural development budget is absorbed by Farm Input Support Programmes (FISP) (providing cheap fertilisers, hybrid seeds and agro-chemical inputs), and food safety nets. These strategies have been shown not only to be ineffective development support mechanisms, but also a wasteful use of resources. Long term research in Britain, Denmark, Switzerland, Germany and the United States shows that after a few years of organic management, soil water- and nutrient-holding capacity is increased in a robust way which improves soil productivity. In addition, African EOA research (e.g. the Mandela Trials in South Africa and the FiBL long term system comparison trials in Kenya) shows that compost application, gentle soil cultivation and crop rotation improve soil biological activity, counter soil acidity, raise soil organic matter and make some nutrients more readily available; where available soil phosphate is low, rock phosphate can be used to improve soil fertility. With crop rotation and regular modest dressings of compost, this will allow good production levels and vastly improve climate change resilience.

Assisting farmers with training, institution building, compost production and, where needed, the supply of other mineral fertilisers, contributes to building the capacity of African farmers to produce diverse and nutritious food for Africa. EOA is a strategy which will help Africa reclaim food sovereignty, improve food security and make African farmers independent of harmful agro-chemicals and expensive synthetic fertilisers. By combining scientific research on organic agriculture and agro-ecology with African Indigenous Technical Knowledge, African farmers can produce nourishing food at competitive yields and prices.

Given the variable state of EOA-sector development in Africa, a typology has been developed to aid policy makers in assessing where countries stand; this is summarised in Table 1 and Figure 1. We looked carefully at six sets of attributes:

- Has an organic policy been adopted and provided for in the agricultural budget?
- Are there national organic standards and certification bodies?
- Is the government supporting EOA as an acceptable farming system?

- Are there regulations promulgated and implemented?
- Are farmers well organised, is there a NOAM?
- Are there well-developed domestic and/or export markets?

The typology also provides a useful guiding framework for civil society organisations to lobby for the changes needed in their organic sectors, so that every two years each African country can assess its own progress against its organic development plan (the EOA Initiative, EOA-I, which includes Organic Agriculture and Agroecology). The EOA-I is the response to the AU's "Decision on Organic Farming" taken by the African Heads of State in 2010, which recommended research, guidance and support for organic agriculture. Nine countries have joined the EOA-I to date, and a Continental Steering Committee has been set up to manage transition towards sustainable food systems.

Table 1: Summary of EOA status of the 55 countries of North, West, Central, East and Southern Africa

Typology for EOA	Organic Policy	Product standard	Govt support	Farmers organized	Export and domestic markets	Countries	No./Type n=55
1. Advanced EOA sector	Yes	Yes	Strong	NOAM / Farmes Assoc.	Yes, both	Madagascar; Morocco, Tunisia, Uganda	4
2. Active EOA Sector	Comi ng	Yes	Promis e	NOAM (NOAM is National Organic Agricultural Movement)	Yes, both	Burkina Faso; Egypt; Ghana; Kenya; Mali; Mauritius; São Tomé & Principe; Senegal; Seychelles; Sudan; Togo	11
3. Infant EOA Sector	No	Yes or No	Little	Yes	Yes Export; Domestic developing	Algeria; Benin Cameroon; Ethiopia Liberia; Namibia Nigeria; Rwanda; South Africa; Tanzania; Zambia Zimbabwe	12
4. Nascent EOA Awareness	No	No	None	Weak	Some export; little domestic	Cape Verde; DR Congo Gambia; Guinea Rep; Ivory Coast; Malawi Mauritania Mozambique; Niger; Sierra Leone	10
5. Awaiting Inspiration	No	No	None	None	None	Angola; Botswana; Burundi; Central Afr Rep; Chad; Comoros; Congo Republic; Djibouti Equator. Guinea; Eritrea; Eswatini; Gabon; Guinea- Bissau; Lesotho; Libya; Somalia; South Sudan; West Sahara	18

Madagascar, Morocco, Tunisia, and Uganda are leading the way in EOA in Africa. They have put in place various support systems to develop the sector, which will contribute significantly to food security, employment, food sovereignty, climate change resilience and export earnings. From West Africa, Benin, Mali, Nigeria, and Senegal are part of the EOA-I (black diagonal lines). In Eastern Africa, Tanzania, Uganda, Ethiopia, Kenya, and Rwanda have made significant progress and are part of the EOA Initiative (Figure 1).

In summary, the Typology divides countries as follows (colours refer to the map in Figure 1):

1. **Advanced EOA Sector:** Country has a NOAM, a policy and standards, and government is supporting the vibrant sector.
2. **Active EOA Sector:** Country has some government support, there is a policy underway, a strong NOAM, a domestic market and strong NGO farmer support**.**
3. **Infant EOA Sector:** Country has a developing domestic and export market, some civil society activity, some guidelines and exports, but little government support**.**
4. **Nascent EOA Awareness:** Country has some NGO capacity, no guidelines, little or no support from government but could have some commercial activity in EOA and could be exporting.
5. **Awaiting Inspiration:** Country has very little institutional capacity, no government support, not exporting

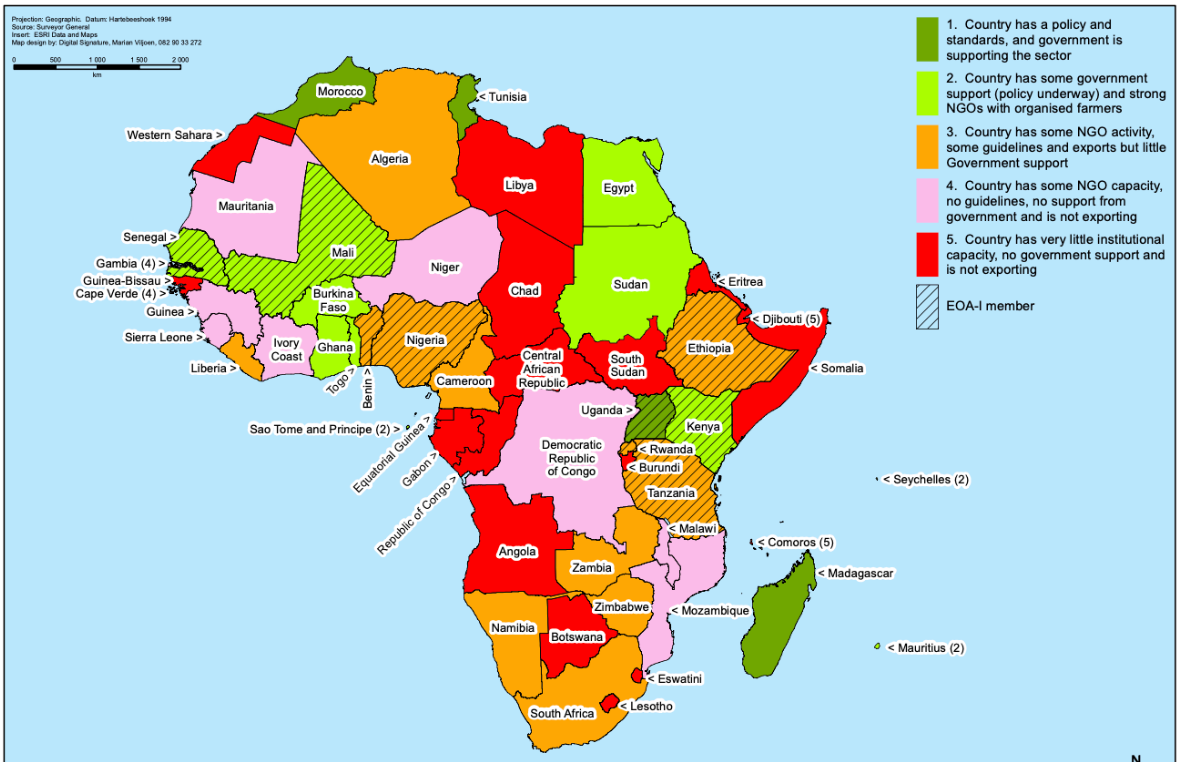

Figure 1: Ecological Organic Agriculture Status of the 55 Countries of Africa
Prepared by Biological Systems Consulting & Research for the African Union Commission in 2020.

Implications for African Food Systems

EOA can contribute to a transition strategy for a just transition to sustainable food systems. This can be done while maintaining yield levels, improving soil fertility and water use efficiency.

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Organic agriculture: sustaining the sustainability via research

MAHESH CHANDER [1]

Key words: organic agriculture, research, priorities, sustainability

Abstract

Over the years, many groups, organizations, associations and individuals have floated various names, viz. Agroecology,biodynamic, permaculture,organic agriculture, regenerative agriculture, zero budget natural farming, green agriculture, do nothing farming etc, with the basic intent-freeing agriculture from toxic chemicals and sustainable intensification. Does multiple names help agriecology and sustainability or create confusion & chaos? what are some of the practices that agroecology, permaculture, natural, and regenerative farmers are doing that organic farmers can't do? Are we helping to make organic agriculture sustainable which nourish human, animals and safeguard environment or busy coining new terms to safe food production systems, while criticising each other to establish their own supermacy? Serious research is needed like in conventional agriculture to find solutions to problems like low productivity being faced by organic farmers and organic input producers for the want of suitable technologies. The research priorities need to be identified and relevant research taken up to generate technologies for making organic agriculture sustainable.

Introduction

Chemicals were introduced in agriculture to enhance farm productivity quickly to meet the rising demand for food for growing population, to address food security & sustainability. Once chemicals entered in food chains, the concern shifted to adverse impact of chemicals on environment, human and animal health making agricultural sustainability questionable. Several countries are now engaged in organic food and fiber production mostly driven by consumer demand for safer & healthier products. Is there an equal interest in research on organic agriculture in all these countries or organic movement is driven just by marketing push?

Eying at rising export demand for organic products, Indian Ministry of Industry & Commerce launched National Programme on Organic Production (NPOP) in 2001. A Network Project on Organic Farming (NPOF) was initiated during 2004-05 by Indian Council of Agricultural Research (ICAR), coordinated by Indian Institute for Farming Systems Research with several centres across the country. India is number one country in terms of number of organic producers and fourth in the world in terms of area under organic agriculture. India currently exports across the globe a range of certified organic edibles and fiber to 58 countries. Organic food products exports grew by 51% to US$1040 million in 2020-21 compared to US $689Million in 2019-20. A Master's Course in Organic Farming has also been approved recently by the ICAR. With this success story in organic front, the Indian government is focusing on natural farming in a big way currently. As such, all possible modes of organic agriculture viz. agroecology,biodynamic, permaculture, regenerative agriculture, zero budget natural farming, green agriculture, do nothing farming etc can be found in India, each claiming to be superior to other.

Recently, the Indian government has given a big push to natural farming announcing several measures over and above the existing organic farming schemes (NPOP, NPOF,PKVY, MOVCDNER) under implementation in the country. India is currently developing curriculum for Natural Farming and all agricultural institutions are expected to devote their resources on natural farming research. There is fundamental difference in organic farming and natural farming as the former depends on organic inputs, while natural farming is close to do nothing farming. The recommended practices need validation through research, if these help agriecology and boost farm productivity without chemicals. Do we have bio-inputs and technologies to enhance farm productivity following organic farming and natural

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farming? Are we following science when promoting these farming methods, if yes what are these practices?

Results

To make organic agriculture sustainable, farmers need to incorporate practices prescribed under agroecology,biodynamic, permaculture, regenerative agriculture, zero budget natural farming, green agriculture, do nothing farming etc into their systems. In fact, it's a requirement that organic farmers incorporate these practices before they become certified (Brian 2022). Scientists need to analyse- what research is being done, where, with what impact? Is it contributing to sustainable intensification and agriecology, while ensuring healthy foods to consumers and safeguarding the environment. Low investment in organic agriculture research is a serious issue since currently there is very little attention on research allocation for organic farming research globally and in developing countries in particular.

The research need to be prioritised and taken up to make organic or natural farming sustainable and widespread having capability to feed over 1.4 billion population, in case of India! Long–term results of organic management clearly establish that the scientific Package of Practices (PoPs) for organic production of crops in cropping systems and farming system perspective should be adopted for keeping the crop productivity at comparable or higher level than that of chemical farming. Under ICAR–All India Network Programme on Organic Farming (AI–NPOF), 51 location–specific package of practices for organic production of crops in cropping systems, suitable to 12 states of India, have been developed which can be practiced for getting optimum productivity under organic management. Likewise, in all other forms of organic agriculture, research is underway with low or high intensity and budgetary allocations. There is little coordination observed all different organic agriculture forms in India, may be th esituation is similar in othe rcountries as well.

Discussion

The organic agriculture movements around the world and scientific community in particular should answer whose interests they are going to serve- producers, consumers or both? The producers are looking for ways to make organic agriculture profitable/sustainable, while consumers are expecting safe and healthy foods at cheaper cost. Is it possible, if yes, how? Let's work on this science based "How" part of the sustainable organic agriculture development. There is clear need to document, develop sustainble organic production, processing, marketing and consumption prctices.Let there be more science to make organic agriculture vibrant and sustainable. There is clear need for systematic research along various dimensions of organic agriculture, possibly on network mode. Some of the important steps required are listed below:

- Development of evidence based package of practices for sustainable ecological intensification
- Enhanced budgetary allocations for research on prioritized researchable issues
- Proven technologies to be developed after research based validation
- Right technologies available to organic farmers at right time to boost productivity of organic production systems
- Coordinated research efforts like Organic Plus Horizon 2020, the European Network for Scientific Research Coordination in Organic Farming, ISOFAR & IFOAM Sector Platforms can help boost organic research

Organic farming involves complex, diverse systems with varied crop rotations and other soil-building practices, animal integration, and ecosystem preservation etc.. There is a lot of room to improve organic farming practices, which is why more research is crucial in context of well defined principles of organic farming.

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Organic farming system supports the development of indigenous vegetables in Indonesia as functional food and herbal medicine

MAYA MELATI [1]

Key words: animal manure, green manure, indigenous knowledge, secondary metabolite

Abstract

The geographical position of Indonesia gives advantage for having a large area of land for agricultural activities, high biodiversity, and cultural diversity. As part of the biodiversity, Indonesia has many kinds of indigenous vegetables and medicinal plants that can contribute to the improve peoples' health. These two groups of plant have been cultivated with local wisdom technology as well as with improved technology to increase the production and quality. Implementation of organic farming in cultivation of indigenous vegetables and medicinal plants can give added values in the market. The Government of Indonesia has issued the standard and guidance for organic production. Research is continuously conducted to produce various technology related to organic products. Strict procedure to obtain the organic certificate is the main obstacle to claim the products are cultivated organically.

Introduction

Indonesia is located between 6*0* 04’ 30’’ North latitude and 11*0* 00’ 36’’ South latitude, and between 94*0* 58’ 21’’ and 141*0* 01’ 10’’ East longitude, and lies on equator line located at 0*0* latitude line (BPS-Statistics Indonesia 2021). Total area of Indonesia is 1 916 906,77 sq km with 3,89% of the area is water area.

Geographical position makes Indonesia has a large area of land for agricultural activities. Data for 2018 shows that land use for agriculture reached 34,830,063 ha (Figure 1). The extent of land for agriculture and supported by climatic conditions in Indonesia allows agricultural activities to take place throughout the year. Since the green revolution, as in the world, Indonesian agriculture has also developed rapidly with the support of high production inputs.

In addition to conventional cultivation technology, organic farming systems are also applied to produce agricultural products in Indonesia. The organic farming system is carried out to meet the needs of domestic and foreign consumers who follow a healthy lifestyle, but the organic farming system has also been implemented as part of local knowledge (indigenous knowledge). Some organic commodities that are widely available in Indonesia are rice, fruit, vegetables, eggs, milk and plantation products (honey, coffee, and vanilla). According to the Ministry of Foreign Affairs go.id, the potential markets for organic products are the USA and Europe (Germany, France, Italy, the Netherlands, and Switzerland).

Indonesia's geographical position also causes Indonesia to become a country with high biodiversity. In addition to staple foods consumed by some Indonesians, there are many local food sources that are consumed by people from various regions, both carbohydrates and vegetables. Indonesian culture is very diverse because there are 1,300 ethnic groups in Indonesia (BPS-Statistics Indonesia 2010) affecting the types and ways of processing food, including local plants. Local vegetable plants (indigenous vegetables) which are still local varieties (landraces) are vegetables found in certain areas, both native to Indonesia and from other countries, but have long been grown in agricultural ecosystems in Indonesia. This indigenous vegetable has become part of the eating culture of certain groups of people without realizing its benefits, but its consumption can also develop later because of the benefits that have been popularized (Rachman 2002 in Putrasamedja 2005).

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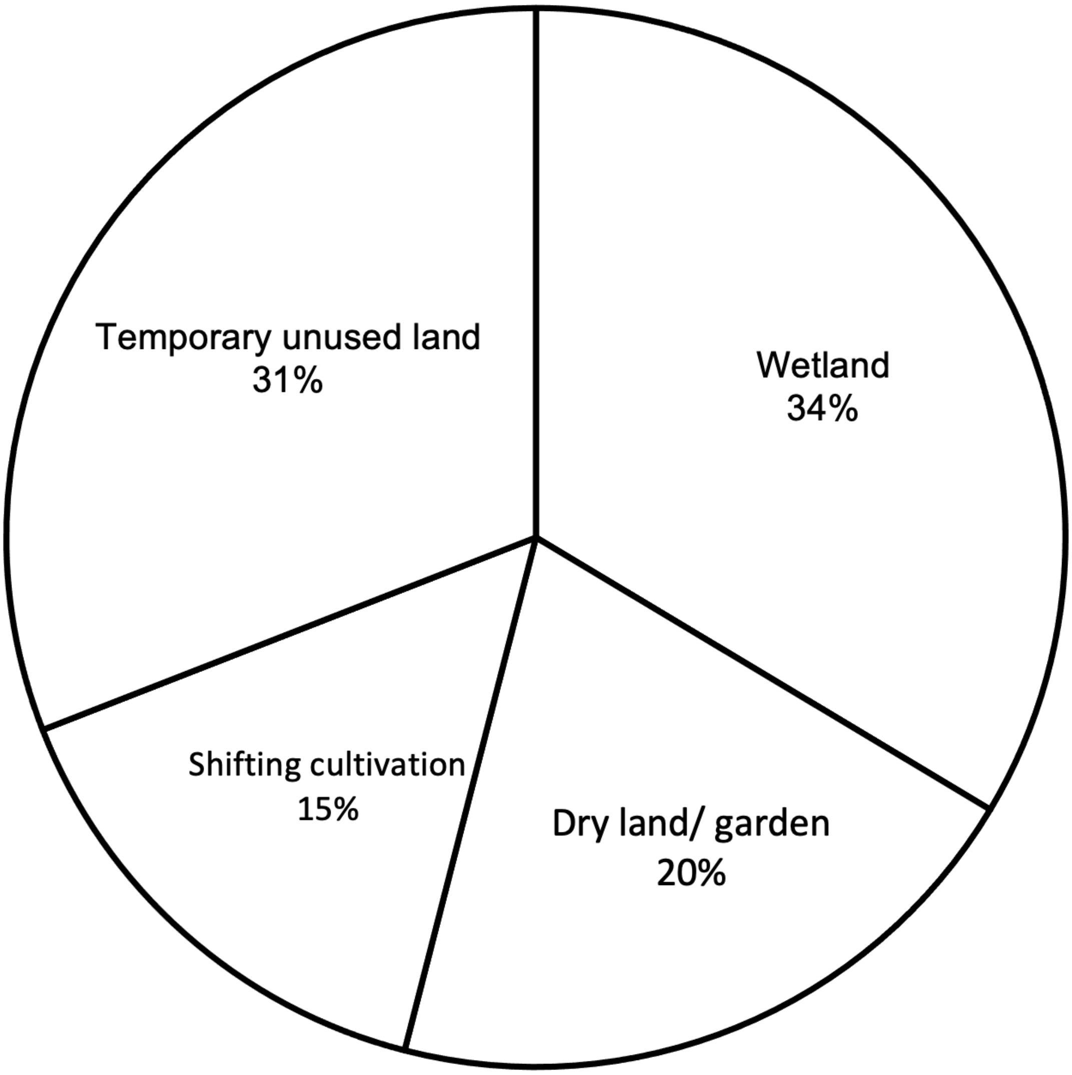

Figure 1. Percentage of land utilization in Indonesia 2018 (Agricultural Statistics 2019)

The so-called indigenous vegetables are vegetable species native to Indonesia originating from certain regions/regions/ecosystems, including immigrant species from other geographical areas but which have evolved with the climate and geography of Indonesia. The Vegetable Crops Research Institute (Balitsa) in collaboration with the Asian Vegetables Research Development Center (AVRDC) has collected data on these vegetables, especially those that contain nutrients needed by the human body, namely Vitamin A, iron and anti-oxidants. This activity was deliberately appointed to promote food security and improve better health for family members in rural areas, as well as to improve the nutrition of underprivileged family members through accelerating the use of indigenous vegetables. Indonesian ancestors have used many indigenous vegetables because of the taste and benefits based on knowledge from generation to generation. The development of culture and technology causes the development of indigenous vegetables to be urgent, so the potential of these vegetables must be explored and re-examined to obtain better benefits in improving family nutrition in rural areas (Lembang Vegetable Research Institute).

In addition to indigenous vegetables, Indonesia is also rich in plants that have potential as medicine. Medicinal plants themselves have thousands of species. From a total of about 40,000 types of medicinal plants that have been known in the world, 30,000 of them are allegedly located in Indonesia. This number represents 90% of medicinal plants found in the Asian region. Of this amount, 25% of them or about 7,500 species are known to have herbal or medicinal plant properties. However, only 1,200 types of plants have been used as raw materials for herbal medicines or herbs (PT. Sido Muncul 2015 in Salim & Munadi 2017).

Based on the source, medicinal plants traded in Indonesia can be divided into cultivated medicinal plants and medicinal plants resulting from collection (exploitation) from the forest/nature. Currently, medicinal plants are cultivated only at 22% and taken directly from the forest by 78% (DPP GP Jamu, 2016 in Salim & Munadi 2017).

As an indigenous vegetable, which is still an underutilized crop, generally this plant is usually cultivated organically with local farmers' cultivation technology. If these vegetables are marketed more broadly, then the cultivation technology and marketing need to follow the standards set for organic food. The government has issued the organic food standard SNI 6729-2016 ORGANIC AGRICULTURAL SYSTEM. Apart from SNI 6729-2016. Ministry of Agriculture No 57 of 2012, although it does not explicitly require it, it is recommended to use organic fertilizers and pesticides in the cultivation of medicinal plants. However, this Ministry of Agriculture has been revoked and replaced by Minister of Agriculture Number 22 of 2021 concerning Good Horticultural Practices. As another form of support from the government to improve the appearance of organic products, the government provides export funding support, training, information on export market opportunities and product design development. Organic products marketed in Indonesia with organic claims must have been certified organic based on SNI 6729:2016, Minister of Agriculture No. 64/2013 and Perka BPOM No.1/2017; and labeled ORGANIC Indonesia.

Results

Indigenous vegetables

Indigenous vegetables in Indonesia, can be region specific. For example, in West Java, indigenous vegetables are known as leaf vegetables (kenikir, katuk, moringa, basil), fruit vegetables (oyong, leor, jaat, paria, koro, sword beans, koro benguk, baligo, winged bean). Indigenous vegetables also have several promising characteristics, including adapting well to relatively diverse environmental conditions, being an alternative source of protein, vitamins, minerals, and fiber that are relatively inexpensive, and traditionally have been a component of cropping patterns, especially in the utilization of yard and relatively resistant to environmental stress (Putrasamedja 2005).

Medicinal plants

Among the many types of medicinal plants, the Indonesian statistical center bureau presents data on planted area and harvested area for only 13 dominant commodities, with ginger as the most cultivated commodity (Table 1).

Organic farming guidance

In the development of organic farming cultivation in Indonesia, it is necessary to have a guide for the preparation of good and correct Organic Farming Methods (GAP Organic). Organic GAP is issued by each Directorate General of Ministry of Agriculture in charge of the commodity concerned. In order to provide guidance/direction for each party in compiling Organic GAP, a Guide to Compilation of Good Organic Agricultural Cultivation Methods (Organic GAP) is issued.

Apart from being a reference in the preparation of Organic GAP, this Guide for Preparation of Organic GAP can also be used as a general reference for officers and operators of organic agriculture (in addition to SNI for Organic Food and other technical regulations).

Table 1. Harvest area of dominant medicinal plants

Types of medicinal plant	**Harvest area (m2)**
Dringo (*Acarus calamus*)	189 537
Ginger (*Zingiber officinale*)	80 765 542
Java cardamon (*Ammomum cardamomum*)	37 467 409
East India Galangal (*Kaempferia galanga)*	24 361 593
Turmeric (*Curcuma longa*)	81 003 471

Galanga (*Alpinia galangal*)	25 637 709
Lempuyang (*Zingiber aromaticum)*	3 902 573
Aloe vera	1 150 729
Indian mulberry (*Morinda citrifolia* L.)	762 165
Black turmeric (*Curcuma aerogynosa*)	4 303 114
Chinese keys (*Boesenbergia rotunda*)	2 501 413
Java turmeric (Curcuma zanthorrhiza)	14 830 703
Sambiloto (*Andrographys paniculate*)	2 093 883

Source: BPS-Statistics Indonesia (2021)

Constrains in developing organic farming

In general, yearly land area for organic agriculture increases (Figure 2). However, according to Professor Dwi Andreas Santosa from the Faculty of Agriculture, Bogor Agricultural University (IPB) University, Indonesia's certified organic land area has only reached 90,000 hectares, while those that have not been certified are no more than 225,000 hectares. The potential is high, but in fact the land area and market share are still very small. Indonesia's total organic agriculture [market share] is only 0.2 percent. Compared to other countries, China is 0.3 percent, India is 0.7 percent, and European countries are more than 5 percent, such as Germany at 6.5 percent." Limited certified land and market share of organic Indonesia is inseparable from the complexity of the certification procedure that producers or farmers of organic products that must undergo both domestic certification which refers to SNI 6729:2013 (note: it has been renewed with SNI 6729:2016) and certification required by export destination countries. [https://ekonomi.bisnis.com/read/20210824/99/1433205/permintaan-produk-organik-tinggi-luas-lahan-tak-memadai]

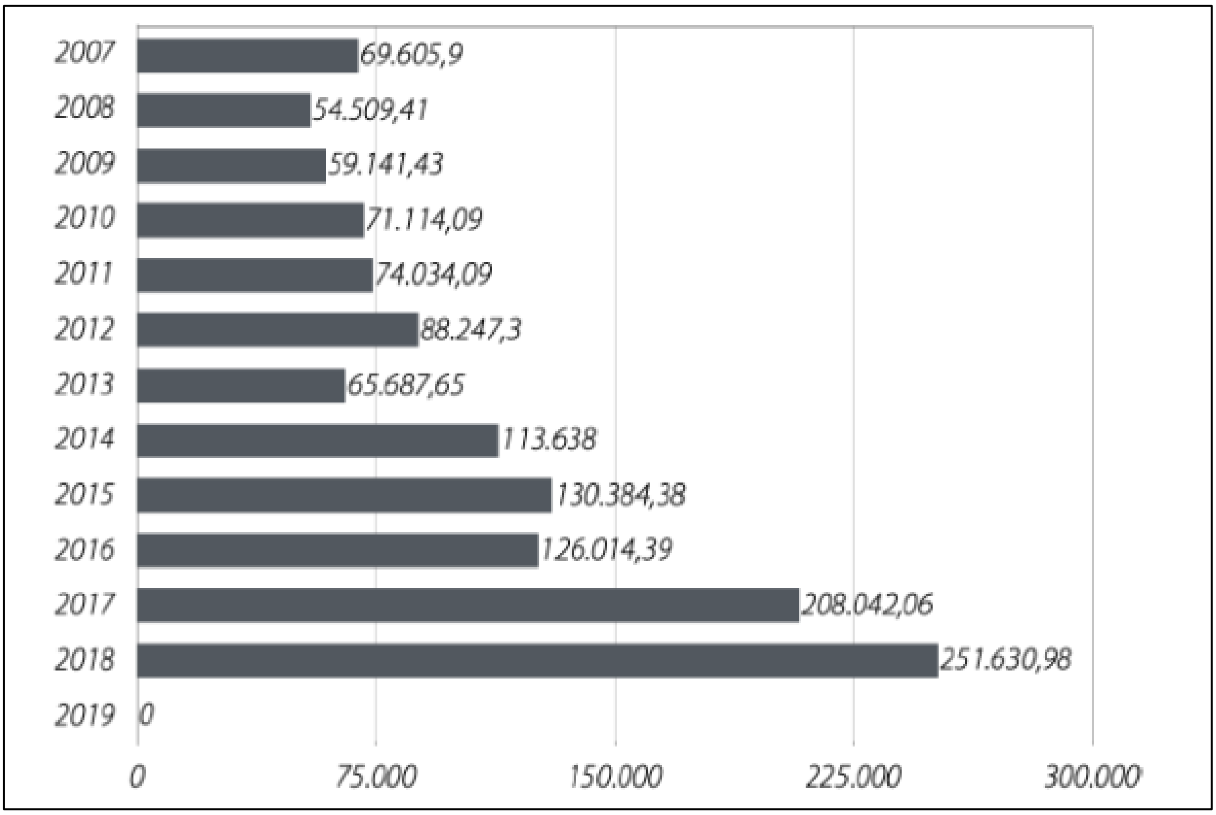

Figure 2. Yearly land area (ha) for organic agriculture in Indonesia (Indonesia Statistics of Organic Agriculture 2019)

The number of organic operators in Indonesia is high in 2008, but then it is declining (Figure 3). The strict rules for organic farming system and high certification process fee, might have obstructed the organic operators to renew the certification.

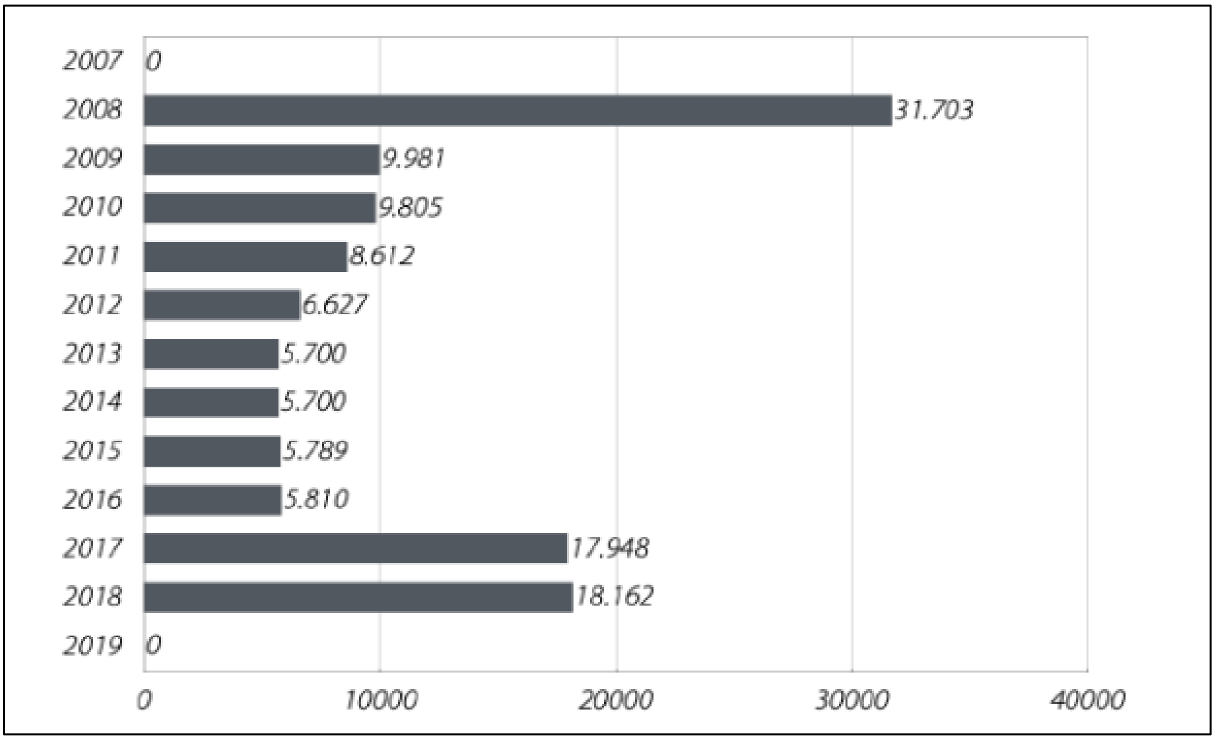

Figure 3. Yearly number of organic operator in Indonesia (Indonesia Statistics of Organic Agriculture 2019)

To overcome consumer doubts about organic products, especially those that are not certified, there is a proposal for organic certification for local consumers. That is a certificate for products cultivated with the LEISA system.

Research for developing organic farming

Research on organic cultivation in Indonesia, especially for functional vegetables and medicinal plants, continues to be developed both to increase production and product quality. The research was carried out on various types of commodities, the cultivation technology for example in the method of organic fertilization (the use of animal manure, green manure), the use of organic pesticides, also the determination of harvest time which is important in relation to the phytochemical content.

Conclusion

Organic farming practices have been developed in Indonesia to support the need for organic products, including functional vegetables and medicinal plants. Guidelines for good cultivation practices and standards for organic cultivation are available from the Ministry of Agriculture, without neglecting local wisdom in its implementation. Obstacles in implementing organic cultivation are expected to be resolved with the participation of various stakeholders including ABGC (academic, business, government and community)

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Best Fit Practices of Organic soil amendment producers in Bicol region, Philippines

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Key words: organic soil amendments OSA, OSA producers, Total % N-P_2O_5-K_2O, pathogens, heavy metals

Abstract

This study aimed to describe the process implemented by producers of organic soil amendment in the Bicol Region, Philippines, and assess its final product. It underwent three processes: (1) identification of commercially engaged organic soil amendment producers in the Region, (2) collecting data on farm characteristics, management and production procedures, production level, and marketing, and (3) characterizing the organic soil amendment produced concerning the specifications set by the Department of Agriculture-BAFS. The findings indicate variations in the production process adopted and the type of final product. The OSA Producers vary in the type of management implemented, raw materials used, housing system, equipment used, and marketing strategies. Some products qualify as organic fertilizer, while others conform only as a soil conditioner.

Introduction

The trend in agriculture is in the adoption of organic agriculture production technologies. The increasing popularity of adherence to sustainable agriculture has created strong demand for natural or organic farm inputs. This demand brought potential agribusiness activities that augmented farmers' income. However, issues on quality, standardization, and volume of produce should be a concern of the producers to ensure supply and safety to consumers and the soil environment. Some farmers have engaged successfully in this, but these are undocumented and non-validated. Hence, model cases of organic soil amendment producers will provide OA enthusiasts with a clear picture of how OSA be produced on a larger scale, thus contributing to a sustainable manner. The results of this paper served as a basis for preparing strategic investment programs to support organic agriculture and served as model enterprises for existing and future farmers in achieving sustainable agriculture in the region.

Material and methods

This three-phase procedure was undertaken to identify and describe some major variations and patterns in the production and processing of organic soil amendments, and was not intended to provide competition among producers nor downgrade a product. The same basic protocol and method for data collection was used in all the producers using survey questionnaires, in-person interviews, site visit and farm observation.

- *Identification of commercially engaged producers of organic soil amendment.* The list of organic agriculture Practitioners in the six provinces of the Bicol region was obtained from the Department of Agriculture- Region V (DA-RO5).
- *Collection of data on farm characteristics, management and production procedures, production level and marketing.* The characteristics of each farm were gathered through interviews, questionnaires, site visits and observations.
- *Characterization and classification of the organic soil amendment produced.* Samples of the final product were collected from each farm-producer and were subjected to laboratory analysis.

Identification of commercially engaged producers of organic soil amendment

The producers of organic soil amendment from the provinces of Albay, Camarines Norte, Camarines Sur, Catanduanes, Masbate and Sorsogon were investigated using the list obtained from the Department

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of Agriculture. Two criteria: an advocate of organic agriculture and production level being sustainable served as basis for the selection of OSA producers for further study. Figure 1 presents the geographical distribution of OSA producers in the region.

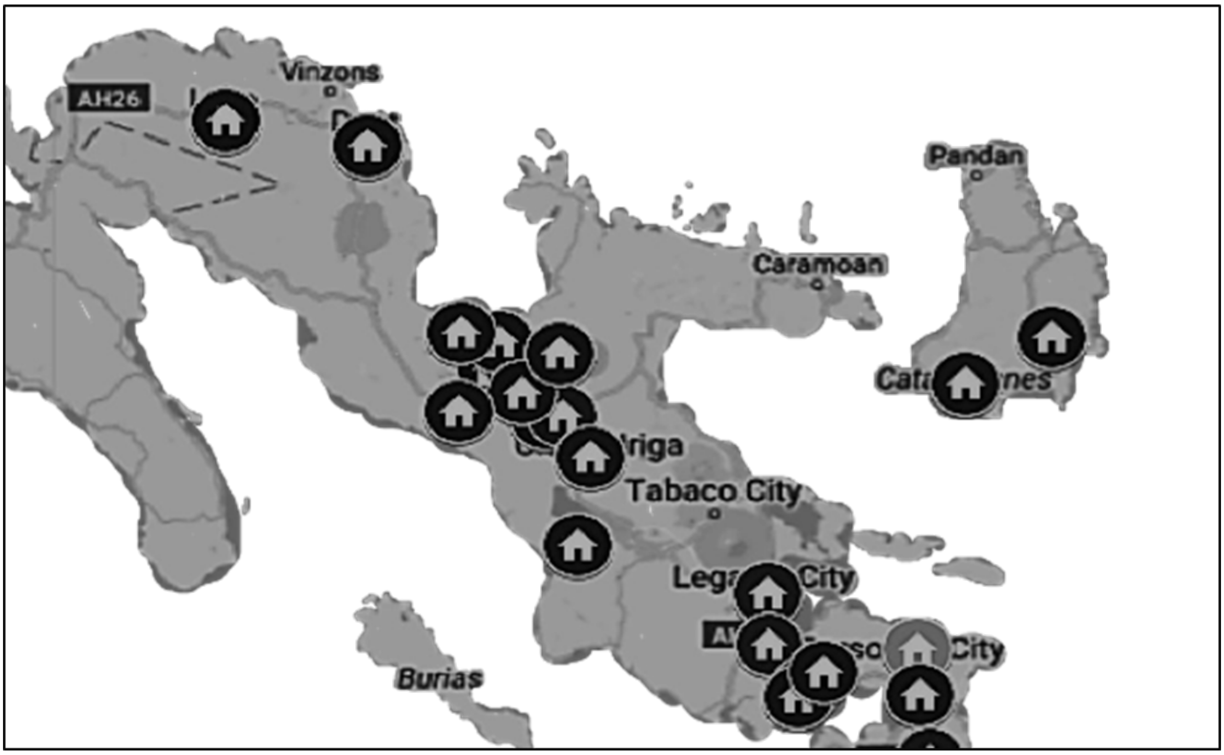

Figure 1. Geographic distribution of OSA producers in Bicol Region, Philippines

Collection of data on farm characteristics, management and production procedures, production level and marketing.

The characteristics of each farm identified were investigated in an in-depth farm survey that included detailed questions on multiple items, such as farm location and structure, production process adopted including raw materials, equipment, manpower and housing, production level, processing of final product and marketing.

Characterization and classification of the organic soil amendment produced.

Table 1: Specifications for organic soil amendments

Specifications	Organic Fertilizer (Solid)	Organic Fertilizer (Liquid)	Organic Soil Conditioner (Solid and Liquid)	Organic Plant Supplement (Solid and Liquid)
Total NPK: N-P2O5-K2O, %	5 - 10%	5 - 10%	2.5 - < 5%	0.5 - 10% for Solid 0.5 - < 5% for Liquid
C:N ratio	10:1 - 20:1	-	10:1 - 20:1	-
Organic Matter (OM), %	≥ 20	-	≥ 20	_
Actual Moisture Content (MC), %	≤ 35	-	Solid: < 35 Liquid: none	_
Odor	No foul odor: (ammonia, rotting or fermentation)	-	No foul odor: (ammonia, rotting or fermentation)	-

Source: BAFS PNS on Organic Soil Amendment (PNS/BAFS 183:2020 ICS 65.080).

Chemical and pathogen composition of the final product of each producer were determined in terms of pH, Total %N-P2O5-K2O, heavy metals content and pathogens. Such parameters served as basis for classifying whether it is an organic fertilizer or soil conditioner or plant supplement as per specification in the BAFS PNS on Organic Soil Amendment (PNS/BAFS 183:2020 ICS 65.080) Table 1.

Results

The producers of organic soil amendments.

The response of farmers in the campaign for organic agriculture technologies adoption vary among provinces. A total of twenty two (22) farmers and/or organizations immediately engaged in the production of organic soil amendments. These producers of organic input were classified as small scale (55 %) and medium scale (commercially engaged) (45 %) producers. Forty-one percent (41 %) of the producers are located in Camarines Sur, 14 % from Sorsogon, 14% from Albay, 9 % each from Camarines Norte and Catanduanes, 4 % from Masbate as shown in Figure 1. Twenty three percent (23 %) are operated by Local Government Units, 9 % by State College and Universities and 68% by private individuals. Different types of organic soil amendment were produced as vermicompost, bio-organic compost and bokashi compost, however majority (86 %) preferred vermicomposting as the process of production.

Table 2 presents the producers significantly engaged in OSA production in the region. Successful organic agricultural enterprises were selected using the following criteria: (1) The owner or prime mover of the enterprise must be an organic advocate. (2) The enterprise should possess certain elements of consistency and sustainability in its operation. Out of the 22 respondents in the initial investigation, nine met the criteria.

Table 2. Commercial Producers of organic soil amendment in Bicol Region, Philippines

Province	Name of Farm	Geographical Location of the Farm	OSA production system
Albay	OCENR-Albay Organic Fertilizer Project	13°02'11.2"N 123°46'00.5"E Brgy. Banquerohan, Legazpi City, Albay	Bio-organic composting
Camarines Norte	The Provincial Farm-OPAG	14°05'16.4"N 122°56'03.9"E Brgy. Calasgasan, Daet, Camarines Norte	Vermicomposting
Camarines Sur	Pensumil Organic Fertilizer Plant	13°31'32.2"N 123°18'15.9"E, Himaao, Pili, Camarines Sur	Vermicomposting
	Pecuaria Development Cooperative	13°30'39.7"N 123° 19'01.1"E, Pecuaria Estate, Brgy. Lanipga, Bula, Camarines Sur	Bio-organic composting
	Pilipinas Shell Foundation Organic Farm	13°40'52.4"N 123°13'07.9"E Zone 5, San Antonio, Bombon, Camarines Sur	Vermicomposting
	Iriga City Organic Agriculture Learning Farm	13°26'22.1"N 123°23'44.3"E, San Agustin, Iriga City	Vermicomposting
Catanduanes	None		
Masbate	Fascenda de Esperanza	12°10'27.0"N 123°23'14.6"E Barangay Bangad, Milagros, Masbate	Vermicomposting
Sorsogon	Del Rosario, Bacon Fishermen and Farmer's Folks	13°02'36.1"N 124°01'42.7"E, Brgy. Del Rosario, Bacon, Sorsogon	Bokashi composting

Farm characteristics, management and production procedures, production level and marketing.

This phase of the study focused on the commercially engaged OSA producers either managed by a private, government or non-government organization. Majority of them use different mixtures of substrates collected from the farm- rice straw, banana trunks, kakawate leaves, grass trimmings and animal manure. Others use sugar mill wastes (bagasse) and another use the municipal wastes. Carbon containing substrates used by majority of the producers are farm wastes such as rice straw, corn cobs and banana bracts/trunks while three producers use municipal wastes and one producer uses mud press. Nitrogen containing materials commonly used by producers are manures of cow, swine and poultry. Majority prefer vermicomposting although some are into Bokashi composting and conventional composting. Concrete and light materials were used as composting house of the majority of the producers. Water source was commonly from water pump and deep well, but some harvested rain and free flowing water. The target market are the local farmers interested to grow natural and organic crops.Some producers cater to the needs of non-government and government organizations, student researchers and ornamental gardeners.

Characteristic composition and type of organic soil amendment produced

The data on OSA chemical and pathogen analysis is presented in Table 3. Majority (67 %) of the farms produce vermicompost while two farms produces bio-organic compost and one farm produces bokashi compost. The OSA produced have pH ranging from 5.6 to 7.9. Majority are in the neutral range while two OSA produced are moderately acid. With reference to the PNS on Organic Soil Amendment (PNS/BAFS 183:2020 ICS 65.080), two of the OSA under study qualified as organic fertilizer having more than 5% Total %N-P2O5-K2O and six samples as organic soil conditioners with less than 5 %Total N-P2O5-K2O and one is considered as organic plant supplement since it contains less than 2.5 % Total N-P2O5-K2O.

The heavy metal content of the organic soil amendments produced were all found to be in the acceptable level having <10 than the maximum allowable level. Data also reveals that in terms of allowable level of pathogens, two (22 %) are found positive with Salmonella. Moreover, 78 % or 7 producers has an estimated coliform count of less than ten colony forming unit (<10 cfu) and two (22 %) of the organic soil amendments under study has higher coliform counts than that of the allowable level.

Table 3. Chemical and pathogen composition of organic soil amendment

OSA Producer	Product	pH	Nutrient composition % N-P2O5-K2O	Pathogens		Heavy metals, ppm			
				Salmonella	E. coli	Arsenic (As)	Cad-mium (Cd)	Chrom-ium (Cr)	Lead (Pb)
Allowable level				Absent in 25 g	<5 x 10 ^{2} cfu/g, <2 MPN/g	20	5	150	50
OSAP 1	Bio-organic compost	7.5	1.86	Negative	<10	0.87	0.39	5.45	22.6
OSAP 2	Vermicompost	6.1	2.67	Negative	<10	0.31	0.07	0.093	2.7
OSAP 3	Vermicompost	6.6	4.89	Positive	16,000	0.89	0.67	8.54	8.7
OSAP 4	Bio-organic compost	7.1	5.76	Negative	<10	1.88	0.36	37.45	7.7
OSAP 5	Vermicompost	7.9	5.15	Positive	120	0.72	0.65	4.39	19.3
OSAP 6	Vermicompost	7.1	3.71	Negative	<10	0.884	0.39	6.81	12.9
OSAP 7	Vermicompost	6.9	4.23	Negative	<10	0.72	0.65	4.39	19.3
OSAP 8	Vermicompost	7.7	6.728	Negative	770	0.28	0.08	0.23	6.57
OSAP 9	Bokashi compost	5.6	1.592	Negative	<10	1.01	0.078	0.23	6.57

* OSAP - Organic Soil Amendment Producer

Discussion

In Bicol Region, various entities, government or privately owned are engaged in organic soil amendments production. They provide available inputs to farmers wanting to practice organic farming but lack the workforce, time, and material resources to produce their farm inputs.Farm input producers used vermicomposting, conventional composting, and Bokashi composting. Farm and municipal wastes are used as substrates since these are in greatest abundance. Water sources are from deep well and pump either from free flowing water or rainwater. Compost housing are designed depending on their capacity and preference. These critically determines the quality of the product in terms of nutritional value and presence of pathogens and heavy metals. Pathogens pose an immediate threat. Challenges arise in providing a more holistic approach to production management. OSA producers should observe proper protocols and government should monitor its operation to ensure safe soil amendments.

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Organic plant-based food in Thailand

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Key words: organic, plant-based food, Thailand

Abstract

Plant-based and organic food are gaining popularity and are capturing the interest of Thai consumers. In addition to being attractive to Thai people, it is also interesting for the export market. However, there are limitations such as both organic and plant-based foods in Thailand that have just begun to develop. Organic food is still a primary production, not a variety of plants. Plant - based food has not been developed to be similar in texture and taste to the original product. Moreover, it is also expensive. For the development of organic plant-based food to be successful, it requires cooperation between the government and food product developers.

Organic food in Thailand

Over the past decade, the organic food market in Thailand has grown rapidly. Due to health awareness, Increased food and environmental safety, the demand for organic food has expanded. Many consumers look for healthy food (Carvalho & Vasconcelos, 2013). In Thailand, the production of organic products can be divided into two categories (Trade, 2020).

1. Organic by native

The production is mainly for household consumption, and the rest is sold in local markets where this type of production is not certified as organic products.

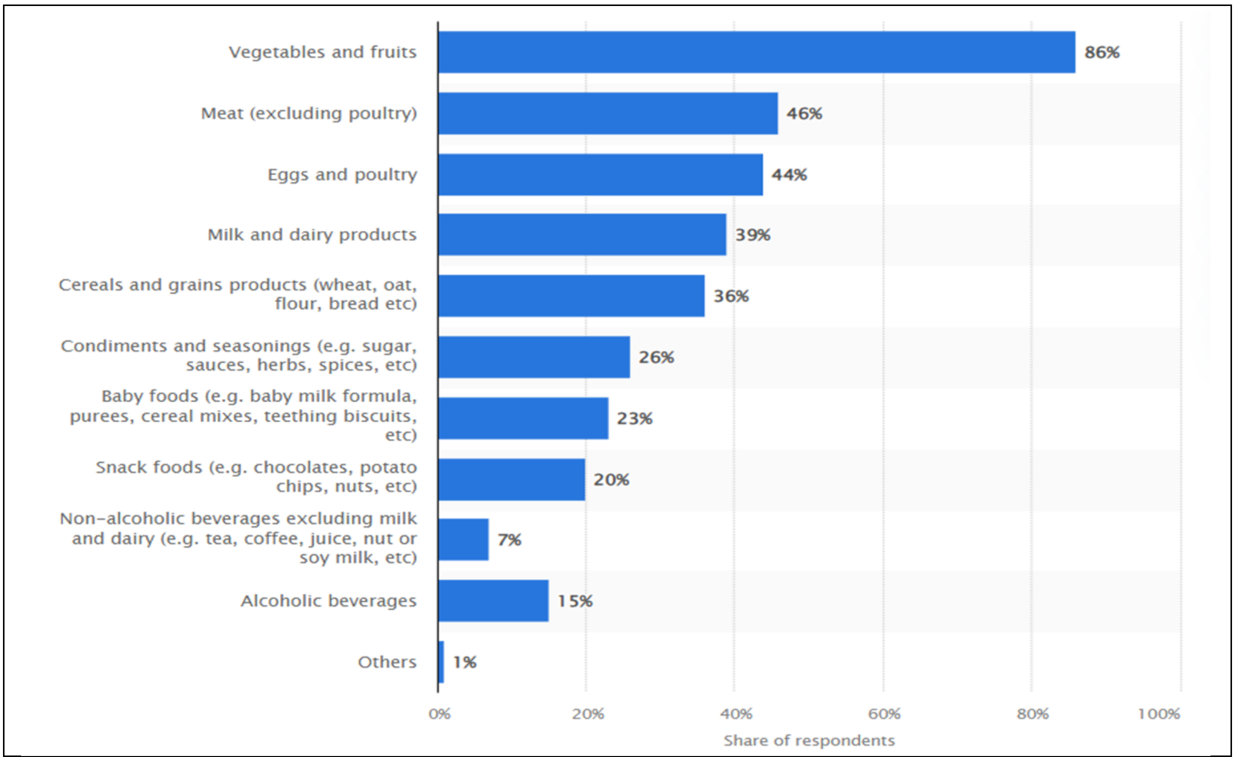

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Figure 1. the category of organic food consumed in Thailand as of September 2021 (Manakitsomboon, 2021)

2. Organic commercial

Production for sale through a marketing system that must be certified. However, organic agriculture in Thailand is still in its early stages, with a limited number of organic farmers (Kantamaturapoj & Marshall, 2020; Roitner-Schobesberger et al., 2008).

Figure 2. Texturized soy protein used as main ingredients in vegetarian festival (From https://ifrpd.ku.ac.th/th/products/ifrpd-protein.php)

The problem with organic food in Thailand today is that the production is insufficient to meet the increasing market demand. Moreover, most of the production is preliminary production without processing. Figure 1 shows the category of organic food consumed in Thailand. From the figure, it can be seen that the organic food that is consumed in Thailand is primarily processed foods such as fruits and vegetables, with less processed foods. Therefore, the problem with organic products today is that the production is insufficient to meet the needs of consumers, as well as the lack of product variety and convenience of consumption.

Plant-based food in Thailand

Another popular dietary approach in Thailand is the consumption of plant-based foods. The plant food market has increased in recent years due to health concerns. The plant-based food market in Thailand is growing by 2-10 % per year and is expected to continue growing by 10-35% per year, with an estimated value of this sector reaching $1.5 billion by 2024 (Sirikeratikul, 2021). The plant-based food in Thailand has developed in many forms, including plant-based meat, milk and egg. Most development focuses on making the product similar to the original product in taste and texture (Kittibunchakul et al., 2021; Santana & Macedo, 2019). One interesting aspect of plant-based food in Thailand is that it is a staple in meals, especially Thai-Chinese food. Every year, millions of Thai-Chinese participate in the Abstaining Meat Festival, known as the Vegetarian Festival, usually held in October for nine days. Food development companies often launch various plant-based food products during vegetarian festivals. Although it is not a vegetarian festival, plant-based food is commonly seen. Such soy milk and Pa tong go (Chinese donuts) are part of Thais' popular breakfast and readily available at street vendors (Jeaheng & Han, 2020; Sirikeratikul, 2021).

Like organic food, plant-based food in Thailand has just been developed thoughtfully. Plant-based food, mainly plant-based meat, is still less popular and expensive, while plant-based beverages tend to be more accepted.

Figure 3. Plant based meat such as minced pork used as an ingredients in Thai cuisine (Pad Kra Pao Mu Sub : Stir Fried Basil with Minced Pork)

Organic Plant-based food : when consumer needs meet

It's an exciting and possible combination. However, several things should be taken into account, such as producing organic raw materials or ingredients for use in plant-based food must be in sufficient quantities and certified to be organic. Getting too much or too little of certain nutrients, such as amino acid, vitamin B12, vitamin D, iodine, calcium, and zinc, is also an issue that must be paid attention to. If these problems are solved, organic plant-based is an attractive alternative to consumers and an attractive export product for Thailand.

Conclusion

Thailand's organic plant-based food still has a lot of potential for development. The development will be accomplished through the government's cooperation with organic plant certification bodies and the plant-based food developer.

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Improvement of growth, yield, and biochemical properties of potato by foliar application of Zinc; an agronomic biofortification technique

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Key words: biofortification, zinc, foliar spray, *Solanum tuberosum,* commercial potato, yield, quality

Abstract

Considering the widespread deficiency of zinc (Zn) in soils and crops, a comprehensive investigation of soil and plant is required. Foliar application could serve as a wise and economical approach for agronomic Biofortification of Zn deficiency. Information regarding the effect of foliar application of Zn on potato crop in calcareous soil is still underdeveloped. Therefore, the present study was designed to quantify the efficacy of foliar spraying of Zn on the physio-chemical attributes of potato cvs. "Red Bull" and "Montreal" grown in an alkaline calcareous soil. A field experiment was conducted with four treatments: CK (control), Zn1 (Zn @ 3.3gL^{-1}) Zn2 (Zn @ 6.67gL^{-1}) and Zn3 (Zn @ 10gL^{-1}) following randomized complete block design (RCBD) with three replications. The results revealed that Zn application at 10gL^{-1} showed higher number of total number of tubers per plant, moreover, the same Zn application rate increased marketable yield, dry matter content, total soluble solids, starch content, ascorbic acid content, and total protein contents. Foliar application of higher Zn concentrations resulted in increased level of Zn in tubers dry matter. Similarly, among potato cultivars, "Red Bull" performed better toward Zn application and showed significant positive impact on vegetative growth, yield and biochemical properties. It can be concluded that foliar application of Zn @ 10gL^{-1} on potato cv. "Red Bull" showed better tuber quality, higher marketable yields and along with elevated physicochemical properties. The agronomic biofortification through foliar application is an effective technique to enrich the Zn in field potatoes through soil-plant interaction.

Introduction

Potato (Solanum tuberosum L.), which belongs to the family Solanaceae, is a root crop and considered as one of the most important non cereal crops in the world (Dolničar 2021). It is used for humans' consumption (Dolničar 2021). Potato is playing important role in ensuring food security and incomes for developing countries (Devaux et al. 2021). Roots of potato are rich source of vitamins A, beta-carotene form and good source of vitamin C, copper, manganese, potassium and iron (Moura et al. 2021). In Pakistan potato is planted over the area of 15403 thousand hectares producing production of 2539.0 thousand tons (Iftikhar et al. 2020). Zn deficiency in humans is worldwide problem and the most of the countries soils are found to be low in phytoavailable Zn (Cakmak, 2017). It has been estimated that over one-third of the World's population are zinc (Zn)-deficient (Cakmak, 2008; White and Broadley, 2009; Cakmak et al., 2010; Stein, 2010). It is fact, that potato tubers contain relatively high concentrations of organic compounds that stimulate the absorption of Zn, and low concentrations of compounds that limit Zn absorption, the bioavailability of Zn in potato tubers is potentially high (Burlingame et al., 2009; Kärenlampi and White, 2009; White et al., 2009).

Foliar application of Zn maintains soil fertility, improves crop yield and prevents potato seed tubers from rottenness (Ierna et al. 2020). Atanaw (2021) reviewed that Zn protects bio membranes and stabilizes against oxidative stress. Previous published research confirmed that application of Zn significantly increases the number of potatoes, potato weight, size and other micro-nutrients improve vegetative growths and net yield of potato (Vinichuk et al. 2021). Zn bioavailability is often considered as a serious problem in alkaline calcareous soils of the world (He et al. 2021), high pH of these soils are often considered the main factor associated with low Zn bioavailability (Duffner et al. 2012). There is insufficient knowledge about foliar zinc application for potato and the factors affecting its quality in Pakistan. In this study we hypothesize that foliar application of Zn may enhance yield and physico-chemical attributes of potato (cvs. "Red Bull" and "Montreal") grown in an alkaline calcareous soil and on Zn concentrations potato crop which will lead to prioritize the best potato cultivar to be cultivated in Mingora of district Swat, Pakistan.

Materials and methods

This study was carried out at Agriculture Research Institute; Mingora, Swat Khyber Pakhtunkhwa (KP), Pakistan, during 2018-19. The weather of the experimental site during potato growing season 2018-19 is presented in Fig. 1. Cuttings of two potato varieties Red Bull and Montreal were grown during 2018-19 under drip irrigation system. Before the experiment, a total of ten composite soil samples (0-30 cm) were collected from the field. All agricultural practices were used required for potato production recommended by the local Agriculture department. Three weeks after cultivation, plants were sprayed twice (10 days' interval) with the chelated form of different levels of Zn: (3.3 gL^{-1}, 6.67 gL^{-1} and 10 gL^{-1}) while control plants were only sprayed with water. The experiment was laid under randomized complete block design (RCBD) with three repetitions, considering the Zn (Zn-EDTAZnSO_4) application dose as factor A (0, 3.3, 6.67, 10 g L^{-1}) and the two potato varieties (cvs. Montreal and Red bull) as factor B. A total of 24 plots were developed, with plot size of 9$m^2$and maintained four rows in each plot. Plants from each treatment were randomly selected and harvested and data regarding to total weight of potato Tubers of each plant were recorded separately. For marketable yield potatoes with a diameter of 30mm and maximum were weighted and expressed in ton per hectare. Tuber samples were oven dried at 70°Cto constant weight (for about 70 hours) and then dry matter (%) was determined (El-Tohamy et al. 2014). Digital refractometer was used to record the Total soluble solids for each replication. A few drops of muslin cloth strained juice of potato were kept on the clean slab of the refract meter and the results were noted as °Brix. Ascorbic acid contents were measured by following the method of Hans (1992). Slices of potato cultivars (Montreal and red bull) (5g) was homogenized with 5 ml of 1.0% Hydrochloric acid (HCL) and centrifuged at 11,000 rpm for 10 minutes. Absorbance of the solution was checked at 243 nm with a UV spectrophotometer. Ascorbic acid contents were expressed as mg g^{-1} edible portion. Protein contents were measured by Kjeldahl procedure in which at first N concentration was recorded from potato tubers and then total protein content was evaluated using the following formula (Rutkowska 1981).The results were expressed as percentage of the fresh production.

$$\text{Protein (\%)} = \text{\% N of the produce } \times 6.25$$

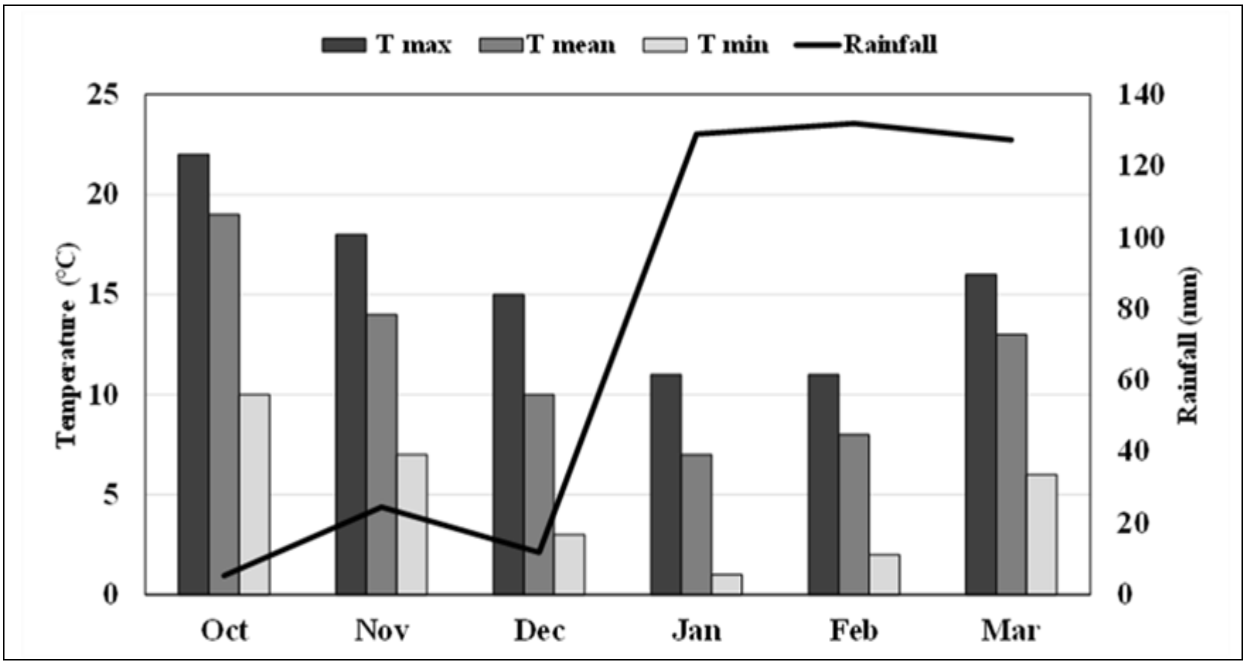

Figure 1: Mean rainfall and temperature variation of the study area during the growing seasons (2018 and 2019)

The Starch content (%) was measured according to the method as described by (Winton and Winton 1935). Data obtained were subjected to statistical analysis using Statistix 8.1 (Statistix 8.1, Tallahassee, Florida, USA). Four treatments were arranged in a completely randomized block design of two factors (cultivars and foliar application of Zn, 2x4) with three replicates. Two-way ANOVA for randomized complete block design (RCBD) and multiple comparison analyses using Tukey's test ($P< 0.05$) were performed and the means were separated using least significant difference (LSD0.05) test.

Results

Total number of tubers plant^{-1} of potato cultivars also varied significantly with applied Zn levels. Maximum value of (10.83) was recorded by the application of Zn@ 10gL^{-1}, followed by (10.16) where Zn was applied@6.67 gL^{-1}, while minimum value of (6.33) was recorded in control treatment (Table 1). In two- way interaction of varieties and different levels of Zn maximum number of tubers per plant^{-1} (12.66) was recorded for variety red bull when Zn was applied @ 10gL^{-1}, while minimum value of (6.00) was recorded in control treatment for variety Montreal (Table 1). The data of marketable tuber yield of potato cultivars showed highly significant variations with applied Zn levels. For dry matter content of potato cultivars the treatment Zn @3.33 L^{-1} gave the highest percentage of dry matter at 24.07%, while minimum value of (21.05%) was recorded in control treatment (Table 1). Maximum dry matter content (24.63) was recorded for variety red bull when Zn was applied @10gL^{-1} while minimum value of (21.17) was recorded in control treatment (Table 1). For total soluble solids content of potato cultivars, maximum value of (4.32) was recorded by the application of Zn@10gL^{-1}. Red Bull gave the highest percentage of TSS (4.61) when Zn was applied @10 gL^{-1}, compared to control treatment, which gave the lowest TSS content (2.33) (Table 1). Maximum ascorbic acid was recorded for variety red bull (14.78) while minimum value of (12.78) was noted for variety Montreal (Table 1). Maximum value of (14.63) was recorded by the application of Zn@10gL^{1} followed by (14.12) in treatment for where Zn was applied @ 6.67 gL^{-1}, while minimum value of (13.02) was recorded in control treatment. Red Bull showed the highest values of ascorbic acid (16.02) when Zn was applied@10gL^{-1}. While minimum value of (12.25) was recorded in control treatment (Table 1). For protein content of potato cultivars, maximum value of (15.91) was recorded by the application of Zn@ 10gL^{-1} followed by (15.16) with the application of Zn@ 6.67 gL^{-1}, while minimum value of (12.50) was recorded at control treatment (Fig.2). While, Red Bull variety gave the maximum proteins content (16.58) when Zn was applied @ 10gL^{-1} (Table 1). For starch content of both potato cultivars showed, maximum value of (13.26) was recorded by the application of zinc@ 10gL^{-1}which was followed by (12.15) by the application of Zn@ 6.67 gL^{-1}, while minimum value of (8.14) was recorded at control treatment. In two- way interaction of varieties and different levels of Zn maximum starch content (13.79) was recorded for variety Red Bull when Zn was applied @ 10gL^{-1}, while minimum value of (7.49) was recorded in control treatment (Table 1). Tuber Zn concentration were significantly increased with the higher level of Zn foliar fertilizer application and highest Zn was found in Red bull (Fig. 2).

Table 1: Effect of foliar application of Zn on yield and yield parameters of potato cvs. "Red Bull" and "Montreal" grown in an alkaline calcareous soil

Parameters studied		Zinc Levels			
	Varieties	Control	3.33 g/l	6.67 g/l	10 g/l
Effect of zinc on Total Number of tuber per plant^{-1} of potato cultivars	*Montreal*	6.00e	7.66cd	11.00b	7.66cd
	Red bull	6.66de	8.66c	10.66b	12.66a
Effect of zinc on Marketable yield ton h^{-1} of potato cultivars	*Montreal*	20.34d	22.54d	24.91c	27.69b
	Red bull	21.88d	25.07c	29.40b	31.83a
Effect of zinc on Dry matter content of potato cultivars	*Montreal*	21.17cd	21.70cd	22.22c	24.63a
	Red bull	20.92d	22.11c	23.52b	24.63a
Effect of zinc on Total soluble solids of potato cultivars	*Montreal*	2.33d	2.65d	3.23c	4.04b
	Red bull	2.44d	2.75d	3.58c	4.61a
Effect of zinc on Ascorbic acid of potato cultivars	*Montreal*	12.25g	12.66fg	12.96ef	13.24de
	Red bull	13.78cd	14.03c	15.29b	16.02a
Effect of zinc on Total protein content of potato cultivars	*Red bull*	13.51c	12.44d	14.10c	16.58a
	Montreal	11.48d	15.42b	16.23ab	15.25b
Effect of zinc on Starch content of potato cultivars	*Montreal*	7.49g	10.15e	11.67cd	12.72b
	Red bull	8.80f	11.23d	12.64bc	13.79a

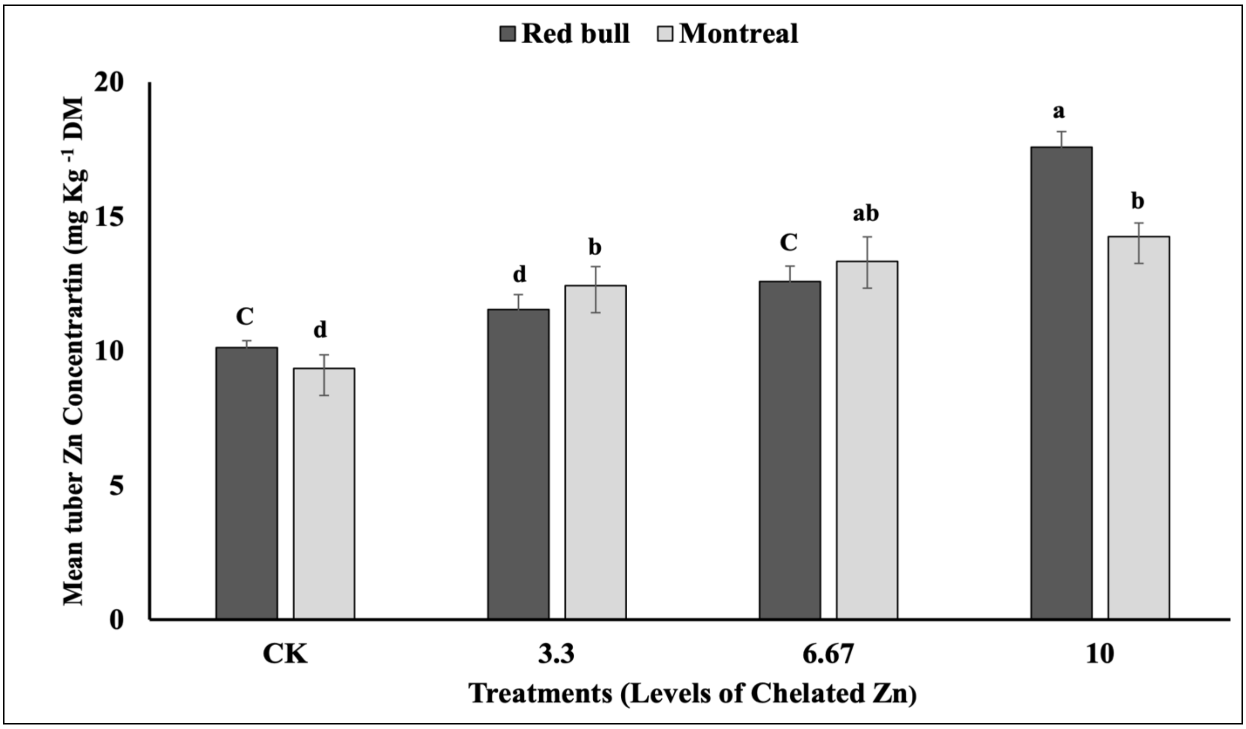

Figure 2. Variation in mean tuber Zn concentration of potato cvs. “Red Bull” and “Montreal” grown in alkaline calcareous soil. Data are expressed as means and ± standard deviation.

Discussion

It is well known that Zn kick-starts growth and development through improved seedling vigour, root growth and chlorophyll concentration resulting in improved nutrient uptake and crop yield productivity (Atanaw 2021). The possible reason for increase in total number of tubers in our study might be due to the zinc role in enhancing the vegetative growth of plants (Ierna et al. 2020). Moreover, foliar application of zinc increases all plant characteristics relating to potato crop yield and quality (Rahman et al. 2018).

In the current study, we achieved maximum yield of (30.18tons ha^{-1}) as reported Zn also increase productivity of various crops (Mengist et al. 2021; Zaman et al. 2018). Our results are corroborated with the work of (Kaur et al. 2018b).We achieved maximum dry matter yield for variety red bull with application of 10 gL^{-1} of Zn, as it was reported earlier by (Manjunath et al. 2017) (Kaur et al. 2018b) that foliar application of Zn at 10 gL^{-1} significantly increased dry matter yield up to (19.76%) as compared to control. Similarly,Sharma et al. (2021) and White et al. (2017) also reported positive role of Zn in dry matter yield of potato.

Published literature revealed that foliar application of Zn significantly enhanced the biochemical parameters of crops (Noreen et al. 2021; Osman et al. 2021). Maximum value of TSS was recorded by the application of Zn @ $10gL^{-1}$. The higher TSS might be linked to the use of Zn metalosate. Singh et al. (2002). The findings were also similar with those of Mishra et al. (2003). Our results are also corroborated with the work of Kaur et al. (2018a), they reported highest value (4.90) of TSS with the application of Zn at 10 ppm. Similarly, Khan et al. (2019) reported that application of Zinc at 10 kg ha^{-1} resulted in maximum TSS (4.87 °Brix).

In the current study, we observed positive effect of Zn application on ascorbic acid content in potato tubers. The content of ascorbic acid increased with increase in Zn application rate. Maximum values were recorded by the application of Zn @ $10gL^{-1}$. The increased amount of ascorbic acid may be attributed to the increasing size of tubers, which leads to an increase in total dissolved solids such as sugars, organic acids, vitamin C, mineral salts, and other essential components (Najem et al. 2020). Red bull variety performed better in the present study, and it showed maximum proteins content. These results are in line with the findings of Rahman et al. (2018),they also observed in their experiment that the application of Zn10ppm recorded the highest value of protein (8.85%). Starch content increased with increase in Zn application rate. Red bull variety showed maximum starch content recorded by the application of zinc @ 10gL^{-1}.The findings of Khan et al. (2019) supported our results, they reported that Zn application with variable rates had significant impact on potato quality and high values of quality parameters of potato starch content (14.34%) were observed with the application of 10 kg Zn ha$^{-1.}$

Zinc is required by plant in fewer amounts but its viability is most important, especially for improving quality(Ierna et al. 2020). The observed improvement in vegetative growth and the tuber quality parameters as affected by zinc nutrition can be explained on the basis of that Zn promotes growth hormone biosynthesis, the development of maturation and starch (Awad et al. 2021). The results of Zn concentrations in tuber dry matter were consistent with previously reported research that potato genotypes have different Zn concentrations in their tubers (e.g Bethke and Jansky, 2008; White *et al*., 2009; De Haan *et al*., 2010). In addition to significant genotypic effects on tuber Zn concentrations, our study suggested that tuber Zn concentration was also influenced by soil environment in which the plants were grown. Compared to soil Zn application, foliar Zn application has been found to be more effective in Zn biofortification of food crops such as in wheat and rice grown under field conditions with diverse of soil and climatic conditions and different cultivars (Phattarakul et al. 2012; Zou et al. 2012).

Conclusion

The results of this study indicate that foliar application of Zn at 10 g L^{-1} is beneficial for potato growth, yield, and physicochemical quality attributes. Nutrient absorption (such as micronutrients) through foliar application is very quick than the soil application through plant roots. For these reasons, we recommended foliar application of Zn @ 10 gL^{-1} on potato cv. “Red Bull” variety grown under calcareous soil conditions which showed better tuber quality, higher marketable yields as well as biochemical parameters. The agronomic biofortification through foliar application is an effective technique to enrich the Zn in field potatoes through soil-plant interaction.

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Organic Agriculture: Building resilience in changing climate for sustainable food systems

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Key words: Organic Agriculture, Climate Change, Food systems, Resilience

Abstract

Evidence show that climate change is impacting agriculture in various ways and this in turn is impacting the food systems. In fact, climate change, agriculture and food systems are known to impact each other and are intertwined at different levels to be looked into their individual silos for any potential solutions to mitigating the reinforcing impacts on each other. Nevertheless, this paper proposes organic agriculture as an entry point in addressing the circular impact in this climate change-agriculture-food systems nexus. The review of numerous studies and literature suggest that addressing climate change and making food systems sustainable and resilient require multi-pronged approach and I hypothesize that organic agriculture could be one of the important approaches. The four principles on which organic agriculture hinges mandate practices that ensure the perpetual soundness of socio-economic, environment and biodiversity richness without compromising the quality and production of food. The integrity of the environment is fundamental to food production and food systems in addition to conducive social and economic policies. Building sustainable food systems, in large parts, require resilient agriculture, which in turn requires conducive climatic conditions.

Introduction

Food systems are complex (Steiner, 2020) and building food systems that are sustainable and resilient is even more complex visa-vis changing climate and its impact on agriculture. When climate change impacts agriculture, it invariably impacts food systems (Ericksen 2008). Agriculture is reported to be both a cause and a solution to climate change (Umesha 2018), and the agriculture that seeks to address climate change has to also be one that is capable of producing safer food and restoring the ecosystem services on which agriculture *per se* depends. Here a more promising farming system, which is holistic and ecologically based such as organic agriculture, and is widely accepted as a tool to addressing at least eight of the 17 Sustainable Development Goals should be a natural option (FAO 2017).

Organic agriculture relies on local resources, knowledge (IFOAM 2012) and legume-based diversified crop rotation to not only build a robust production system but also to enhance socio-economic and environmental sustainability (Scialabba & Lindenlauf 2010) primarily stemming from its four principles. The Principles of Care, Ecology, Fairness and Health go beyond farming emphasizing the role of the soil-plant-environment-social linkage and the centrality of interdependence. A deeper analysis of these four principles reveal that there is a common thread between the organic agriculture practices and the ongoing global and local efforts directed at tackling climate change and making food systems sustainable and resilient. This indicates that organic agriculture can contribute to fighting climate change and building sustainable food systems.

But to what extent and how organic agriculture can contribute towards climate change mitigation and sustainable food systems? This paper will present the answer to these questions based on the past and existing studies and literature. However, resilience can not be built overnight more so with complex systems such as food systems that encompass not just production, consumption and distribution but also human and environment dimensions (Ericksen 2008).

Food Systems-Climate Change-Organic Agriculture nexus

Food systems, according to the Food and Agriculture Organization (FAO) (2018), broadly include the entire range of actors and their interlinked value-adding activities involved in not just production, aggregation, processing, distribution, but also consumption and disposal of food products that originate

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from different sectors, including agriculture, forestry or fisheries, and parts of the broader economic, societal and natural environments in which they are embedded. Due to these multitude of components, the dynamics in food systems inherently make them complex and inclined to change when change occurs in their other components (Beddington 2012). For instance, a climate change-triggered extended drought or a new disease could have a significant impact on food systems.

The mean temperatures due to climate change has been increasing since the mid-1900s mainly due to burning of fossil fuels and intensive agriculture coupled with deforestation of forests (FAO 2008). Human influence, according to the IPCC (2021) report has altered seasonality, warmed the atmosphere, ocean and land and increased well-mixed greenhouse gas concentrations with devastating impact on agriculture production (FAO 2018).

It has now become urgent to act on the impact of climate change on food systems (FAO 2022). Food systems, climate change and agriculture are intertwined and any action on any of these will have corresponding effect, good or bad, on both. For instance, heavy use of petro-chemical-based synthetic agro-chemicals in conventional agriculture to enhance productivity could not only contribute to warming temperatures but also compromise the integrity of ecosystem services on which food production and agriculture itself depend on.

Climate change adaptation and mitigation through organic agriculture

Unlike its conventional agriculture counterpart, organic agriculture is reported to have both adaptation and mitigation potential to climate change and by extension the ability to contribute to sustainable food systems. The emphasis and reliance of organic agriculture on local resources and closed nutrient cycle help to reduce emissions and mitigate climate change through enhanced carbon sequestration. When such practice is scaled-up to country level as done in the Indian state of Sikkim and as aspired in Bhutan, the mitigation impact could be significant.

Reliance of organic agriculture on plant residues, diversified legume-based crop rotation, cover cropping, conservation tillage, use of organic compost amongst others help to sequester increased soil organic carbon, which is a store-house of plant nutrients. Restrictions on burning and use of synthetic agro-chemicals contribute to decreasing greenhouse gas emissions and the overall ecological footprint resulting from not just the manufacturing of these compounds but also the shipment involved. Agriculture is reportedly contributing about 25% of the greenhouse gas (IPCC 2021) and this could further increase if we continue business as usual.

Diversified farm production, increasing resilience of farm through better soil nutrient management and using healthy seeds and planting materials (IFOAM 2012) and adjusting planting time are some of the practical adaptation practices that farmers in both industrialised and non-industrialized countries can adopt. The adaptation practices also contribute to mitigation strategies, for instance, good soil fertility practices adopted through use of crop rotation, cover crops, crop residues etc. also improve carbon sequestration potential of the soil thus reducing the impact of climate change. Such practices also enhance the resilience of the farm, which in the long-run helps in enhancing crop productivity.

Many of the climate change mitigation and adaptation strategies through organic agriculture are cheaper, easy to adopt and up scale. For instance adopting diversified crop rotation, use of cover crop, agro-forestry, composting, etc. do not require additional investment, though know how of these practices would be critical.

Building sustainable and resilient food systems through organic agriculture

The adaptation and mitigation potential organic agriculture makes it a fundamental part of the solution to build sustainable food systems and combat climate change. A sustainable food system, according to the FAO (2018), is one that provides food security and nutrition for all without compromising the economic, social and environmental bases to generate food security and nutrition for future generations.

The four principles of organic agriculture in combination aim to create a sustainable system that conserves energy, protects soil and water, reduces GHG emissions and inspires responsibility in treating animals, farm workers and consumers well. These practices directly and indirectly contribute to sustainable food systems. For instance, the Principle of Health aims to provide healthy and nutritious food through practices that enhance the health of the soil on which the health of the plant, humans and animals also depend. The practices in this principle not only protect the health of the soil, plant, animal and human, but also minimize climate change through diversified crop rotation and avoidance of the use of synthetic agro-chemicals amongst others.

The Principle of Fairness aims to create fairness through the promotion of good relationship between all stakeholders in food production chain (IFOAM 2010). Such a good and reliable relationship is pre-requisite in sustainable food systems which rely on different actors and their web of activities. The principle also promotes animal welfare through proper care and treatment, which in the long run is known to improve farm productivity and reduce farm expenses.

The Principle of Ecology recognizes the imperative of the integrity of air, water, biodiversity, climate and land in agriculture production and therefore mandates practices that protect and promote the health of these elements. Such protection in turn will mitigate climate change and provide an enabling environment for agriculture, which ultimately would make it possible to create functional food systems.

In order to protect and ensure the health and well-being of current and future generations and the environment, the Principle of Care requires production practices to be managed in a precautionary and responsible manner (IFOAM 2010). Taking long-term care of the environment through varied technologies is fundamental to making agriculture productive and contributing to sustainable food systems.

Conclusion

Food systems, climate change and organic agriculture are interlinked and any impact on any of these also impact the other two, either positively or negatively. Therefore, any mitigation intervention on any of the three will not only reduce the impact on the other but will also have positive impact on all three. In light of this, organic agriculture as a tool can be an entry point in mitigating climate change, improving agriculture productivity and thereby building a sustainable and resilient food systems.

Clearly building resilience in complex systems as a food systems will take time and additional resources and interventions, including affirmative polices backed by financial resource in many of the less industrialized nations would be essential. Adoption of organic agriculture is only a part of a bigger solution and it is reported to be cheaper and suitable in all agro-ecological zones.

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Drivers and barriers for sustainable food consumption – from a Danish perspective

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

Abstract

Introduction: Modern dietary patterns have a large environmental impact while being linked to the high prevalence of non-communicable diseases. Promoting sustainable diets is the first step toward a shift to more sustainable, healthier, and equitable food systems. Knowledge about drivers and barriers enabling consumers to make sustainable choices are, however, still scarce. In the SYSORG project we aim to investigate how to design successful sustainable food systems by transdisciplinary mapping and analysis of 5 different geographical regions in Europe and Africa. The present study investigates the dietary patterns and health status of the Danish population at a national and a regional (Municipality of Copenhagen) level.

Method: Diet in Copenhagen was assessed using the SysOrg Household Level Survey and evaluated using the SysOrg Sustainable and Healthy Diet Index (SysOrg SHDI), developed in this study. National diets were evaluated using adherence scores for food-based dietary guidelines (FBDG) and the Planetary Health Diet (PHD).

Results: In the Copenhagen-SysOrg population (n=337), age and gender was significantly correlated to the SHDI. No other socioeconomic factor was determinant for the SysOrg SDHI. The average national adherence to FBDG was 46.9 (± 3.7 out of 80) and Danish females are better at following their guidelines (adherence score=52.3/80),

Conclusion: Age was a diet quality determinant in the SysOrg population, where older and female people reported healthier and more sustainable diets. Furthermore, consumption of red and processed meats and fruits seemed to have the highest impact on SysOrg SHDI scores.

Introduction

Planetary boundaries are challenged by current dietary patterns, that have high greenhouse gasses (GHG) emissions, high water usage and excess nutrient while being wasteful and health-damaging. A shift into more sustainable and equitable diets is urgent to achieve the sustainable development goals (SDGs) agreed by the member states of the United Nations (UN) in 2015.

Adherence to FBDG's proposed diets studies is a way of assessing how efficient institutions have been in promoting the FBDG. Studies show that groups with higher adherence to FBDG are correlated to lower all-cause mortality and lower environmental impact of their diets compared to non- or low-adherence groups.

It is important to understand factors that impact adherence to FBDG in order to better promote their message to the population; Leme et al., (2021) manifest in their conclusions how social-demographic factors, such as age, sex, and income, may influence in following FBDG. Therefore, those factors should be accounted for in adherence to FBDG studies.

Considering the arguments here presented, we designed this study to investigate whether the Danish society follow the FBDG and the Planetary Health Diet (PHD). Additionally, we aim to evaluate the healthiness and sustainability of the dietary patterns of the consumers in the Greater Copenhagen area.

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As secondary outcomes, our investigation aims at current dietary patterns' correlations with the socioeconomic and health status of the population.

Material and methods

National Danish dietary intake was extracted from the national intake survey and reports. Only mean values were considered, and all data gathered was given as g/day or mL/day. Only the data for adults were extracted.

The SysOrg Household Level Survey was developed as part of the SysOrg work package 1. The survey includes questions about three perspectives: diet, organic and waste. For the present study, only the answers to the questions regarding dietary intake were extracted for analysis. The questions required respondents to inform how frequently they consume a certain food group (e.g., how often do you eat fruits?). The survey was distributed using the river sampling method to recruit respondents and was shared on social media channels. The survey was available in Danish and in English, and answers were collected between January and March of 2022. Participants included were adults (>18 years old) living in the area of Copenhagen. Additionally, incomplete answers about socioeconomics or diet were excluded. For this study, a total of 658 persons initiated answering the survey. Of those, 181 were excluded for not living in Copenhagen, 35 were excluded for not completing the socioeconomics questions or under the age of 18, and 105 for not answering all diet related-questions. The final sample size was 337 respondents.

Results

Three factors were significant in influencing people's organic consumption in our study. Organic consumers tended to be primarily females, older aged and with higher consumption of plant-based food. On the other hand, neither income nor level of education seemed to influence organic food consumption in this study.

Discussion

Denmark's organic policies resulted in the largest organic market share and have the largest share of pro-organic consumers than any other population, according to Organic Denmark. Copenhagen Municipality, the Danish capital, has established initiatives that led to 88% of food offered in public institutions being organic). Understanding the drivers and barriers driving changes in organic consumer behaviour among some of the most frequent organic consumers may be an important step towards a global transition towards more sustainable diets.

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Workshop 3: Climate smart Organic Agriculture

Acronym: Climate

Moderator: Prof. Dr. M. Reza Ardakani (Iran)
Rapporteur: Dr. Sabine Zikeli (Germany)
Date: Oct 2nd, 2022

Oct 2nd, 2022	Impuls presentations by:
10:30 – 12:30	• M. Reza Ardakani (Iran) • Andrew Hammermeister (Canada) • Ulrich Schmutz (United Kingdom) • Raffaele Zanoli (Italy) • Uygun Aksoy (Turkiye) • Maria Dussi (Argentina) (online)
14:00 – 16:00	• Carola Straßner (Germany) (online) • Roberto Ugas (Peru) • Amritbir Riar (Switzerland) • Victor Olowe (Nigeria) • Paola Migliorini (Italy) (online)
16:00 – 18:00	• Khalid Azim (Morocco) • Jalal Rastegari (USA) • Sabine Zikeli (Germany) • Bodapati Subrahmanyeswari (India)

Global climate will change in the coming decades, with heavy impacts in many regions of the world. The international community has agreed to keep global average temperature increase by 1.5°C. Organic agriculture has to contribute to this goal, mainly by reducing CH4, CO2 and N2O emissions. In any case, organic agriculture has not achieved the target to be a climate neutral food production, what is not achieved by any food system, yet. On the one hand, science and organic farming practice need to think out of the box to test new approaches for GHG mitigation. On the other hand, weather extremes will appear more often (droughts, heavy rains, thunder storms) and the resilience of food and farming systems will be increasingly challenged – this will also put some organic farming systems at risk. Therefore, the organic sector needs to move forward to meet the challenge of climate change adaption.

How does Organic philosophy and regulations deal with the climate change?

M. Reza Ardakani[1]*, Farnaz Ghodrati Namin[1], Aliakbar Shafighi[1]

Key words: sustainable agriculture, recarbonization, climate resilience, carbon foot print, Organic regulation

Abstract

Organic food system and its practices has high carbon assimilation capacity. This type of agricultural system has low carbon emission based on its closed loop input management. Organic agriculture's philosophy and regulation are supporting adaptation, mitigation and resiliency strategies through both the carbon farming practices and introduction of new Eco-labels. Nowadays, climate change crisis measuring embodied carbon as a challenge for researchers and organic global movement not only in traded organic goods but also in sustainable food production systems today. Therefore, innovation on designing new indexes and methodologies could be on the agenda. Setting new carbon regulations, implementation, and eventually carbon marketing and labelling products with relevant ecological footprints and greenhouse gas emission can be a solution for marketing imperfections and preserving consumer rights, transparency, lowering costs of productions and helping resiliency strategies. Finally, both the regulation and practices can also help to provide authentic data base for future research on promoting most climate friendly food production systems.

Introduction

During the Conference of the Parties of Durban in 2011 three concepts have emerged in climate agenda-setting: "climate-smart agriculture," "agroecology," and "nature-based solutions." These concepts frame agricultural adaptation and mitigation issues regarding climate change in specific ways. The two concepts of climate-smart agriculture and nature-based solutions are recent, while agroecology is a long-standing term that has recently regained popularity to analyze climate issues (Hrabanski et al. 2022). Agroecology is a holistic and integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of sustainable agriculture and food systems. Although agriculture is a major part of the climate problem and currently generates 19–29% of total greenhouse gas (GHG) emissions, but It has always known as a permanent hub of carbon sequestration. The system of organic agriculture (OA) arose in the early twentieth century and has gone through several stages. The timeline of OA has started since 1920 which calls organic 1.0 and means the first generation of organic movement. Organic 1.0 was based on philosophy of OA which generated by visionaries and funded mainly by Rudolf Steiner and further development by Sir Albert Howard, Lady Eve Balfour, Rashel Carson and J.I.Rodale. They all emphasised that "Organic more issues than foods". Farming in harmony with nature and with the least possible dependence on external input are the fundamental idea of organic philosophy. The ideal is a complex, closed- system (re-circulating) with a direct relationship between plant production and animal husbandry, including arable land and permanent grassland or fodder crops grown on arable land. The philosophy of OA has introduced organic farming as a way of life not an alternative. Till today in many of the poor nations, OA is a way of life as much as it is a method of farming. Chemicalization, excess irrigation, depletion of soil moisture, depletion of organic carbon and organic matter content in soil, burning/wasting of biomass, soil erosion or allowing the soil to dry etc., are all against the ethics of OA. The organic movement applies a cohesive philosophy to these techniques and a focus on developing a system of agriculture as an explicit alternative to conventional agriculture. The organic philosophy can be understood as follows: conventional agriculture treats the soil as an inert medium that will reliably transform chemical inputs into agricultural outputs, like a component in a machine. Problems such as nutrient deficiency or insect infestation are treated as endemic pathologies in constant need of treatment by way of various chemicals, and the farm is not seen as a cohesive interconnected system. By contrast, the organic method describes a radically different

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understanding of soil not as a machine, but as a living entity whose innate fertility can be enhanced through the proper techniques. The farm is understood as a responsive, living system and an effort is made to understand it as a whole rather than in isolated parts. A concise history of the organic food movement is provided going back to the German Lebensreform and the American Natural Foods Movement. At the time of the first appearance of agricultural systems oriented towards the protection of the natural environment, the associated change of lifestyle was linked to romantic notions of a return to nature and a critique of urbanization. According to the OA philosophy OF is not a goal to be attained. It is an ongoing process. It is a journey rather than a destination. OA is a matter of giving back to nature what we tale from it.

The second phase started in the 1970s and was defined by codifying organic agricultural systems and calls organic 2.0 which contained the introduction of standards and 3rd party certification systems along with government regulations (private standards, public regulations and global recognition). Organic farming has become a respected agricultural method which is now precisely defined by law. However, the most important stage is organic 3.0 which started since 2015 and addresses future challenges and aims at entering OA on the global stage (Arbenzet et al. 2015) with focusing on market reinvention, widespread conversion, performance improvement and research & innovation. The recent terminologies in agricultural systems show more focusing in carbon cycling in agro-ecosystems such as carbon capturing, carbon farming, recarbonization, carbon sequestration and carbon foot-print with considering the definitions of food security and climate change, resiliency, mitigation , adaptation, etc. while OA has a long history to contribute significantly to higher soil organic carbon stocks compared to conventionally managed soils, and it delivers benefits for soil health, water quality and biodiversity protection. OA therefore offers a systemic approach to carbon farming which released by IFOAM Organics Europe in 2022. OA should therefore be recognized as a carbon farming system, given its holistic approach to climate and nature and the benefits provide for climate mitigation, adaptation and ecosystem health. Atmospheric concentrations of carbon dioxide can be lowered either by reducing emissions or by taking carbon dioxide out of the atmosphere and storing in terrestrial, oceanic, or freshwater aquatic ecosystems. A sink is defined as a process or an activity that removes (GHG) from the atmosphere. With the current growing understanding of the climate change phenomenon and the urgency of undertaking adaptation and mitigation strategies, resilience has emerged as the preferred paradigm for addressing potential future climate change risks (Zong et al. 2022).

Table 1: Agro-ecological practices which supports Carbon Sequestration & Conservation which are allowed in OA Practices

Trees & Shrubs	**Vegetative Plantings**
Alley cropping	Conservation Cover
Multi-Story Cropping	Conservation Crop Rotation
Riparian Forest Buffer	Cover Crop
Tree and Shrub Establishment	Field Border
Windbreak & Shelterbelt Establishment	Riparian Herbaceous Cover
Silvopasture Establishment	Forage & Biomass Planting
Woody Residue Treatment	Range Planting
Hedgerow Planting	Vegetative Buffer
Forest Stand Improvement	Herbaceous Wind Barrier
Management Activities	
Residue & Tillage Mgmt – No Tillage	
Residue & Tillage Mgmt – Reduced Tillage	
Nutrient Management	

Carbon footprint is one of a family of footprint indicators that accounts for GHGs emitted by human activity. Deforestation and increasing GHGs emitted by human activities are worsening the situation. The average carbon footprint for a person in the United States is 16 tons, one of the highest rates in the world. Globally, the average carbon footprint is closer to 4 tons. To have the best chance of avoiding a 2℃ rise in global temperatures, the average global carbon footprint per year needs to drop to under 2 tons by 2050. OA provides agroecological management practices that can help farmers adapt to climate change, therefore, OA has the potential to help agriculture to become a net sequester of GHGs and to assist in building resilience and adaptation in farming systems and make it like a smart farming system (Table 1). Throughout this manuscript, the authors describe how OA regulations support these three action points which are being strongly supported by the philosophy of OA and furthermore by legislation.

Organic agriculture regulations strongly support its strategies in order to re-carbonization:

Adaptation strategy:

OA emphasizes the use of management practices in preference to the use of off farm inputs that causes industrial emission during production of industrial fertilizers, taking into account that regional conditions require locally adapted systems (Rahmann et al. 2017). A number of organic core practices with the focus on soil quality and fertility support climate change adaptation benefits (Muller et al. 2016).

"…Biodegradable matter of microbe, vegetable or animal origin forms the basis of fertilization…" (Version 06/2021– Naturland).

"…. In order to ensure long lasting soil activity and thus crop yields, special attention has to be paid to the basis of soil fertility; this also serves the purpose of improving its water absorption and retention and increasing the storage of CO_2 (in the soil) as a contribution to the protection of the climate:..." (Version 06/2021– Naturland).

In a meanwhile regarding soil life following statements are obligated in different organic standards:

"…The maintenance and enhancement of soil life and natural soil fertility, soil stability and soil biodiversity preventing and combating soil compaction and soil erosion…" (Regulation (EU) 2018/848).

"…Measures suitable to avoid the erosion of soil and surface runoff must be taken…" (Version 06/2021– Naturland).

"…The humus balance has to be at least at an equilibrium within the margin of varied crop rotation…" (Version 06/2021– Naturland).

"…For permanent crops, this has to be guaranteed by adequate measures such as under sown crops, catch crops, or permanent ground coverage..." (Version 06/2021– Naturland).

"…Despite the emphasis that organic agriculture places on the importance of soil, crops grown in a hydroponic system, rather than soil, can be certified organic" (Figure 1).*"Hydroponics is the production of plants in a soilless medium, whereby all of the nutrients supplied to the crop are dissolved in water…"* (NOP/USDA). In a contrary *"…Hors-sol crop production methods (hydroponics, the nutrient film technique or similar methods) as well as the complete separation of the root zone from the natural soil (e.g. through plastic foil, nonwovens, pots, containers or any other materials impeding root penetration) are strictly prohibited…"* (Biosuisse/2021).

Cultivation of resistant varieties has been introduced as adaptation practices against climate change. (Figure 1) Traditional varieties or landraces are more genetically diverse than modern varieties and so are better able to withstand environmental stresses (CBD Secretariat, 2010).

"…The strains cultivated (their combination with undergrowth, growing methods) should be suitable to local conditions. Criteria are primarily low susceptibility or greatest possible tolerance of and resistance to diseases. Strains which result from protoplast fusion or cytoplast fusion or comparable methods (at the level of the cell nucleus) are not permitted…" (Version 06/2021– Naturland).

Mitigation strategy:

A central principle of the OA philosophy is that everything we have taken from nature should be returned into it. The first organic farmers did not wait for subsidies and the results of research; they voluntarily abandoned industrial farming methods and proved through practice that their new (old) way of farming was viable. OA philosophy offers low-impact farming method. OA is often termed as knowledge based rather than input based (Figure 1). Scientists at the University of Illinois analyzed the results of a 50-year agricultural trial and found that the application of synthetic nitrogen fertilizer had resulted in all the carbon residues from the crop disappearing, as well as an average loss of around 10,000 kg of soil carbon per hectare. This is around 36,700 kg of CO2 per hectare over and above the many thousands of kilograms of crop residue that is converted into CO2 every year.

"…The use of synthetic chemical substances and growth regulators is prohibited…" (Version 06/2021– Naturland).

"…The strict limitation of the use of chemically synthesized inputs to exceptional cases..." (Regulation (EU) 2018/848).

Soil Functions: Soil functions include: *"(i) biomass production, including in agriculture and forestry; (ii) storing, filtering and transforming nutrients, substances and water; (iii) hosting the biodiversity pool, such as habitats, species and genes; (iv) acting as a platform for human activities; (v) source of raw materials; (vi) acting as carbon pool; and (vii) storing geological and archeological heritage"* (Adapted from European Commission COM, 2006).

"…biochar characteristics are those physical or chemical properties of biochar that affect the following uses for biochar: 1) biochar that is added to soils with the intention to improve soil functions; and 2) biochar that is produced in order to reduce emissions from biomass that would otherwise naturally degrade to GHG, by converting a portion of that biomass into a stable carbon fraction that has carbon sequestration value…" (IBI_Biochar_Standards_V1.1).

Researchers from North America and Europe have also shown that organic systems are more efficient in using nitrogen than conventional farming systems. Significantly, because of this efficiency, very little nitrogen leaves the farms as GHGs or as nitrate that pollutes aquatic systems.

"…The total amount of livestock manure, as defined in Council Directive 91/676/EEC (8) concerning the protection of waters against pollution caused by nitrates from agricultural sources, applied on the holding may not exceed 170 kg of nitrogen per year/hectare of agricultural area used..." (Regulation (EC) No 889/2008).

1 ton of soil carbon per hectare per year increases crop yield by 20 to70 kg per hectare of wheat, 10 to 50 kg per hectare of rice, 30 to 300 kg per hectare of maize which would lead to an increase of 24 to 40 million metric tons in grain production at the global level. Restore soils to sequester carbon back where it belongs, in the soils and in the plants is the most efficient and safest climate mitigation strategy (no need for geoengineering!). Therefore, burning crop residue is prohibited in OA (Figure 1).

"…Burning crop residues is prohibited, they must be composted instead. However, if composting is not possible, tree and shrub cuttings may be burnt. Pre-harvest burning of sugar cane fields is also prohibited…" (Biosuisse/2021).

"…In organic production, the burning of crop residues is allowed only for suppression of disease. Rice straw often is burned in the field. Before using this disease-control practice, it must be clearly stated in the organic system plan and approved by the certifier..." (NOP/USDA).

There are some limitations even on transportation of agricultural material in organic regulations that may help reducing GHGs emission from transportation section (Figure 1).

"…Seed, vegetative propagating material and planting stock that is sold under the Bud trademark may not be transported by air…" (Biosuisse/2021). Regenerating soils is a Win-Win solution for mitigating climate change and for food security.

Resiliency strategy:

OA as a model of a sustainable agricultural system, can maintain the cultural landscape and a permanent population in rural areas through its philosophy (Figure 1). OA empowers farmers by helping them design agronomic systems that are more resilient towards the impacts of climate change, by enabling them to reduce dependence on external inputs (Muller et al. 2016).

"…The restriction of the use of external inputs…" (Regulation (EC) No 834/2007). *"…The maintenance of plant health by preventative measures, such as the choice of appropriate species and varieties resistant to pests and diseases, appropriate crop rotations, mechanical and physical methods and the protection of natural enemies of pests…"* (Regulation (EU) 2018/848).

"…The crop rotation for all farm types on a specific field shall be diversified, adapted to the local conditions, and include green manure crops whenever possible. Alternating species of annual or biennial plant families are required and the rotation shall contain at least 20% soil building plants, preferably legumes…" (Biodynamic/Demeter). "…A diverse and balanced crop rotation also serves as a preventive crop protection strategy and enhance biodiversity…" (Biosuisse/2021).

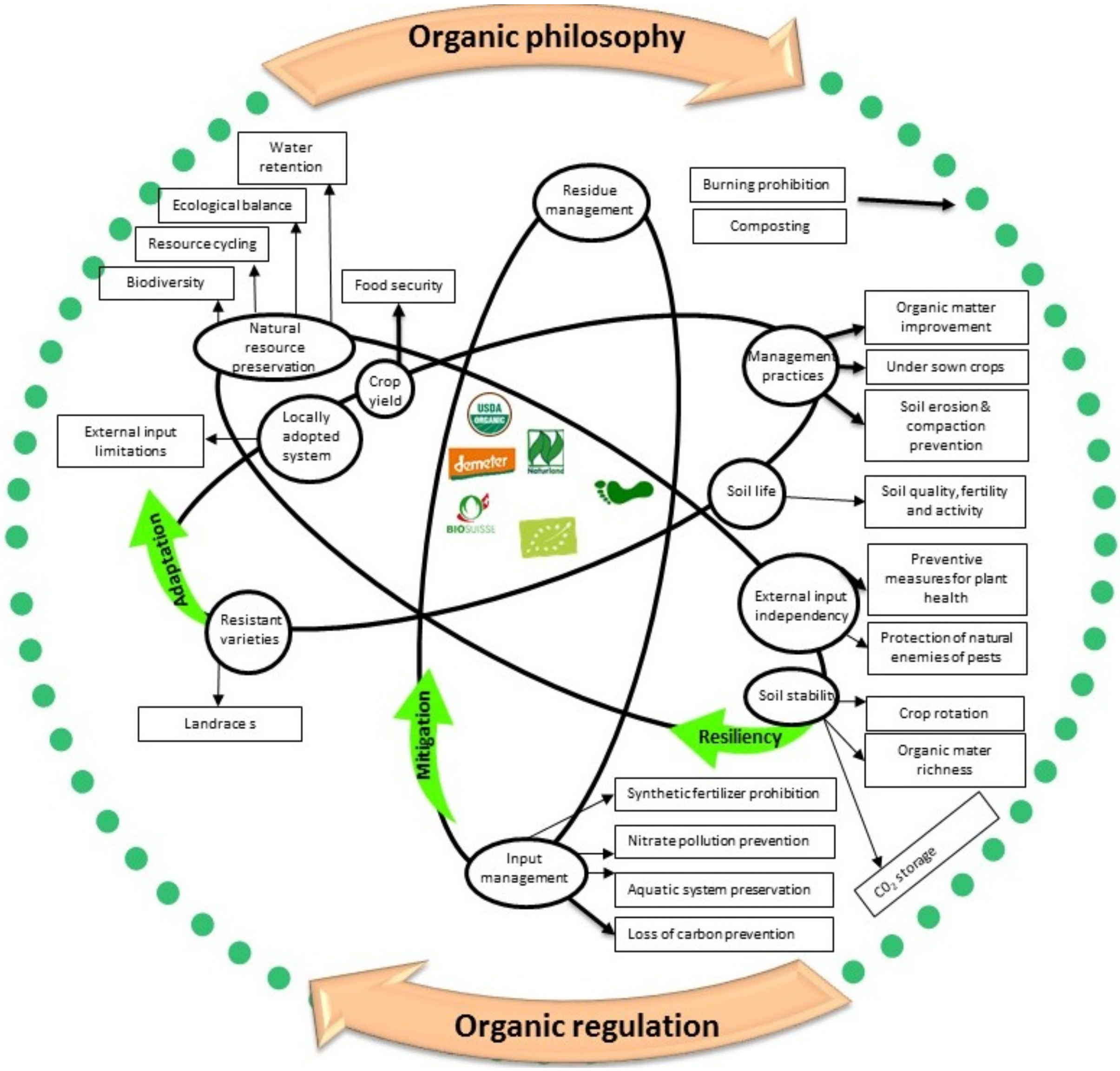

Figure 1: Organic agriculture regulations strongly support its strategies in order to re-carbonization

In OA philosophy significant emphasis is put on symbiosis of fungi with plant roots -mycorrhiza. Its development requires specific soil-tilling activities such as shallow ploughing, together with working plant remains, green manure, organic fertilizers and turf into the soil in the process of renewing grazing land. Soils rich in organic matter are better suited to decrease the impact of climate changes because they are more resistant to erosion and retain water a lot better, especially during extreme events such as droughts (Figure 1).

"…Organic plant production shall use tillage and cultivation practices that maintain or increase soil organic matter, enhance soil stability and soil biodiversity, and prevent soil compaction and soil erosion…" (Regulation (EC) No 834/2007).

In a future of unpredictable weather events, such robust and resilient food production will gain more competitiveness (Lee 2021). The only practical way to achieve food security is to grow the food locally where it is needed by small holder farmers. It is more important to increase the resilience of small holders at local level to ensure adequate food security of the world (Figure 1).

The organic movement believes that the climate and biodiversity crisis have to be tackled together (IFOAM Organics Europe, 2022). OA has been shown to enhance biodiversity (Bengtsson et al. 2005; Fuller et al. 2005).

"… "Organic production" is defined as a "production system that is managed to respond to site-specific conditions by integrating cultural, biological and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity."…" (NOP/USDA). "…Biological diversity or biodiversity is to be maintained and fostered on farms to the best of the farmer's ability; this includes diversity of ecosystems, diversity of species and genetic diversity…" (Version 06/2021-Naturland). "…The farm must show a commitment to the maintenance of farm biodiversity..." (Biodynamic_Demeter).

Implementation of organic farming enhanced strategies through performing carbon farming:

Organic farming should therefore be recognized as a carbon farming practice, given its holistic approach to climate and nature and the benefits it provides for climate mitigation, adaptation and ecosystem health (Figure 2). A variety of third-party programs certify growers whose practices support different aspects of sustainable food production. OA due to Carbon sequestration, release fewer (GHG), Lower-input of fossil fuel dependent resources Use of renewable energy create great opportunities to lead the way in reducing energy consumption and mitigating the negative effects of energy emissions (IFOAM Organics Europe, 2022).

After the adoption of the new European Climate Law in June 2021, several legislative initiatives aimed at reaching the 55% net reduction target by 2030, as a step towards a climate neutral EU by 2050. As part of this package, the European Commission proposed to revise the LULUCF (Land Use, Land Use Change and Forestry) Regulation and the Effort Sharing Regulation (ESR), which both address agricultural GHG emissions and removals (IFOAM Organics Europe, 2022). Such Supports from regulations can help implementing philosophy of OA and its strategies as a climate friendly agri-food system (Figure 2). In other words, just stopping emission will not stop climate change If a boat is sinking, we have to do more than just plug the leak and we have to bail out the water. Soil plays a key role in OA philosophy and care of the soil is an important element of plant production. A carbon emission label or carbon label describes the carbon dioxide emissions created as a by-product of manufacturing, transporting, or disposing of a consumer product. This information is important to consumers wishing to minimize their ecological footprint and contribution to global warming made by their purchases (Figure 2). Carbon labels help consumers identify brands that are eco-minded and transparent. Eco-labeled foods enable purchasers to compare and contrast various social and environmental criteria while ensuring confidence in product claims. A variety of third-party programs certify growers whose practices support different aspects of sustainable carbon standards. One of these parties is Carbon Standards International AG which develops standards, strategies and system solutions for climate-neutral agriculture and industry (Figure 2). There are different types of divisions such as European Biochar Certificate, World-Climate and Carbon Sink standards and guidelines, that certify valuable climate performance products (Figure 2).

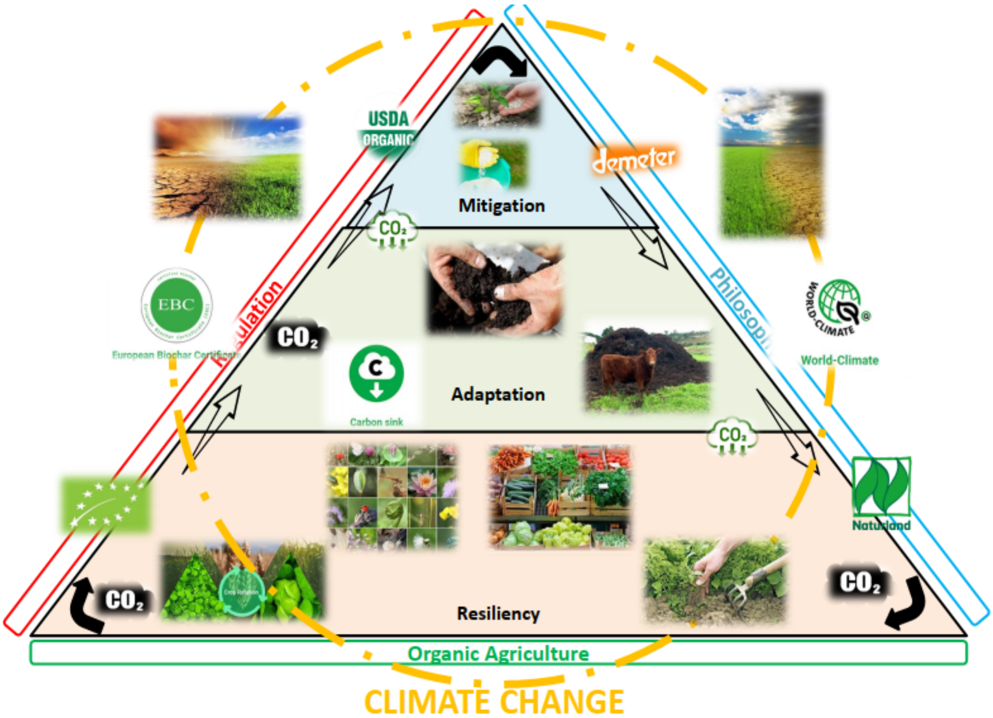

Figure 2: Implementation of organic farming enhanced strategies through performing carbon farming

Conclusion

Climate change mitigation is not (and should not be) the primary objective of organic farming, but increased conversion to OA can contribute to the reduction of (GHG) emissions, while also bringing important benefits, such as improved system resilience to the effects of climate change, maintaining or improving biodiversity on farmland, conserving soil fertility, reducing eutrophication and water pollution, and improving food security and farmers' sovereignty. Furthermore, OA is highly adaptable to climate change compared with conventional agriculture. OA as an alternative approach maximizes the performance of renewable resources and optimizes nutrient and energy flows in agroecosystems and has the potential to help agriculture to become a net sequester of GHGs and to assist in building resilience and adaptation in farming systems. OA due to carbon sequestration, release fewer (GHG), Lower-input of fossil fuel dependent resources use of renewable energy create great opportunities to lead the way in reducing energy consumption and mitigating the negative effects of energy emissions. Similar to the way OA established, consumer support is continuously being viable to promote this potential solution for climate change. Therefore, it is important to maintain consumer confidence in organic products. Organic farmers had to struggle to gain respect in a meanwhile supportive consumers contributed significantly. Due to the booming and profitable organic market today, regulations to certify the status of a product as organic is more important than ever before.

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Balancing multifunctionality with climate focused performance in organic agriculture

ANDREW MARKUS HAMMERMEISTER[1]

Key words: climate smart agriculture, sustainability, tradeoffs, organic agriculture

Abstract

Without a doubt we are in a climate crisis; impacts must be minimized by immediate action and resiliency to extreme climate variability must become the norm. Climate-smart agriculture (CSA) focuses on adopting practices that lower greenhouse gasses while improving resource use efficiency and ensuring food security. However, is such a strong focus on CSA at risk of neglecting other sustainability goals? Similar focus in the Green Revolution resulted in unforeseen consequences socially, economically and environmentally. Not only does a narrow focus risk neglecting other issues, it may also unintentionally affect other sustainability targets. What lessons can be learned from previous global policy initiatives? Here we promote and reinforce that CSA must be positioned as only one component of sustainability when developing programs and setting targets.

Introduction

Climatic variability has always been a challenge for agricultural producers. The climate crisis arising from historically high greenhouse gas emissions and subsequent concentration in the atmosphere has further exacerbated climate variability as well as extremes making weather less predictable and crop production less reliable. These challenges are coupled with the need for increasing food security and sovereignty, particularly in developing countries. A 70 % increase in food production by 2050 is projected to be needed to support increasing population growth (FAO, 2009).

Governments and international organizations have rightfully targeted addressing climate change through greenhouse gases emission reduction, carbon sequestration, and adaptation. Many policies and programs directly target emission reduction and carbon sequestration while seemingly paying little attention to the many other global sustainability challenges. The Green Revolution had a singular focus in increasing global food supply; while being successful in its primary objectives it also overlooked the multidimensionality of sustainable agriculture with negative consequences.

The focus of this paper is to explore whether a focus on climate-smart agriculture may result in a similar neglect of other important issues in agriculture.

Climate-smart Agriculture In Brief

The World Bank (2022) describes climate-smart agriculture (CSA) as “an integrated approach to managing landscapes—cropland, livestock, forests and fisheries—that addresses the interlinked challenges of food security and accelerating climate change.” They further describe three targeted outcomes of CSA: 1) increased productivity, 2) enhanced resiliency, and 3) reduced emissions. These targets appear to ignore other socio-economic and environmental targets.

Practices supporting climate-smart agriculture should, when at their best support a synergistic interaction between enhancing productivity, enhancing climate readiness, and lowering carbon footprints (Figure 1, Government of Alberta, 2022). Working toward a single goal will result in marginal benefits. However, even promoting this interaction has its limitations as other environmental benefits such as reducing water use, avoiding water contamination and maintaining or enhancing biodiversity are not considered.

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While emission of greenhouse gases in agriculture can be reduced in many ways, often government policy targets relatively few practices that are easy to adopt. For example, Agricultural GHG management can include responsible or reduced tillage, use of perennials in a farming system, using cover crops and other practices such as converting marginal land to perennial crops or woody biomass production (Government of Alberta, 2022). These practices can be beneficial if appropriately applied, but may also be of limited impact. Cover crops, for example are a broad category of practice of planting vegetation for some purpose other than harvestable production. Practices can range from multiple years of a deep-rooted perennial legume to shoulder season cover to protect the soil. While the initiative to promote cover crops should be applauded and typically always will yield some benefits, net greenhouse gas emission reduction may be limited with some cover crops while other co-benefits of soil health, biodiversity enhancement, and water protection are not fully recognized.

Sometimes practices heavily relied on in organic agriculture are not fully recognized in tracking greenhouse gas emissions reductions. In organic agriculture the use of cover crops in rotation especially leguminous green manures, is an important source of nitrogen, displacing the need for manufactured fertilizers. Leguminous green manures, and pulse crops for that matter, are important in crop rotation as they displace the manufacture of nitrogen fertilizer, and the related greenhouse gas emissions. However, fertilizer manufacture is not counted under *agriculture* in climate action monitoring programs, rather it is counted under *manufacturing*. Thus the benefits of displacement of fertilizer manufacture may not be incentivized in agricultural programs.

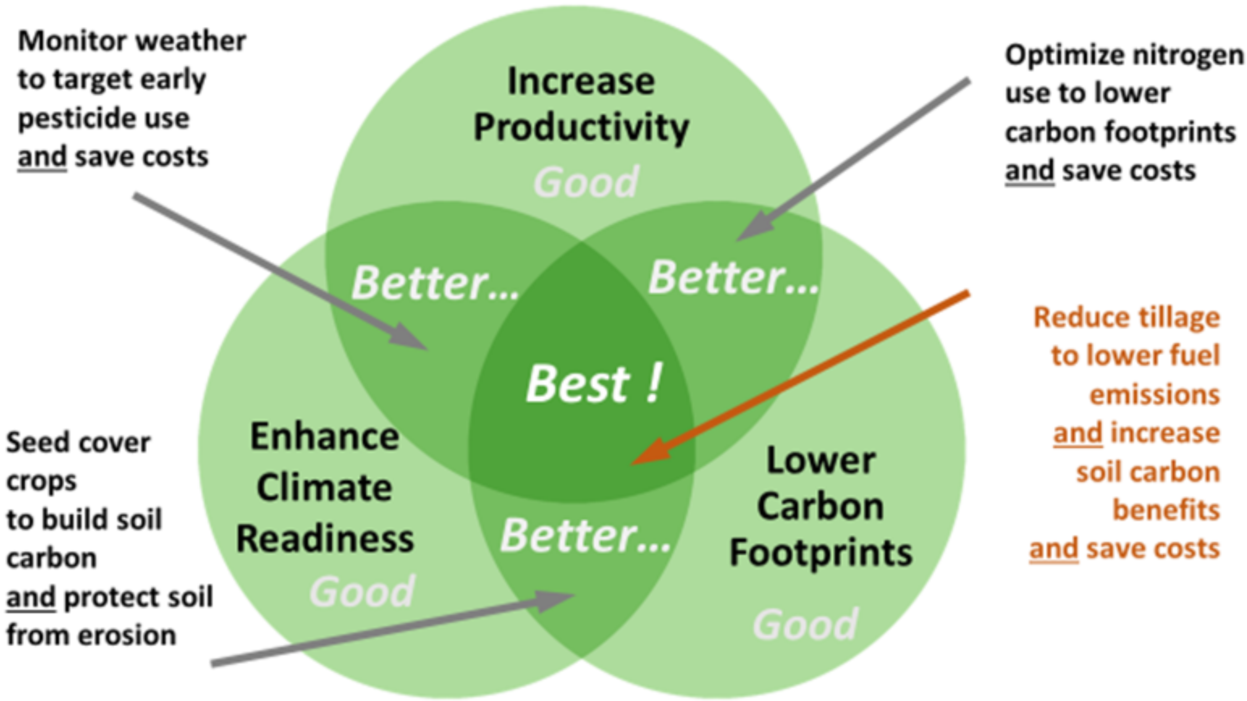

Figure 1. The interaction among climate-smart agricultural pillars. (Source: Alberta Government, 2022; https://www.alberta.ca/climate-smart-agriculture-overview.aspx)

Green Revolution

The Green Revolution (GR) successfully addressed dire predictions of global starvation through a combination of high rates of investment in crop research, infrastructure, and market development and appropriate policy support. The GR resultued in a tripling of cereal crop production with only a 30% increase in cultivated land area. This work was led by international institutions who focussed on the public good of addressing food deficits internationally including the International Maize and Wheat

Improvement Centre, the International Rice Research Insitute, and the Consultative Group on International Agricultural Research.

However, the success of the GR was not equitable geographically where Africa in particular did not see the same rate of improvement in food production in part because the GR focussed on cereals and not the staple crops of Africa such as cassava, sorghum and millets (Pingali, 2012). Genetic improvement of corn, wheat, rice potatoes and cassava were instrumental in raising yield potential in the GR, but sharing of the genetics for public good was also key to adoption. In Canada and the U.S. we see increasing privatization of the seed industry; does this pose a challenge to the development of new genetics for climate-smart farming and their adoption? Although the GR may have reduced conversion of new land to agricultural production (and associated environmental benefits), these genetic yield improvements needed to be supported by high input use which had its own environmental impacts including soil degradation, high water use, water contamination, increased greenhouse gas emissions, and biodiversity loss (Pingali, 2012).

The GR strategy was to focus on improving productivity in favorable areas, which left areas with marginal productivity seeing smaller improvements (Pingali, 2012). Adoption of improved technologies and genetics was reduced in poor regions due to socio-economic constraints in accessing the technologies and knowledge how to apply them. Although calorie consumption increased, micronutrient malnutrition persisted, in part due to less diversified diets as farming and food systems moved toward focussing on the core crops supported by the GR.

Gengenbach et al. (2017) discuss the challenges of adopting a value-chain approach in New Green Revolution for Africa (GR4A). Although including the multiple actors of the value chain, applying a one-plan fits all approach does not address the diverse needs of the many different small-holder farmers. They suggest that the market-based value chain:

... assumes a positive, linear relationship between agricultural productivity and farmer income, and between farmer income and food and nutrition security. It assumes sameness and replicability where there is in fact variation and difference. It assumes that value chains are constructed by groups of agents – principally firms, but also state policy-makers, traders and input dealers – that exclude farmers. And although it pays attention to gender, it does so through a utilitarian development lens, seeking to intervene in gender dynamics from on high, as an antidote to food insecurity. (Gengenbach et al. (2017, p. 213)

So the lessons learned from the GR and GR4A have included:

- international organizations were needed to drive forward the public good goals of the GR,
- public good motivated breeding and sharing of seed was key to the success of new varieties in the developing world,
- a singular focus on yield improvement can result in disparities in adoption of improvements both geographically and and among socio-economical groups,
- a singular focus on solving one problem may neglect other problems and possibly even make them worse, and
- the socio-economic differences among farmers must be considered when adopting policy targets.

Climate-smart organic agriculture must account for this diversity, and should not ignore principles such as fairness.

Sustainability Assessment

The Food and Agriculture Organization of the United Nations (FAO) established the Sustainability Assessment of Food and Agriculture Systems (SAFA) tool in order to create a level playing field in the assessment of sustainability metrics (FAO, 2014). SAFA includes four core dimensions of sustainability assessment: good governance, environmental integrity, economic resilience, and social well-being. Within these dimensions are 21 themes of 58 sub-themes of sustainability. A number of sub-themes would arguably be directly related to climate-smart agriculture including: sustainability management plan, greenhouse gases, soil quality, energy use, profitability, stability of production, risk management, and capacity development. This much more detailed approach appropriately recognizes that a multi-dimensional approach is needed in planning sustainability programs for agriculture.

Schader et al. (2016) found that there could be significant tradeoffs among sustainbility dimensions, themes, and sub-themes, and in particular tradeoffs between the environmental integrity dimension and other dimensions. But most prominent was the identification of significant tradeoffs between the environmental and economic dimensions as well as among sub-themes within the environmental dimension. Schader et al. (2016) used 77 indicators linked with farm management practices to assess the greenhouse gases sub-theme and found in particular that there could be a tradeoff between greenhouse gases and animal welfare.

The lesson from this work is that there can be tradeoffs in sustainability performance indicators, and that not all indicators may be achieved at the same time. Even among envionmental indicators there can be tradeoffs, with a poor relationship among performance measures. Some tradeoffs between environment and economic resilience, however, can be mitigated through government programs.

Seufert and Ramankutty (2018) provided a broad overview of how well organic agriculture addressed multiple performance indicators. While noting weak data sets for some performance indicators, organic systems generally performed well relative to conventional agriculture, particularly when compared on a land area basis. However, the improved environmental and social performance of organic came at a cost of lower yields. There is considerable pressure on organic farming systems to show yield improvement, however, yield improvement will likely come at the come at the cost of reduced performance in other indicators. If organic agriculture focusses on climate-smart practices, will it be able to maintain yields while supporting other performance measures as well? Certainly climate-smart agriculture should result in greater resiliency and thus stability of yields but can organic make significant improvements in greenhouse gas emission reduction, and at what cost?

Conclusion

Policymakers have the challenge of addressing the several dimensions and many themes and sub-thems of sustainability. Overly complex an unfocussed programs can result in minimal impact impact spread across many indicators. However, narrowing the focus on specific targets may result in neglect of many sustainability indicators, or perhaps lack of recognition or optimization of co-benefits. A systems approach is fundamental to organic agriculture in achieving sustainability while adhering to organic principles. Organic agriculture is multi-functional, achieving many benefits at once. Moving toward climate-smart production is important for organic agriculture, but it should not come at significant cost to other performance measures. Can organic agriculture be climate-smart while still being sustainable?

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How can organic agriculture & agroecology contribute solving the climate crisis in a healthy world?

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Key words: organic, contentious inputs, organic-plus, system re-design, agroforestry, mixed farming, climate mitigation, dynamic agrovoltaism, robots, planetary health

Abstract

This vison paper first reflects on the history of the organic movement in the last 100 years. It then describes research examples of how organic agriculture with a deeper understanding of agroecology can contribute not only to the climate crisis, but the overall planetary health crisis, pollution, biodiversity loss, animal welfare and social discrimination. For the description of the present 2020-30, I will use examples of current Horizon 2020 research and innovation actions to improve organic (Organic-PLUS, RELACS) add more perennial and mixed farming (AGROMIX, MIXED) and a deepening agroecology (Agroecology for Europe, All-Ready) with plans for agroecological living labs and research infrastructures, shaping the participation and multi-actor part of Horizon Europe until 2030. The paper will then, as a novel contribution, add thoughts on the next 100 years of the organic movement. Looking so far ahead is of course difficult and highly speculative, but it is not uncommon as perspective in forestry or agroforestry. For this reason this conceptual paper takes the very-long view and describes and discusses an organic-plus pathway to solve the multiple planetary crises within the next 100 years.

Introduction

In the year 2023/24, the organic movement can celebrate its 100st birthday. As with many movements whose ideas and concepts have circumnavigated the globe, the beginnings can be faint, patchy and contested. There are many thinkers and farming practitioners whose ideas are akin to organic farming and which were active before 1923/24, but I argue that the ‘twin-track of organic’, organic-biological and biological-dynamic (bio-dynamic) can be traced back to events in Switzerland and today’s Poland. The Jungbauernbewegung at Grosshöchstetten (1923) and Bauernheimatschule Möschberg (1932), Switzerland, is a school of thought combining the social, political agency of small-scale farmers with biological/organic production methods. It explains why today the largest research institute in the world for organic farming (FiBL Forschungsinstitut für Biologischen Landbau) is located in a small mountainous country. Bioland the largest organic association and certification body in Germany and Europe also has its roots in this political movement. This twin of the ‘twin-track roots’ of organic production with food system change and power redistribution in the food supply chain is combined with making autonomous basis-democratic decisions on certification in a ‘farmer parliament’. All these are ideas very akin to political agroecology today. The second twin, and at the beginning the larger one, is the bio-dynamic movement going back to the ‘Landwirtschaftlicher Kurs’, Gut Koberwitz/Kobierzyce, Silesia (1924), Poland. There the emphasis was less on small-scale farmer empowerment but on holistic diets, health care and lifestyles in combination with spiritual and community supported agriculture. Organic is in both cases a holistic body and ‘organism’ (origin of the word) which is much more than just the certification of agricultural production. Since then the movement has further grown in the ‘twin-track’ but bonded together in 1972 in Paris, France as International Federation of Organic Agriculture Movements (IFOAM) and later made into law in Europe with the EU ‘Eco-regulation’: EEC-No. 2092/1991 European Council Regulation on organic production of agricultural products (plants) and animals EC No. 1804/1999, European Union. Since then many new concepts are adding to the diversity e.g. permaculture, agroecology, agricology, vegan organic, agroforestry, regenerative farming, ecological intensification, carbon farming, all not necessarily currently certifiable as organic, but with

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large affinity to the 'twin-track' described earlier. Organic PLUS, better organic systems without all contentious inputs is just one of those additions and certainly more will be added as every generation within a 30-year cycle has new ideas.

Material and methods

As a vision paper, the main method used is conceptional thinking. This is however built on the transdisciplinary research of many replicated trials on contentious inputs like copper, peat, fertiliser, plastic mineral oils, in laboratories, greenhouses and farmer's fields as well as in-vitro and in-vivo livestock assessment of alternatives to antibiotics, anthelmintics and synthetic vitamins. The natural science was combined with social science, focus groups, large-scale representative consumer samples across Europe and dedicated farmer-consumer competency group research. As a coordinator of this research, the vision paper is not detailing the individual methods as they can be found in project deliverables published papers and further forthcoming work. Instead the purpose of the vison paper is to take the long-view locking at the potential phase-out scenarios currently researched and expand the concept of contentious inputs to all emissions and pollution from fossil fuels and nuclear power, and a vision for organic phase-in in the next 100 years. In addition, to the Horizon-2020 Organic-PLUS and its sister project RELACS, also concepts and ideas on agroforestry and mixed farming from projects AGROMIX and MIXED and on deeper agroecology (Agroecology for Europe, All-Ready) have influenced this vison.

Results and Discussion

The results from the 4-year long 8 million Euro projects Organic-PLUS and RELACS indicate that **all contentious inputs can be phased-out**. The question is only when and the timelines differ. The phase-out timelines are calibrated for organic agriculture in Europe including EU-organic, Britain, Switzerland, Norway, and Turkey. All phase-out timelines (1-14 in the figure) are also applicable worldwide, however the dates may vary and other phase-in could be considered.

For **copper as a fungicide** the use in all crops they can be reduced from 4 kg/ha per year to 2 kg/ha per year after the current 7-year long regulation runs out in 2027. Once 2 kg/ha per year runs another 7 years to 2034 it is possible to reduce copper additions completely. However, copper is a micro-nutrient and copper fertiliser and fungicide use below 2 kg/ha per year should be allowed, if there are copper deficiencies in the soil. A total phase-out of a plant micro-nutrient is impossible and as long as healthy natural soil copper levels are not exceeded, application of below 2 kg/ha after 2034 should be still be acceptable. However, there is also historic copper pollution build-up, and here a '**drawdown**' to retain a healthy soil for carbon storage is needed which could mean no copper additions until 2122. The copper phase-out is more important in perennial crops (e.g. apple, almond, citrus, hops, olive, roses) as crop rotations like with potatoes, aubergines, tomatoes and other greenhouse crops are not possible.

Mineral oils for plant protection can be phase-out immediately, alternatives are available. The same is the case for **mineral oils as machinery lubricants**. This raises teh big question of phasing out all other **mineral oils in diesel, petrol and heating oil**. This was not part of Organic-PLUS research, but a visionary timeline is given based on the ban of diesel and petrol new car sales in the United Kingdom 2030 or EU 2035: For organic agriculture and machinery this should also apply as tractors are slower developed 2035 is a realistic goal for new machinery and 2050 for removing all fossil fuel tractors and machinery while retaining horse power and solar battery power tractors and robots.

Non-organic straw can be phased out immediately as alternative bedding is available. 25% organic land use will help with availability of straw. The same can be concluded for **non-organic manure** this can be phased-out immediately, alternative fertilisers are available and if organic farms need manure they can always increase own organic livestock as mixed farming should be encouraged. This policy is an example of an indirect support for mixed farming and divers land use with agroforestry systems. The increase of organic land to 25% (or 30% in some countries) by 2030 will help with any availability and supply chain problems. **Non-organic fertilisers** can also be phased-out soon but currently there is limited availability e.g. Vinasse from sugar-beet and leguminous fertilisers like bean powder are not (yet) exclusively from organic farming systems. This still provides a pathway for pesticide contamination from conventional inputs. Here, again, 30% organic by 2030 will help with the overall availability of organic product and by product from processing. Further research is needed to explore options to secure and reliable sources enough nutrient inputs required for a growing organic sector. This also includes Humanure and Struvit (a phosphor fertiliser base on human waste).

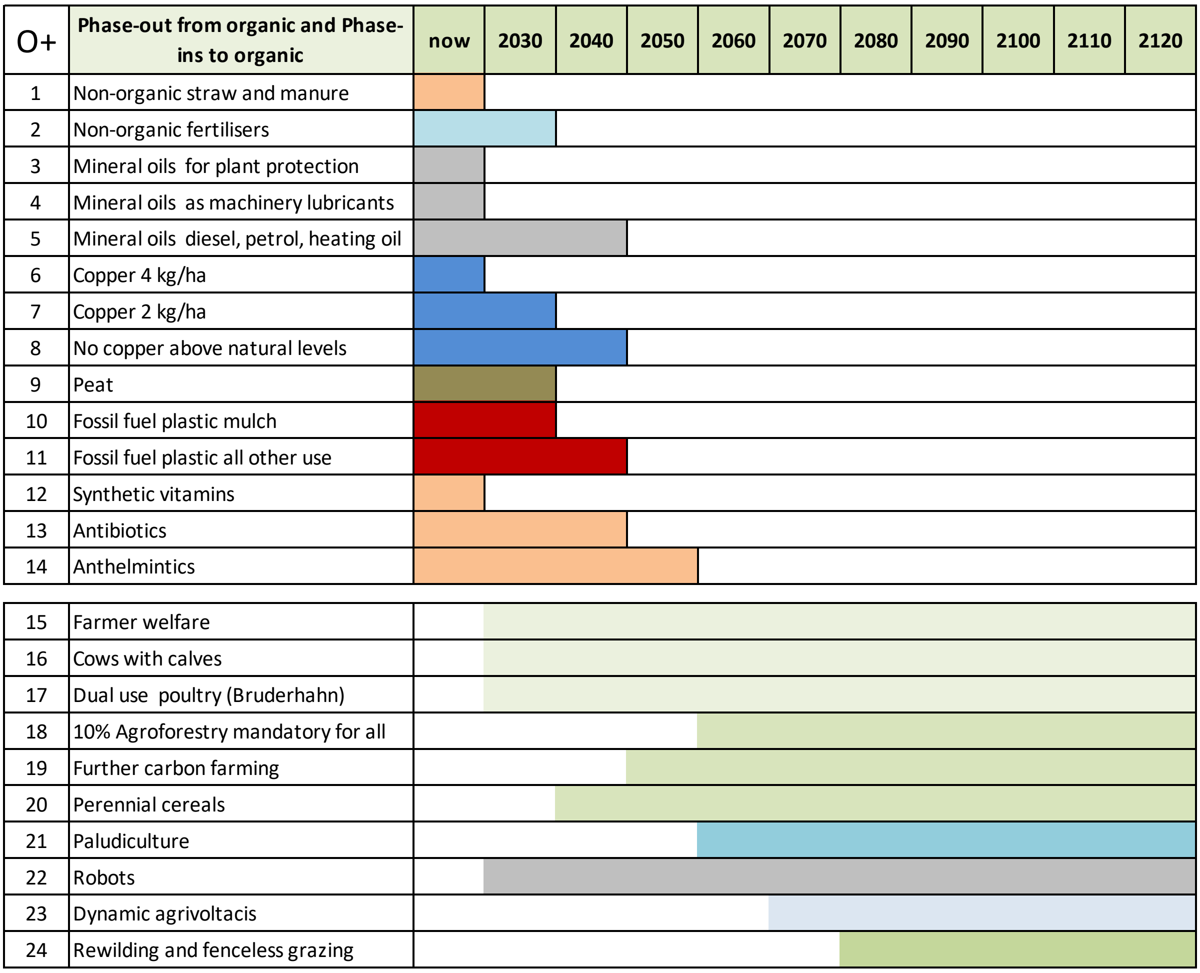

Figure 1. Phase-out vision (1-14) of contentious inputs and phase-in (15-24) vison of other practices until 2120 in Europe and worldwide.

Peat as a soil conditioner is already phased-out, remaining phase-outs are needed for **nursery crop production** (plant and tree nurseries), for **blocking growing media** and as **casing for mushrooms**. Peat smoke is used in very low quantities to flavour whiskey and fish, even for this alternatives are available. Artisan use of peat, e.g. in crofting, small-scale farms who use peat as a traditional fuel, can be exempt. Peat restoration and peat lands are among the key drawdown options, and it is useful to re-wet peatland also where currently organic farming is practised, alternative crops like wet rice, water cress are possible to establish **organic paludiculture** (the practice of farming on wet land, such as rewetted bogs and fens) also in temperate climates where those soils have been drained and given over to agricultural production. Agroforestry can be added around the new 'paddy fields' of Northern Europe.

Fossil fuel derived **plastic mulch** can be phased-out until 2030. Alternative biodegradable bio-plastics are available, they require further research in more applied innovation actions. Like all other phase-outs this phase out is also required in conventional horticulture and agriculture. **Fossil fuel plastic in all other uses** will require more time. Research is ongoing for tree-guards, clips and many horticultural inputs to be 100% bio-based and bio-degradable. The bio-based materials should be ideally from organic crops (potato starch, maize etc.), however it is not likely this will be available until 2050. Therefore, the first aim is to phase out fossil fuels. **Plastic in tools, tractors, solar batteries** will be more difficult to remove and this is often recycled and does not degrade the soil with pollution, therefore this is currently not a priority but by 2060 this should also be possible to remove and replaced with bio-based plastic. **Plastic in packaging** is equally highly contentious, especially among organic consumers as shown in our surveys, and this can also be removed very soon as alternative bio-degradable materials are available. **Plastic films, netting, polytunnels** and other large scale horticultural inputs are difficult to replace as the alternatives are less durable or glass is heavier. However **dynamic agrivoltacis** might bring a solution as this greenhouse will be able to protect crops and equally produce electricity for heating the greenhouse, provide battery storage and charging tractors and robots.

For **synthetic vitamins** alternative are available, they might be slightly more expensive but those synthetic inputs should not be used in organic as not to confuse consumers. By providing more free-range and herbal additions synthetic vitamins are not needed. The use of **antibiotics** is different as this requires system re-design in some intensive organic systems in Europe. These are very 'conventional' still with high yielding dairy breeds and limited grazing. Those systems, without re-design and re-creating a mixed grazing landscape with agroforestry, will have little chance to remain organic until 2050. In all other organic system, including 365 days free-range pigs antibiotics are not needed and should only be reserved for accidental damage in single animal (as per the organic welfare and care principles). Group treatment or mastitis for the whole dairy, sheep or goat herd will be phase-out. The full phasing out of **anthelmintics** is difficult as grazing is still too confined in organic. Mixed grazing and healthy use of pasture is often not possible and here re-design is also required to 'rewild' organic grazing patterns, introduce more trees, (agroforestry) with beneficial anthelmintic properties and generally reduce the intensity further while equally increasing quality.

Items not researched in the contentious inputs projects Organic-PLUS and RELACS are listed in the figure separately (15-24). **Farmer and animal welfare** were interestingly combined as an issue by or farmer-consumer competency groups. Animals have rights and agency in organic food and farming systems and it is therefore interesting to note that the welfare concepts can be applied to all species on a farm. Therefore the vison is to phase-in **farmer welfare** much more prominently as currently the case. This means, living wages, social capital, reduced working hours but generally empowerment of all land-workers, including seasonal workers, volunteers and creating agency for all in community supported agriculture and direct marketing schemes as well as power over the supply chain pricing. This goes back all the way to 1923 and the Jungbauernbewegung at Grosshöchstetten (1923) described in the introduction, at is shameful that farmer welfare has not yet been fully achieved and might hopefully not need another 100 years.

Further issues for **animal welfare** are cows with calves and the practice of separation should have never been allowed in organic. This is equally the case for dual breeds, killing male chickens or goats at birth is just totally unacceptable with the principles of organic care and a shadow of the conventional past of many systems. Total re-design is needed. Further growth of **Vegan organic** is also very welcomed as it gives remaining animal more space to re-design and improve grazing to phase-out anthelmintics. **100% Vegan organic** is not desirable as it would erase all benefits of high welfare animals and make domesticated animals extinct. These are heritage species which have co-evolved with humans in our own 'domestication'.

Mandatory **Agroforestry** (10% or more) in organic, additional carbon farming methods like further reduced tillage, perennial cropping of cereals and vegetables, will be able to store much more carbon in the soil as organic can currently offer. This is also the case for the further promotion of **organic paludiculture**, already discussed under peatland restoration. Items also envisioned for a phase-in, once fossil fuel are completely phased-out, is more **dynamic agrovoltaism**, sharing fields and **agroforestry with solar panels**, which provide sun-burn protection, better micro-climate and hail and heavy rain cover for crops with their dynamic (changeable positioning). Those will be a further mixture in the landscape and able to charge all remaining tractors and robots. It s envisaged that **robotics** will make machinery smaller and more flexible again and a new combination of robots, farm animals and humans working on the land and with agroforestry and forests will be possible by 2120. Humans will be able to do the work on the land they like to do, while the un-wanted work will be done by robots. Humans will have more time for interaction with farm animals, agro-biodiversity and also contribute to **rewilding and fenceless grazing** of large areas. Finally with agroforestry increase, forestry on farms will also be better integrated in livestock grazing, also with the aim to reduce forest fires and increase the carbon storage on farms agroforests and forest with a more combined landscape transforming soil carbon management.

Conclusion

With this vision organic agriculture can phase-out all remaining contentious inputs. This will still take at least 10 more years to achieve, but it is made easier as it is combined with the growth of organic land to 25% or 30% by 2030. In addition further research investment from the Strategic Research and Innovation Agenda (SRIA) for a European Partnership on **Agroecology Living Labs and Research Infrastructures** over the next decade will help that organic is rejuvenated by the social and food system principles of agroecology including the social questions of farmer welfare and fairer community supported supply chains. The phase-out will target inputs head on, which contribute to the **climate crises (all fossil fuel inputs, all peat, all plastic),** while equally open up organic to carbon 'drawdown' back to 350 ppm CO_2, by rewetting peatland, making agroforestry mandatory and improving perennial cereals and vegetables with the integration of trees. **Dynamic agrivoltacis** will make organic energy independent, charging batteries, robots and heating greenhouses. In fact organic agriculture will be a net renewable solar energy exporter. **Wind energy** were appropriate will also be included in some fields, however the large-scale off-shore wind parks (e.g. in Doggerland/Atlantis) will already be sufficient. **Nuclear power** and further pollution with emissions is unwanted and unnecessary. **Anaerobic digestion** (AD) within organic will also play a major role to produce heat, electricity or heating gas, were a gas grid available. Using green manure crops in digesters and digestate from organic and food waste inputs as fertiliser will increase organic yield, however to much higher yields are not required if food waste (once animal fodder from cropland suitable for human consumption is classified as wasteful) is largely removed and globally healthy low meat diets are in place. Organic will also contribute to rewilding and re-wetting peatlands as **higher yields are not needed** following '**peak population' in 2050**. Organic is also well placed for the **degrowth** area following **'peak population'** (currently predicted by me at 8.8 billion). Degrowth requires a further system re-design and this time of **capitalism with ecological economics and social equity**. This will however not be the end of all markets or financial skills as a degrowing economy is much more difficult to manage, and this might be one reason why there is a large intersest to shift 'peak population' further back to 2070.

References

Details of projects and further references are found on the websites, accessible with any internet search engine.

Sustainability and resilience of Organic and non-organic farming systems: a holistic assessment framework

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Key words: confirmatory factor analysis, rapid assessment, validity, reliability, scale, organic farming

Abstract

Over the past 25 years, the sustainability concept and its application have constantly evolved in different directions within the scientific community, organisations, and relevant stakeholders. Sustainability as a concept has been articulated in many variants used in different contexts, as there exists a great number of different definitions and approaches. In this work, the holistic sustainability scale is based on a range of environmental, economic, and social indicators based on the FAO SAFA framework. Differently from SAFA, the scale is developed following a rigorous validity and reliability testing process. Preliminary results show that scale is robust both in rems of content validity and reliability. In the future, a reduced version of the scale will allow assessing the sustainability of different organic vs non-organic farming systems and link their sustainability with resilience.

Introduction

In the last decades, hundreds of different sustainability frameworks were developed, ranging from environmental and social standards to corporate social responsibility and codes of good practices that apply to operational units or specific supply chains (FAO, 2014). Similarly, various sustainability assessment frameworks have been proposed. Since sustainability assessment is a tool aimed to identify, examine, and assess the potential capacity of an initiative to attain sustainability, the concepts, as well as methods of these frameworks, vary with the definitions of sustainability (Lim and Biswas, 2015).

Sustainability assessment tools can generally be divided into indicator- or index-based approaches, product-related, and integrated assessment tools (Ness et al., 2007). The degree of holism of many of these sustainability assessment tools varies. Holism can be defined as "the awareness of the unity and mutual interrelation of all things and events, the experience of all phenomena in the world as manifestations of a basic oneness" (Capra, 1975). Holism is a concept intertwined with quantum mechanics in physics. In the words of Bohm and Hiley (1975), "the quantum theory (…) implies the need for a radical change from the classical notion of analyzability of the world into independently existent parts, each of which can be studied in relative isolation, without our having to consider the whole, and which can, in turn, be put together conceptually to explain this whole. (…) We say that inseparable quantum interconnectedness of the whole universe is the fundamental reality, and that relatively independently behaving parts are merely particular and contingent forms within this whole".

In the agri-food sector, the importance of identifying sustainable models of food production for growing populations has been recognised by many private and public institutes (FAO, 2017, 2016). In response to this, several approaches and tools have been recently developed for assessing aspects of sustainability in the agri-food sector, especially for agricultural production (de Olde et al., 2017; Gaviglio et al., 2016; Pope et al., 2004). Many current sustainability assessment tools rely on objective measures or a mixed model encompassing objective and subjective measures of sustainability indicators (Arulnathan et al., 2020; Marchand et al., 2014). However, the degree of holism of these tools varies, especially when "objective" measures are implied. Subjective measurements represent a better alternative to holistically measure the sustainability of agro-food systems, allowing then to correlate the results of the measurements with "objective" resilience and performance measures. According to Wall et al. (2004), especially when the availability and reliability of objective data are scarce, measurement through self-assessment by the respondents can be even more relevant and accurate than objective measurement. The

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overall aim of this study was to develop and test a rapid, but effective, farm sustainability scale based on a pool of items generated to measure specific sustainability indicators at the farm level. Indicators may be grouped, a priori, into environmental, economic, and social sustainability dimensions (subscales). The practical use of this scale is to serve as a resilience assessment tool able to compare both organic and non-organic farming systems.

The sustainability indicators for the three dimensions were selected in accordance with the Sustainability Assessment of Food and Agriculture Systems (SAFA) framework. The SAFA framework was developed by Food and Agricultural Organization (FAO) as an international guide for sustainability assessment of agriculture, livestock, forestry ,and fisheries operations. The framework is designed according to a hierarchical structure, where the more general level includes four broad dimensions of sustainability (i.e. environmental integrity, economic resilience, social well-being and good governance), and at the intermediate level these dimensions are divided into 21 themes, 58 subthemes and 116 indicators (FAO, 2014).

Materials and methods

A comprehensive review of the SAFA tool and guidelines was carried out to define the most relevant sustainability themes, subthemes and indicators for the crop and animal farming systems. The following step included the establishment of an inventory of items based on the selected SAFA indicators and literature research (i.e. items were classified under three constructs that represent the dimensions of the sustainability of agricultural systems; environment, economy and society). The decision on the most appropriate indicators to be included in the rapid tool was taken by conducting an expert survey carried out in May 2022. Four experts, selected among agronomists and agricultural economists, have rated the degree of relevancy of the collected items through a face-to-face meeting (1=the item is not representative, 2= the item is somewhat representative, 3= the item is clearly representative) (Yusoff, 2019). A total of 78 out of 119 items were selected for the rapid sustainability assessment tool (28 for environmental, 16 for economic and 34 for social dimensions). Given that our goal was to develop a scale to measure the perceived farm sustainability, for each of the 78 selected indicators, we developed specific items to reflect the farmers' perspectives. Examples of the items are "*My farm uses efficient irrigation systems*" (Environmental); "*My farm makes investments with the aim to generate a stable profit in the long run*" (Economic); "*I verify that my workers use personal protective equipment to perform tasks that require it*" (Social). All items were formatted to be responded to using a seven-point Likert scale, ranging from 'totally disagree'(1) to 'totally agree' (7). Most of the generated items were discussed with farmers, agronomists, and academic experts on agricultural economics. Based on their comments, we modified several items. Next, the questions were tested through a pilot which involved three testers to ensure clarity of the items. For the validation of the tool, an online survey was developed using the Qualtrics™ platform in June 2022. The first questions aimed to elicit basic information about the farm's managerial and structural characteristics. Respondents were asked to indicate their level of agreement for each item. The order of items was altered to avoid response biases by using Qualtrics' option for randomisation. The sample on which tec aal was tested was composed of 80 organic and non-organic Italian farms. Measurement reliability and validity of the model were evaluated through Cronbach alpha and confirmatory factor analysis (CFA). All analyses were done using STATA statistical software.

Results

A confirmatory factor analysis (CFA) was conducted on multi-item scales (Environmental, Economic and Social sustainability). Some of the items included in the first version of the scale were removed, as they have revealed poor and not significant standard loading. The final measurement model has a total of 38 items (11 for environmental, 14 for economic and 13 for social dimensions). The model had a close fit (χ^2 = 1447.53, p < 0.000) and measurement reliability and validity were also evaluated. Cronbach's alpha provided strong evidence of measurement reliability for all constructs (see Elling et al., 2012) (see Table 1). According to Anderson & Gerbing (1988), the convergent validity of the measurement model can be supported by the high and significant standardised loadings for the measures, particularly for what concerns the social multi-item scale.

Table 1. Measurement properties for the multi-items constructs (nr 80)

Construct	Standard Loading	Mean	S.D.	Cronbach's Alpha
Environmental sustainability (ENV)				**0.76**
ENV1	0.54 ***	5.33	1.84	
ENV4	0.49 ***	6.00	1.47	
ENV5	0.42 ***	4.86	2.12	
ENV7	0.57 ***	5.32	1.84	
ENV8	0.35 ***	5.85	1.44	
ENV10	0.47 ***	5.7	1.64	
ENV13	0.67 ***	6.11	1.44	
ENV14	0.56 ***	6.15	1.50	
ENV15	0.39 ***	6.32	0.96	
ENV19	0.34 ***	5.75	1.87	
ENV22	0.42 ***	6.28	1.56	
Economic sustainability (ECON)				**0.84**
ECON1	0.61 ***	5.75	1.53	
ECON2	0.49 ***	5.55	1.62	
ECON3	0.31 ***	5.82	1.48	
ECON4	0.57 ***	5.50	1.60	
ECON5	0.86 ***	4.61	1.93	
ECON6	0.30 ***	5.40	1.60	
ECON8	0.38 ***	5.67	1.38	
ECON9	0.45 ***	6.15	1.05	
ECON10	0.35 ***	4.52	1.88	
ECON11	0.90 ***	5.00	1.78	
ECON12	0.38 ***	4.73	1.84	
ECON14	0.29 ***	6.12	1.28	
ECON15	0.28 ***	6.06	1.34	
ECON16	0.33 ***	6.06	1.31	
Social sustainability (SOC)				**0.92**
SOC3	0.62 ***	6.35	1.11	
SOC4	0.68 ***	6.38	1.06	
SOC5	0.61 ***	6.50	1.03	
SOC7	0.71 ***	5.82	1.46	
SOC9	0.83 ***	6.38	1.26	
SOC10	0.61 ***	5.13	1.40	
SOC11	0.60 ***	5.1	1.51	
SOC16	0.76 ***	6.2	1.24	
SOC17	0.61 ***	6.06	1.19	
SOC18	0.83 ***	6.23	1.24	
SOC19	0.73 ***	5.32	1.23	
SOC20	0.75 ***	5.57	1.29	
SOC22	0.59 ***	5.48	1.74	

Results of the analysis carried out on a "construct base" reveal that most of the surveyed farmers have a high score for all three dimensions of sustainability. However, the average value of the *Economic sustainability* scale was relatively low (Mean = 5.49, S.D. = 0.88), if compared with those of *Environmental* (Mean = 5.80, S.D. = 0.88) and *Social sustainability* (Mean = 5.89, S.D. = 0.92) scale.

Discussion

The scale developed and tested in this study can be considered a powerful tool for assessing multi-dimension sustainability at the farm level. Compared with the existing tools, this approach can provide several advantages. First, the assessment can be completed rapidly, within 15/20 minutes. The farmers can quickly identify the degree of the farm's performance with respect to the indicators included in the tool. This is particularly appreciated by smallholder farmers, due to their limited resources in terms of time and personnel. A second advantage is related to the holistic nature of the tool, which can help both farmers and practitioners to determine important drivers of sustainability and clearly identify potential areas of improvement. Third, compared with other assessment tools like SAFA (FAO, 2014), from which is partially derived, the proposed scale has been tested for validity and reliability, though on a still small groups of organic and non-organic farmers. Future research will allow validating the scale on different samples of organic and non-organic farmers and link their sustainability with the resilience of both farming systems.

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Enhancing resilience in Mediterranean perennial agroecosystems under organic management

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Key words: Fruit trees, biodiversity, chilling requirement, climate risks, pollination, soil health

Abstract

Mediterranean-climate regions are important in global organic fruit production however most are simple agroecosystems based on one or few species and thus affected by climate change. The perennial nature and longer juvenile phase of fruit trees and vines make rapid changes in land-use difficult and slow. Extreme weather events when coincide with the critical phenological stages of fruit trees may cause significant economic losses. The impact of climate change and adaptation strategies to improve resilience vary significantly according to the crop, site-specific factors, and management as well as the prevailing regional and global, environmental, and socio-economic conditions. To develop sustainable organic agroecosystems local, regional, and global data need to be collected and risk assessments made for organic fruit ecosystems.

Introduction

The Mediterranean climate characterized by mild and rainy winters following dry and hot summers prevails mainly in five regions of the world as the Mediterranean Basin, California (USA), Central Chile, and specific parts of South Africa and Australia. Although these areas represent only 2 % of the world's land surface, it encompasses 20 % of the plant species present on earth and are major producers of horticultural crops (Del Pozo et al., 2019). Within Mediterranean climate regions that are under scrutiny for climate crisis, the Mediterranean Basin has been the region of interest due to rapid warming and higher frequency of extreme weather events. Among various challenges, climate change is top-listed in this region due to its consequent impacts on water availability, soil degradation and domestic (e.g., rural to urban or in-land to coastal) or international (from south and east towards north) migration flows that have been exerting pressure in the region's food availability (BCFN, 2016). Agriculture and food security suffer from climate change, and conversely starting from farming practices and going through the agri-food system up to consumption habits, our choices create a significant impact on greenhouse gas emissions, climate change and resilience.

The studies and models performed in the Mediterranean basin report 20-25 % faster warming than the global average (Cramer et al. 2018, MedECC 2020). Moreover, increases over land compared to sea results in strong air fluxes, including moisture flux toward land. Other disturbances like significant decreases in precipitation or changes in precipitation regimes (e.g., accumulated precipitation over a certain time period), changes in soil moisture, and heat waves and associated risks as extreme drought and increased risk of fires and extreme cold periods are already encountered (BCFN 2016, Zappa and Shepherd 2017, Tuel and Eltahir 2020, Aurella et al. 2022). Mediterranean basin is highly heterogenous regarding share of agricultural land, ranging between 4 and 76%, land-use types, farm structures, management practices and agricultural inputs and outputs. The foremost drawback is low soil organic matter making the region a net importer of nitrogen. Traditional extensive farms are located on mountainous terrain whereas lowlands are managed more intensively and mostly irrigated. Water scarcity and quality are common problems especially in some parts of the region and irrigation is practiced only on 8% of the Mediterranean agricultural land area (MedECC, 2020).

Mediterranean region affected by human interactions throughout history is still a 'mosaic of biodiversity-rich ecosystems' however the threat posed by climate change is alarming (Aurella et al, 2022). Dense population coupled with high population increase rates create added pressures on

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biodiversity through land use dynamics and hinders adaptation to climate change. Within agroecosystems, perennials as the fruit trees receive special attention regarding resilience for adaptation since they are permanent and as in the case of olives may occupy the same point for more than a millennium. Thus, land use change is not as fast as in the annual crops and may require a decade after establishment until stabilized. In due course, some phenological acclimatization could occur however experiences have shown that some detrimental extreme events cannot be avoided unless farmers are supported to build resilience for adaptation.

The Mediterranean climate-regions are important venues for agrobiodiversity and organic production, globally. As of 2020, organically managed permanent tree crops led by olives, nuts, coffee, grapes, and cacao occupy 7% (5.2. million hectares) of the total organic area world-wide. The transition rate was high between 2019 and 2020, and organic certified area increased by 15.7% (712 000 ha). The leading Mediterranean fruit species mentioned in global organic land use data are exemplified as olives, citrus, dates, grapes, figs and almonds and pistachio as nuts, among which some are evergreen whereas some are deciduous species. Olive, an evergreen is the leader among Mediterranean fruit species with an organic area of 894 989 ha. Olive is the symbol of the Mediterranean culture and diets and nearly all olive oil (conventional and organic certified) production comes from the Mediterranean basin. At global level, the FIBl and IFOAM survey reveal that organic grapes occupy a surface area of 498 445 ha, citrus 140 837 ha, dates 48 053 ha, almonds 4 776 ha, figs 1626 ha, and pistachio nuts 1450 ha as of 2020 (Willer et al 2022). There is some additional land area as in the case of data reported for Turkey that is not included in the FIBL statistics as 11 770.38 ha of fig orchards and 2395 ha of pistachio nuts reported for Turkey in 2021 (www.tarimorman.gov.tr). Among these species, olives, dates, and figs are traditionally grown as extensive rain-fed monocultures whereas citrus and most of the vineyards are irrigated monocultures.

The impact of climate change and adaptation strategies to improve resilience vary significantly according to the crop, site-specific factors, and management as well as the prevailing regional and global environmental and socio-economic conditions. In principle, organic farming is a sustainable management system that considers bringing together best adapted elements however this experience and ‘selection of best adapted elements’ is based mainly on the past and partially on the current conditions. Thus, to build resilience for future risks and to better develop the pathways toward adaptation, highly complicated issues involving the agroecosystem interactions, physiological status of the plant and the occurring extreme events need to be unfolded. Most of the studies on climate change in the Mediterranean focus on land-use to develop strategies at national or regional level and those that focus on specific crops evaluate staple food as wheat and maize which are annual. Mediterranean fruit production including those certified as organic relies on stockless monocultures established by varieties/cultivars selected or released in breeding programs for high productivity and quality. Organic principles and certification provide basic guidance however pinpointing best practices in organic management becomes crucial in building resilience to adapt climate change. Cramer et al. (2018) groups climate related risks under 5 different domains that are closely linked to each other as ‘water resources, ecosystems, food safety and security, health and human security’. In this paper, the aim is to evaluate the impact of climate change on Mediterranean fruit systems including vineyards and make recommendations for improving resilience regarding ecosystem services and productivity. These aspects are also inter-linked and have marked effect on well-being and security of societies (Debolini et al. 2018).

Climate-fragility of fruit ecosystems

The climate change may impact existing orchards or even individual trees in the same orchard differently either due to microclimatic conditions created by the terrain or due to acclimatization of the species/tree to survive without making any changes in their genetic structure that enables buffering the environmental changes. Loss of diversity and simplification is a critical issue for Mediterranean organic fruit orchards since on one hand reduce resilience and on the other hand, restrict its capacity to recover after disturbance. Therefore, diversification to create variable responses to the disturbances is the major tool for resilience (Du Val et al. 2019). Diversification can be achieved through various means as integrating animals and/or other plant species as mixed cropping with other fruit, annual crops, or wild, neglected, or underutilized species, hedgerows, or as functional forestry, or agroforestry. Creating habitats for beneficials and pollinators, by having flowering strips and making nectar available for longer periods of time, and designing suitable habitats ensures their survival and helps delivering the ecosystem functions. Diversification or enrichment must be considered for the soil microbial communities, as well. While preventing competition from weeds, biodiversity should be preserved. Orchard floor should be managed as no-till or as reduced tillage to ameliorate soil structure, prevent erosion, and enhance soil organic matter and carbon and microbial population. Spontaneous vegetation can be trimmed and left as mulch which will help preservation of soil moisture and reduction of soil temperatures especially during the dry and hot periods. Mulching can be practiced with locally available low-cost material, avoiding plastic mulches. Circularity should be attained as much as possible especially in organic matter and nitrogen deficient Mediterranean agroecosystems. Composting of spontaneous vegetation, residues of pruning and low-quality fruit or plant material from hedges or shade trees is an efficient practice.

Agroecosystems should be evaluated from a multifunctional perspective through its services and disservices. Zabala et al (2021) states that the ecosystem services requiring special attention in western semi-arid Mediterranean conditions are biodiversity (38%), recreation and tourism (20%), local climate regulation (7%), and food provision (5%). On the other hand, main disservices came out as water and waste treatment (15%), and water purification (15%) which had a total of 30% importance. Mediterranean biodiversity is reflected on its cuisine and healthy diets, and agroecotourism in different forms e.g., restaurants, B&B, educational farms, hand crafts, or local products is an opportunity that enable farmers to generate additional income. This also helps to develop short marketing channels and link consumers with the farmer, the farm, and the rural communities enhancing social inclusiveness.

Productivity and quality

The site and appropriate rootstock/interstock/species/variety selection are the main determinants in climate change adaptation since problems in orchards may be visible only after the juvenile period. The chances of establishing a more resilient orchard are higher based on a thorough evaluation of the orchard conditions. Planting varieties which are 'pre-adapted to a broad range of environmental conditions or that has ecological tolerances matched to projected future climates can enhance adaptive capacity' (Du Val et al. 2019). Using resistant or locally adapted rootstocks and in case beneficial, adding an interstock can improve resilience by granting tolerance or resistance to stress conditions. Grafting can also help to recover old trees affected from extreme events if the below-ground part survives and remains healthy. To obtain standard tree growth and production, clonal rootstocks are recommended commercially however still many fruit species are grafted on seedling rootstocks which may reveal variable responses within the orchard under extreme events.

Drought and heat resistance is of prime importance in Mediterranean fruit culture. In olive production, 50% loss is expected to occur due to drought (Fraga et al. 2021, MedECC 2020). Drought and other extreme events decrease yields directly by limiting vegetative growth and/or reducing marketable yields. Depending upon the species, high temperatures and drought may also intensify photoinhibition by hindering photosynthetic carbon mechanism (Aksoy 2022). Upper altitudes and northern aspects can be a solution if elevated temperatures are forecasted. Planting density and training of the tree (single trunk, multi trunk or bush; open vase, central leader etc.) are also the tools that can be utilized to overcome water scarcity and high temperature effects. Additionally, coastal regions are prone to salinity due to intrusion of sea water thus salt resistance must be considered in these regions. In grape production drought or salt resistant rootstocks have proven to perform well in maintaining optimum yields. Many fruit species started to be irrigated to overcome drought however with the climate change, this option will be extremely limited. Water harvesting can be practiced in some areas. Farmers may opt to make choices among management practices, whether to obtain higher yield or acquire resilience (DuVal et al 2019). In this regard, not only production cost but true-cost accounting started to be considered especially in organic value chains.

Mediterranean fruit species are sensitive to cold however they must also be exposed to certain cold periods to fulfill their chilling requirement, break winter dormancy, and start blooming for fruit set. The total amount of chill units may vary according to the species/varieties and methods utilized in calculation however milder climates brought by climate change may result in insufficient chilling hours especially in apples or cherries, species better adapted to temperate climates (Kaufmann and Blanke 2019).

Response to extreme temperatures during flowering and fruit development could be detrimental. Subject to the means through which pollen is transferred, changes in air movements impact pollination directly or indirectly through the presence of bees and other pollinators. It is reported that in 2017, a late frost in 2017 spring caused an economic loss of €3.3 billion across Europe (Lemichhane 2021). The frost risk is not limited to late spring frosts and extreme low temperatures in autumn prior to dormancy may also cause serious damage. Similarly, not only crops but also crop-associated species as the pollinators or seed dispersers or wild relatives of crops will also be at risk under such conditions. To overcome pollination problems, farmers need to focus on self-fertile varieties preferably those setting parthenocarpic fruit or in case of monoecious species homogamous. Shade nets or plastic covers over the rows either partially during the risky periods like extreme heat, rain, or hail during flowering or completely over grapevine or fruit rows to protect from cold could help to mitigate risks.

With global warming many pests and diseases will shift their geography and new pests and diseases will appear in the Mediterranean and most likely create problems in organic management. Changes in temperatures, CO_2 and ozone levels, radiation, and water availability affect morphology, physiology and biochemistry of fruits. The climate change affects secondary metabolites which also contribute to health properties of the fruit as antioxidants (MedECC 2020, Didier et al. 2022). Extreme weather events e.g., rain, hail, high moisture, excess heat at pre and harvest stages affect fruit quality and marketability. Reductions in water availability, soil moisture and relative humidity or strong/hot/dry winds enhance water loss from leaves reducing fruit size and triggering physiological disorders like cracking, sunburn, and mechanical damage. In organic management, since there are severe limitations on use of chemicals at pre- or post-harvest stages, shelf-life periods are comparatively shorter therefore the fruit crop that is harvested should be intact and free from blemishes as much as possible to reduce losses. Paying attention to the maturity at harvest, care during handling, segregation of quality, and marketing more susceptible ones locally could be applicable.

Conclusion and recommendations

Organic management is a sustainable farming system that has proven to contribute adaptation to climate change. However specific management practices help building resilience. For fruit production systems in the Mediterranean which are more simple ecosystems prone to risks, the first step should be to make a risk assessment under current available information and climate-change models and predict the general climate change trend and extreme unexpected events for that specific region and/or crop. Capacity to increase carbon sequestration should be the goal in addition to building resilience and reduction of greenhouse gas emissions. The recommendations should be built on the site- and species-specific environmental and socioeconomic conditions. Despite the large area covered, still very little is known about the Mediterranean fruit specie's responses. Evaluating diversity among wild relatives, revealing economic benefits of ecologically fit underutilized species, carrying out breeding programs to reveal resistance and/or adaptability to climate change under organic conditions are important. Precision farming based on remote spatial data collection and monitoring are important as decision tools and can be utilized in managing extreme events, recovering from disturbances, and managing a climate-smart organic farm. These decision tools must be affordable and available for small and resource limited farmers thus more research work is required. Generating pilot sites for demonstration and showing best examples especially successful in long-term trials are important. Preserving the rich biodiversity in the Mediterranean region for future should be a priority. Research on water and soil health management, storage of soil organic carbon, carbon sequestration in soil and fruit trees, and recycling of crop residues and by-products may serve organic agroecosystems at large (MedECC 2020). Special focus on traditional extensive and intensive perennial systems to identify risks requires local research to generate solutions. The results must be communicated with farmers to help build resilience to adapt climate change.

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Translating organic agriculture through the food system into human diets – vegan, vegetarian and omnivore contributions to GHGE

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Key words: diet, omnivore, vegetarian, vegan, GHGE

Abstract

Human activity has unfolded over millenia to meet its basic needs of clean water and food. Globally aggregated today that sum activity has contributed to anthropogenic climate change. This necessitates a climate resilient development, which entails protecting biodiversity as well as natural and near-natural ecosystems (IPCC 2022). Where organic agriculture may contribute to both goals (Stein-Bachinger et al. 2021, Bengtsson et al. 2005) its produce may be incorporated in a variety of dietary regimens including omnivore (using all food groups), vegetarian (excluding meat and meat products) or vegan (excluding all animal-based products). On the basis of such major differences in food groups included or excluded, the downstream consumption patterns of diets are likely to be a critical factor in food system transformation. This paper explores the contribution of various human diets to greenhouse gas emissions (GHGE).

Material and methods

Data for the mini-review was collected from peer-reviewed English-language literature spanning the most recent decade (2013-2022). Web tools used were Science Direct, google scholar and snow-balling from these search results. Original studies on GHGE of diets (omnivore / flexitarian, vegetarian, vegan) with or without organic food consumption were sought with per capita reporting and covering a wide array of countries / regions globally. Applying these criteria resulted in a set of twenty-three papers.

Results

In the set of papers found many factors vary appreciably between them. These include system boundaries (for example cradle to farmgate, cradle to retail, cradle to consumer), inclusion or exclusion of land use changes, methodologies used to collect human consumption data (for example 24-hour recall over 2 non-consecutive days, 4-day food diary), and functional unit of dietary energy (2.000 kcal/d and above). The calculations and reported figures are for idealised diets based on national or international recommendations and/or for observed diets based for the most part on representative national consumption studies and/or on dietary scenarios.

Although the GHGE per kg CO_2 equivalents per person and day are not directly comparable amongst these studies on account of the diverging frames used, a certain tendency is evident. Diets particularly rich in meat and meat products in clear excess of dietary recommendations have a high GHGE figure as compared with figures described on the basis of dietary recommendations and as compared with both vegetarian and vegan regimens. Furthermore, the differences between vegetarian and vegan figures are not large or not even significantly different to each other (Corrado et al. 2017). Based on cookbook recipe analysis Kolbe (2020) also found no major difference between the somewhat higher vegetarian GHGE per unit but did find vegan recipes to be much more expensive because of the many exotic products and imitation products used. Kolbe (2020) did not analyse for organic produce but assumes that organic ingredients would be more expensive as her basis was the cheapest food available for any ingredient.

Some researchers analysed the contribution of individual food groups. Temme et al. (2014) found that the largest dietary contributors were the animal products meat and cheese, which contributed about 40%, and beverages including milk and alcohol which contributed about 20% to GHGE in diets. Hyland et al

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(2017) divided their data set into three clusters of distinct dietary emission patterns and compared these to dietary recommendations. The most unfavourable cluster (the unsustainable pattern) had processed meat, savoury snacks and the beverages alcohol and carbonated drinks, as the highest food group contributors. Typically, meat, cheese and soft drinks / carbonated beverages had a high GHGE load, although some researchers found fruit and vegetables also to have a high GHGE contribution. Even so, Vieux et al. (2012) inferred after testing that excluding entire food categories such as meat was not necessary for European diets to become sustainable.

Table 1: GHGE calculated for a variety of diets including varying amounts and categories of animal products (GHGE in kg CO_2e pppd unless otherwise indicated)

References	*Area*	*organic*	*omnivore*	*(ovo-lacto) vegetarian*	*vegan*
Kolbe 2020	DE[c]		1004 g CO_2e pp&meal	488 g CO_2e pp&meal	319 g CO_2e pp&meal
			296 g CO_2e/100 kcal	114 g CO_2e/100 kcal	103 g CO_2e/100 kcal
			2.43 t CO_2e/d	0.94 t CO_2e/d	0.84 t CO_2e/d
Meier & Christen 2012	DE[ab] NNS I (1985-9) NNS II (2006)		4.99 (recommended diet) 6.26 (NVS I) 6.16 (NVS II)	4.27	2.63
Treu et al. 2017	DE[a]	3.42	3.42		
Vidal et al. 2015	ES[aa]		5.08		
Temme et al. 2014	NL[a]		3.7 / 4.8 (m/w)		
Vieux et al. 2012	FI, FR, IT, SE, UK		3.55-7.03 (range for 6 clusters)		
Lacour et al. 2018	FR[a]	2.12-4.10 (5 quintiles range for highest organic consumptio n	2.27-4.56 (5 quintiles range for Vt)		
Rabes et al. 2020	FR[a]		4.16	1.59	1.02
Corrado et al. 2019	IT[b]		3.24-3.92	2.76-3.20	2.61-3.13
Ulaszewska et al. 2017	EU / MED[bb]		3.37 MED 3.69 NND		
Berners-Lee et al. 2012	UK[a]		7.40 (based on supply)	5.54-6.06 (3 scenarios)	5.14-5.55 (3 scenarios)
Scarborough et al. 2014	UK[a]		7.19 (>100g meat pd) 5.63 (50-99 g meat/d) 4.67 (<50g meat/d)	3.81	2.89

continue					
References	*Area*	*organic*	*omnivore*	*(ovo-lacto) vegetarian*	*vegan*
Hyland et al. 2017	IE[a]		5.1 / 7.4 (m/w) (culturally sustainable) 7.7 / 5.1 (m/w) (nutritionally sustainable) 9.0 / 5.8 (m/w) (unsustainable)		
Cambeses-Franco et al. 2021	ES, PO[bb] SNND		3.58		
Castaldi et al. 2022	CY, HR, GR, IT, PO, ES, MT		4.46 (MED7) 4.03 (21otherEU) 2.3 (idealised MED)		
Broekema et al. 2022	NL		4.21		
van de Kamp et al. 2018	NL[aaa]		6.7 / 5.1 (m/w) highest tertile (185/119 g meat /d)		
Tepper et al. 2022	IL		2.84		
Blackstone et al. 2018	US[b]		3,54 (healthy US) 3,53 (healthy US MED)	1.81	
Bassi et al. 2022	US[a]		4.02 (2003) 2.45 (2018)		
Lopez-Olmedo et al. 2022	MX[a]		3.90		
Arrieta & Gonzalez 2018	AR[a]		5.48 2.11 (no ruminant meat)	1.73	1.48
Arrieta & Gonzalez 2018	AR[b]		3.95		
Auclair & Burgos 2021	CA[a]		3.98		

[a] based on national consumption studies, [aa] based on hospital diets (the normal and 17 therapeutic diets), [aaa] based on original 24-hour recalls, [b] based on national dietary guidelines, [bb] based on regional dietary guidelines, [c] based on 311 recipes in 9 cookbooks, [d] national scenarios, m/w = men / women, V = vegan, Vt = vegetarian

Discussion

Food-based dietary guidelines worldwide recommend smaller amounts of meat products than typically eaten in average diets. They also caution to consume alcohol in moderation, if at all, and the same applies to highly processed foods and carbonated beverages. As such many dietary recommendations for specific food groups fit inversely with their larger contribution to GHGE. Though there is no explicit organic diet, an implicit organic diet may be inferred from the principles or organic agriculture and their codified regulations. Central to this is the closed nutrient cycle, the land-based animal production, its coupling with feed production, and the gentle processing of agricultural raw materials to food. A diet arising from organically farmed land, therefore, will have a limit to animal products, which may fall within the reference range of the planetary health diet (Willett et al. 2019). Further research is needed using yield data in various regions globally.

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Scaling up, out and deep: involving citizens for more agroecological food systems research

ROBERTO UGÁS[1]

Key words: agroecology, scaling, participation, food systems

Abstract

Agroecological transitions in the Andes mountains are analyzed using four examples of participatory research and three models of scaling. Research and development projects related to smallholder management of agrobiodiversity and climatic forecasts provide useful insights to suggest avenues that may allow a greater societal impact.

Introduction

The main contributions of Latin American farmers, practitioners, researchers and value chain actors to the worldwide growth of agroecology and organic agriculture include:

- The development of the concept of agroecology, grounded in rural development work with farmer's groups, NGOs and donors;
- The establishment of group certification schemes, which are now a standard way for millions of smallholders in the global South to access international markets;
- The growth of participatory guarantee systems for local organic markets, grounded in community interactions; and
- The emergence of a wide range of organic and biodiverse products from the region in world markets (Ugas 2018).

Along the agroecological transition or transformation, farmers and various stakeholders often get involved in participatory research of different vision, type or size. Here we report on four examples of participatory research in the Andes mountains, based on the experience of The McKnight Foundation's Collaborative Crop Research Program (CCRP) and of Universidad Nacional Agraria La Molina, Peru. CCRP funds projects in Ecuador, Peru and Bolivia that are interested in learning about agroecological transitions with local populations and challenges relevant stakeholders to work on theories of change and participate in communities of practice (Nicklin et al 2021). Typically, projects are run by NGOs and universities and receive support in areas like food system analysis, agroecology or research methods and there is an increasing move to review CCRP's actions in order to provide stronger answers to today's challenges. Farmer research networks (Richardson et al 2022) have been highlighted as a pathway in the scaling of agroecology.

Scaling agroecology

Moore et al (2015) ask: "How can brilliant, but isolated experiments aimed at solving the world's most pressing and complex social and ecological problems become more widely adopted and achieve transformative impact? Leaders of large systems change and social innovation initiatives often struggle to increase their impact on systems, and funders of such change in the non-profit sector are increasingly concerned with the scale and positive impact of their investments." The organic and agroecological movements worldwide struggle to learn about, understand and promote mechanisms to increase and deepen the reach of their efforts towards a more sustainable agriculture and food systems. Anderson et al (2019) develop the notion of 'domains of transformation' as overlapping and interconnected interfaces between agroecology and the incumbent dominant regime, with six critical domains that are important in agroecological transformations: access to natural ecosystems; knowledge and culture; systems of exchange; networks; discourse; and gender and equity. The findings of Moore et al (2015)

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show the success of six different strategies that may be adopted to scale innovation on the pathway to largescale or systemic impact, which cut across three different types of "scaling": scaling out, scaling up, and scaling deep (Fig 1). Kania et al (2018) propose six interdependent conditions of systems change that typically play significant roles in holding a social or environmental problem in place (Fig 2).

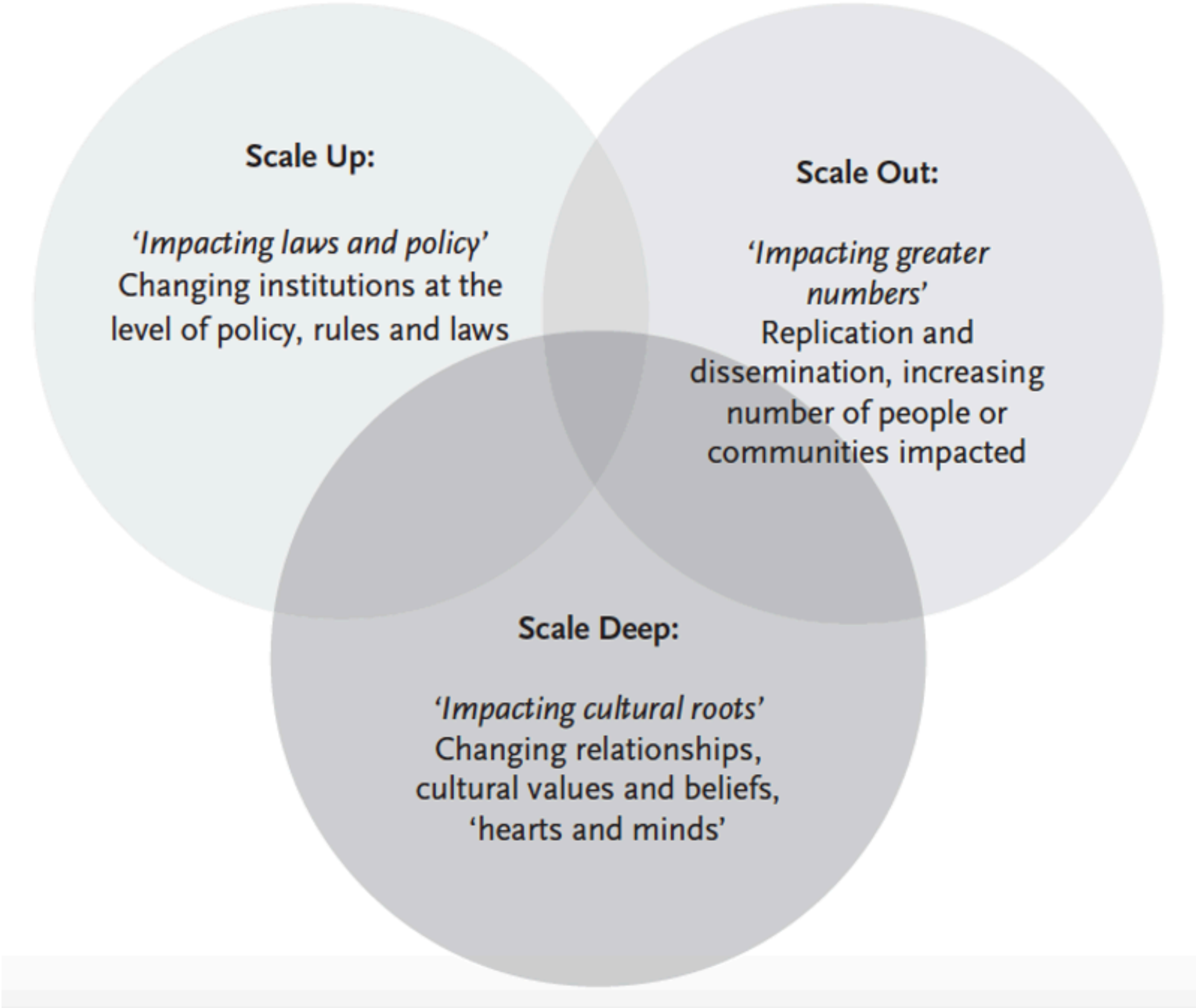

Figure 1: Scaling out, up and deep for social innovation (Moore et al 2015)

Research for the scaling of agroecology in the Andes

We will present a description of four examples of participatory research in the Andes and highlight the challenges of how this research can be integrated in larger processes of scaling agroecology:

- The design of improved forage/fallow options in the Central Peruvian Andes (Vanek et al 2020 and others)
- The co-production of agricultural forecasts while validating local meteorological forecast knowledge in the Bolivian Altiplano (Gilles et al 2022 and others).
- Institutional coordination to rescue a traditional landrace of chilli pepper in Northern Peru (Morales-Soriano et al 2018 and others).
- Farmer networks for the conservation of potato landraces in the Peruvian Andes (de Haan et al 2019 and others).

Discussion

In this section the four examples of participatory research in the Andes will be analyzed taking some of the main features of the models proposed by Moore et al (2015), Kania et al (2018) and Anderson et al

(2019). Furthermore, the four examples will be used to highlight some of the socioeconomic challenges that very often are overlooked when assessing agroecological transitions and transformations, including the role of organic agriculture.

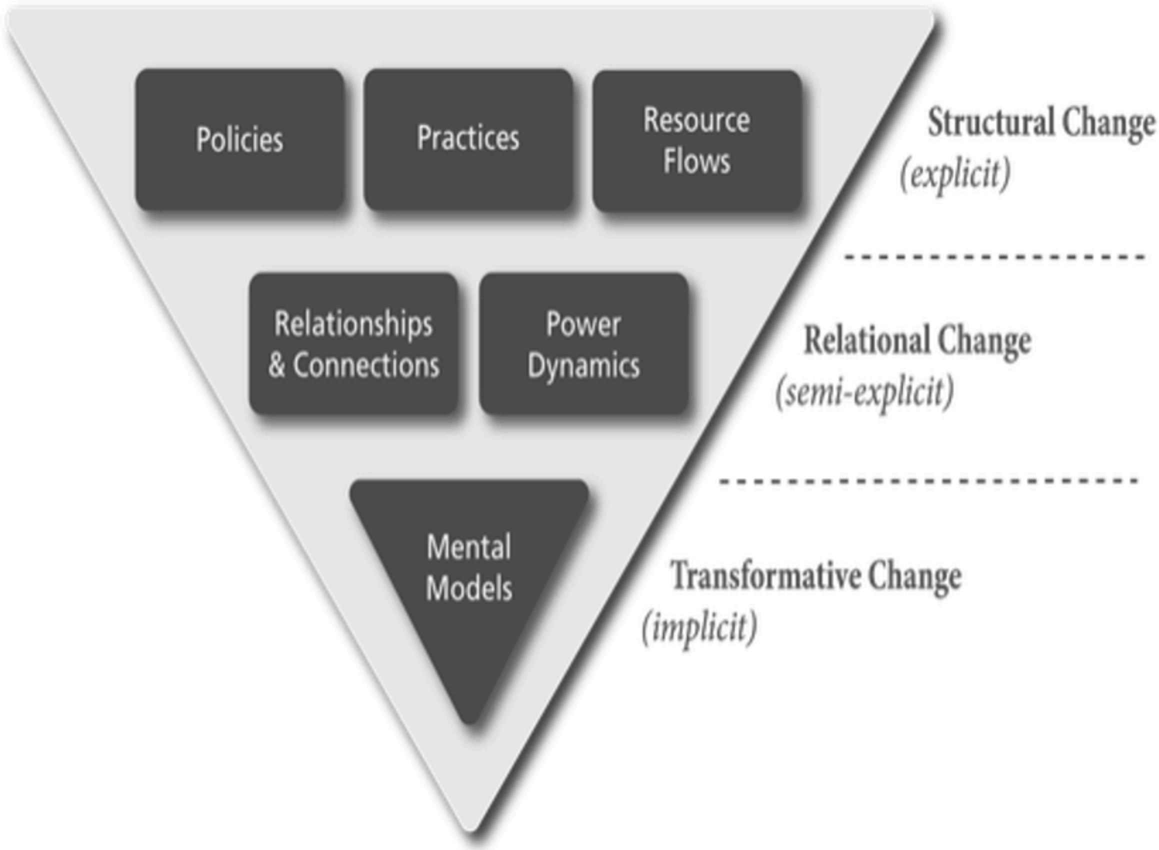

Figure 2: Six conditions of systems change (Kania et al 2018)

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Enhanced diversity of local production systems through participatory approaches is key for climate-resilient organic farming

AMRITBIR RIAR[1]

Key words: Agrobiodiversity, Participatory approaches, Climate resilience, Agri-Food Systems, Dietary diversity.

Abstract

Climate change is becoming a defining factor for our current food security and future diets. With limited resources, the only way out of the paradox is to enhance the functional diversity of local production systems for climate-resilient organic farming. However, more diverse systems are much more complex to manage and highly context-dependent; thus, achieving climate-neutral or positive production systems at a farm level often proves to be unsustainable in the long run. We hypothesize that if urban and rural consumers' demand for products from diverse local production systems increases, farmers will embrace functional biodiversity as a viable business and improve their livelihoods through climate-resilient organic farming. We propose to achieve this through participatory approaches, which have been proven to be highly efficient and successful for climate resilience at farm level and, when coherently applied together, have the potential to transform food systems into climate-resilient food systems.

Introduction

Food systems are one of the biggest causes of biodiversity loss and simultaneously are major contributors to Climate change (Benton et al., 2021; Bongaarts, 2019). As a result of continued genetic diversity loss, farmers have a narrow gene pool on which to depend for food, nutrition and income. Unfortunately, these challenges do not appear to be going away soon, especially when the availability of the essential input- "Seed" pose a major challenge (Fenzi et al., 2022). Enhancing on-farm functional biodiversity can be one game-changer for millions of poor people and a step toward climate-resilient organic farming(Muluneh, 2021). The functionality of biodiversity in given farming systems can be hindered due to perception and behaviour toward some outputs at societal levels. Therefore, it is important to create awareness and link on-farm biodiversity with diverse food systems as viable businesses for climate-resilient organic farming. Thus, it requires system thinking and adoption of participatory approaches.

Key Participatory approaches for climate-resilient organic farming

1. Participatory Organic plant breeding (POPB):

Participatory plant breeding (PPB) offers an excellent opportunity to develop locally adapted cultivars and maintain and increase genetic diversity (Ceccarelli et al., 2009; Lançon et al., 2004). In the short term, currently available seeds suitable for organic production must be tested under organic and low input conditions, and seed chain must be established for the most suited ones. In the medium and long-term improved cultivars need to be bred specifically for organic and low-input farming.

It can take at least eight years from the first cross to create the F1 generation, selecting better performing population in early generations (F1-F4) to the single plant selection in advance generation (F5-F8) until purification, followed by replicated yield trials, multi-location trials and seed multiplications in F8 onwards (Fig. 1). For the commercialization of seed according to the respective Seed Act, the cultivars need to be tested (2-5 years) by the network of national research Institutes or agricultural universities. Therefore, the inclusion of committed partners from public research domain is also vital. By joining forces, not all organic grower organizations need to get involved in long-term breeding activities, but they can develop other organizations and build on material that has already been developed in former seed projects. To avoid any conflict of interest between breeder and organic grower organizations, we

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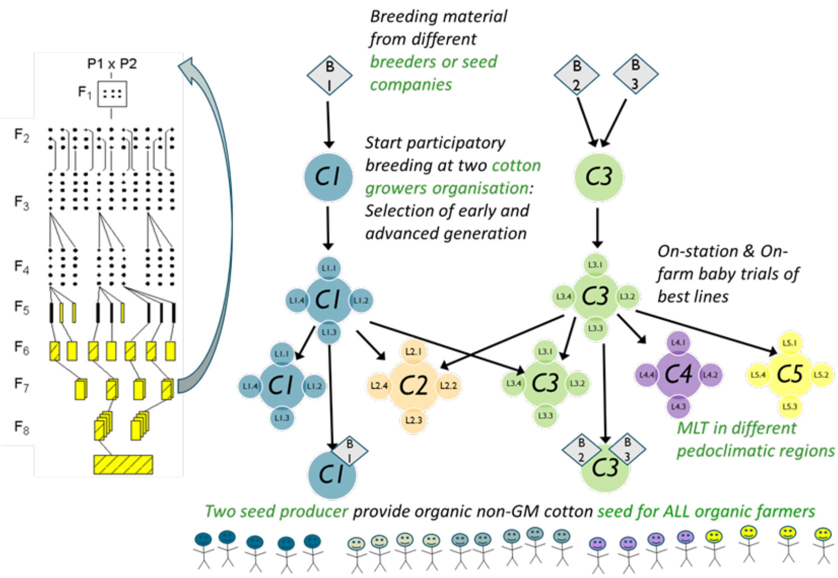

Figure 1: Relationship between the different actors of decentralized participatory breeding involving more than one breeder.

streamlined the process so that breeding material and cultivars provided by a private or public breeder will remain the property of breeder and the organic growers' organization which is improving cultivars. We call the organic grower organization together with their farmers in the different districts a "cluster". In our example, cluster C1 collaborates with breeders B1 and C3 with breeders B2 and B3 to obtain new breeding material and segregate populations developed by the breeders (Figure 1). Both clusters C1 and C3 get engaged in participatory breeding, including early generation single plant selection as well as the advanced generation replicated on-station field trials together with on-farm trials of farmers in different villages attached to the growers' associations (L1.1, L1.2, L1.3, L1.4, and L3.1, L3.2, L3.3, C3.4). Cluster C2, C4 and C5 are not involved in active breeding but are interested in the supply of organic seeds with high agronomic performance and good fiber quality. In very advanced generations (F7-F8) when cluster C1 and C3 have identified potential candidate cultivars and sufficient seed is available, this material is shared with all interested clusters (C1-C5) for Multi-location Trials (MLT) under the respective growing conditions. If the new cultivars perform well under the growing conditions of cluster C4 and C5, then cluster C3 in collaboration with the involved breeders B2, and B3 will multiply sufficient seed to cover the demand of all organic farmers of this cluster. In that way, the organic farmers as a whole can participate in the progress and not only individual grower associations. Therefore, it is important that the partners that agree to collaborate are willing to exchange information and seed to serve the spread of improved organic seed.

2. Participatory On-farm Research (POR) and Participatory Technology Development (PTD):

The approach of participatory technology development followed an 'innovation development cycle' where farmers and stakeholders participate at every step, from setting the research priorities to identifying potential solutions and testing in farmers' field, sharing new developments/challenges with research staff, and establishing consensus on next steps (Figure 2) (Cicek et al., 2020; Goodrich et al., 2008). The POR & PTD approach capitalizes on the extensive network of organic farmers willing to participate in the technology development process and volunteer to test innovations in their fields(He et al., 2009). Using a 'mother-baby trial concept', the proposed innovations are first tested in mother trials i.e., on a research station, and then the selected solutions in a more refined

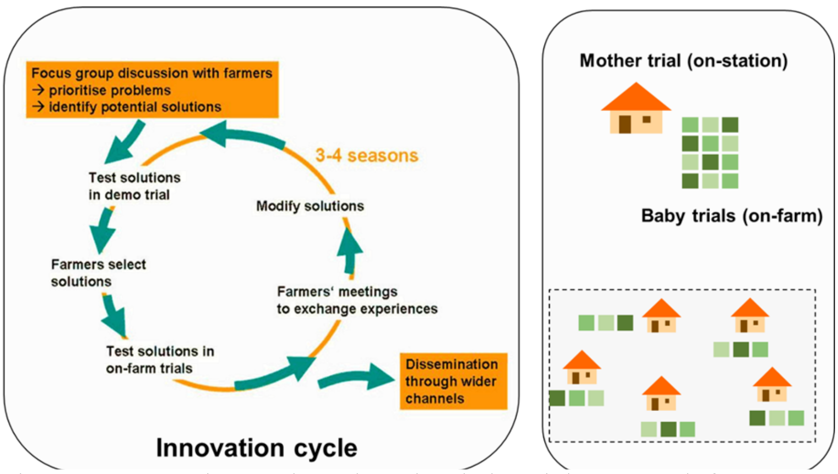

Figure 2: Innovation cycle and mother-baby trials approach for Participatory On-farm Research (POR) and Participatory Technology Development (PTD).

form are tested in baby trials i.e., on farmers' fields. The performance of both the on-farm and on-station trials is co-evaluated by researchers and farmers. This is where scientific perspective with farmers' know-how offers unique strength to the process of locally adapted technology development.

3. **Participatory Market Chain Approach (PMCA):**

PMCA is a new way to upscale agriculture R&D; it brings a complete range of relevant actors together from the beginning rather than undertaking research and attempting result transfer conventionally. Like POPB, POR & PTD, all relevant actors set priorities and develop innovations together while focusing on market chain context. PMCA is a radical departure from traditional agricultural production marketing models such as "pipeline model". PMCA is known for its potential for unexpected innovation, which often continues and keeps evolving even when the formal PMCA exercise is over. It is often seen that subsequent innovations are more reliable, sustainable and vital for actors than the first one, which evolved during PMCA exercise, which also highlights the power of this approach for transferring ownership to involved actors.

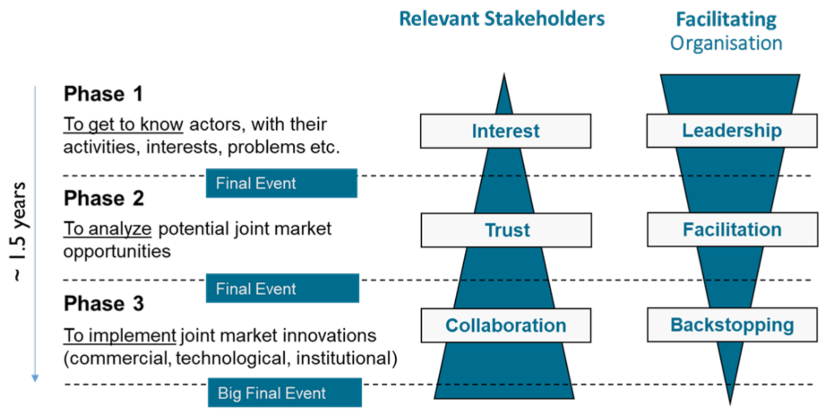

Figure 3: Participatory Market Chain Approach (PMCA) general Process Structure

The PMCA engages the actors linking farms with the market, marketing produces and stakeholders influencing these processes such as influencers, researchers, investors, development organizations, cooks, policymakers and consumer representatives or organizations to identify and exploit the market opportunities by using facilitation process (Zschocke, 2012). A structured process with three phases can happen over 12 – 18 months (Figure 3). Phase 1 is getting to know each other, activities and challenges. In this phase, PMCA initiating partners select the market chain/s and partners and carry out diagnostic research for 2-4 months, leading to a public event to discuss the findings. Group discussions generate ideas for possible innovations and motivate market chain actors from different levels to collaborate more and participate in phase 2. Phase 2 starts with jointly analyzing market opportunities in 6-10 meetings accompanying technical and/or market study. A public event marks the end of 2nd phase, where business opportunities are discussed, and actors with appropriate knowledge and experience are encouraged to join phase 3 of PMCA. Phase 3 is the final phase of PMCA and is about the joint development of innovations; during this phase, the group focus on product development, testing, and marketing strategyincluding processing, packaging, labelling or branding and product launching. PMCA exercise ends with a third public event where different developed innovations are presented to a wide range of stakeholders for awareness creation (Horton et al., 2020, 2022).

Framework for climate-resilient organic farming through enhanced diversity of local production and Food systems using participatory approaches

It is much more efficient if forces from production and consumption sides are joined to cover the most urgent need for climate-resilient Food systems. The Improved inter-and intra-specific diversity in seed systems also provides smallholder households with increased dietary and nutritional diversity and offers varied food choices that can improve food security outcomes (FAO, 2018). We propose a framework which works on the so-called ‘PULL-PUSH Model’, which functionally combines factors that drive both demand (=PULL) and supply (=PUSH). Since PULL and PUSH factors relate along the value chain to food and seed production and consumption, the intervention approach involves a ‘double PULL-PUSH approach’ (Figure 4). Thus, the model

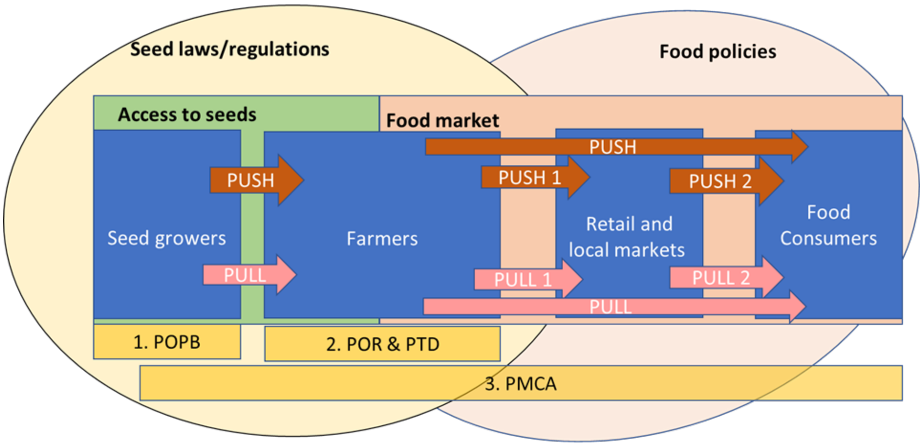

Figure 4: Framework for climate-resilient organic farming through enhanced diversity of local production and Food systems using participatory approaches.

focuses on factors that drive not only the demand and supply of diversified production, but it also explicitly looks into those factors that drive demand and supply for the seed of these crops. This framework synergizes the balance between the influencing factors and participatory approaches, increasing the adaptive capacity of smallholder farmers to climate change and meeting sustainable development goals through enhanced demand, productivity and income generation (Otieno et al., 2022; Quarshie et al., 2021; Zhang et al., 2016). Application of participatory approaches under this framework will enhance the competitiveness of the organic sector and the income security and autonomy of smallholder organic farmers. The goal can most efficiently be achieved in a trans- and interdisciplinary approach, where smallholders, breeders, researchers, advisors, consumers, market actors and industry representatives will work closely together. The involvement of farmers at the very beginning is vital to integrate their knowledge and to achieve a high adoption rate and ownership of new cultivars or products. Seed security is a prerequisite for smallholder farmers' food security. Integrating production systems interventions with food systems through participatory approaches creates an enabling environment that ensures on-farm biodiversity and promotes much-needed diverse food systems, thereby promoting climate-resilient organic farming.

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Crop rotation and use of early warning systems (EWS) in climate smart Organic Agriculture

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Key words: climate change, cotton, organic agriculture, rainfall distribution, rotation, yield

Abstract

Climate change is now an established challenge to global agriculture. Crop rotation and early warning systems (EMS) can mitigate its effects. Therefore, agronomic performance of cotton was evaluated under five cropping systems {continuous cropping (without organic fertilizer), continuous cropping (with Organic fertilizer), rotation (with Organic fertilizer), rotation (without organic fertilizer) and conventional system} in a randomized complete block design replicated three times in 2019 and 2020. On average, crop rotation system plus organic fertilizer application enhanced number of bolls/plant, seed cotton weight, weight of seed and cotton yield relative to continuous cropping system without fertilizer application and conventional system. This paper also highlights the implications of delayed onset of rains in 2022 for agricultural productivity in Nigeria. It is opined that a merger of the two systems will help in fostering Climate-Smart Agriculture (CSA) in tropical Africa.

Introduction

Globally, agriculture is facing increasing drought frequency and severity, and other climate-induced challenges that negatively affect agricultural productivity. Consequently, integrated approaches to reduce these losses are being developed, while tackling other traditional challenges to crop production (Saha et al. 2018; Koyana et al. 2020). Recently, Climate-Smart Agriculture (CSA) has been gaining attention among sub-Saharan African farmers as a means of strengthening resilience to the threats where 70% are impacted (Azzarri & Signorelli 2020). Early Warning System has often been advocated for integration with other best practices in agriculture such as crop rotation (Dengwei et al. 2014). Globally, organic cotton constitutes approximately 0.93% of the world cotton production with Africa's organic cotton at 1% of the continent's total production (OCMR, 2020). This paper reports agronomic performance of cotton under different cropping systems and examines the potential of EWS in CSA.

Material and methods

The study was carried out on the Organic Research plot of the Research Farm of Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR) of the Federal University of Agriculture, Abeokuta (FUNAAB), located within (7° 13'51.17" - 7° 13'5316N, 3° 23'49.12 - 3° 23'51.86"E) with an altitude of 131.5 m above sea level during the late cropping season of 2019 and 2020. In 2019 and 2020, cotton was preceded by soybean and sesame in the rotation scheme. Soil samples were taken for pre and post planting analysis. The five cropping systems {Continuous cropping (without organic fertilizer), Continuous cropping (with Organic fertilizer), Rotation (with Organic fertilizer), Rotation (without organic fertilizer) and Conventional system (60kgN, 56 kgP_2O_5 and 60 kg K_2O)} were laid out in a randomized complete block design and replicated three times. The test variety of cotton was Samcot 11 (a long staple and late maturing variety). Sowing was done on July 10, 2019 and July 24, 2020 by dibbling 2-3 seeds per hole at a depth of 2 – 5 cm at a spacing of 90 cm × 40 cm corresponding to a plant population of 55,555 plants per ha. The organic fertilizer used was Aleshinloye Grade B fertilizer (an abattoir based fertilizer). Organic fertilizer was applied at 3 WAS using side dressing method at the rate equivalent to the recommended nitrogen level (60 kgN/ha). The inorganic fertilizers was applied in the conventional system at the rate of (60 kgN, 56 kgP_2O_5 and 60 kgK_2O) using band placement method to avoid injury to the plant. Weeding was done at three weeks after sowing, 6

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WAS and 9 WAS. Five plants was randomly selected and tagged at 5 WAS from the net plot for plant height and yield attribute measurement on plot basis. Neem oil (bio pesticide) was used to control insect pest. It was applied using a knapsack sprayer at 40ml in 20 liters of water.

Data were collected on plot basis from the tagged plants on growth and yield parameters. All data collected were subjected to analysis of variance (ANOVA) and means of the parameters significantly affected by cropping system separated using the Least Significant Difference method at 5% probability level. The EWS station located at the Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR), FUNAAB was completed in 2020. Generally, warning systems comprise of sensors, tools, and other decision subsystems for the early detection of negative events that could destabilize any aspect of agricultural production. The EWS is aimed at helping farmers to militate against climate-induced agricultural disasters. The station receives climate and environmental data in near real time from the European Meteorological satellite (Eumetsat) in Germany and such data are processed, interpreted, model and disseminated to farmers as advisory service through mobile phones provided for them. Farmers are advised on safe planting period, against drought, pests and diseases.

Results

Cotton in rotation

Data on cotton seed yield and some yield attributes are presented in Table 1. Cropping system significantly ($P<0.005$) affected number of bolls per plant, seed cotton weight, weight of seeds per plant and cotton yield in both years. Cotton plants grown on plots under rotation and conventional production systems recorded significantly ($P<0.0\%$) higher values for the measured traits than the plants grown on the continuous cropping control plots in both years. Year 2020 (493.3 mm) was dryer than 2019 (693.1 mm) during the late cropping season. Markedly low rainfall (2.9 mm) was recorded in August, 2020. However, the months of September (246.3 mm) and October (127.6 mm) were relatively wet (Figure 1a).

Early Warning System (EWS)

Figure 1b shows the schematic diagram on information flow from the agricultural early warning system to the end users. The maps in Figures 2 (a & b) show the parts of Nigeria that received rainfall in early 2022 and the simulated soil moisture levels of the nation from the forecasted climatic information in early 2022. Most parts of Nigeria did not receive adequate rainfall, and the soil moisture index, reveals gross inadequacy of soil moisture in most parts of the country except areas in white to light black. The forecast of false onset of rains in early 2022 was based on the Atlantic Multi-decadal Oscillation (AMO) which induced the enhanced northward movement of the intertropical discontinuity with an influx of moisture and early showers before the actual onset of rains in Nigeria.

Table 1: Cotton seed yield and some yield attributes under different cropping systems in 2019 and 2020

Cropping systems	2019				2020			
	NBLS	SCWT (g)	WTS (g)	CY (kg/ha)	NBLS	SCWT (g)	WTS (g)	CY (kg/ha)
Continuous cropping (-OF)	13.6	7.3	5.3	204.96	9.1	8.6	6.3	230.44
Continuous cropping (+OF)	24.3	22.5	16.0	631.95	11.7	19.3	12.1	541.80
Rotation (+OF)	24.4	24.1	18.9	675.08	17.6	25.7	18.1	692.16
Rotation (-OF)	22.3	24.2	19.3	677.88	9.8	28.0	20.1	784.56
Conventional	21.6	11.3	5.7	318.40	13.5	9.7	5.8	272.72
LSD (5%)*	5.60*	4.3**	3.75**	122.048**	2.90**	7.90**	4.06**	207.380**

* significant at $P<0.05$ and ** significant at $P<0.01$, NBLS - number of bolls per plant, SCWT - seed cotton weight, WTS – weight of seeds, CY – Cotton yield, OF - Organic fertilizer,

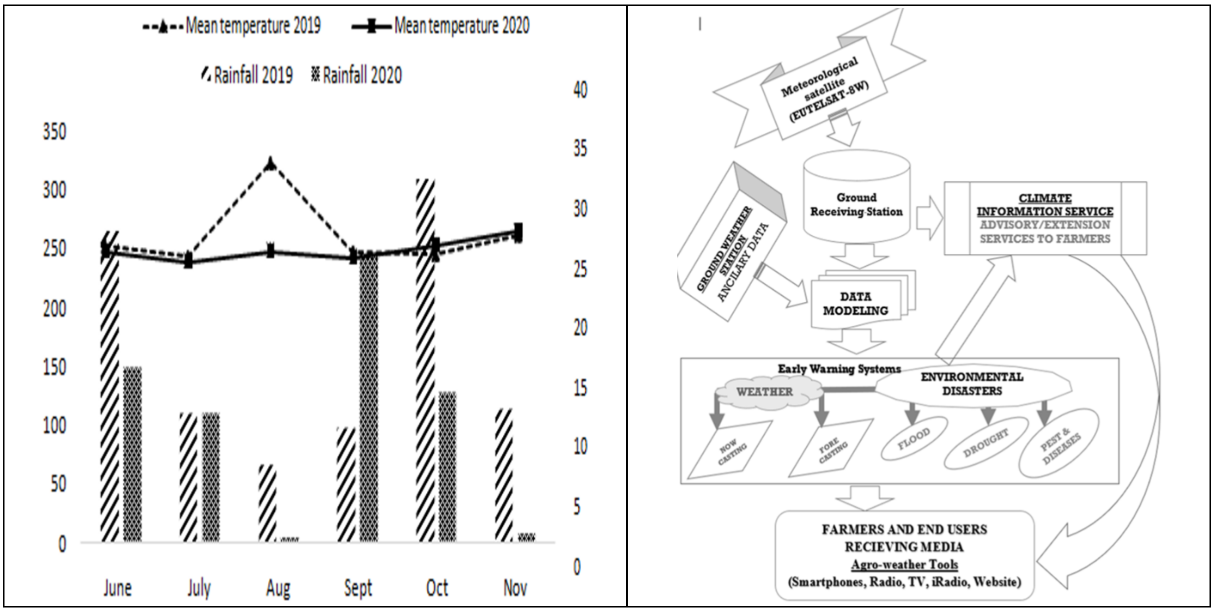

Figure 1a. Monthly Rainfall Distribution and Mean and Figure 1b. Schematic flow of information in the EWS (Temperature July-November 2019 and 2020)

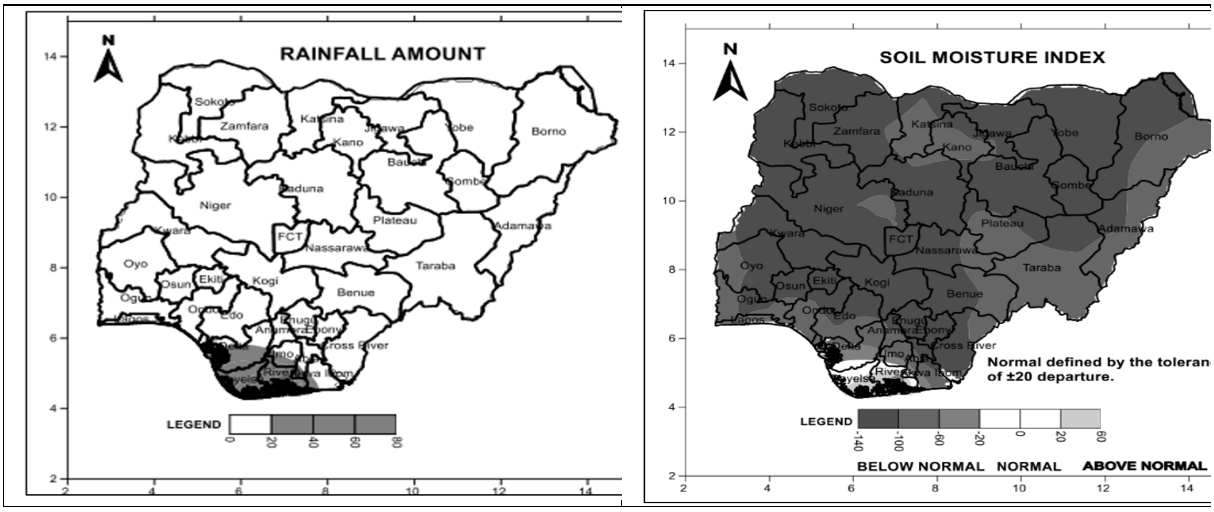

Figure 2a. Amount of rainfall in January 2022 and Figure 2b: Soil Moisture Index in January 2022
Source: NIMET, 2022

Discussion

Rainfall distribution varied considerably in both years resulting in under performance of cotton with cotton yield under rotation system ranging from 675.08 to 677.88 kg/ha in 2019 and 692.16 to 784.56 kg/ha in 2020 as against average 842.8 and 1,044.1 kg/ha in Nigeria and Africa, respectively (FAO 2020). Total rainfall in 2019 (693.1 mm) and 2020 (493.3 mm) were markedly lower than 700-1000 mm required for optimum productivity of cotton (Bhaskar et al. 2005). Nevertheless, cotton grown under rotation with organic fertilizer produced significantly higher number of bolls per plant, seed weight, seed cotton weight and cotton yield than cotton grown under the control and conventional system The information generated from rainfall distribution and the soil moisture index suggest an ample amount of rainfall later in the year (NIMET 2022). Thus, the farmers have been armed with management decision support to curtail economic injuries thereby saving their farms from crop failure.

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The need for the reduction of emissions and the limits of carbon farming in EU CAP: a holistic perspective

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Key words: agroecology, eco-schemes, food system, sustainability assessment

Abstract

The present paper shortly discusses the relevance of the Carbon farming approach in the frame of the European Union policy on climate. Carbon farming is defined, its objectives are summarised, and the relevant technical approaches based on land use change and farming practices implementation are described. Public (i.e. CAP) and private (Carbon credits) schemes to incentivise farmers to adopt Carbon farming solutions are considered and their strengths and limits presented. Finally, the main Carbon farming key challenges are discussed.

Introduction

EU Policy on Climate and the role of agricultural sector

Climate change and environmental degradation are an existential threat to Europe and the world (IPPC, 2022). To overcome these challenges, the European Commission adopted (EC, 2019) a set of proposals to make the EU's climate, energy, transport and taxation policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. The European Green Deal (EC, 2019) has the following goals: increase the EU's Climate ambition for 2030 and 2050; supply clean, affordable and secure energy; build and renovate an energy and resource efficient way; mobilise industry for a clean and circular economy; develop the 'Farm to Fork': a fair, healthy and environmentally friendly food system; accelerating the shift to sustainable and smart mobility; preserve and restore ecosystems and biodiversity; zero pollution ambition for a toxic-free environment. The European Climate Law (9 July 2021) writes into law the goal set out in the European Green Deal for Europe's economy and society to become climate-neutral by 2050. The law also sets the intermediate target of reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels.

The agricultural sector is both a source and a sink of greenhouse gases (GHG). In EU-27 agriculture (crop and livestock) contributes to GHG emissions with 382.449,70 kt CO2 eq in 2020 (11,78%). But globally, the food system contributes to global emissions up to 21- 37% IPCC (Mbow et al. 2019): 9-14% from agriculture; 5-14% from land use and land-use change including deforestation and peatland degradation; 5-10% is from supply chain activities (storage, transport, packaging, processing, retail and consumption).

Reaching the objectives of the Treaty on the Functioning of the European Union (TFEU) (EU, 2016) and the priorities of the future CAP for the 2021–27 period (EC, 2018) requires a major change in the way agriculture is practised and a reform of current policies for reducing the negative impacts identified in the European Green Deal.

The Carbon farming approach and its inclusion in the CAP

According to McDonald et al. (2021), the term carbon farming is used to refer to a new business model for farmers, which consists of incentives for farmers to take up land use change and farming practices that deliver a climate benefit at farm level as 1) carbon removal (sequestration of atmospheric CO2) and subsequent storage in biomass above/below ground and in agricultural soils; 2) the avoidance of future CO2 and other GHG emissions; and/or 3) the reduction of existing CO2 and other GHG emissions. In its original vision, carbon farming involves the management of both land and livestock, all pools of

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carbon in soils, materials and vegetation, plus fluxes of carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O).

Referring to land use change, carbon farming strategies and solutions range from afforestation, management of peatlands, agroforestry and conversion to permanent grasslands; in terms of management practices to be implemented at cropping system/farm scale, carbon farming relies mainly on specific techniques as conservation agriculture, use of catch crops and biochar.

The incentives for farmers to take up carbon farming practice can come from public funds, private payments, or a combination of the two. In recent years, carbon farming mechanisms have been set up that enable private actors to pay farmers for delivering climate mitigation. Transfers of private funds can either happen via the supply chain for agricultural products (i.e., as a mark-up to product prices) or via carbon markets. To activate private funding, carbon farming is based on voluntary schemes or agreements in which farmers (or a group of them) commit themselves to apply carbon farming measures in return for a payment in any form. Different schemes have been designed, including the direct payment of land managers/farmers by a public funder and/or and NGO, by a private agri-food company, or by an intermediary who can act collecting the carbon certificates offered by the land managers and organising the demand of the private funders interested to buy the credits (i.e. private companies and/or finance corporates). Once emitted carbon certificates, can be also exchanged on the voluntary market, as financial stocks/securities (Mc Donnel et al., 2021).

Reading public funding, The Common Agricultural Policy (CAP) is one of the most fundamental structures of the European Union, as it represents around 40% of the EU budget and directly impacts 14 millionf armers, and indirectly another 4 million working in the food sector. One of the principal changes within the new CAP has been the inclusion of Eco-schemes – voluntary programmes linked to the first pillar which will be available to farmers with the hope to incentivize more ecological and environmentally-friendly farming practices. The CAP Strategic Plans include areas of environment, climate and animal welfare actions. In particular, the "climate change mitigation" area include reduction of GHG emissions from agricultural practices, as well as maintenance of existing carbon stores and enhancement of carbon sequestration; while the "climate change adaptation" area include actions to improve resilience of food production systems, and animal and plant diversity for stronger resistance to diseases and climate change.

However, the Carbon farming Eco Schemes include: conservation agriculture; rewetting wetlands/peatlands, paludiculture; minimum water table level during winter; appropriate management of residues (i.e. burying of agricultural residues, seeding on residues); establishment and maintenance of permanent grassland; extensive use of permanent grassland. Other Eco Scheme practices related to GHG emissions are feed additives to decrease emissions from enteric fermentation and improved manure management and storage.

By the 17th of March 2022 all Member States (MSs) submitted their draft CAP Strategic National Plans (CSPs, "the Plans") to the Commission for assessment and approval. On the 31st of March 2022, the Commission services sent to the MSs the observation letters containing the outcomes of analysis and the suggestion for improvement. The revised version of the Plans is expected to be sent to the Commission by the end of July 2022.

Carbon farming key challenges and organic farming and agroecology systemic approach

All farming operations have some ability to mitigate climate change, though the potential differs widely across farm types and regions. However, it is likely that single, specific on-farm techniques as conservation agriculture, use of catch crops, reduction of fertilisers use or biochar cannot get significant impact on long term C sequestration and, in turn, on climate change mitigation if not accompanied by a systemic shift towards more sustainable land uses (i.e. agroforestry) and/or the whole redesign of the farming system implementing the fundamental agroecological principles of diversification, synergy and resilience (Barrios et al. 2020). Moreover, to deploy all the potential of the carbon farming approach, in addition to the implementation of measures and schemes at farm level, wider operational scales should be considered. Strategies to circularly manage organic wastes at territorial level should be effectively designed, supported and rewarded. Finally, but importantly, carbon farming should be accompanied by demand-side changes, including dietary shifts away from emissions intensive foods such as meat and dairy, and reduced food waste.

A key challenge for carbon farming is measuring the mitigation impact of carbon farming actions at low-cost; therefore, novel, and effective “Monitoring, Reporting and Verification” (MRV) methods and tools should be developed to enable widescale uptake of carbon farming. Reporting and verification processes are especially important if carbon farming mitigation is used to generate offset credits that will be used by other sectors in lieu of their own emissions reductions. Without robust reporting and verification - including random and targeted auditing, secure registry systems, and long-term reporting obligations – there is significant risk that carbon farming mitigation could be low-quality. Additionally, the relatively high MRV costs pose a significant barrier to widespread uptake and needs careful assessment of risks and effectiveness and robust certification before scaling up (Mc Donnel et al., 2021).

Moreover, while carbon farming explicitly targets climate mitigation impacts, the same actions designed to implement the carbon farming approach are claimed to deliver other environmental, climate adaptation and socio-economic co-benefits as cost savings, productivity increase, water quality improvements and even biodiversity protection. Therefore, to demonstrate the impact of the carbon farming approach on these “co-benefits”, the mere implementation of MRV methods and tools based on direct and indirect assessment of C soil pools and processes, as direct measurements and modelling, is not adequate. In this perspective, a more coherent and complex assessment approach based on multicriteria analysis which encompasses a wide range of environmental, social, economic and good governance criteria should be used. Indeed, the main sustainability pillars need to be simultaneously considered in any assessment to evaluate potential synergies and trade-offs of the agricultural processes within and among the attributes of the dimensions (Iocola et al., 2021). It is therefore advisable that multicriterial assessments schemes and tools for carbon farming and co-benefits impact are specifically developed and implemented either in ex-post or in ex-ante analyses.

In order for Eco-schemes to truly lead to a long-term redesign of agricultural systems, it is important for them to be multi-dimensional. Policymakers should encourage the implementation of several practices at once, avoiding as much as possible the so called “cherry picking approach” as a practice on its own has little strength in creating true sustainability. Therefore, rather than a menu of options farmers can choose from, packages should be constructed in a way where complexity and synergy is created on farms with many proven environmental benefits (Agroecology Europe, 2022). Moreover, it should be taken into account that, at present, too limited is the effort to reduce emission in the livestock sector from the CAP carbon farming eco-schemes.

Finally, it should not be neglected that using carbon farming to offset mitigation in other sectors poses significant risks. This is due to relatively high MRV uncertainty, impermanence concerns, and difficulty ensuring that removals are additional. Besides that, strategies to avoid the reduction of ambition of the non-agricultural sectors in implementing effective mitigation measures should be opportunely considered. Indeed, to guard against the potential for “greenwashing” it is crucial to ensure high levels of transparency, use of proven methodologies, and regulating of corporate claims.

Good strategies and practices in Carbon farming are the following:

- Nutrient management on croplands and grasslands: Improved nutrient planning and timing; Avoiding over-fertilisation; Legumes / temporary leys in the rotation
- Livestock and manure management: Reducing enteric methane (feed, feed additives..); Reducing N2O emissions manure (storage and processing)
- Managing peatlands: Protecting existing peatlands; Rewetting peatlands: nature conservation, palidiculture
- Developing agroforestry and hedges
- Sequestering carbon in mineral soils

A review of more than 100 experimental studies worldwide (Conant et al., 2001) identifies the conversion of arable land into grassland as an effective carbon sequestration (C-sequestration) measure.

Results (Migliorini et al. 2014) from the long term comparison trial "MOLTE" Italy showed comparable grain yields in three agroecosystems (2 organic and 1 conventional). The conventional system showed a larger N surplus and a lower crop N use efficiency in comparison with the organic ones. Moreover, the organic systems presented a lower potential risk of N losses with respect to the conventional one. The Young Organic agroecosystem was the most effective in terms of long term soil C (13% higher than conventional) and the oldest organic agro-ecosystem was the most effective in terms of soil N storage (9% higher than conventional).

However, there is the need for a holistic and multi-dimensional approach to carbon farming focussing not only on the amount of carbon stored in soils but also on biodiversity protection and the systemic transition of farming systems towards agroecology, as an agricultural redesign and food system approach.

Recommendation & Conclusion

Carbon farming (CF) and Carbon removal certification (CRC) mechanism – that are plan to be adopted as legislative proposal in 2022, should support a transition to agroecology by encouraging:

- Ecosystems restoration, biodiversity enhancement & soil health;
- Climate mitigation & adaptation;
- Minimise the risk of competition for land.

In order to do this is the following clarification are needed:

- To define what is a removal (Nature-based or Technology-based?)
- To define what counts as a tonne of carbon removed from the atmosphere
- To set rules on governance of the carbon credits
- To provide financial incentives for land managers to apply organic and agroecological practices

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Toward novel slow release biofertilizers as a resilient strategy to increasing fertilizer cost in organic vegetables production in arid regions

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Key words: compost, arid, sandy soil, slow-release fertilizer, soil fertility, organic zucchini.

Abstract

The lack of synchrony between vegetable's need and amount of nitrogen released by compost in sandy soils, constitutes a significant restriction to organic vegetables growers. The aim of this experiment was to study the effect of a slow releasing organic nitrogen fertilizer (SRF) combined with compost (COM) on soil fertility, growth, and yield of organic zucchini under greenhouse in arid region. Results showed significant improvement of soil organic matter (SOM) content (from 1.55 to 2%) after compost amendment. Soil nitrate release was high during first 2 months for all treatments and has decreased till the end of the cycle. Addition of compost to soil has increased SOM and has optimized nitrogen releasing which means that COM was more efficient than SRF which didn't give the required advantage of optimum nitrogen supply but has caused yield decrease due to vegetative promoting effect to the detriment of quality and productivity of the crop.

Introduction

Very few studies have dealt with the management of soil fertility and plant nutrition under organic systems in the Mediterranean arid and semi-arid climate (Ramli et al 2020). The timing and amount of mineralized nitrogen often does not coincide with crop needs, making in-season fertilization necessary (Morris et al., 2018). This lack of synchronization between mineralized nitrogen in organic matter and nitrogen uptake by crops remains a major challenge for fertility management in organic production systems (Gaskell et al., 2006). Soil organic matter (SOM) content and its mineralization rate can influence levels of potassium (K), phosphorus (P) and micronutrients in soil and this will directly affect crop's productivity (Rawal et al., 2022). Maintaining SOM through compost amendment is important not only for sequestration and greenhouse gas mitigation, but it also has a significant influence on the physical, chemical, and biological properties of soil (Ashagrie et al. 2007). The aim of this experiment was to study the effect of a slow releasing organic nitrogen fertilizer (SRF) combined with compost (COM) on soil fertility, growth, and yield of organic zucchini. The mineralization rate and availability of nutrients in the soil during the crop cycle were investigated.

Material and methods

The study was carried out at the experimental field of the National Institute of Agronomic Research (INRA) 40 Km to the south of Agadir (Latitude=30.6; Longitude=9.36; Altitude= 75m). The region is characterized by an arid climate with climatic mean values as follows: T°min=11.5°C; T°max=24.8°C; Relative Moisturemax=85%; Relative Moisturemin=85%; Sunshine period=3600hr.year-1 and Rainfall=173mm. Soils in the region are generally sandy with alkaline pH and very poor in terms of total nitrogen content. A Completely Randomized Blocs design was adopted with 4 replicates following north-south and irrigation direction senses. The experimental field measured 500m², blocs 11.25m² (12.5

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m * 9 m), plots 8.1 m2 (9m X 0.9 m). Quantities of COM and SRF were applied following nitrogen needs (NN) of the crop cycle witch are 160 Kg-N.ha^{-1}.crop cycle^{-1} (Rouphael et al 2004): T1 (100% of NN as COM incorporated before planting date [IBPD]); T2 (50% of NN as COM [IBPD] and 50% of NN as SRF divided into 3 amendments in crop cycle [4 weeks after planting, 8 weeks after planting and 11 weeks after planting]); T3 (25% of NN as COM and 75% of NN as SRF divided similarly as T2) and T4 (100% of NN as SRF divided into 4 amendments: first before planting and 3 amendments similarly as T2). The incorporation of compost and organic fertilizer were done 10 days before planting date (tables 2). Compost and the SRF chemical analysis are presented in the table 1:

Table 1. Treatments description of the experiment

Treatments	*10 days before planting (DBP)*		*4 weeks after planting (WAP)*	*8 WAP*	*11 WAP*
T1	160 Kg of NN (100%) as COM	***Plantation***	-	-	-
T2	80 Kg of NN (50%) as COM		26.3 Kg of NN (16.6%) as SRF	26.3 Kg of NN (16.6%) as SRF	26.3 Kg of NN (16.6%) as SRF
T3	40 Kg of NN (25%) as COM		40 Kg of NN (25%) as SRF	40 Kg of NN (25%) as SRF	40 Kg of NN (25%) as SRF
T4	40 Kg of NN (25%) as SRF		40 Kg of NN (25%) as SRF	40 Kg of NN (25%) as SRF	40 Kg of NN (25%) as SRF

For standard soil chemical analysis Composite soil samples were taken with an auger (Ø=2.5 cm), just before compost and SRF amendment and monthly 4; 8; 12 and 16 WAP from topsoil (0-30cm depth) by mixing four or five soil samples in one sample by plot. Other parameters were assessed such as plant height, plant biomass, crop yield. At the end of the crop cycle, leaves samples were taken of foliar analysis.

Results and discussions

Soil and foliar Total nitrogen content

Figure 1 presents the evolution of the STN over crop cycle and according to this graph, after application of the first amendment total STN increased in all treatments, until 8 weeks after planting date then a decrease is recorded until rest of the crop cycle. For all treatments in the first month when the plants were small, their NN were less than the nitrogen released by SRF and COM, consequently STN increased.

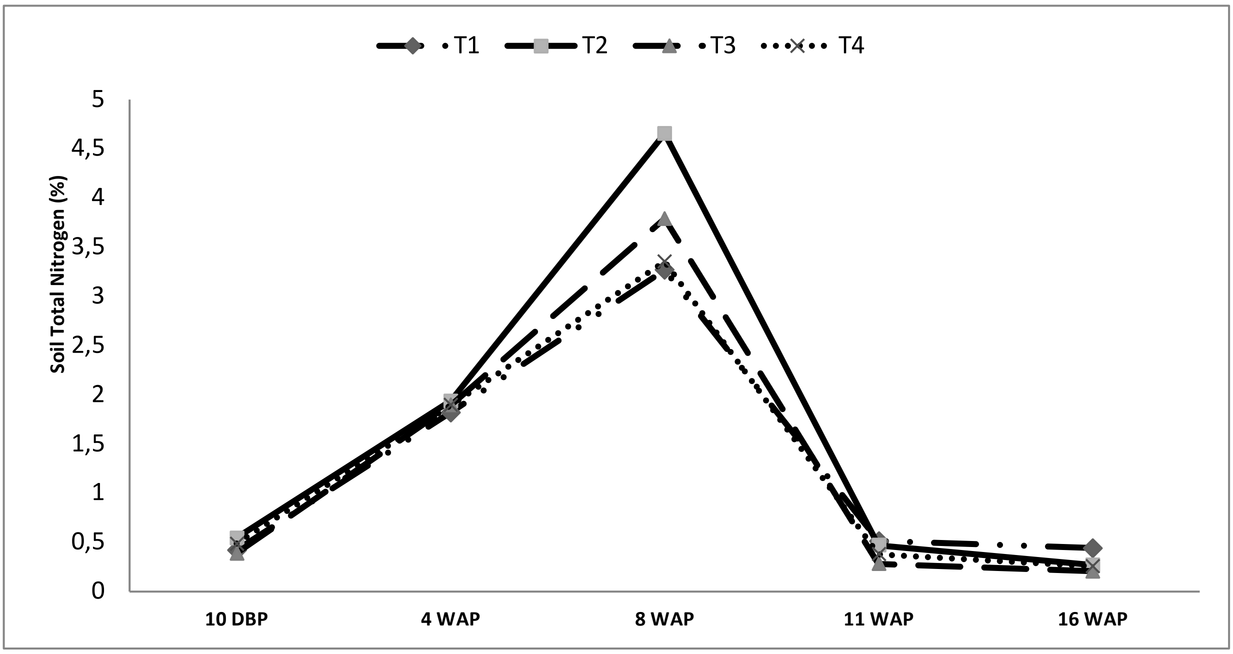

Figure 1. Evolution of Soil Total Nitrogen Content

Nevertheless, the crop needs increased in the following months, and mineralization rate decreased, so that STN decreased in the rest of crop cycle showing an unbalance between mineralization rate and NN. The low content of STN can be explained by nitrate leaching due to sandy soil nature. There is no significant statistical difference among treatments, and all treatments followed the same tendency during the whole crop cycle. Figure 2 represents the foliar analyses to confirm soil analysis results and field observation. There is no significant statistical difference among treatments in terms of foliar total nitrogen content in all treatments.

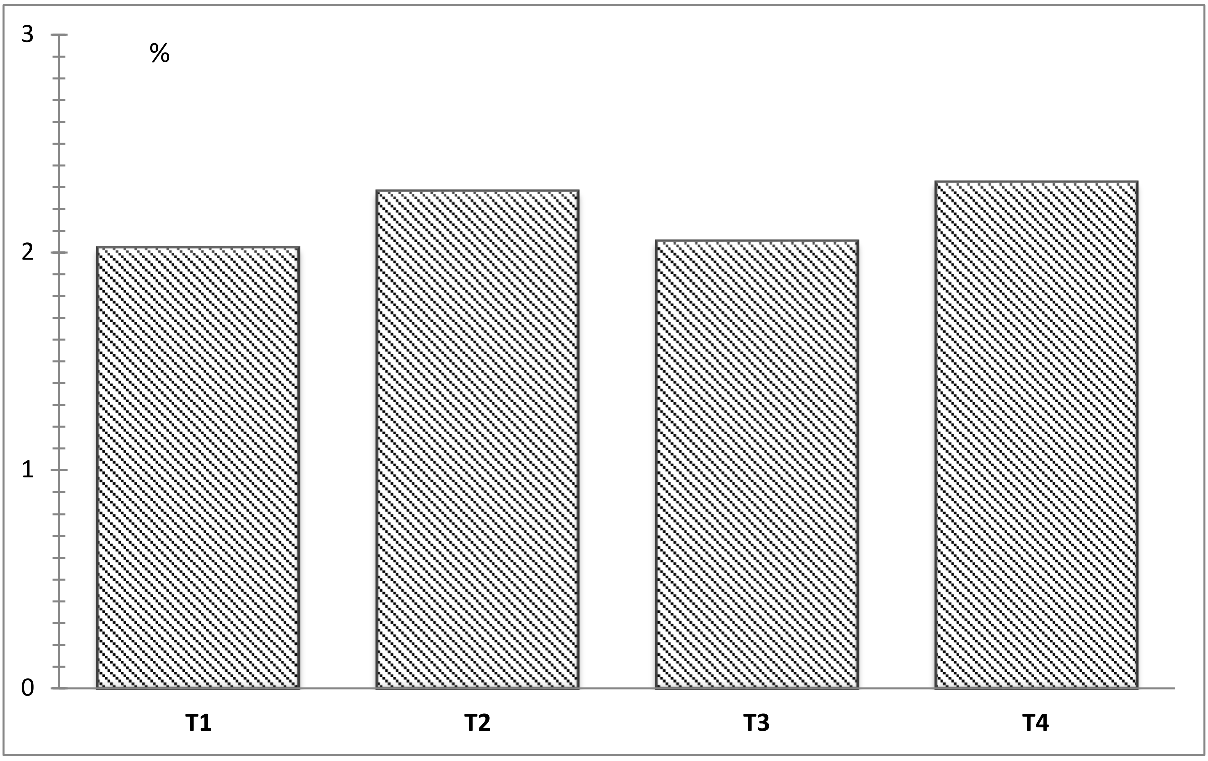

Figure 2. Foliar Total Nitrogen Content

Yield of organic zucchini

Statistical analysis (Figure 3) revealed a significant difference between treatments, and the highest yield recorded was under treatment T2 where 50% of NN was applied as COM and 50% as SRF, followed by treatment T1 than treatment T3 and T4 with lower yield. T2 gave the highest yield, and this can be explained by fertilization program which was adopted. This program may reduce nutrient losses and respond to crop requirement over time.

Concerning fruit quality all treatment shown the same result, with no significant difference between treatments. For all treatment the exportable yield that is mean fruit with caliber CII and CIII presents about 70% and the no exportable yield, fruits with caliber CI and C VI presents about 30% of total fruits harvested. The most part of no exportable yield was harvested in the first two weeks of harvesting period as small fruits of caliber CI.

Conclusion

Based on obtained results about the effect of compost and commercial organic fertilizer on soil fertility, growth and yield of zucchini grown under greenhouse in Souss Messa we conclude that the soil pH has been improved significantly under treatment T1, due to high amount of compost applied in this treatment. the application of compost, there was a significant increase in soil organic matter content, and this will improve long term soil fertility. Soil content of Phosphorus and Potassium increased in all treatments but with no significant difference between them. The highest yield was recorded under treatment T2, with a value of 35.75 t/ha followed by treatment T1 with 33.49 t/ha, then T3 with 32.01 t/ha and the lowest yield was recorded under T4 with 30.92 t/ha. Although we did not record any significant difference between treatments in terms of available Magnesium and Calcium but may be in long term. Concerning fruit quality, no significant difference was recorded between treatments and the no exportable yield was high with 30% of total harvested fruits but may be in long term this problem can be resolved. Based on obtained results about the effect of COM and SRF on soil fertility, growth and yield of zucchini grown under greenhouse in Souss Massa, the adequate combination between COM and SRF is T2, where 50% of NN was applied as COM and 50% as SRF. Fertilization approach should take into consideration the integration of phosphorus and potassium needs under an improvement of organic matter content in a midterm program.

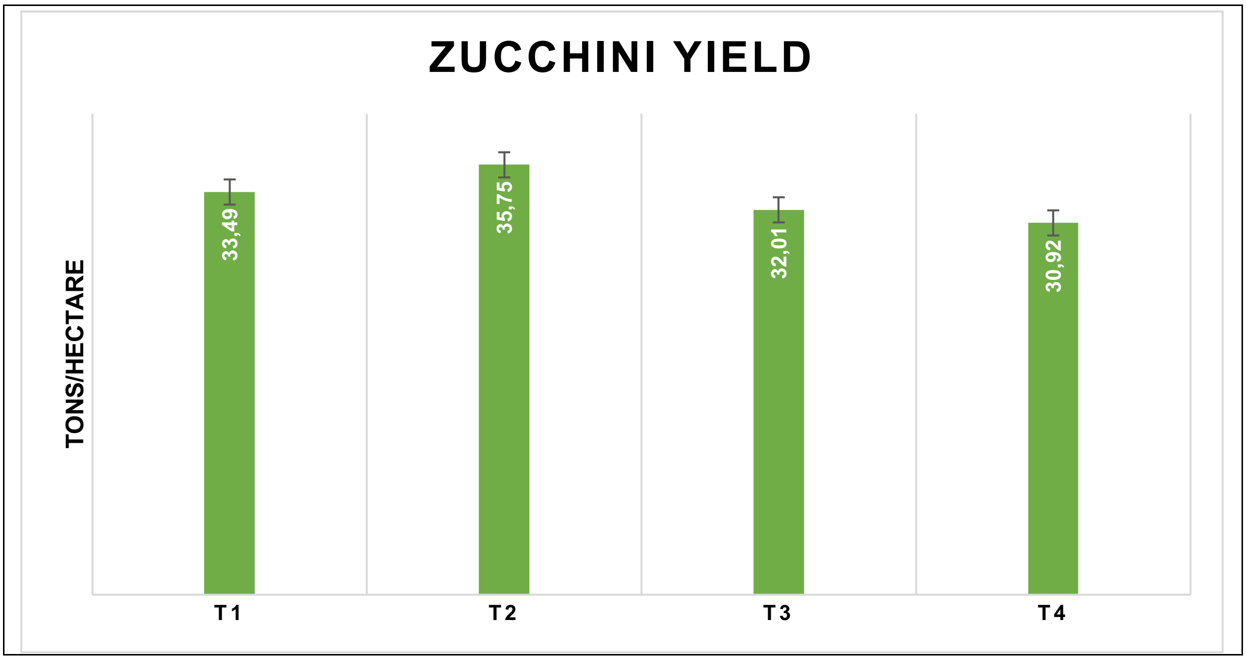

Figure 3. Yield of organic zucchini with respect to different treatments

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Increasing energy efficiency in Organic Agriculture to offset climate change

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Key words: efficiency, organic farming, water conservation, CO2 emission, waste reduction, pollution prevention

Abstract

The College of Engineering, Office of Outreach and Recruitment (COEOOR) at New Mexico State University supports Pollution Prevention (P2) and Energy, Economy, and the Environment (E3) implementations to increase sustainability and reduce the environmental impact of businesses throughout New Mexico. In a novel approach, this review will theoretically apply implementations to increase the efficiency of organic farming to reduce water consumption and waste, energy consumption, and CO2 emissions of the operation. The primary goal of this review was to display the effectiveness of P2E3 Best-Practices, and some novel implementations in the realm of organic farming. A literature review was performed to establish a baseline of knowledge regarding the use of energy and water, as well as energy, crop, and waste generation of organic farming operations. Then, in a novel approach, this review theoretically applied certified P2E3 implementations to increase the efficiency of organic farming, and by doing so, reduce the negative impact the organic farming operation has on climate change.

Introduction

Within the past few decades, the call for the United States to further implement organic farming practices has gotten louder. Conventional agriculture systems in the United States require an alarming amount of energy to produce both food and fiber. The water use and waste, CO2 emissions, and energy consumption generated by conventional methods of farming have become of paramount concern with the climate crisis becoming more prevalent. Organic farming has been widely accepted as a sustainable alternative to conventional agricultural methodologies. Organic farming is less petroleum-dependent than conventional agricultural systems and eliminates the use of chemical pesticides, herbicides, fertilizers, and soil enhancements. However, to produce crops competitively, organic farming operations still generate water waste, CO2 emissions, and solid waste, and experience water, fuel, and electricity usage. Fuel and electricity consumption on farms is just as important to sustainability and energy savings as the utilization of soil and water. As such, energy efficiency is an integral part of sustainable agriculture. While many farms across the United States have almost doubled their average energy efficiency over the past 25 years, most farms still have abundant opportunities to save energy, water, and money. [1]

Methods

The primary goal of this review was to display the effectiveness of increasing energy efficiency through both established P2E3 Best-Practices, and novel P2E3 implementations in the realm of organic farming. Energy efficiency is the use of less energy to perform the same task or produce the same result. Increasing this efficiency is one of the easiest and most cost-effective ways to combat climate change, reduce energy costs for consumers, and is a vital component in achieving net-zero emissions of carbon dioxide through decarbonization. Energy efficiency saves money, increases the resilience and reliability of the electric grid, and provides environmental, community, and health benefits [2].

The first step was to perform a literature review on common methods of organic agriculture to establish a baseline of knowledge regarding common operation size, energy, and water expenditures, as well as

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energy, crop, and waste generation. This gave a clearer image of the inputs and outputs of organic agriculture operations in terms of the parameters listed above.

Cases from the past in which P2E3 best practice recommendations were suggested to organic farming businesses were then reviewed [3-6]. It was important to familiarize ourselves with past implementations that were suggested at these locations so that it could be discerned if these same implementations would be viable at most organic businesses across the country. Further, the verification by the Organic Management Systems and Regulations for each suggested implementation was performed during this process [7]. It should be noted here that "when the terms "conservation" and "efficiency" are distinguished from each other, "conservation" generally means reducing total energy usage (for example, using fewer gallons of fuel), while "efficiency" means increasing the work or yield per unit of energy (for example, getting more miles per gallon)" [2]. It should also be noted that all numerical values used in calculations and estimations were drawn from both the information accrued in the literature review and in reviewing past P2E3 assessment reports.

Values were calculated for the different types of energy P2E3 focuses on water consumption and waste, electricity usage, CO2 emissions, and solid waste generated by the business. In the case of best-practice implementations made in past reports for organic agricultural businesses, most, if not all, of the implementations could be translated over to any farm using organic methodologies. To better suit the particular needs of organic farming operations in different geographical locations throughout the United States, some novel approaches to the conservation of energy on organic farms were also considered.

Past Implementations. As mentioned, there are several implementations suggested by past P2E3 assessments made at agricultural business locations that follow organic farming methodologies. These implementations are easily translated over to any large-scale (>$5000 generated annual revenue [7]) organic farming operation, as the use of heavy machinery, electricity, water, and the generation of waste are energy expenditures that any organic agricultural operation will incur. Best Practices suggested by P2E3 implemented upon these energy expenditures result in the optimization of each system. The amount of energy saved can be calculated by taking the difference between the initial energy spent and the energy spent by the new, optimized system. This value is then multiplied by the price per unit of energy that the business is charged by the government. This yields the amount of money saved in United States Dollars (USD).

While the saving of money is an important factor in any business model, it should be mentioned that the most important implications of these savings lie within the conservation of the environment. With the reduction of energy usage and the increase of efficiency within everyday operations, organic agricultural businesses can reduce their CO2 emissions, water consumption, and waste generation, and decrease the amount of electricity consumed. With the climate crisis coming to a critical point, these parameters must be held paramount when considering any agricultural model. Since large-scale agriculture historically necessitates the utilization and maintenance of large areas of land held to specific biological parameters, the utilization of large quantities of water and electricity, and the use of heavy machinery, it's especially critical for businesses in this field to look to the future and implement new equipment and practices which can help offset the negative impact of these large-scale consumptions. The P2E3 initiative is at the forefront of innovation for creative solutions to help the organic agricultural methodology streamline further to make an even more meaningful impact on the conservation of the environment.

The first implementations considered were standard P2E3 Best-Practices. These include: installing LED and motion sensor lighting, ensuring the proper insulation of crop storage areas, maintaining equipment and machinery to an optimized level, and taking measures to maintain soil fertility to increase the efficiency of irrigation processes. The installation of LED and motion sensor lighting can substantially reduce the amount of energy consumed by lighting fixtures throughout the operation, as LED bulbs consume less energy than traditional halogen bulbs, and motion sensors will turn off lighting when not in use. This will reduce the amount of CO2 emitted from these fixtures. By properly insulating and sealing off the exteriors of their buildings, agricultural producers can reduce the energy required to heat and cool their indoor operations. By increasing the insulation and reducing air infiltration of all exterior walls, windows, and doors, farmers can substantially decrease the amount of energy required to maintain their desired temperature [1]. There are several different types of industrial insulation materials available to meet the needs of both heated and cooled areas. Implementing these materials properly requires the consultation of a trained professional, and can be sourced locally. Similarly, the maintenance of heavy machinery and equipment like pumps is an important implementation to consider. By keeping machines running at peak performance, both the number of operating hours and the waste of fuel (and therefore emissions of CO_2) are reduced [1]. Many farmers can maintain their machinery without the help of outside labor, and therefore only incur the cost of parts when repairs must be made. The manufacturer and/or owner's manual should be consulted for maintenance guides and help with difficult repairs. The use of crop rotation and nutrients sourced from the farm to maintain soil fertility is effective implementation. By keeping the soil fertile and dense in nutrients, the amount of water the soil retains increases. This means less water is needed to irrigate crops, as the soil can retain water and nurture the plants for longer. Since different crops deplete and replenish different nutrients from the soil, rotating crops ensure that the soil remains nutritionally dense.

Another source of P2E3 savings was generated from the lack of chemical pesticides, herbicides, fertilizers, and soil enhancements and their applications within certified organic operations. Because certified organic farms do not use any chemically synthesized pesticides, herbicides, fertilizers, or soil enhancements [3], they must handle the pollution generated by farming differently than conventional methods of farming might. An opportunity for savings can be found in weed control by performing a singular pass through crop fields with a tractor equipped with a cultivator attachment, followed by a singular pass of a tractor with a rotary hoe attachment. This method cuts costs and emissions of CO_2 roughly in half when compared to conventional forms of weed control cost (in the form of herbicide and sprayer applications [4]) while only experiencing a minor increase in diesel consumption and CO_2 outputs from running the tractor. With this in mind, even organic operations in which natural pesticides and herbicides are used can benefit from controlling weeds through the cultivator and rotary hoe method.

Another implementation taken seriously by the organic community is that of utilizing photovoltaic (PV) cells and/or solar collectors to harness solar energy. Solar collectors eliminate the need for grid electricity to heat water, and can be applied to a variety of other applications on a farm. Replacing the dependency on the electrical grid and generating its own electrical power can significantly offset the costs for electricity that an organic operation incurs. In some cases, enough electricity can be generated by the PV system to make the entire operation self-sufficient and may make the operation eligible for rebates, tax credits, or other incentives by the U.S. Government. Further, the use of solar energy to power equipment conventionally powered by fossil fuels can help decrease the emission of CO_2 into the atmosphere. This concept is discussed further in the next section.

Solar-powered pumps are also an effective form of conservation organic operations can practice. Certified organic operations are required to utilize renewable and organic resources whenever possible [5]. Replacing traditional diesel pumps with solar-powered pumps is a viable way to make that happen by converting solar energy into electricity to transport water. This eliminates the need to burn diesel to power pumps, ergo eliminating the output of CO_2 into the atmosphere generated by burning diesel. Solar pumps are an excellent implementation in the Southwestern United States where the solar insolation is consistently extremely high and can be utilized directly. Solar power harnessed by these pumps can also be stored in batteries or capacitors, which can be drawn from at a later time. This makes solar pumps a viable implementation within operations located in areas that might not experience constant sun during the day.

Results

There are several P2E3 best-practice implementations applicable to the organic industry. Using the method of calculation described in the Past Implementations section above, numerical values were found for the average annual expenditures in terms of units of energy (kWh), CO_2 emissions (tons of CO_2), and monetary values (USD) per recommendation. An operation size of 115 hectares was assumed for all calculations.

An average value for annual energy expenditures within organic agriculture operations sans P2E3 implementations was sourced [2-6] and converted into kilowatt-hours (kWh). This value includes electricity usage and consumption of fossil fuels. To obtain the cost paid by the operation, 41% was multiplied by the cost of diesel in Las Cruces, NM, and the other 59% was multiplied by the cost of electricity. Each value was then multiplied by the respective price per unit, such as cost per gallon of diesel fuel or cost per kWh. These percentages represent the amount of each form of energy used by the operation respectively. Lastly, the total amount of kWh was then converted into tons of CO2 emitted from the operation. Values for the savings generated by LED and motion sensor lighting were drawn from past P2E3 reports done by the COEOOR at NMSU [10]. The differences in annual expenditures and savings generated by implementing P2E3 best practices can be seen below in Figure 1.

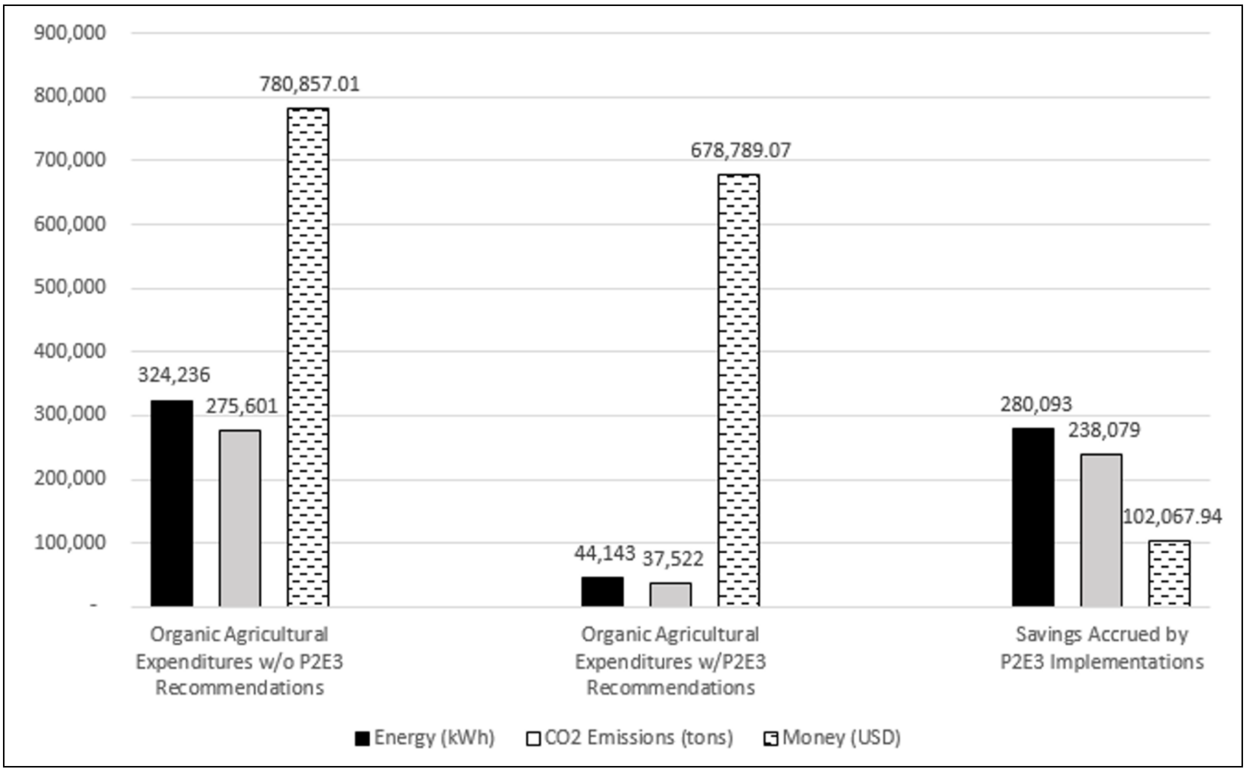

Figure 1. Expenditures experienced bx Organic agriculture operations with and without P2E3 recmmendations in place

Discussion

Thanks to efficiency-increasing measures implemented on farms across the United States, the energy use in U.S. agriculture is about the same now as it was in 2000, despite economic growth of about 30 percent. Energy efficiency has done more to meet America's energy needs than oil, gas, and nuclear power over the past four decades [9]. Through the use of past P2E3 reports and some creative thinking, it can be seen that P2E3 Implementations can help organic methodologies of agriculture even further offset their negative impact on climate change. Any organic operation can easily benefit from suggested P2E3 implementations, such as installing LED and motion sensor lighting, properly insulating buildings, maintaining machinery, and rotating crops. Organic agricultural operations can also benefit from utilizing the discussed method of weed control and exploring different methods for soil enhancement to maintain soil fertility and increased water retention. Implementing solar-powered pumps to replace diesel pumps shows huge promise in savings of both CO2 emissions and money.

It can be seen that even though organic methodologies strive to reduce their carbon footprint and offset climate change, there is room for significant improvement through the implementation of P2E3 recommendations. The implementation of these recommendations not only results in significant monetary savings, but also significant reductions in CO2 emissions, water usage, and electricity consumption. By reducing these expenditures, organic agricultural operations in the United States can do their part to aid in the fight against the climate change crisis.

To view checklists and tips which can help increase farm energy efficiency, please visit https://farm-energy.extension.org/farm-energy-efficiency-checklist-and-tips/. [11].

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Organic agroforestry systems in Europe - a tool to make Organic Farming more climate smart and circular?

SABINE ZIKELI

Key words: temperate regions, silvo-pastoral, agrosilvopastroral, sustainability assessment, participatory research

Abstract

Currently, agroforestry gains importance in European organic farming because it is perceived as a tool to mitigate greenhouse gas emissions and to adapt to climate change. However, due to political and administrative reasons only a few European pioneer farmers established agroforestry systems so far. Therefore, very limited experience on the system design or on the impact of these systems on greenhouse gas emissions and many open questions on the design of the systems and their impact on ecosystem services exist. Changes in agricultural policy and administration may now encourage more organic farmers to establish agroforestry systems, therefore knowledge exchange and further research is needed. Scientists and pioneer farmers could co-design research questions and gain together a deeper understanding in a living lab approach.

Introduction

The current conventional agricultural system is a major contributor to the transgression of the planetary boundaries climate change, biogeo-chemical flows, land-system change, freshwater use, biodiversity / biosphere integrity (Steffen et al. 2015, Rockström et al. 2009). The growing need for changes fosters many different "alternatives" to the current conventional farming system: organic farming, agroforestry, regenerative agriculture, permaculture, agroecology. In this context, agroforestry is currently discussed as a miracle weapon to combat and adapt to climate change and to improve circularity for energy, water and nutrient flows on on-farm level, but also within existing agricultural and food systems.

The term agroforestry refers to agricultural practices that cultivate woody perennial plants together with animals and/or other crops on the same parcel of land in a spatial arrangement and a temporal sequence (FAO, 2015). Different agroforestry systems can be distinguished: silvoarable (combination of woody perennials with (annual) agricultural crops), silvopastoral (animals and woody perennials) and agrosilvopastoral (woody perennials, animals and agricultural crops). Traditionally, agroforestry systems exist worldwide since millennia. The modern term "agroforestry" was termed in 1970s (FAO, 2015) and gained scientific attention, but with a focus on tropical and subtropical regions and small scale farming systems. Interestingly, nowadays agroforestry receives a lot of interest in temperate regions from civil society and farmers. While agroforestry traditionally has its' role in organic farming in the tropics and subtropics, organic farming systems in temperate regions were so far designed – with a few exceptions - without agroforestry elements. On the contrary, under conventional management, traditional agroforestry systems like extensive fruit orchards with pastures and fodder production or hedges have been removed in the last decades to ease mechanization of agriculture. Today, in many European countries and in the US, agriculture and forestry are not integrated and adequate policies to enhance agroforestry are missing, therefore, modern agroforestry systems are rarely developed (Mosquera-Losada et al. 2018, USDA 2013).

Nowadays, the benefits of agroforestry are recognized by European and US policy makers and new support measures are integrated into the Strategic Plans of the different EU member states in the framework of the Common European Agricultural Policy (e.g. for Germany) and in the strategic plan of the USDA (USDA, 2019). In addition, funding for agroforestry research is increasing and different donors engage in agroforestry projects in Europe resulting in the funding of numerous research projects by the European Union (e.g., in the Horizon 2020 and in the Horizon Europe funding schemes) and national funding bodies (e.g. from the German Ministry for Food and Agriculture). The aim of these projects is to foster research on agroforestry systems, with or without livestock, for food purposes and to produce renewable resources while maintaining or improving ecosystem services and adapting to climate change.

This impulse paper is intended as "Food for Thought" for a discussion on the topic of agroforestry as a new approach for organic farming in temperate regions. Its genesis is closely related to our project "SENSE -Synergies in integrated systems: Improving resource use efficiency while mitigating GHG emissions through well-informed decisions about circularity". In the frame work of SENSE partners from Argentina, Uruguay, Brazil, the United Kingdom, Italy, The Netherlands and Germany measure, model and analyse the impact of different management measures in agroforestry systems (silvoarable, silvopastoral, agrosilvopastoral) and assess their impact on different aspects of sustainability in a participatory approach together with organic pioneer farmers.

Organic agroforestry systems in temperate European regions

Currently, it's mainly pioneer farmers who implement modern organic agroforestry systems in temperate regions. Currently, most of the available information on organic agroforestry systems is anecdotal and case study based. As these systems are not wide spread, data on the type of systems (silvoarable, silvopastoral or agrosilvopastoral), their impact on ecosystem services and their economic feasibility is not available. Little is known about the benefits and constraints and about the motives for the implementation of organic agroforestry systems by the pioneer farmers. For conventional agroforestry systems in temperate regions, a considerable amount of scientific literature exists. Basically, deductions can be made from such data sets for organic agroforestry systems, however, organic farming methods often differ from conventional methods (e.g. in plant protection or variety selection), therefore, results from conventional system cannot necessarily be transferred.

Generally, silvopastoral systems seem to be more widespread in organic farming in Europe than silvoarable systems. They include pastures for ruminants with tree strips or individual trees (Fig. 1a), but also silvopastoral systems for laying hens that mimic the natural habitat of the hens and improve the use of free range runs (Fig.1b).

Fig. 1a) Dairy cows in a traditional fruit orchard / pasture system (Austria)

Fig. 1b) Laying hens in mobile hen house system with short rotation coppice as structural element in the free range run (Germany)

Very diverse organic agroforestry systems exist in a permaculture context either as so called forest gardens or as tree strips often as an addition to existing annual cropping systems as described for horticultural farms in France by Warlop and Fourrié (2017). Other organic farmers implement tree strips and hedges as agroforestry elements, mainly for protection from wind and water erosion. Due to the fact that agroforestry was included very late in the funding schemes of the CAP, organic forestry systems on pioneer farms appear to be rather established rather recent with a few exceptions. That means it is difficult to assess their long-term effects and the temporal development of yield levels of different crops, crop-animal interactions and the long-term economic performance of the systems. In addition, it is difficult to assess if organic agroforestry really makes organic farming more climate-smart and diverse as the pioneers often claim. System approaches are needed for a scientific assessment agroforestry, which induce a specific challenge in the funding system: Agroforestry research needs a long-term perspective, which is often difficult to realise in the current research system. Fortunately, pioneer farms exist whom may join research projects in living lab approaches in a co-creation of research questions and research design as shown by Caccia et al. (2021).

Climate smart organic farming with agroforestry in Europe?

Agroforestry shows several benefits for mitigation of and adaption to climate change. As climate change starts to affect European agriculture, conventional and organic farmers face new challenges. On the one hand, droughts and heat waves as in 2018 and 2022 will occur more often and on the other hand, extreme rain events become more frequent and winter rain will increase in some regions, too, as in line with the models of climate change research (Kovats et al. 2014). Organic farmers therefore try to diversify their cropping pattern, adapt animal husbandry to a changing climate and search for methods to increase the water storage capacity of soils. In addition, in line with organic farming principles, many farmers want to adapt methods that mitigate greenhouse gas emissions.

Agroforestry could be viable tool to make organic farming climate-smarter:

GHG mitigation:

- Storage of carbon in the tree biomass, using the wood for long-lasting products
- Increased carbon sequestration
- Provision of renewable energy on-farm, reduction of the use of fossil fuels

Climate change adaption:

- Increased resilience of the farming system by diversification
- Higher resilience of the system in case of early drought periods
- Reduction of light intensity
- Reduction of wind and water erosion
- Lower air and soil temperatures
- Improved product quality

In addition, agroforestry may have other benefits that are in line with the IFOAM Principles of Organic Farming:

- Farming systems that come closer to the natural ecosystems of the locations, increased biodiversity
- Better integration of livestock and cropping systems
- Increase animal welfare in organic animal husbandry (protection from excessive sunlight, tree fodder with medicinal properties, closer to the natural habitat of some domestic animal species)
- Increased use of functional biodiversity for improved plant health and pollination
- Increased soil health
- Improved nutrient cycling
- Options to transform the food system (self-harvest, additional regional produce)
- However, many open questions remain:
- Are organic agroforestry systems in temperate regions really more resilient and adaptable to a changing climate than annual cropping systems?
- Nature protection in temperate regions will prohibit agroforestry in certain agroecosystems – where are the conflicts between the different management practices?
- Are organic agroforestry systems in temperate regions productive enough considering the ongoing yield gap debate?
- How about the economic feasibility in the short- and long-term?
- How about the impacts of agroforestry on the microclimate on plant health? Do the benefits override the disadvantages?
- If animal ruminant keeping has to be reduced to mitigate GHG emissions: Are silvopastoral systems that mostly focus on ruminants still a viable an option for organic agroforestry?

- Are organic silvoarable systems in temperate regions as labour and resource efficient as agroforestry systems in the tropics?
- How to deal with the high amount of hand labour in diverse organic agroforestry systems in developed countries with high wages?
- How to develop value chains for agroforestry products (wild berries, nuts etc.) that have not been marketed so far?
- Legal and political issues concerning funding, tenancy agreements etc.?
- How to create the networks that provide the knowledge on how to implement the systems?

Conclusions

Agroforestry has the potential to make organic agriculture in temperate regions climate smarter, but currently, scientific data is missing and many open questions remain. Pioneer farmers who already established organic agroforestry systems could be excellent partners for co-designing research approaches to fill this gap including social and ethical aspects of system redesign. In addition, as copious practical experience as well as scientific knowledge on organic agroforestry exists in many other countries, the establishment of networks for knowledge exchange between different actors can contribute to the development of organic agroforestry in Europe.

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Climate friendly organic livestock farming by diversified farming communities in India:The way forward

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Key words: Organic livestock farming, farming communities, collective action, interventions

Abstract

Livestock farming and climate change has strong linkage since both impact each other. Animals are blamed for adversely impacting environment and climate while climate change has bearing on animal production. With suitable interventions, animal production can be made climate friendly and organic farming with its well conceived principles can play significant positive role in making climate harmonious animal production. This paper explains how this positive relationship between animal production and climate can be achieved by making suitable interventions.

Introduction

Agriculture is highly dependent on climate conditions and is therefore subject to change and variability, with obvious impacts on food security.Climate change holds the potential to alter agro-ecosystems which pose new challenges to farmers. Climate change threatens livestock production because of its impact on various livestock management resources including loss of biodiversity. At the same time, livestock sector is blamed for its contribution of 14.5% of the global green house gas emissions driving further climate change. Good agricultural management practices can compensate for most of the sector GHG emissions, while providing food and livelihoods. Farms need to be self resilient i.e. the farm's dependence on its own resources instead of external inputs and the farmers' ability to experiment with different practices and learn what works best. Farming communities as a whole need to put increased efforts towards adaptation to the changing climatic conditions through enhancing farm resilience to handle new challenges.

Adaptation in agriculture is certainly not new, as changing weather has always concerned farmers to develop ways to respond over the years, and the phenomenon of global climate change is not an exception. Farmers in developing countries especially the tribal communities and small holders in India can rely to the greatest extent possible on resources available within their communities and on their farms. The traditional farming systems among the local and indigenous communities of farmers in India may stand chances of better adaptation to mitigate climate change, if their age old farming practices can be incorporated in the innovative farming concepts like organic agriculture through proper validation. Organic agriculture principles and practices blended with farmers' traditional knowledge of ecological processes, offers farmers in developing countries many accessible and affordable opportunities to strengthen their farms' resilience.

Results

Organic agriculture might be an effective tool to mitigate climate change!

As per the Codex Alimentarius Commission, organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem's health taking into account that regional conditions require locally adapted systems. Though climate change adaptation is not one of the primary goals of organic agriculture, its systemic ecological approach, emphasis on biodiversity for integration of nutrients among various components of ecosystem, indicates well its possible role to play in climate change adaptation and mitigation. Moreover, the four principles of organic agriculture contributes to the

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long term health of the farm and have a strong potential for building resilient food systems and offers alternatives to energy-intensive production inputs.

There is need of collective action in climate change adaptation and mitigation for effective technology transfer in agriculture and natural resource management among small holders and resource dependent communities.Farming communities as a whole need to put increased efforts towards adaptation to the changing climatic conditions through enhancing farm resilience where farmers' knowledge and skills play an important role. Farmers have the unique capacity to observe conditions and develop responses to new challenges yet their skills need to be refined. Farmers can do much more to base their practices in ecology and interface between techniques of organic agriculture and farmers' indigenous knowledge may offer a fertile ground in mitigating climate change apart from improvement in local agriculture productivity. Many indigenous farming practices are based on ecology, and combining the best of traditional knowledge with support from ecological science offers farmers in developing countries an opportunity for success in minimizing the vulnerable effects of climate change.

Need of interventions at various levels to tackle the challenges of climate change

i. India endowed with rich resources of indigenous potential livestock breeds and diversified species and with strong heritage of animal health management systems can contribute to the development of climate friendly organic livestock production systems.
ii. ii.To make effective use of farmers' traditional wisdom on animal health management, there is need of capacity building of various stakeholders for identifying local and regional agro-ecological practices followed by various farming communities for scientific validation and wide propagation of the same for better adoption in a systematic way.
iii. iii.Standardization and popularisation of less energy consuming practices through focus on region specific practices is also helpful.
iv. iv.Development of package of practices for diversified livestock and poultry species and popularisation of integrated crop-livestock systems through suitable dissemination systems among the farming communities for effective adoption by farmers.
v. iv.Identification and popularisation of region specific crop and livestock varieties which are well adapted to local environment.
vi. v.Development of efficient low cost livestock manure management practices as a mitigating effort. The old practices of using straw as bedding, as well as innovative designs to separate the dung from the urine, is getting some renewed attention in livestock farming, because when separated, greenhouse gas emissions can be reduced by up to 75% (Paul 2022).Bedding with crop residues such as wheat and rice straw may provide substantial benefits.
vii. vi.Encouraging farmers to go for cultivation of fodder trees thereby reduced dependency on pastures for reduction in emission of GHG.
viii. vii.Diversification and sustainable intensification of production systems, developing integration of crop and livestock production for harmonious balance, which is one of the principles of IFOAM too.
ix. viii.Livestock breeding plan has to be revisited and a suitable breeding plan has to be put in place especially for countries like India with largest number of livestock. Efforts are required to reduce the number of unproductive animals through adoption of breeding practices like Sex Sorted Semen Technology could be one viable option.
x. ix.The farmer participatory research may help in developing techniques and practices to meet climate change challenges. Promotion of proven and successful practices developed by farmers and empowering tribal communities for effective communication and integration in promotion of agro-ecological practices may be useful.
xi. x. Involving farming families’ in large scale training and orientation on climate friendly livestock production practices could be helpful at the farmers’ level. Moreover, imparting training in organic production systems, certification standards and marketing organic livestock products on price premiums may further encourage farmers to go for climate friedly organic livestock production.
xii. xi.Research and development agencies need to engage more in organic livestock production and processing to empower farming communities with tools and techniques to manage climate

change sustainably, since the need of capacity building of scientists, extension workers and trainers at various levels is arising, apart from strengthening of farmers.

Discussion

The livestock sector is considered to be the major contributor for climate change by emission of green house gases but can also deliver a significant share of the necessary mitigation effort (Gerber *et al*. 2013). Possible interventions to reduce emissions from animals are to a large extent based on technologies and practices that improve production efficiency at animal and herd levels. Climate change adaptation, mitigation practices, and policy frameworks are critical to protect livestock production. Besides, better management of grazing lands have potential to improve productivity and create carbon sinks with the possibility to help offset livestock sector emissions.

Livestock greenhouse gas emissions can be reduced by following 4 approaches, viz. husbandry (animal breeding, feed supplements, improved pastures), management systems (stocking rates, biological control), numbers of livestock and manure management. Research and Development efforts are needed for increasing the supply of new and improved mitigation technologies/practices.

The local breeds in India are well adapted to local situations doing well under limited feed and fodder availability, sustain well on crop residues, grazing on harvested field etc. But, these native breeds must produce more, for which research is required along different dimensions of animal production including nutritive feed and fodder. Dietary supplements and feed alternatives can be evaluated to assess whether they can reduce methane emissions from livestock. There are approved methodologies now available for using dietary supplements to reduce greenhouse gas emissions from dairy cows and cattle.

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Is it possible to construct a sustainable agrifood system as a resilience strategy to climate change?

MARIA CLAUDIA DUSSI [1]

Key words: agroecology, sustainability, organic, food system

Abstract

Local, national and global Agrifood systems have and will have in the future increasingly complex challenges such as adapting to and mitigating climate change, conserving natural resources, reducing food losses, providing enough nutritious food for a continuously growing world population, increasing healthy diets, and end social injustice and cultural erosion. The new paradigm to feed the world requires an agroecological approach based on the right to food of all people and the vindication of the social function of the land. Agroecology is conceived as a holistic model of global change that includes technical, social, organizational and political dimensions. Sustainable agroecological transformation refers to multidimensional and fundamental transformational processes through which the established sociotechnical systems shift to more sustainable production and consumption systems, which also involves changes in consumption practices, policies, cultural meanings, infrastructure and business models. The transformative process of the entire food system, include its perspectives on equity, justice, and access and implies the redesign of the food system and the integration of both horizontal and vertical diversification of production systems within sustainable food systems. This implies that the ways of studying, designing and evaluating agroecosystems will need to change considering aspects such as footprint/biocapacity, carbon and water footprinting, agroecosystem diversity and technology, energy efficiency, multifunctionality of agroecosystems, ecological economics, human values (commitment, ethics, dignity and respect), social organization, environmental costs, food sovereignty, among others. In summary, rethink the sense of development.

Introduction

Land use patterns in general reveal the importance of agriculture as a major land management system transforming and making use of natural ecosystems. More than half of the earth's land surface is intensively used for agricultural purposes such as cultivation, grazing, plantation forestry and aquaculture; and since 1950 one third of the soil has been profoundly altered from its natural ecosystem state because of moderate to severe soil degradation (IAASTD, 2009).

Local, national and global Agrifood systems have and will have in the future increasingly complex challenges such as adapting to and mitigating climate change, conserving natural resources, reducing food losses, providing enough nutritious food for a continuously growing world population, increasing healthy diets, and end social injustice and cultural erosion.

The challenges related of hunger eradication will vary in different countries in 2030, the average global availability of food per person will grow 4% reaching a little more than 3,025 kcal/day (OECD/FAO, 2021). Although this global average will be highly inequitable, consumers in middle-income countries will increase their food intake significantly, while the diet in low-income countries will remain about the same. In sub-Saharan Africa, where 224.3 million people were undernourished in 2017-2019, per capita daily caloric availability is projected to increase by only 2.5% over the next decade, to 2,500 kcal in 2030 (OECD/FAO, 2021). Over the next decade, world agricultural production is projected to increase by 1.4% per year, with the additional amount coming mostly from emerging economies and low-income countries.

The OECD/FAO report (2021) forecasts that global GHG emissions from agriculture will increase by 4% over the next 10 years, with livestock accounting for more than 80% of this increase. Therefore, the

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agricultural sector will be required to adopt additional policy measures to contribute effectively to the global reduction of GHG emissions.

The characteristics of the agriculture of the future will take into account: Oil-independent agricultural models, agroecosystems with low environmental impact that are resilient to climate change, multifunctional agriculture (economic, social and environmental services) and local food systems, among other aspects.

Demand of consumers for organic products is increasing in the world, more farmers grow organically, more land is certified organic, and 186 countries report organic farming activities. Globally, 1.5% of the farmland is organic. The countries with the most organic agricultural land are Australia (35.7 million hectares), Argentina (3.6 million hectares), and China (3.1 million hectares) (Willer et al., 2020). The ten countries with the largest organic agricultural areas represent 74% of the world's organic agricultural land (Dussi, 2018). World organic food market reached more than 95 billion euros in 2018. The United States is the leading market with 40.6 billion euros, followed by Germany (10.9 billion euros) and France (9.1 billion euros) (Willer et al., 2020).

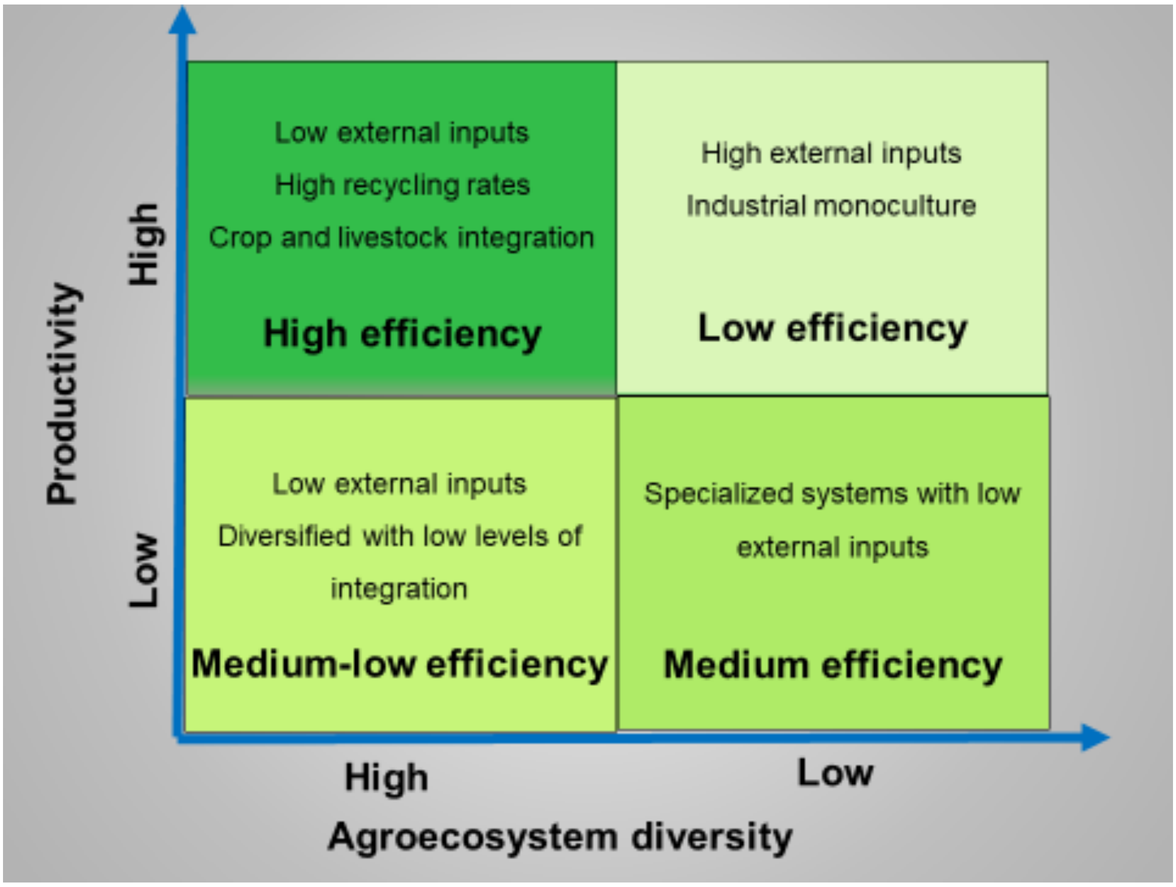

Figure 1. Characteristics of the agroecosystems of the future: productivity, diversity, integration and efficiency. Modified from Altieri et al. (2012).

Organic food production allows rural workers to work in a healthy environment and consumers to eat food with no chemical residues. It can also be observed that organic or ecological agriculture that maintains monocultures depends on external biological and/or botanical inputs, which substitute to chemical inputs. "Input substitution" is not based on agroecological principles; it essentially follows the same paradigm as conventional agriculture, i.e. overcoming the limiting factor, but this time with biological or organic inputs. Many of these "alternative inputs" have become commodified, therefore, farmers continue to depend on suppliers, cooperatives or companies (Altieri & Toledo, 2010). According to FiBL, world's smallholders organic producers are in low and middle-income countries, for whom individual organic certification would be unaffordable and administratively too complex to manage (Willer et al., 2020).

The ETC group (2017) calculates that smallholder farmers in the world (peasant food network), which make up 80% of the total farm numbers, produce using agroecological methods 70% of the food available for human consumption (measured in calories and weight) and use less than 25% of the world's agricultural land. In turn, they use approximately 10% of the fossil energy and no more than 20% of the water that all agricultural production demands.

In contrast, the agribusiness chain uses more than 75% of the world's agricultural land, provides food for only 30% of the world's population, and is responsible for the consumption of almost 90% of the fossil fuels used in agriculture (and consequently the corresponding emissions of greenhouse gases), as well as at least 80% of the fresh water (ETC, 2017).

The new paradigm to feed the world requires an agroecological approach based on the right to food of all people and the vindication of the social function of the land. The conversion of a specialized agricultural system to an agroecological system follows three principles: diversification (by including different species of crops, trees and animals), integration (by the dynamic exchange and recycling of energy and nutrients between the components of the system) and the achievement of food self-sufficiency. It is not just about replacing industrial inputs with others with low environmental impact, it is about reducing the amount of inputs used per product obtained (Figure 1).

Sustainable transformation of the agrifood system. A perspective

Sustainable agroecological transformation refers to multidimensional and fundamental transformational processes through which the established sociotechnical systems shift to sustainable production and consumption systems, which also involves changes in consumption practices, policies, cultural meanings, infrastructure and business models

Agroecology is a scientific discipline that involves the holistic study of agroecosystems and food systems; a set of principles and practices that improves the resilience and durability of food and agricultural systems while preserving social integrity; and a socio-political movement, which focuses on the practical application of agroecology, pursues new ways of considering agriculture, food processing, distribution and consumption, and its relationships with society and nature (Wezel et al., 2009; Cidse, 2018)

There is an interdependence of agroecology and food sovereignty. The declaration of food sovereignty made in the International forum for agroecology at Nyéléni, Mali in 2015 defines agroecology as a movement led by people, and a practice that needs to be supported, rather than directed, by science and policy.

Agroecology is conceived as a holistic model of global change that includes technical, social, organizational and political dimensions. It´s principles are a set of general guidelines that constitute the fundamental pillars of agroecology, its practice and implementation. They are encompassed in four dimensions (CIDSE, 2018):

The first one is the <u>*Environmental dimension of agroecology*</u> with the following principles:

> Agroecology enhances positive interaction, synergy, integration, and complementarities between the components of agroecosystems (plants, animals, trees, soil, water, etc.) and food systems; - Increases biomass recycling, optimizing organic matter decomposition and nutrient cycling over time and promotes the biological functioning of the soil; - Optimizes and maintains biodiversity above and below ground (a wide range of species and varieties, genetic resources, locally-adapted varieties/breeds, etc.) over time and space (at plot, farm and landscape level); - Eliminates the use of and dependency on external synthetic inputs by enabling farmers to control pests, weeds and improve fertility through ecological management; - Supports climate adaptation and resilience while contributing to greenhouse gas emission mitigation (reduction and sequestration) through lower use of fossil fuels and higher carbon sequestration in soils.

The second is <u>*The social and cultural dimension of agroecology*</u> with the following principles:

> Agroecology is rooted in the culture, identity, tradition, innovation and knowledge of local communities; -Contributes to healthy, diversified, seasonally and culturally appropriate diets; - Is knowledge-intensive and promotes horizontal (farmer-to-farmer) contacts for sharing of knowledge, skills, and innovations, together with alliances giving equal weight to farmer and researcher; - Creates opportunities for and promotion of solidarity and discussion between and among culturally diverse peoples (e.g. different ethnic groups that share the same values yet have different practices) and between rural and urban populations; - Respects diversity between people in terms of gender, race, sexual orientation and religion, creates opportunities for young people and women and encourages women's leadership and gender equality; - Supports peoples and communities in maintaining their spiritual and material relationship with their land and environment; - Agorecology does not necessarily require expensive external certification as it often relies on producer-consumer relations and transactions based on trust, promoting alternatives to certification such as PGS (Participatory Guarantee System) and CSA (Community-Supported Agriculture).

The third one is *The economic dimension of agroecology* with the following principles:

> Agroecology promotes fair, short distribution networks rather than linear distribution chains and builds a transparent network of relationships (often invisible in formal economy) between producers and consumers; - Helps provide livelihoods for peasant families and contributes to create stronger local markets, economies and employment; - Agroecology is built on a vision of a social and solidarity economy; - Promotes diversification of on-farm incomes giving farmers greater financial independence, increases resilience by multiplying sources of production and livelihood, promoting independence from external inputs and reducing crop failure through its diversified system; - Encourages food producers to sell their product at fair prices and actively respond to the demand of nearby markets; -Increases community autonomy by enhancing livelihoods and dignity.

The forth one is *The political dimension of agroecology* with the following principles:

> Agroecology prioritizes the needs and interests of small-scale food producers who supply most of the majority of the world's food (ETC, 2017); - Establishes control of seed, biodiversity, land and territories, water, knowledge and the commons into the hands of the people who are part of the food system and so achieves better-integrated resource management; - Requires a set of supportive, complementary public policies, supportive policymakers and institutions, and public investment to achieve its full potential; - Encourages forms of social organization needed for local adaptive management of food and agricultural systems and decision-making. It also incentivizes the self-organization and collective management of groups and networks at different levels, from local to global (farmer's organizations, consumers, research organizations, academic institutions, etc.).

Scales and dimensions of agroecological research range from plot and field scale to agroecosystem and farm scales, and expand into the full dimensions of the food system. "Massification", "scaling", expansion", "amplification" or "territorialization" of agroecology is defined as the process that leads an increasing number of families to practice agroecology in increasingly larger territories, and that involves more people in the processing, distribution and consumption of agroecologically produced food. Scaling means that a greater fraction of the population, both urban and rural, can produce and access healthy, nutritious, diverse food that is environmentally compatible and culturally appropriate (Mier et al., 2018).

A study group on the massification of agroecology, analyzing emblematic cases of its expansion worldwide, identify eight key drivers of the process of taking agroecology to scale: (1) recognition of a crisis that motivates the search for alternatives, (2) social organization, (3) constructivist learning processes, (4) effective agroecological practices, (5) mobilizing discourses, (6) external allies, (7) favorable markets, and (8) favorable policies (Mier et al., 2018). A more detailed understanding is needed on how these multiple dimensions interact with, reinforce, and generate positive feedback with each other to make the territorial expansion of agroecology possible.

The transformative process of the entire food system, include its perspectives on equity, justice, and access and implies the redesign of the food system and the integration of both horizontal and vertical diversification of production systems within sustainable food systems (Gliessman 2014).

Climate change is pushing the transformation of agroecosystems towards multifunctional systems. This implies that the ways of studying and evaluating agroecosystems will need to have another form of assessment that includes indicators like footprint/biocapacity, carbon and water footprinting, agroecosystem diversity and technology, energy efficiency, multifunctionality of agroecosystems, ecological economics, human values (commitment, ethics, dignity and respect), social organization, environmental costs, food sovereignty, among others, and, in summary rethink the sense of development. For example, Dussi et al. (2020) determined that, in the production area of North Patagonia, Argentina, organic and agroecological apple orchards are more efficient than conventional ones, requiring half the energy to obtain the same unit of product.

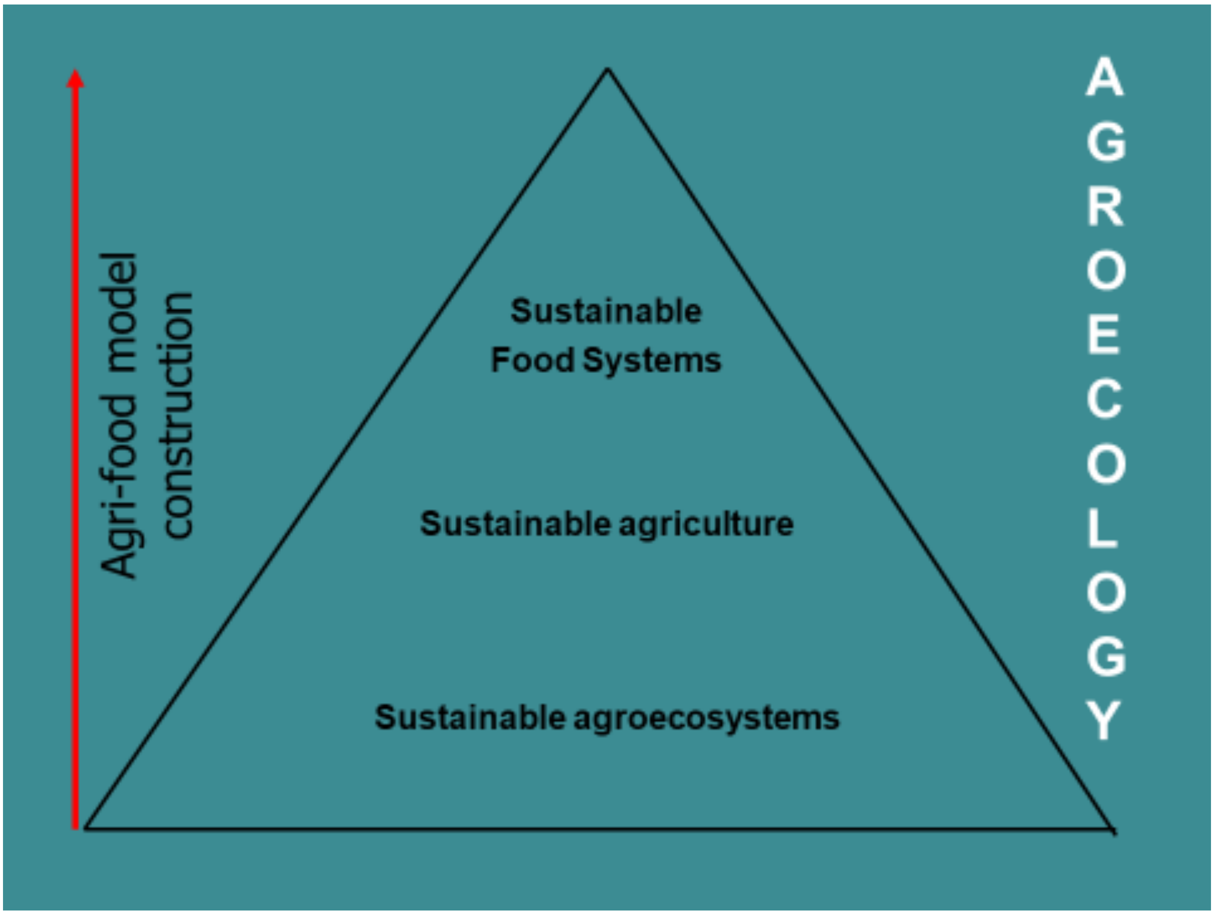

Figure 2. Complexity of the agri-food model construction. (Dussi, 2019)

Agroecological transformation is a gradual process of co-innovation for biological input integration, adjustments and technological changes in the design and management of agroecosystems, which leads to leaving behind the conventional focus on agricultural production. The transformation of conventional production systems towards agroecological-based systems includes not only technical, productive and ecological elements, but also sociocultural and economic aspects of farmers, their families and their community (Caporal and Costabeber 2004), which goes much further beyond the transformation of the production system from conventional to agroecological: it goes through achieving internal capacities, recovering and conserving natural resources, improving the quality of habitat for productive species and workers, and being efficient in the productive, economic, ecological and social order (Vázquez and Martínez 2015). It also involves changes in consumption practices, policies, cultural meanings, infrastructures and business models.

According to Gliessman (2016), the transformational process involves 5 levels Level 1: Increase the efficiency of industrial and conventional practices in order to reduce the use and consumption of costly, scarce, or environmentally damaging inputs. Level 2: Substitute conventional inputs and practices with agroecological alternatives. Level 3. Redesign agroecosystems so that it functions on the basis of a new set of ecological processes. Level 4. Re-connect producers and consumer's thought the development of alternative food networks. Level 5. Construct a new global food system, based on equity, participation, democracy, and justice. Whereas levels 1 and 2 are incremental, levels 3 to 5 are transformational.

For the construction of a sustainable agri-food model (Figure 2) analysis can be carried out starting at the farm level towards sustainable food systems where agroecology is the discipline that generate knowledge, validate and apply adequate strategies to design, manage and evaluate sustainable agroecosystems and pursue this construction over time (Dussi, 2019).

The agroecological transformation focuses on moving from a technological model of conventional agriculture to a sustainable one, which scales from the fields and productive units, the production system and the agricultural landscape to the territory, through multisector transformations that consolidate territorial food systems.

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Workshop 4: How can research help to make Organic more productive?

Acronym: Productivity

Moderator: Dr. Daniel Neuhoff (Germany) and Dr. Amber Sciligo (USA)
Rapporteur: Dr. Jochen Mayer (Switzerland)
Date: Oct 2nd, 2022

Oct 2nd, 2022	**Impuls presentations by:**
09:00 – 12:00	Off-Campus excursion
14:00 – 16:00	**Session 1:** • Daniel Neuhoff (Germany) • Jonas Hett (Germany) • Shanti Kumar Sharma (India) • Paolo Barberi (Italy) (online)
16:00 – 18:00	**Session 2:** • Jochen Mayer (Switzerland) • Amber Sciligo (USA) • Megan Shipanski (USA) • Khaoula Mokrani (Tunisia)

The future challenge will be to reduce the yield gap between organic and conventional systems by a substantial yield increase in organic systems without trade-offs between productivity and sustainability of agricultural management. The main drivers are an improvement of nitrogen availability and a synchronisation between supply and crop demand. Further improvements in weed control by new technologies and crop protection by cultivars that are more resistant or by crop diversification will be a key measure of future management. Does increased productivity in Organic Agriculture necessarily mean lower ecological services?

In response to continual population growth, food production must keep pace not only by increasing efficiency, but by simultaneously increasing environmental sustainability, while securing future generations of farming families. Organic farming offers a viable solution to meet these needs by producing food in ways that reduces climate impacts and chemical pollution of food growing regions and farming communities. But despite the increase in demand, the organic system continues to face a variety of challenges that constrain its growth. To meet goals to improve organic yields, research addressing climate change mitigation as well as adaption to climate change is critical. The development of equitable, accessible agricultural technology developed with organic needs in mind will also be key to tackling challenges association with weeds, pests, soil fertility and water management, as well as delivering food from the farm to the table. While many organic research gaps have been identified, a collective mapping of the greatest needs from around the world will identify the research most critical for organic to fulfill its potential.

The aim of the workshop is to discuss options for improving productivity in organic farming systems without significantly affecting ecosystem services.

Suitability of mixed farming systems for land poor regions

DANIEL NEUHOFF[1]

Key words: organic farming, soil fertility, agricultural land, arable land per capita

Abstract

The development of organic farming (OF) is very different in the world. While countries such as Austria have more than 20% of organic land, in countries such as Bangladesh or the Republic of Korea the share is low. Here we argue that the availability of agricultural land per capita is both, an economic and agronomic factor limiting the conversion to OF. In the countries concerned future farming needs sustainable management options beyond OF, including key elements of OF such as diversification and biological pest control.

Introduction

On a regional scale the development of Organic Farming (OF) has been impressive during the last decade. However, globally the share of organically managed land still remains low with less than 2% of the agricultural land. Here we try to analyse the situation of OF in selected countries with variable shares of available farmland per capita such as the Republic of Korea (ROK) and discuss options for further development.

Key drivers for successful development of OF

Important drivers for OF are growing markets resulting from increased consumer demand for certified organic products, ready to pay premium prices. This is in particular the case in high income countries with consumers sensitive to environmental issues (see list of countries with high share of OF in Willer et al. 2022.) Conversion to and maintenance of OF can additionally be promoted by policy either by direct subsidies to farmers or by giving infrastructural support, in particular training and extension services (Sapbamrer & Thammachai, 2021).

Key players in the organic sector are farmers, ready and able to produce the certified organic quality.

Successful organic management requires a proactive behaviour on the part of the farmers, combined with a mentality that is not purely economically oriented. For this reason, the principles of OF were included in the 2007 revision of the EU regulations on OF. These principles should result in multifunctional farming systems that demand a high degree of commitment, responsibility and know-how from the farmers involved. The level of training of organic farmers is often correspondingly high.

In a given region socio-economic constraints may limit the growth of OF. Important drivers include market dynamics mainly as a function of consumer demand and profitability for farmers, the latter strongly depending on prices and subsidies. However, agronomic factors strongly affect the development of OF as well, due to bio-physical constraints as imposed by the system approach of OF. Soil fertility building in farming systems, which do not use synthetic mineral fertilisers, either depend on the use of fertility building crops such as grass-clover ley, or need to import soil fertility via farm yard manure. The latter, however, is not possible on a larger scale. For sustainable management of organic land it is important to have soil fertility building crops such as grass-clover ley on arable land (Watson et al. 2002) to keep soil nitrogen balance in equilibrium (Döring & Neuhoff, 2021). In addition to nitrogen and carbon input, grass-clover leys help to control weeds and erosion, provide high value fodder for ruminants. These leys, however, are often not profitable, in particular if pressure on land use

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for income generation is high. In particular in Asia, rice farmers often only dispose of little amounts of arable land.

The case of the Republic of Korea (ROK)

In 2019, the total arable land area (without permanent crops) was about 1 581, 000 ha. Permanent grassland does not play a role in ROK only covering some 56.000 ha, which is less than 4% of the agricultural land (Tab. 1). The major crop grown in ROK is rice covering some 726,000 ha (45.9%) of land requiring nitrogen fertilizers for a yield level > 6 t ha^{-1}. Legume growing, which is essential for OA does not play a relevant role in Korea except soybean, which covers some 55,000 ha (3.5%).

Organic rice farmers in Korea do not grow clover grass. They import soil fertility in the form of manure. By not using mineral fertilisers and chemically synthetic pesticides, they produce a special quality.

From a nutrient balance perspective, however, this is only possible because they import nutrients from outside of the system. The manure used usually comes from conventional farms, often produced with imported feed. Under these conditions, a significant expansion of OF cannot to be expected.

What is the development potential of certified organic agriculture under these conditions? Here, a distinction must be made between basic foodstuffs, i.e. calorie supply, and fruit and vegetable production. For the latter, organic production methods are particularly suitable, since quality aspects are of great importance due to the fresh consumption. Due to the small amount of land required, an expansion of organic cultivation of these crops is agronomically possible, probably linked with a decrease of yields. The actual development depends on the demand for organic fruits and vegetables as well as on the willingness and ability of farmers to produce appropriate qualities. The greening of Korean agriculture could also be incorporated into conventional practice to a certain extent by integrating core elements of organic production such as diversified crop rotations, mixed cropping, the use of biological pest control and mechanical weed control. However, the basic problem of a comparatively one-sided land use with rice can only be solved to a limited extent with these measures.

Bangladesh is a land poor country as well with only 2.249 ha of organic land, corresponding to a share of less than 0.0% of the total agricultural land. Due to double cropping the harvested area of rice (11.4 x 10^6 ha) is bigger than the size of arable land (FAO Stat 2022). In addition to high pressure to produce food for more than 165 x 10^6 people the purchasing power other than in ROK is low. To save energy and to green agriculture, the systematic use of Azolla water fern might be considered or using renewable mineral nitrogen (see Hett and Neuhoff in this volume).

In India agronomic conditions for OF are favourable due to mixed farming with cow manure production (see Sharma et al in this volume), but population pressure is high and average purchasing power is low. However, there is a growing middle class demanding higher standards for food quality.

In Tanzania, the share of organic land is low with 0.5% (Tab. 1) and organic production is mainly for export of tropical commodities. A more systematic land use with organic management practices would basically be possible from an agronomic point of view, in particular by using green and animal manure if available (Kwesiga et al. 2020). Socio-economic constraints, however, are strong and include various aspects such as missing markets and the weak economic situation of the farmers.

Table 1: Allocation of agricultural land to different purposes of use in selected countries. Based on FAO – Statistical Yearbook 2021 and *Willer et al. 2022

Country	Cropland	Grassland	Total agric. land	Share of Cropland	Cropland per capita	Organic agri-cultural land *	Share of Organic *
Unit	10^6 ha	10^6 ha	10^6 ha	%	ha	10^3 ha	%

Rep. of Korea	1.581	0.056	1.637	96,6	0.03	38.540	2.3
India	169.317	10.261	179.578	94,3	0.12	2,657	1.5
Germany	11.913	4.751	16.664	71,5	0.14	1,702	10.2
Rep. of Tanzania	15.650	24.000	39.650	39,5	0.24	198.226	0.5
Bangladesh	8.797	0.6	9.397	93,6	0.03	2.249	0.0

In Germany, the development of OF has been impressive during the last decade now resulting in a 10% share of the total agricultural land. Both, consumer demand, but also decreasing profitability of conventional farming, at least in less favourable regions and of dairy farms. Here the development mainly depends on an attractive stable premium price level for the farmers. Competitiveness within the EU vis-à-vis Eastern European countries could be promoted through targeted marketing strategies for the regional promotion of OF.

Discussion

It has been shown that the global development of organic agriculture varies greatly. Due to socio-economic and agronomic constraints, a strong expansion of organic agriculture in terms of certified production is unrealistic in many countries. Nevertheless, there is a need for the greening of agriculture, especially in intensive rice-growing regions. Here, diversification approaches such as those common in OF are helpful as a source of ideas. Nevertheless, farmers in the countries concerned cannot be forced into the narrow corset of certified OF if the markets do not develop accordingly.

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New nitrogen sources – Closing nutrient cycles and harnessing renewable energy sources for a sustainable intensification of organic agriculture

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Key words: nitrogen cycle, nitrogen fertiliser, biological N fixation, yield gap, renewable energy

Abstract

Within the 21st century organic agriculture will have to significantly increase its productivity to stay competitive towards conventional agriculture. To adequately meet this challenge, a further intensification of organic farming systems is necessary without loosing its pioneering role in environmental sustainability. Considerable yield reductions in organic agriculture up to 50% or more are frequently caused by an insufficient plant supply with nitrogen (N). To minimise this problem, first and foremost, biological nitrogen fixation (BNF) as the most important N source in organic farming needs to be exploited more efficiently. Second, N losses from the system must be reduced by adequate management practices. Both of these approaches may help to increase crop productivity, but they do not solve the problem of an insufficient N availability in crucial growth stages. To sufficiently match N demands in organic systems throughout the growing period, mineral N added to the crops in terms of 'green' ammonia (NH_3), produced by the use of renewable energy sources could help to overcome the above-mentioned challenges. Clear rules for the production and tight boundaries for a suitable application with limited quantities could provide a sufficient framework for a sustainable application. To maintain the basic principle of organic fertilization, application should not be done substitutive, i.e. in pure forms but only be permitted in terms of N enriched organo-mineral fertilisers like upgraded farmyard manure or compost.

Introduction

The perception of nitrogen (N) in organic cropping systems, being often the most important yield limiting factor in organic agriculture, is ambivalent. Insufficient N supply and availability during yield sensitive developmental stages in combination with the renunciation of pesticides may result in slow growth rates, poor yields with low quality and inadequate protein levels. Depending on the local yield level, N shortage can account for yield differences (gaps) up to approx. 25-50% between organic and conventional yields. Higher yields and yield security in conventional systems usually depend on various agrochemical inputs, including the excessive application of mineral N fertiliser. In contrast, organic systems mainly rely on biological nitrogen fixation (BNF), on-farm produced organic fertilisers, crop rotation, and a further tightening of nutrient cycles to maintain soil fertility and improve crop productivity. Considering that agricultural land is finite and human population still grows fast, further and future yield increases are also mandatory in organic systems. Hence, N management in organic agriculture must be optimised in a sustainable way. This also implies the strict avoidance of potential negative consequences of N fertilisation for the environment like e.g. eutrophication. However, the scope of action for further short-term improvements in N availability based on the measures being currently available in organic agriculture is limited for different multifunctional reasons (e.g. self-compatibility of legumes, competition of human food and animal feed on fields, livestock capacities, and duration of crop breeding programs). Considerable additional improvements due to a higher N supply via BNF, a more pronounced N recovery via minimisation of losses and an enhanced N productivity, as well as an increased N use efficiency via crop breeding can currently not be expected in the near future. Based on these observations, it is necessary to discuss the possibility of yield improvements in organic agriculture through 'eco-innovations'. These innovations could also include a targeted but restricted application of 'green' mineral N fertiliser produced by the use of renewable energy sources like, e.g. wind or solar energy combined with water electrolysis. A conscientious

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application and quantitative restrictions of 'green' mineral N fertilisers thus could help to further close the yield gap between organic and conventional farming without causing further environmental threats.

Optimising nitrogen management in organic farming

Closing the cycle: Maximising nitrogen use efficiency and minimising nitrogen losses

Due to a frequent N shortage and the absence of chemic-synthetic mineral N fertiliser in organic agriculture, it is even more important to achieve a high N use efficiency within and to prevent any N losses from the system. The amount of nitrogen being potentially available for plants in the soil is based on the N turnover in the N cycle (Fig. 1) and can be the determined by the sum of N from (I) precipitation and dry deposition, (II) BNF, (III) farmyard manure, (IV) mineralisation, and (V) mineral fertilization minus N that was already (VI) taken up by plants, (VII) leached into the groundwater as nitrate (NO_3^-), (VIII) passed in gaseous forms (N_2, N_2O, NO, NH_3) into the atmosphere or (IX) flow off during soil erosion and surface runoff (Cameron et al. 2013).

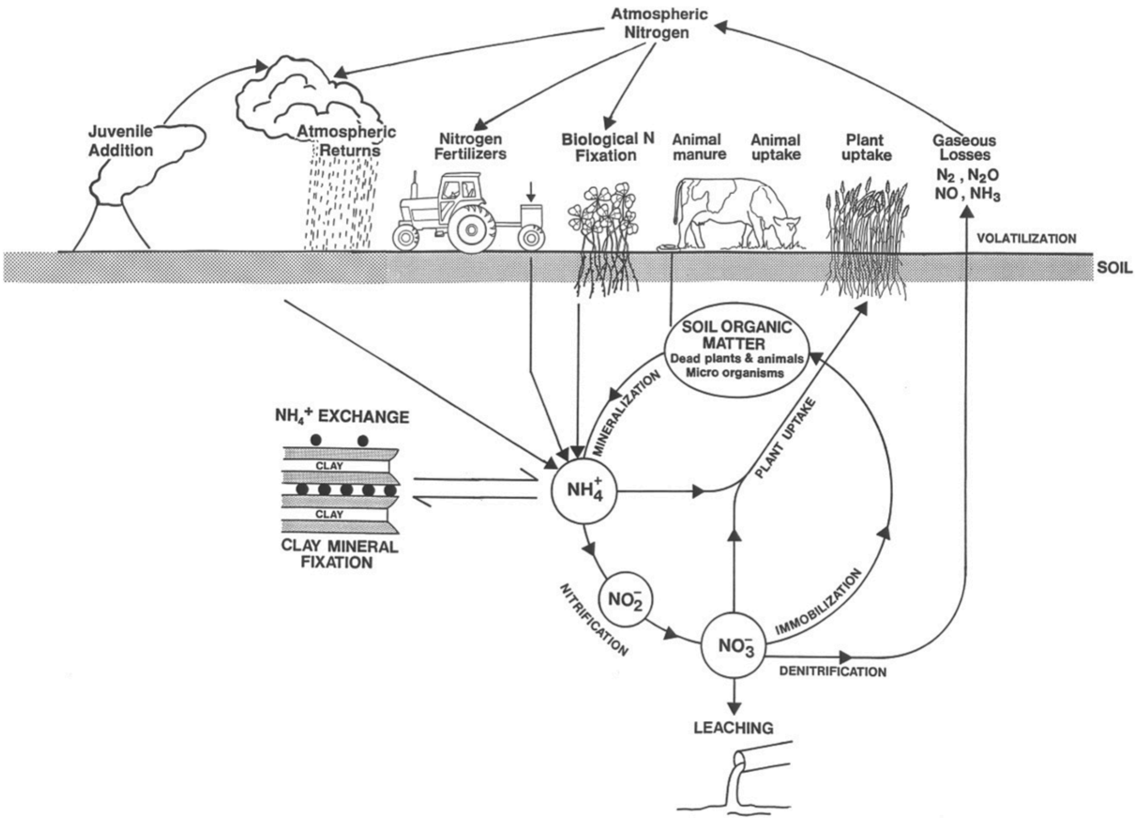

Figure 1. The nitrogen cycle for plant and soil in farming systems (from Cameron et al. 2013).

Deposition from the atmosphere and non-symbiotic N fixation from associative microorganisms as external N sources are usually only of limited importance with contributions of often less than 20 kg N ha^{-1} and yr^{-1} (Kizilkaya 2009, Döring and Neuhoff 2021). Even though crop residues of non-legumes and the application of on-farm produced organic fertilisers (e.g. farmyard manure or slurry) are an integral part of the N cycle, they cannot be seen as a further N input source. Symbiotic BNF by legumes (fodder legumes > grain legumes) is by far the most relevant source to bring additional N into organic cropping systems. The efficacy and efficiency in gaining extra N via BNF in organic agriculture is affected by a plethora of different properties including: (1) the proportion of legumes in the crop rotation, (2) the amount of nitrogen derived from the atmosphere, (3) the dry matter production as a function of the abiotic and biotic growth conditions, (4) the species and variety specific N fixation capacity as well as (5) its intended use (green manure or fodder or cash crop) and thus the amount of shoot and root residues remaining after harvest (Herridge et al. 2008, Döring and Neuhoff 2021). Optimisation of N fixation also depends next to the availability of different nutrients for the nitrogenase-enzyme-complex (especially iron, phosphorus and molybdenum) on the amount of mineral N in the soil being already directly available for plants.

Despite of good agricultural practice, unavoidable N losses are also often present legume-based cropping systems in organic agriculture. Nitrogen losses can occur at different stages of the on-farm N cycle (Fig. 2). Considering an organic mixed farming system with 31.3 ha arable land, 18.2 ha permanent grassland and a suckler cow herd with 1.4 livestock units ha^{-1}, Küstermann et al. (2010) estimated that the total N losses from the system were in sum approx. 52 kg N ha^{-1} and yr^{-1}. Unavoidable, but reduceable N losses can occur throughout fodder conservation (10 kg N ha^{-1} and yr^{-1}), animal housing systems (10 kg N ha^{-1} and yr^{-1}), storage of farmyard manure and slurry (11 kg N ha^{-1} and yr^{-1}) and from the soil in terms of gaseous emissions (NH_3, N_2O and NO_x), denitrification and leaching (9, 3, and 9 kg N ha^{-1} and yr^{-1}). Important agricultural practices to minimise N losses from the system include e.g. targeted crop rotations with legumes and non-legumes, cover crop cultivation, nurse cropping, immediate incorporation of fertiliser in the field, adjusted animal feeding and slurry acidification and purification. Lower absolute N input rates and the rigorous compliance of different strategic agronomic measures to minimise N losses usually lead to considerably lower N surpluses of organic farming systems (3-15 kg N ha^{-1} yr^{-1}) compared to conventional ones (59-68 kg N ha^{-1} yr^{-1}) (Küstermann et al. 2010, Chmelíková et al. 2021). An even-tempered N-balance is a first good indicator for a sustainable N management, since this means that N is not wasted on the farm level. However, the N balance of a system does not provide information about the N use efficiency, since low N surpluses and thus a sufficient N balance can also occur in low productivity systems with a poor N turnover and thus low yields.

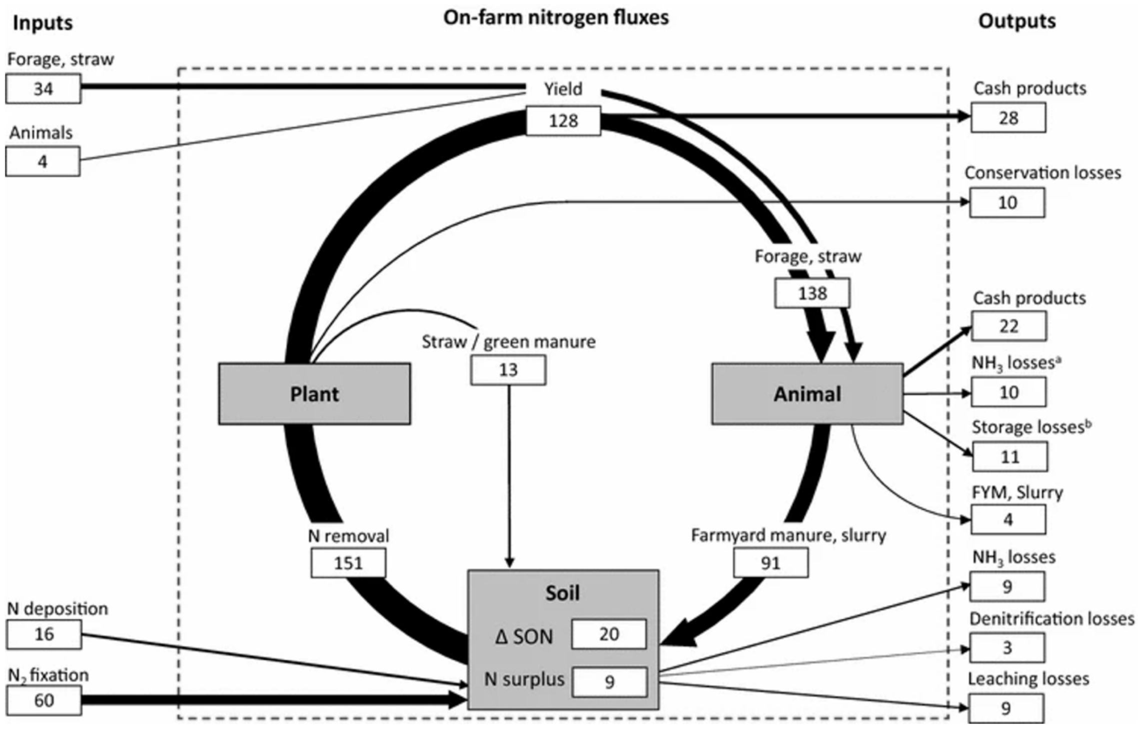

Figure 2. Modelled on-farm nitrogen cycle of an organic mixed farm with 31. 3 ha arable land, 18.2 ha permanent grassland and 1.4 livestock units ha-1 (from Küstermann et al. 2010). Unit: kg N ha-1 yr-1. a) Losses of ammonia in animal housing systems; b) N Losses during storage of slurry and farmyard manure.

Revitalizing 'old' versus tapping 'new' nitrogen (re)sources?

Although being repeatedly discussed due to its excellent ecological assessment, intensifying organic cropping systems and improving N supply by increasing the proportion of grain and fodder legumes is not sufficient in many cases. Different abiotic (e.g. temperature or water and nutrient supply) and biotic (e.g. absence of fitting *Rhizobia* strains or presence of diseases like *Sclerotinia trifoliorum*) constraints, the missing direct usability especially of N efficient fodder legumes for human nutrition and the huge requirement for agricultural land currently limit a further BNF intensification in organic agriculture. Regarding the latter, if it would be hypothetically envisioned to reach mineral N fertilisation levels of conventional farming (~83 Tg N in 2000) in organic systems by the mean of BNF, a total agricultural area of ~0.5 •10^9 ha has to be cultivated using fodder legumes with a minimum BNF capacity of 165 kg N ha^{-1} and yr^{-1} (Herridge et al. 2008). Since the total global area for cropping system is only ~1.5•10^9 ha and following the calculation above, fodder legumes had to be grown on approx. 33% of the arable land to reach the same amount of N input (Döring and Neuhoff 2021). However, land poor farmer, e.g. in the Republic of Korea, often cannot afford to cover a third of their land with fodder legumes. Despite, being neither necessary nor desirable to reach the same absolute amounts of N applied to conventional farming systems, a proportion of 33% legumes would likewise represent the maximum recommended share of legumes in crop rotations due to self-compatibility issues (Döring and Neuhoff 2021).

For these reasons, 'green' ammonia (NH_3) synthesis from renewable energy sources is nowadays discussed as an additional option to bring further N into organic systems. Based on the exotherm reaction of nitrogen and hydrogen gas, ammonia is produced following the equation: $N_2+3H_2 \rightarrow 2NH_3$. While nitrogen purification is due to high amounts of ca. 78% (N_2) in the atmosphere relatively simple and energetically efficient, hydrogen production requires huge amounts of external energy. Currently fossil fuels like natural gas, heavy oil or coal are due to their dominance of the energy system the main energy sources to produce ammonia (Tallaksen et al. 2015). Despite being technically possible, estimations suggest that renewable ammonia production today only accounts for 0.01% of global ammonia production which equals ca. 1.83 Mt NH_3 yr^{-1} (Rouwenhorst et al. 2022). Among other reasons, this is probably mainly due high capital costs per ton NH_3 capacity being ca. 50% higher for 'green' ammonia when compared to conventional one (Tab 1).

Table 1. Key inputs and emissions for conventional (steam methane reforming) and renewable (water electrolysis) production technologies to produce 1 t of ammonia (from Ghavam et al. 2021).

Technology (Haber-Bosch)	Water consumption (kg H_2O/t NH_3)	Greenhouse gas emissions (kg CO_2/t NH_3)	Energy consumption: electricity and heat (kWh/t NH_3)	Efficiency (%)	Capital costs per ton/days NH_3 capacity
Steam methane reforming	ca. 0.656	ca. 1.8	ca. 9,500	~61-66%	500,000
Water electrolysis coupled with solar or wind energy	ca. 1.588	Negligible	ca. 12,000	~54%	750,000

A potential obstacle, often mentioned together with 'green' ammonia production on the basis of wind or solar energy combined with water electrolysis, is the supposed huge demand for water of this process. A total of ca. nine tons of pure water is necessary to produce one-ton of hydrogen. Hence, if the total amount of ammonia produced in 2016 (146 Tg) would have been manufactured using water electrolysis for hydrogen production this would have required a total of ca. 233.6 billion litres of water (Ghavam et al. 2021). However, considering that five million people with an average yearly water consumption of $50m^3$ already use more fresh water than the production of 146 Tg of 'green' ammonia, the necessary water quantities for mineral N fertiliser production through electrolysis seem to be low. Despite, in part, local water scarcity, these amounts should not hamper 'green' ammonia production on a global scale. However, there are further reasons why the organic society has refused mineral N fertiliser in the past. Among them are: (1) potential negative health effects upon nitrate (NO_3^-) leaching into the groundwater or accumulation in vegetables, (2) the environmental damage due to eutrophication of nutrient sensitive ecosystems and uncontrolled NO_x emissions into the atmosphere, and (3) agronomic challenges like e.g. an increased susceptibility of crops for pests and diseases or the promotion of weed growth. Next to the uncontrolled fate of N in sensitive ecosystems, negative impacts for the environment in terms of conventional production processes with 2.16 kg CO_2-eq/kg NH_3 and 30 GJ/t NH_3 (Ghavam et al. 2021) are frequently complained by the organic society.

Discussion

In times of climate change with unpredictable extreme weather events and increasing pressure on land use on a global scale, organic farming, if considered as the future way of agriculture, needs to significantly improve its productivity without compromising its ecological pioneering role. Since crop yields in organic systems are mainly limited by N shortage, it is necessary to access new N sources. Due to several reasons, traditional N sources used in organic farming are not suitable for providing sufficient further N in order to achieve considerable yield improvements and to guarantee yield security. Despite legitimate reluctance against mineral fertiliser, organic agriculture should be open for this option since many points of criticism could be easily eliminated by creating clear boundaries for a regulated use in organic agriculture. Other purchased commercial organic fertilisers based on plant products (e.g. alfalfa with 4% N, cotton-seed meal with 6% N, corn gluten with 9 % N or soybean meal with 7 % N), animal by products (e.g. blood meal with 12% N, guano with 8-12% N, feather meal with 14-16% N or fish meal with 10-14% N) are only of limited importance as their availability is often restricted and not sufficient to meet the needs for further N on a broader scale (Mikkelsen & Hartz 2008). Of course, it is neither desired nor pursued to substitute organic management practices by application of mineral N or to reinforce the division of animal husbandry and crop production. For principle reasons N needs to remain expensive in organic farming. But, low amounts of mineral N applied at critical growth stages could significantly help to increase the productivity in organic farming without endangering conservation objectives. Hence, the necessary restrictions should include definitions for a maximum application amount per ha and year, permit the usage only in combination with organic fertiliser (e.g. N enriched manure or compost) and make sure that the energy and water used for production are from renewable sources and do not compete with other basic human needs. In addition, independent of the origin of potential 'new' nitrogen sources, the synchronisation between the hard to predict mineralisation and release of nutrients from organic fertilisers and the demand of crops is a further problem. However, this issue could be, at least in part, solved by the upgrade of organic fertilisers with 'green' and soluble ammonia, allowing a more predictable plant availability of N.

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Organic farming systems in India: productivity, economics and way forward

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Key Words: Organic farming, productivity, economics, India, strategies

Abstract

Globally, 190 countries are involved in organic farming with 74.9 million hectares land. To promote organic farming, many government schemes were initiated over the years in India and the area under organic farming has increased rapidly from 58000 hectares in 2003–04 to 2.74 million hectares in 2020–21. Of the farmers involved in organic farming globally, 46.76% are from India, yet India's share is only 5.6% to global certified organic land area. Over the years, many technologies have been developed to facilitate organic farming, which have resulted in increase in yield and net returns but still far lower when compared to conventional systems across all crops at different agro-climatic regions. Community or cluster based organic farming, improved technology backup, policy support and price premiums for organic produce are important for further up-scaling organic farming in India.

Introduction

The total area under certified organic agriculture in the world and Asia was 74.9 and 6.1 million hectares, respectively in 2020. There were nearly 3.4 million producers in the world, most of them were in India (1.59 million). The India is one of the leading countries by area in the world (2.7 million hectares) followed by China with over 2.4 million hectares(Willer et al. 2022). In India, the organic sector continues to develop rapidly. Partly due to COVID-19, consumer awareness of safe, local, and organic food sales for organic products increased. India formulated policies and strengthened existing laws to promote development of organic agriculture.

India is now the 4th largest country in terms of total arable land under organic farming and largest in terms of total number of organic producers in the world. India produced around **3.50 Million** ton (2020–21) of certified organic products, with export volume and value of 0.89 million tonnes and US$**1040.95 million**, respectively. However, the furhter progress in terms of speed & scale of organic farming in India will depend on its capacity to meet the food grains requirement of 400 million tonnes for 1.7 billion population in 2050, with total nutrient requirement of 60 million tonnes through organic sources and availability of premium prices for organic products to farmers for profitable farming under organic systems.

India produces wide range of crops under organic management which includes all varieties of food products namely oil seeds, fibre, sugarcane, cereals & millets, cotton, pulses, aromatic & medicinal plants, tea, coffee, fruits, spices, dry fruits, vegetables, processed foods etc. The production is not limited to the edible sector but also produces organic cotton fibre, functional food products etc. The Government of India has set a target of bringing minimum of 4% net cultivated area under organic farming by March 2026. However, organic farming promotion is constrained due to limitations in terms of yield, availability of bio-inputs for soil fertility, weed, insect and disease management among other factors. Hence, niche area and exportable commodities' production approach is largely being followed for promotion of organic farming being a viable and efficient option for promotion of certified organic farming.

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Organic farming research and technologies for field & horticultural crops

India is blessed with wide range of agro–climatic conditions, which are suitable for cultivating various field crops, vegetables, fruits, flowers, spices, tuber crops and plantation crops. However, improper crop production practices such as monocropping, imbalanced fertilization, poor soil organic matter management, depletion of nutrients and groundwater, loss in soil biodiversity and changing pest and disease complex are major problems in conventional agriculture. So, several options for nutrient, pest and weed management have been tested in multi-location trials which resulted in development of technologies for organic farming. Important technologies for organic farming in India are given Table 1.

Table 1: Organic production technologies in crops and cropping systems

1.	**Improved varieties:**Resistance to biotic and abiotic stresses, high–yielding with quality traits, nutrient use efficient, local market demand, indigenous varieties & crops
2.	**Agronomic/cultural practices:** Summer ploughing, field hygiene, mulching, crop rotation, season of planting, spacing, intercropping/ border cropping, cropping system/ farming system
3.	**Nutrient management:** Cover cropping with green manure/leguminous crops, green leaf manure, crop residues, oil–cakes, farmyard manure,vermi composts, biofertilizers/ PGPRs, liquid organic manures (*Panchagavya, Beejamrith and Jeevamrit*)
4.	**Water management:**Planting across the slope, drip irrigation, ridging after sowing and mulching
5.	**Weed management:** Cover cropping, mulching with crop residues, intercrops, mechanical weeding (use of harrow, heel hoe, tools) and polymulch

Productivity and Economics of crops and farming systems under organic farming

Long–term results of organic management clearly establish that the scientific Package of Practices (PoPs) for organic production of crops in cropping systems and farming system perspective should be adopted for keeping the crop productivity at comparable or higher level than that of chemical farming. Under ICAR–All India Network Programme on Organic Farming (AI–NPOF), Modipuram (India), 51 location–specific package of practices for organic production of crops in cropping systems, suitable to 12 states of India, have been developed which can be practiced for getting optimum productivity under organic management. Ramesh et al. 2010 reported a decrease of 5–15% in rice grain yield and 35– 58% in wheat grain yields with FYM as source of nutrition. Higher yield reduction in wheat could be due to slow release of nutrients from FYM during cool winters.

Experiments were undertaken during 2015-16 to 2020-21 at Udaipur, India with the six management practices in main plots with four cropping systems in subplot in non-replicated strip plot design. Four cropping systems *viz* maize + blackgram (2:2) – durum wheat – sesbania (GM), sweet corn + blackgram (2:2) – chickpea, blackgram – wheat (*Triticum aestivum*) and soybean - fenugreek with six management practices viz 100 % organic management, 75% organic + 25 % innovative practices, 50 % organic + 50% inorganic, 75% organic + 25% inorganic, 100% inorganic nutrient sources and state recommendation were evaluated. Results of six years study (2015-16 to 2020-21) indicate that among the different nutrient management practices, maximum wheat equivalent yield was recorded in durum wheat in state recommendation (4110 kg/ha) followed by 100 % inorganic management practices (3947 kg/ha) but among organic management practices, the maximum wheat equivalent yield was recorded in durum wheat in 75 % organic + 25 % innovative practices (3567 kg/ha) followed by 100 % organic managed crop (3287 kg/ha). The maximum net returns were recorded in durum wheat in under 100%

inorganic management practices (US $1566.39 /ha) followed by state recommendation (US $1566.13/ha) but among organic management practices the maximum net returns was recorded in durum wheat in 75 % organic + 25 % innovative practices (US $1074.60/ha) followed by 100 % organic managed crop (US $901.88/ha) (Annual Report, 2020-21).

Productivity and economics of organic farming system in India

An integrated organic farming system for 0.45 ha consisting of field crops in 0.25 ha (sweet corn + blackgram during *kharif* and wheat during *rabi*), fodder crops in 0.05 ha. (fodder maize + fodder cowpea during *kharif* and berseem in *rabi* and sesbania green manuring during *zaid*), vegetables in 0.10 ha (tomato and cowpea), fruit crop in 0.04 ha (guava) and compost unit in 0.01 ha were evaluated at Udaipur, India during 2015 to 2020 (Annual Report 2020-21). Results indicate that on mean data basis of six years study , the total wheat equivalent yield of 3461 kg/ha and net return of US $528.48/ha can be obtained from different components of organic farming system of 0.45 ha. One acre Integrated Organic Farming System (IOFS) models, suitable for marginal farmers, have been established in Kerala, Meghalaya and Tamil Nadu states of India as mentioned in Table 2 which provides scope to generate more than 80% of inputs required for organic farming within the farm, thus, reducing the cost of production by 15-20% is given Table 2. (Ravisankar *et al.* 2021)

Table 2: Net return under different integrated organic farming systems in India

State	**IOFS model components**	**Area (ha.)**	**Total net returns (US $)**
Kerala	Spices–based system [turmeric, ginger, cassava, taro, vegetable cowpea and fodder grass) + livestock (2 cows)]	0.40	2194.00
Meghalaya	Field and horticulture–based system [cereals + pulses + vegetables +fruits + fodder) + dairy (1 cow + 1 calf) + fishery + vermicompost]	0.43	935.48
Tamil Nadu	Field crop–based system (green manure–cotton–sorghum; Okra + coriander–maize + cowpea (fodder), desmanthus, 1 milch cow, 1 heifer and 1bull calf + vermicompost + boundary plantations (Gliricidia, coconut)	0.40	1609.73

* 1 US $ = 79.0 Indian Rupees

Way forward for organic farming

Presently, in India, several schemes have been formulated and implemented to promote the organic agriculture which have resulted in many–fold increase in area and organic export over the years, but still lot has to be done. The salient recommendations for way forward of organic farming in India are as follows:

- Integrated strategy to address the issues like a decline in yield in the initial years of conversion, insufficient availability of organic manures within the farm to meet out the nutrient demand and slow release of nutrients from organic manures leading to mismatch between crop demand and soil supply through proper research.
- Ensuring continuous and reliable supply of certified inputs (such as seeds, bio–agents, bio–fertilizers, manures) and economically viable marketing of organic farm produce on cluster basis requires priority in policies.

- To exploit high–end domestic and international export markets, potential organic agriculture zones need to be identified on the lines of “Special Economic zone” and be named as “Special Organic Agriculture Systems Zone”.
- Cluster of villages must be encouraged for community organic farming systems in different agro-climatic zones of India.
- Farmer Producer Organizations (FPO’s) should be involved in production, processing and marketing of organic produces in the country.
- Establishment of sufficient and accessible laboratories for testing of products mainly for pesticide residues to maintain the quality of organic produce and inputs are essential.
- Networking of academic, research institutions, markets, certifying agencies and NGOs in the Asia and world over are essential for sharing of technologies and harvest the benefit of complementarity.

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Yield gaps versus ecological trade-offs in organic agriculture: what do we know?

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Key words: actual yield, agricultural diversification, agroecology, ecosystem service, potential yield, soil health

Abstract

Despite growing interest in the organic yield gap debate, evidence is still controversial. Here, I aim to shed some light on this issue through a critical analysis of the key literature by framing the problem in a broader system perspective and taking into account major global challenges like climate change and biodiversity loss. There is a general consensus on quantifying the global yield gap at around 19-20%, but estimates by crop and geographical area largely diverge among studies, likely due to different methodological approaches. For improving yield gap estimates and make them closer to the real world, I suggest to: (i) better defining the conventional counterpart; (ii) privilege data from long-term on-farm studies; (iii) include key socio-economic issues across food systems and value chains. There is increasing evidence that more diversified organic systems are more likely to close the yield gap while maintaining or improving vital ecosystem services, including increased climate resilience through better adaptation and mitigation: this should be the way to go.

Introduction

It has been advocated that yields in organic agriculture should increase to make it a viable approach to feeding an increasing world population in a sustainable way. Often, this goal is more specifically termed as closing the yield gap with mainstream conventional agriculture, with the least possible impingement on environmental resources. There is a growing body of literature addressing this issue; however, these studies have often different methodological approaches and perspectives, giving rise to equivocal conclusions. The goal of this paper is to shed light on this issue through a critical analysis of the key literature and an attempt to contextualise the problem in a broader system perspective by also taking into account major global challenges like climate change and biodiversity loss.

Yield gap: how much?

The most accurate global meta-analyses on organic *vs* conventional yield gap seem to converge towards an overall value of 19-20% (de Ponti et al. 2012; Ponisio et al. 2015). However, while there is general accordance on the existence of broad differences in yield gap among crops, there is no consensus on type of crop showing such differences and on differences among world regions. For example, de Ponti et al. (2012) found lower yield gaps in Asia, Middle East and North Africa than in Northern Europe, while Ponisio et al. (2015) did not observe any significant differences in yield gap between developed and developing countries. These discrepancies are likely due to the different approach to statistical analysis taken in the two papers, which calls for the importance of developing a standardised methodology for conducting such broad meta-analyses. A downplayed yet important point is the dependence of yield gap values on soil type, an issue highlighted by Schrama et al. (2018) that deserves more attention in future studies.

Yield gap: what to compare?

Any credible estimation of the yield gap depends first and foremost on a clear definition of the terms to be compared. At this moment, there seems to be a general consensus on calculating the yield gap (Y_g) upon the following formula (Grassini et al. 2015):

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$$Y_g = Y_p - Y_a$$

where Y_p is the potential yield that a crop can attain with use of best practices under irrigated systems (in case of rainfed systems, the term is substituted with Y_w, the water-limited yield potential), and Y_a is the actual average farm yield for that crop.

This formula is the basis of yield gap estimation in the Global Yield Gap Atlas, an endeavour recently launched by the University of Nebraska and Wageningen University (www.yieldgap.org). In case of application of the yield gap analysis to the comparison between organic and conventional agriculture, there are a couple of important points to be considered:

What is the reference system, i.e. what do we define as "conventional"? A conventional system could be a large-scale high-input intensive system in the Global North and a small-scale low-input subsistence system in the Global South. If we do not want to restrict the yield gap debate to a Global North issue, we should duly consider defining the conventional counterpart appropriately. Actually, we may use the same argument also for defining precisely what type of organic agriculture we are referring to in the comparison (e.g., input substitution-based *vs* agroecologically-based organic agriculture). However, the existence of international organic standards somehow reduces the breadth of variation encountered in organic systems *vs* conventional systems.

In the papers on the organic yield gap, most of the data come from field-scale on-station experiments. This situation largely deviates from the "average farm yield" data required by the commonly accepted yield gap formula. Kravchenko et al. (2017) found larger differences between yield data in experimental *vs* commercial farms for organic than for conventional management, suggesting that actual organic yield gaps may be underestimated. In addition, a more accurate understanding of the yield gap issue cannot neglect the importance of spatial and temporal dynamics.

Yield gap and yield stability: spatial and temporal scales

It has been argued that the organic *vs* conventional yield gap may be larger at spatial scales higher than the field scale typically investigated, i.e. at farm or landscape scale, due to higher nutrient-based limitations to crops (de Ponti et al. 2012). In contrast, Schrama et al. (2018) pointed out that yield gaps tend to be closed in a longer time perspective – as highlighted by data from long-term experiments – due to the progressive improvements in soil conditions under organic management that play for increasing yields and higher yield stability than conventional agriculture. Lesur-Dumoulin et al. (2017) found no differences in yield stability but a 10 to 32% lower yield in organic *vs* conventional horticultural crops, whereas Knapp and van der Heijden (2018) found a 15% lower stability per yield unit in organic than conventional agriculture *vs* a 3% lower stability for no-till *vs* conventional agriculture.

Provided that the organic yield gap may be closed after some time, key questions that are still to be answered are: How much time is needed to close the gap? Which (combinations of) organic management practices can shorten this time? What are the underlying ecosystem processes? Although these mechanisms are yet to be fully elucidated, it seems that improvement in soil health and soil fertility are key ecosystem services likely driving the yield gap closure dynamics. This is in line with recent ecological theories like the Resource Pool Diversity Hypothesis (Smith et al. 2009), suggesting that organic agriculture supports higher potential crop productivity while reducing crop/weed competition by creating a diversity of soil resource (e.g., nutrient) pools that can be differentially exploited by crops and weeds through niche partitioning.

Yield gap in a socio-economic perspective

An important drawback of the current literature on the yield gap is its limited focus on the socio-economic context, which is often a major determinant of crop actual yields. Schrama et al. (2018) pointed out that yield stability is higher for more skilled farmers, and that skills should be improved in a longer-term perspective thanks to a "learning effect". Meemken and Qaim (2018) predicted that larger adoption of organic farming (like that expected in the European Union by 2030 thanks to the Green Deal provisions) would increase the yield gap because of a larger proportion of unskilled organic farmers, at least initially.

Closing the organic yield gap logically calls for an increase in organic food production, but should we increase the organic actual yield or rather increase resource use efficiency in organics (e.g., the production per unit of external input)? In the context of Malawi, Berre et al. (2017) showed that better results – especially for local livelihoods – could be obtained with the second approach, aimed at decreasing inputs, and lamented that too much emphasis is put on technology, ignoring the opportunities and constraints given by the socio-economic context.

Other issues worth being considered in a yield gap closure perspective are the effects of maximising organic yields on food quality, product prices and farmers' revenues, that may change upon type of produce (commodities *vs* specialty crops) and type of market (globalised *vs* localised). Furthermore, would a boost to organic production generate a food waste problem similar to that of mainstream industrialised food systems?

Yield and ecosystem services: is there always a trade-off?

A common assumption is that higher yielding crops should pay a toll in terms of loss of biodiversity and ecosystem services, an issue that deserves due attention if one aims at reducing the organic yield gap. However, there is a growing body of literature demonstrating that in diversified cropping systems there could be synergies more often than trade-offs between higher productivity and the provision of ecosystem services. In this respect, two recently published second-order meta-analyses are particularly illuminating (Tamburini et al. 2020; Beillouin et al. 2021). In both papers, a series of agroecological practices commonly applied to organic agriculture have been investigated, but only in Tamburini et al.'s paper organic farming is explicitly included among the agricultural diversification practices studied. They highlighted that in 63% of pairwise comparisons between diversified and non-diversified arable systems there is a win-win situation, i.e. a concurrent increase in yield and in the provision of ecosystem services (mainly soil fertility, nutrient cycling, pest control, biodiversity and pollination). However, this does not apply to organic farming where, in spite of clear improvements in soil fertility, nutrient cycling, carbon sequestration, biodiversity and pollination, the trade-off with yield still exists. However, Ponisio et al. (2015) highlighted that diversified organic farming systems (based on more diverse crop rotations and polyculture) can significantly reduce the yield gap with conventional farming systems, from 16-21% to 8-9%. Their findings suggest that if organic farmers want to close the yield gap they should play on the lever of cropping system diversification through targeted combinations of the many diversification practices available, something that is fully in line with the very essence of organic agriculture.

Discussion

Despite recent advances in data acquisition and analysis, there is a need to improve the quality of data used to estimate the organic *vs* conventional yield gap, especially where this figure is used to develop targeted policies. So far, most of the data have been taken at crop and field level, whereas we need more data collected at the cropping system level, e.g. to test the potential of organic diversification strategies to close the yield gap and increase yield stability across different cropping sequences and geographical contexts. In addition, better estimates of the yield gap and identification of optimum solutions would require investments in long-term on-farm research, as well as taking into account both resource availability and socio-economic context (Fig. 1).

Closing the yield gap requires framing a combination of novel technological solutions aimed to improve resource use efficiency (radiation, water, nutrients) in diversified organic cropping systems, with the primary goal of avoiding that intensification occurs through increased use of external inputs, which may turn into higher environmental impact. It should be kept in mind that part of the yield gap might be due to sub-optimum technology use in organics, e.g. the use of cultivars developed for conventional agriculture. Improvements in organic breeding, machinery and bio-based solutions (e.g., biostimulants and biopesticides) are expected to contribute closing the gap.

A key issue is to understand whether increased uncertainty due to climate change may limit the potential of reducing yield gaps. Achieving climate resilience through system diversification and targeted adaptation strategies should help in this respect, by increasing yield stability in organic agriculture. In a climate change perspective, the yield gap could paradoxically be closed not by increasing organic yields but by decreasing conventional yields, should these systems turn out to be less resilient than organic ones. Obviously, a minimum acceptable yield threshold would need to be identified in such cases.

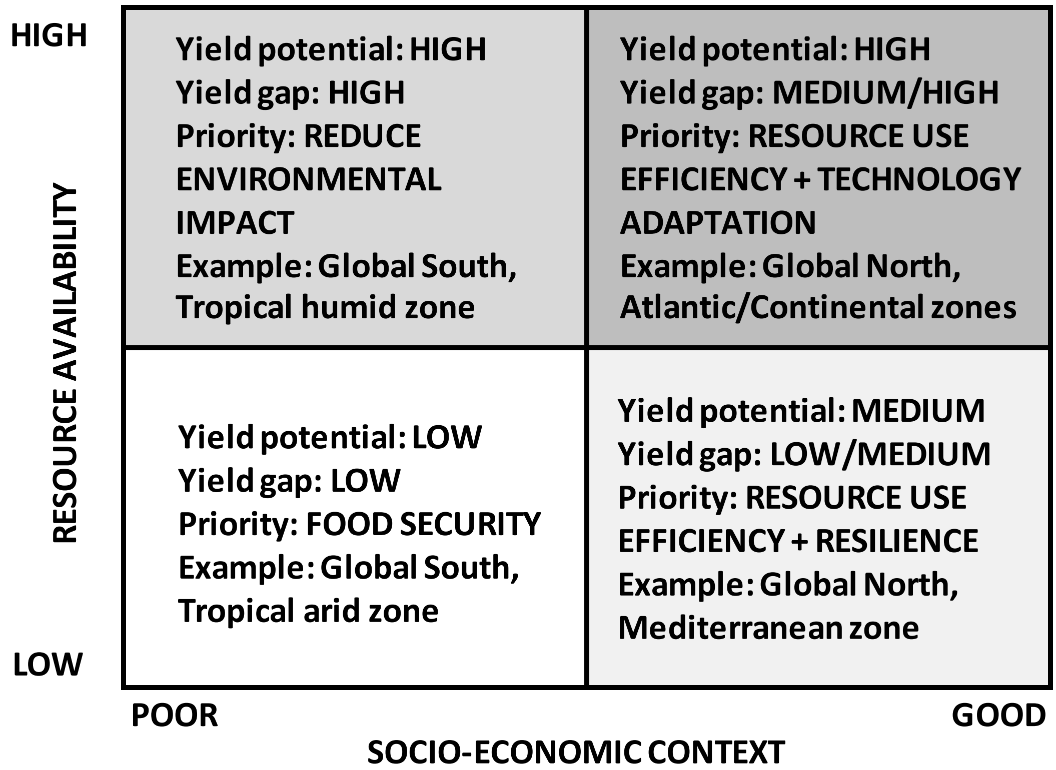

Figure 1. Predicted yield potential, yield gap level and related priorities for different situations characterized by combinations of resource availability and socio-economic context

The goal of increasing organic production without impinging on biodiversity and ecosystem services would likely require a combination of land sharing and land sparing approaches depending on natural and socio-economic context, trying to get the most out of all levels of agrobiodiversity: genetic, species and habitat.

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The nitrogen challenge in Organic Agriculture

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Key words: yield gap, nitrogen supply, N budget, legumes, new technologies

Abstract

Sufficient and stable crop yields build the basis for feeding a growing world population. It requires new solutions for future cropping systems beyond existing management practices. The future challenge will be to reduce the yield gap between organic and conventional systems by a substantial yield increase in organic systems without trade-offs between productivity and sustainability of agricultural management. The main drivers are an improvement of nitrogen availability and a synchronisation between supply and crop demand. In Organic Agriculture, nitrogen (N) supply is based on biological nitrogen fixation, mainly by cropping of legumes. That limits the yield potential in Organic Agriculture. However, improvements of nitrogen use efficiency on field and system scale can still be achieved by enhanced management measures and technologies. Closing nutrient cycles on a regional level might provide new N sources for Organic Agriculture but a reconsideration of existing concepts and guidelines is also required.

Introduction

Sufficient and stable crop yields build the basis for feeding a growing world population. Limited cropland, climate change, loss of soil quality and biodiversity coupled with excessive use of non-renewable resources require new solutions for future cropping systems beyond existing management practices. World population is expected to peak at about 2065 with large regional variations (Vollset et al. 2020). However, the available cropland per capita decreased in the last 50 years by 50% from 0.45 ha / person (1961) to 0.21 ha / person (2016). The future challenge will be to reduce the yield gap between organic and conventional systems by a substantial yield increase in organic systems without trade-offs between productivity and sustainability of agricultural management. The main drivers are an improvement of nitrogen availability and a synchronisation of supply and crop demand. In Organic Agriculture, nitrogen (N) supply is based on biological Nixation, manly by cropping of legumes. Mineral N fertilisers from the Haber-Bosch-process are banned and other external inputs are restricted, which limits the yield potential. However, improvements of nitrogen use efficiency on field and system scale can still be achieved by enhanced management measures and technologies. Closing nutrient cycles on a regional level might provide new N sources for Organic Agriculture but a reconsideration of existing concepts and guidelines is also required. This contribution discusses possible solutions to solve the N gap in Organic Agriculture, possible related trade-offs and the need of extensions of organic guidelines.

The organic conventional yield gap

Today average yields of organic cropping systems achieve 80% of conventional systems. However, large differences exist between crop types. Organic non-legumes yields achieve 75%, but legumes 90% of the conventional level (Ponisio et al 2015). In high yielding regions the yield gap can be much greater. Organic systems achieved only 50% of cereal and 55% of potato farm yields in Germany. Also within the group of non-legumes the yield gap differs largely. An evaluation of long-term cropping system experiments with a duration of more than 15 years shows that wheat achieved about 70 %, potatoes 75%, but maize 82% of conventional yields (Mayer and Mäder 2016).

Beside sufficient yield levels, a key question is how crop yield development performs in the long-term in different cropping systems. In addition, temporal yield stability is crucial for regional food security. Here organic cropping systems show , per unit yield, a 15% lower temporal static stability (Knapp and v. d. Heijden 2018). Fertilisation, mainly nitrogen, is the main driver for the yield gap between the

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systems. The basis for the yield level is nutrient supply (fertilisation), stability is mainly determined by crop protection and not by fertilisation.

N limitation on system level

A central idea of Organic Agriculture is a holistic system approach (living farm organism) with widely closed nutrient cycles on the farm level and minimal external inputs. This requires an obligatory animal husbandry and recirculation of nutrients / organic matter via farm manure. Results from the DOK long-term system comparison in Switzerland, the longest lasting organic-conventional cropping system comparison (45 yr), shows that organic cropping systems are sustainable at stocking rates between 1.3 – 1.5 livestock unit / ha. Below that number, organic and conventional systems lose soil fertility. Recirculation of nutrients by animal excretions (mean over animal categories cattle, pig, and poultry) are high: 73%, 75% and 91% of feed for nitrogen, phosphorous and potassium, respectively (GRUDAF 2009). However, the price for high nutrient recirculation is an inefficient production of human food if feed comes from cropland. The efficiency for nitrogen recirculation from animal excretion via the manure cascade (barn, pasture, storage, application) to crop recovery is very low due to large ammonia losses at several steps of the cascade. Crop N recovery under Suisse temperate climate and livestock housing conditions are only 35% of excreted N, with best available practice it can be improved to only 50%! Hence, animal husbandry as system approach is very limited to close N cycles on farm level.

A second limitation are the primary N sources in Organic Agriculture: Biological N_2-fixation and atmospheric deposition. Atmospheric deposition provides, depending on the anthropogenic portion, diffuse inputs of 5 – 40 kg N / ha. The main N source is legume N_2-fixation, which is roughly between 100 and 300 kg N fixed per ha. Feeding non-legumes sufficiently requires about 33% of the arable land cropped with legumes. Considering this land demand, organic systems have the potential to produce 62% of conventional cereal yields under optimistic scenarios (Döring and Neuhoff 2021).

The N use efficiency sustainability trade off

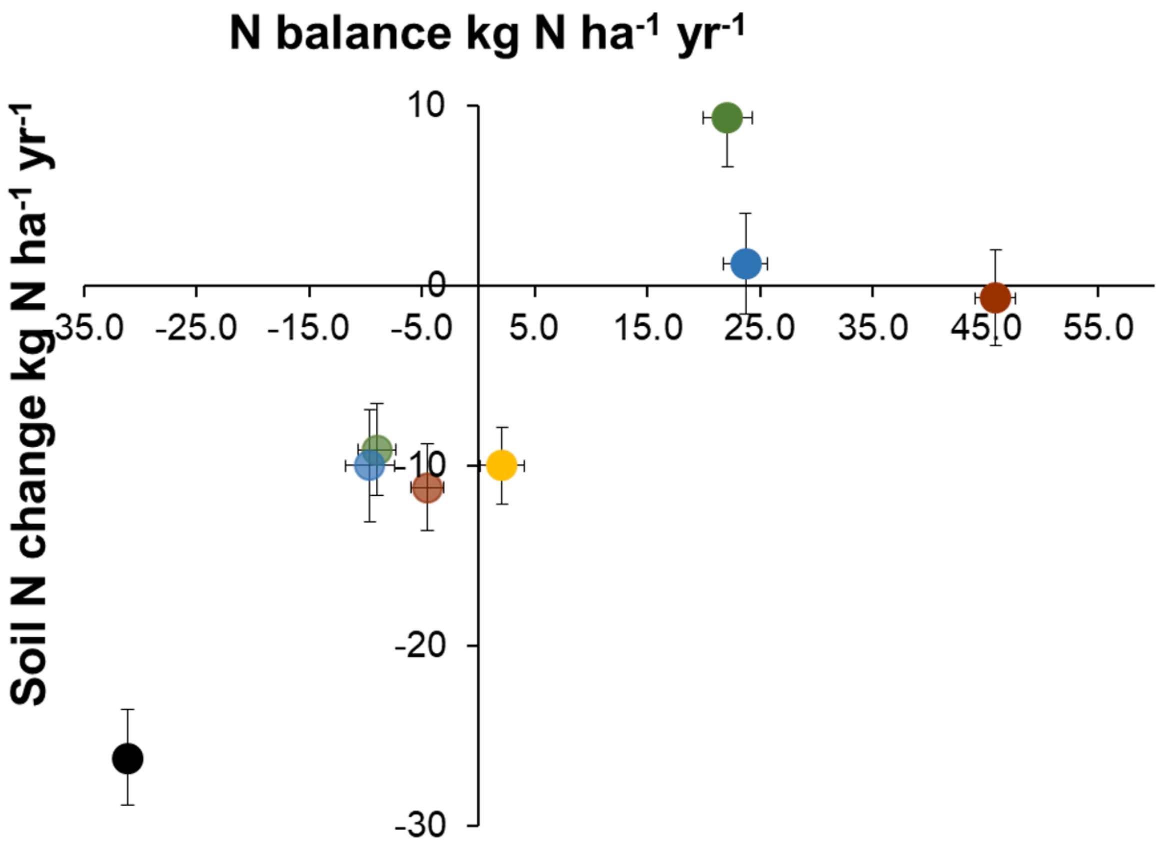
Soil system N budgets in the DOK experiment opposing N inputs via fertilization, symbiotic fixation, seeds, deposition and soil carbon stock change to N outputs via harvested products have been computed at the plot level over 35 years. The resulting balances range from negative values of -5 kg N ha^{-1} yr^{-1} (in the non-fertilized control) to surpluses of +47 kg N ha^{-1} yr^{-1} in the conventional treatment with mixed organic-mineral fertilization. The budget based N use efficiency (NUE; N output via harvested products divided by sum of N inputs) in the case of negative balances suggests irrationally high NUE (>100%), while positive balances are related to lower NUE for treatments with inputs exceeding outputs. Estimated soil N stock changes based on regular total N concentration measurements in the topsoil layer ranged from -26 to +10 kg N ha^{-1} yr^{-1}, with a significant decline in most treatments (non-fertilised, animal manure at 0.7 livestock units / ha, mineral fertilisation) except those receiving animal manure at a level of 1.4 livestock units / ha. Figure 1 shows this trade off and reveals the need of a N surplus (and loss into environment) to sustain long-term soil quality.

Figure 1: Soil N stock change versus N balance. Results over 35 years DOK experiment. Green bio-dynamic, blue bio-organic, red conventional mixed (at levels of 0.7 and 1.4 livestock units / ha), yellow conventional sole mineral fertilisation, black unfertilised control.

Matching N supply and demand

Another challenge in Organic Agriculture is the synchronisation of crop N demand and N supply from soil organic N sources, crop residues from preceding legumes (or N rich non legumes) and organic fertilisers. N mineralisation depends strongly on site conditions (soil type, temperature, rainfall) as well as on the quality of organic amendments (Berry et al. 2002). Cool and temperate climates as well as warm and dry climates are more restricted than wet and warm climates. Under temperate climate conditions, the DOK experiment shows impressively the effect of the availability of mineral N forms on the yield potential. The conventional mixed farming system on a low fertilisation level (50% of regular fertilisation, 0.7 LU / ha) with 90% N fertilisation compared to regular organic systems with 1.4 livestock units / ha gained 16% and 24% higher winter wheat and potatoes yields, respectively.

However, it provided 30 kg ha^{-1} more mineral N forms. Over all DOK systems mineral N forms (in organic as well as in mineral fertilisers) had the major impact on the level of crop yields.



Future prospects

Crop yields in Organic Agriculture can be improved if the system boundaries will be redefined in a way without calling into question the basic idea of Organic Agriculture. That can be achieved if the idea of the closed nutrient cycles on farm level will be extended to a regional level with the aim to close nutrient cycles in the context of urban – rural relationships. The use of a limited amount of mineral N forms e.g. from human urine collection or separation from sewage sludge have the potential to close the N gap in Organic Agriculture. Further, processing of liquid manure is obligatory to reduce ammonia losses and keeps N in the system. Stripping technologies producing “farm ammonium sulphate” or modern N separation technologies can help to reduce the mismatch of crop N demand and supply.

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Organic Agricultural Research Needs in the U.S.

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Key words: Organic farming, United States, research needs, reducing barriers, production challenges

Abstract

While consumers and governments recognize the benefits or organic and increase the demand for organic food, fiber and feed production, the organic system continues to face a variety of challenges that constrain its growth. To meet goals of increasing organic production, investing in research and education is critical. This paper offers a summary of the highest prioritized research areas that have recently been identified for U.S. organic production. These areas include research that will help increase organic yields, quantify and continuously improve sustainability, and reduce barriers to transition. Beyond focus areas, organic stakeholders have made a call for more, future research to take place on-farms (with proper compensation for farmer involvement), to be more interdisciplinary with a systems approach, and include a stronger extension and education component to increase practice adoption. More investment from government, industry and consumers needs to be made so that academic and monetary resources can support the research needed to advance organic.

Introduction

U.S. organic agriculture has continued to grow rapidly and become a 62 billion USD-a year-industry. It is the fastest growing sector of the U.S. food supply chain and holds promise to retain and recruit the next generation of farmers. From 2012-2017, in the U.S., the overall number of farms declined by 3%, while the number of organic farms increased 39%. Organic food now accounts for nearly 6% of total food sales in the U.S., with a demand that continues to outpace production (Knuth and DeBates 2020). Organic production is hindered by a lack of tools for organic farmers, such as a paucity of methods to overcome challenges with weed management, soil fertility, administrative burden, and compliance with organic regulations (Stephenson *et al*. 2017) To meet goals of increasing organic production, investing in research and education is critical).

Outcomes-based research is needed to illuminate the benefits of using organic practices so that consumer demand can be fueled and sustainability policy goals can be met for both government and business. Research that compares impacts of conventional and organic practices helps consumers, retailers and policy makers understand the differences between these farming systems and the benefits of supporting organic farming. Showing the benefits of organic farming will also allow organic farmers to advantage of existing environmental incentive programs (e.g. government payments, carbon credit markets) and meet sustainability goals of buyers.

While organic farming excels in supporting the health of people and the planet, short-term yields still lag behind those of conventional agriculture. This is partly because resilient, highly functioning farming systems take time to rebuild when transitioning from conventional management, and partly because research that addresses production challenges in organic systems is lacking in comparison to conventional production. The body of science for organic is relatively new in the US where the USDA National Organic Program that developed and enforced national standards for "organic" wasn't founded until 2001 (USDA NOP). Meanwhile, while research and extension (technical assistance for farmers) advancing the adoption of tools and practices that are not allowed in organic, have been ongoing with heavy industry and governmental investment for more than 70 years (USDA NIFA).

The goal of this paper is to present organic research needs that are emerging as highest priority in the United States of America, as identified by the organic community. These areas of research will help

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advance the success of organic production in the field, navigate the rules and regulations set forth by the National Organic Program, and to meet consumer expectations.

Discussion

The Organic Center (TOC) is a 501(c)3 non-profit organization with a mission to facilitate research in organic food and fiber production, and to communicate the results of organic research to consumers, industry leaders and policy makers so that the public understands the differences made by organic production. To achieve this mission, TOC heavily engages with stakeholders across the supply chain to first identify challenges in the organic industry that should be addressed by scientific research, and then convenes academic researchers and other organic stakeholders to develop robust research programs and raise funds to conduct the work.

The following is a summary of the highest prioritized research areas that have recently been identified and need further investment from academic institutions, government and business.

Increasing Organic Yields

To help increase organic yields, research is needed that tackles applied, on-farm production constraints such as crop pests, diseases, weeds, and soil fertility/health. Organic seed breeding and agricultural technology developed with organic needs in mind may offer key solutions to these production challenges, especially in the face of changing environmental conditions related to large scale climate changes.

Pest, Disease, and Weed Management

These are frequently cited as three of the top farmer needs for scientific research and extension. There is a strong need for systems-based approaches that use multiple, simultaneous strategies versus singular "silver bullets" that mimic conventional techniques. As an example, citrus greening disease (*Huonglongbing*) is spread by the invasive Asian citrus psyllid (*Diaphorina citri*). Preliminary research shows that insecticide sprays alone are not enough to manage the disease and instead wholistic programs that include growing pest-resistant plants, improving soil health (and in turn plant health), and organic compliant insecticides is much more successful in the long run (Cochrane and Shade 2019). This kind of whole-systems research is the approach that is needed to develop solutions for many pest challenges, and there is still much to learn about these kinds of strategies.

Seed breeding

Regional breeding of organic seeds can enhance crop performance, particularly in response to changing environmental conditions. Breeding for specific conditions in different regions across U.S. is critical as not all varieties will perform the same under a broad range of conditions. For instance, plants bred for mildew resistance in drier regions of northwestern states will likely be less resistant than needed for success in much more humid southeastern states. Additionally, for organic seeds to be robust, they must be bred under organic conditions so that real-time growing conditions match those during trait selection.

Soil health

While past research on organic systems has made significant advances in supporting on-farm soil health, new areas of interest include systems-based investigations of the connections between soil health and crop production. There is particular interest in understanding how microbial communities in the soil can benefit not just plant health, but also quality and flavor of crops.

Climate change resiliency

Climate change mitigation and adaption are areas of high interest by farmers and consumers. While impacts of organic production on long-term climate change mitigation are valuable to understand, there is also great interest in exploring how climate change will continue to affect farmers and how organic can help farmers be more resilient to those changes. Specifically, a range of research is needed to explore livestock forage management to water usage, seed breeding for resilience in different regions, and the role of crop diversification in protecting against losses from extreme weather changes.

Increasing environmental sustainability outcomes

Measuring outcomes- soil health, water quality, LCAs- true cost accounting

Organic farming is climate smart, protects biodiversity, reduces impacts of pesticides on people and the environment, and has been shown to improve livelihoods of farmers across the globe (Knuth and DeBates 2020), particularly in organic hotspots (Marasteanu *et al.* 2019). There is always room for improvement and the U.S. National Organic Program was developed with this in mind. Though organic is a practice-based, more research is needed to quantify outcomes of those practices. This kind of research will help guide farmers in continually adapting and evolving to improve sustainability under changes environmental and economic conditions, and as mentioned earlier, will help organic farmers access markets and incentive programs that require knowing outcomes of their practices. Specific areas of interest include soil health and carbon sequestration metrics, impacts on water quality, and true cost accounting of organic versus conventional systems to improve accuracy of life cycle assessments. More outcomes of livestock integration need to be understood including not just greenhouse gas emissions, but also how this integration can influence health of the animals, health of the soil, nutrition of the animal products, food safety risks, and efficiency of land use.

Reducing plastic along the entire organic supply chain

The overuse of plastic in our society has led to serious environmental issues such as increasing fossil fuel use and greenhouse gas emissions, chemical leaching into soils and waterways, and poisoning of wildlife on land and in water (Bandopadhyay *et al.* 2018; Teuten *et al*. 2009). The United States is a major contributor of plastic waste generating nearly twice as much plastic waste per capita as residents of the EU (Law *et al.* 2020). However, plastic remains to play an important role across the entire organic supply chain. Research is needed that helps improve recyclability of and reduces the need for plastic from the field to consumer.

Reducing barriers to organic transition

Transitioning to organic can present many types of challenges, particularly when organic certification is involved. Beyond production constraints including learning curves that comes with changing practices and environmental conditions, there are administrative complexities that are added with certification. The paperwork and the process can present a learning curve and excess administrative burden. Even when certification is achieved, there may be other policies and regulations that farmers and processors need to meet for additional certifications and audits (e.g. food safety and chemical contamination) that conflict with organic certification policies. Research is needed that can identify and addresses barriers that keep farmers from transitioning to organic or from continuing to farm organically. The following are two examples of important barriers that need to be better understood and addressed:

Tensions between National Organic Program and 3rd party food safety regulations-

Over half of farmer respondents for the USDA 2019 Organic Survey (NASS 2020) reported regulatory problems as a major production challenge, higher than any other challenge reported (e.g. price issues = 38%, market access =30%). Stakeholder engagement has revealed that joint compliance with NOP standards and third-party food safety requirements is significantly challenging. For instance, NOP guidance requires farmers to maintain and promote biodiversity (NOP 2016), while some third-party food safety risks mitigation strategies require the reduction of wildlife intrusions. Other incongruities include the use of biological soil amendments of animal origin (BSAAOs), where are perceived to be risky to food safety, and food safety requirements on irrigation water treatments and postharvest sanitizers that conflict with allowable substances for organic certification (e.g. chlorine-based sanitizing solutions). Research that finds points of leverage to reduce tensions between these different regulations is needed.

Inadvertent pesticide contamination

Organic farmers have repeatedly voiced their concerns over inadvertent pesticide contamination in their crops and stakeholders along the entire supply chain are burdened with the cost of testing and experience losses when test results are positive. Contamination, whether caused by drift or other pathways (e.g. runoff, contaminated groundwater and rain, etc.) can have a disproportionate impact on organic farmers who face the loss of product from damage by sprays, loss of income when their products can no longer be sold as organic, and in some cases, loss of organic certification of their farms.

Despite being consistently highlighted as a top priority for organic farmers, little data have been collected to synthesize current experiences with chemical contamination, prevention strategies, and specific research needs of the organic community. Some targeted research has been conducted to identify protection strategies, but chemical contamination remains a widespread problem.

Realizing the promise of technology

Many of the challenges presented in this paper can be alleviated with a broad range of agricultural technologies, *if* they are developed with organic needs in mind. Usability, access, and equity must be a top priority. For the full organic sector to reap these benefits, there must be a focus on small farms and marginalized farmers, because a large proportion of traditional AgTech is only accessible to large-scale farms and/or farmers that come from a privileged background – thus widening the current socioeconomic disparities in the agricultural sector. Interdisciplinary, systems-based research conducted both on short and long-term scales will be essential to advancing organic production.

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Improving decision support tools for quantifying GHG emissions from Organic production systems

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Key words: cover crop, soil carbon, climate change mitigation, models, metrics

Abstract

As food vendors have adopted sustainability metrics to quantify the environmental impacts of supply chains, we need data-driven decision support tools that represent organic management practices. We collaborated to improve COMET-Farm and the Cool Farm Tool (CFT), tools that estimate management practice impacts on soil carbon (C) and greenhouse gas emissions (GHG) from agricultural systems. We focused on three key organic practices: cover crops (CC), organic amendments and management intensive grazing. Through a meta-analysis, we estimated that CC increased soil C by 1.1 Mg C ha^{-1} relative to non-CC controls from 0-30 cm. Planting window, biomass production, and soil texture were important predictors of soil C outcomes. We then applied this dataset to parameterize empirical models suitable for the CFT and concluded that CC biomass was the most important predictor to include as an input variable to improve soil C estimates. While both tools contain a range of customizable, organic amendment options, grazing management options still need further improvement. These improved decision support systems can help identify opportunities for enhancing the sustainability of organic systems.

Introduction

Organic foods have gained broad consumer support due to expectations that organic production systems provide healthier food and support healthier ecosystems. At the same time, sustainability metrics have emerged to quantify the relative impact of different production systems and supply chains on environmental outcomes. We need improved, data-driven decision support tools to meet these growing demands for organic foods and supply chain metrics. In addition, the emergence of carbon markets requires improved estimates of agricultural management impacts on soil carbon (C) stock changes.

Organic production practices are not always accurately evaluated within existing tools. This is due in part to a lack of data and quantification methods and the oversimplification of management scenarios included. Our goal was to empower organic producers and buyers to evaluate the relative effects of different management practices on GHGs and other ecosystem services by developing more robust decision support tools that include realistic organic management scenarios.

We focused on two decision support systems (COMET-Farm and the Cool Farm Tool) that have been rapidly adopted for quantifying the impacts of land use and management practices on soil C and GHG emissions from agricultural systems. The COMET-Farm system (http://cometfarm.nrel.colostate.edu/) was developed as a decision support system to estimate C sequestration and GHG emissions at the farm-scale for a wide variety of soil conservation practices. The Cool Farm Tool (http://coolfarmtool.org) is an

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online calculator that enables farmers to measure their GHG emissions, and understand mitigation options for agricultural production at the scale of an individual crop.

Material and methods

We synthesized existing datasets to improve the capacity of both tools to estimate the soil C outcomes of cover crop practices. We conducted a meta-analysis of cover crop studies in temperate climates to quantify the effect of cover crops on soil C stocks from the 0-30 cm soil depth and to identify key management and ecological factors that impact variation in this response. We conducted a systematic review of the literature and identified 40 unique publications with 181 observations that met our inclusion criteria. These publications were restricted to temperate climates representing six countries across three continents. We estimated the effect size of SOC for each combination of cover crop (treatment) and no cover crop (control) within a study where the only variation across treatments was the presence or absence of a cover crop. All calculations were done using the *metafor* package (Viechtbauer 2010) in R version 3.5.2 (R Core Team 2013). See McClelland et al. (2021) for a full overview of methods.

We then utilized this meta-analysis dataset to develop an improved empirical model relevant for use by the CoolFarm Tool. We applied linear, multiple mixed effects regression models to evaluate the potential of different models to predict changes in soil C using 25 possible predictor variables, including numeric variables that represented climate, soil texture, pH, CC biomass, fertilizer inputs and categorical variables of CC type, tillage management, planting window, termination method. All statistics were conducted using R software (packages included lmer). We evaluated 300 models and retained 10 models with the lowest Akaike Information Criterion (AIC, Akaike, 1998), values which also satisfied R_m^2>0.1 and p_{int} < 0.05. Models were compared with IPCC Tier 1 approach (IPCC 2019) and the response ratios from our meta-analysis (McClelland et al. 2021).

In addition, we conducted stakeholder listening sessions, teaching workshops and interviewed organic dairy producers regarding the utility of the decision support tools, with a focus on simulating management intensive grazing systems. Stakeholders surveyed over the life of the project included organic industry and research professionals, organic food company representatives, undergraduate students in the agricultural sciences, and organic producers. Feedback was solicited through workshop surveys, undergraduate classrooms (Jabbour et al. 2021), and project informational meetings and presentations. Examples of questions asked of stakeholders included:

What suggested practices/scenarios need to be represented in these decision support tools for cover crops, organic amendments and/or management intensive grazing?

As a result of this workshop, please explain what you are and are not comfortable using the models for (supply chain engagement, internal corporate GHG management, corporate responsibility reporting, reporting to The Sustainability Consortium, reporting against Science Based Targets, carbon insetting, carbon markets).

Who do you see as the ultimate end user of these tools?

What would increase the value of these tools to motivate improved practice?

Given that the science is good and that the uncertainties are unavoidable, how much does improved trust /usefulness of the tools depend on better science, models better capturing the science and/or user interface improvements?

What additions you would like to see in the user interface in COMET-Farm and/or the Cool Farm Tool?

Results

From our meta-analysis, we found that inclusion of cover crops in annual and perennial cropping systems increased soil organic carbon stocks from 0-30 cm by 12%, averaging 1.11 Mg C ha^{-1} more soil C relative to a similarly managed system without cover crops (Figure 1). Management and environmental variables were responsible for variation in soil C responses across studies. The variables explaining the most variability in soil C effects of cover cropping were planting and termination date (i.e., growing window), annual cover crop biomass production, and soil clay content. Cover crops planted as continuous cover or autumn planted and terminated led to 20-30% greater total soil C stocks relative to other cover crop growing windows. Likewise, high annual cover crop biomass production (> 7 Mg ha^{-1} yr^{-1}) resulted in 30% higher total soil C stocks than lower levels of biomass production. There were no differences in soil C stock responses to cover crops when management system (conventional or organic) was used as a predictor.

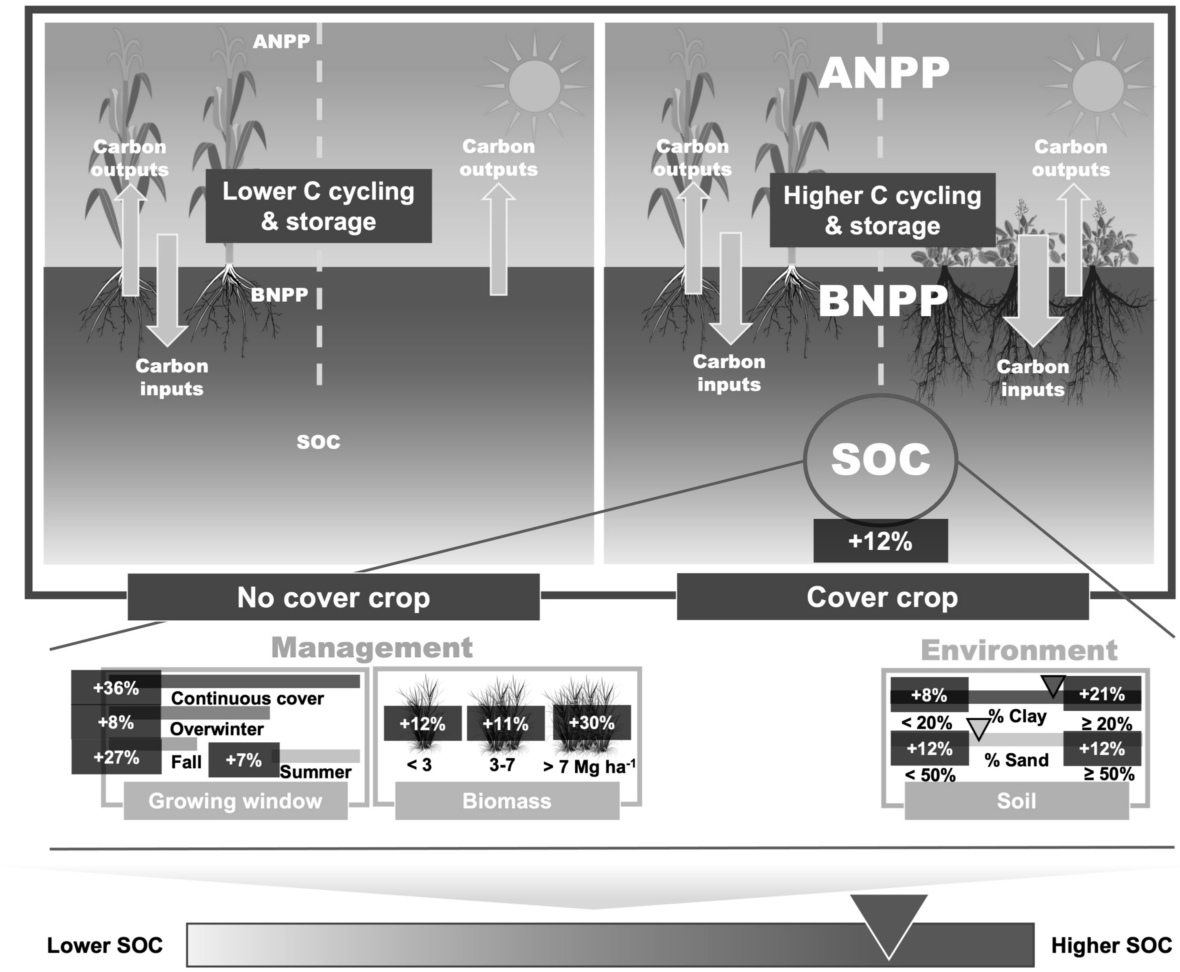

Figure 1. A summary of meta-analysis results of the relative impact of different cover crop management decisions on soil organic carbon (SOC) response relative to a no-cover-crop control. Relative to conventional cropping systems (first panel), represented by a continuous corn monoculture with limited above and belowground residue inputs, the alternative cover crop system (second panel) increases the quantity and quality of plant residue inputs and continuous plant roots. Management decisions (lower panel) interact with environmental factors (soil type) to influence SOC response through altered decomposition patterns (growing window), and residue quantity (biomass). The dark gray boxes indicate overall percent change under each of these moderators relative to a no-cover-crop system. Adapted from McClelland et al. 2021.

An analysis of this same dataset to identify the most parsimonious empirical, regression model for predicting CC effects on changes in SOC resulted in 10 best-fit models. Predictor variables included soil bulk density, CC biomass, CC C:N ratio, soil texture, experiment duration, mean annual precipitation, mean annual temperature, soil pH, and tillage. Of these models, the most parsimonious model that also performed better than the current IPCC Tier 1 model approach, included the predictor of CC biomass. In particular, a CC biomass greater than approximately 1 Mg ha^{-1} yr^{-1} was required for a positive change in SOC in surface soils (Table 1).

Table 1. Quartiles of cover crop biomass and corresponding mean predicted change in soil carbon (SC) using a simple regression model. Adapted from Hughes et al. in review

Biomass range	ΔSC_{yr}
Mg ha^{-1}	**Mg ha^{-1} yr^{-1}**
0≤x<1	-0.167
1≤x<3	0.153
3≤x<7	0.793
x>7	1.432

Stakeholder Feedback

Throughout our four-year project, we collected feedback across a wide range of stakeholder groups regarding the COMET-Farm and Cool Farm Tools, including priorities for tool improvement and factors that would increase their utility and adoption. Following is a brief summary of this feedback.

Practices. Stakeholders wanted to see increased management options within the tools for practices such as cover crop companion cropping and grazing. Livestock systems are currently separate from land use systems within COMET-Farm, which makes it difficult for integrated grazing systems to understand where to input certain variables such as manure. Increased management options would be beneficial to represent varying manure quality throughout the year.

- *Confidence.* Stakeholders wanted a better understanding of the confidence in model estimates, particularly with regards to potential payments for ecosystem services or soil C credits.
- *Tool integration.* Farmers are unlikely to use these tools unless there is another motivation or incentive. For example, U.S farmers are required to create nutrient management plans already so it would be helpful if these tools could be linked to other required reporting programs. The key is simplicity and integration with existing farm recordkeeping systems or tools. Tools are more likely to be used when supported by a technical service provider.
- *Learning tools*. One stakeholder commented that the best use of these tools is educational more than quantitative because they enable a discussion of the potential impact of different practices that a producer might adopt, but this usually comes with technical support. Similarly, comments from undergraduate students who used the tools in the classroom emphasized an enhanced appreciation for the connections amongst farming system components, such as tillage and amendments, and their impacts on environmental outcomes and that certain ‘small’ changes can have large impacts.

Discussion

Our goal with this integrated research and outreach was to enhance the capacity across the organic food supply to evaluate and improve management systems and environmental outcomes. Due to the complexity of diverse, organic management systems, and the interactions between management systems, climate and other site characteristics, decision support tools that are broadly applicable and user-friendly have been relatively elusive. Through the use of large datasets, meta-analyses, and regression analyses, we identified the most important management and site characteristic variables likely to best predict the soil C impacts of integrating cover crops within temperate cropping systems. Both statistical approaches highlighted the importance of developing tools and approaches to easily estimate cover crop biomass production for reducing uncertainty in soil C outcomes.

We also integrated a wide range of stakeholders to better understand the barriers and potential opportunities for improving the utility of soil C and GHG decision support tools within the organic agriculture sector. We identified key areas for potential to streamline and clarify management input requirements, particularly for integrated grazing systems, as well as the important role that technical service providers will likely continue to play in assisting producers in utilizing these tools. Across the spectrum from producers to students, these decision support tools can serve as critical educational tools that facilitate systems-thinking and the relative potential benefits and trade-offs of implementing different management practices.

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Digital tools as effective enablers of research in organic farming

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Key words: Organic farming, digital technology, research, effective knowledge, collection, dissemination.

Abstract

Organic agriculture is presented as an approach to handle with the detrimental effects of modern agriculture. These challenges are: food security and the way to feed the world population in crucial ecological and climate conditions (climate change, the loss of biodiversity, loss of soil fertility, water, soil and air pollution, etc.).Digital technology together with organic farming is being spread rapidly in agriculture systems and, while it can provide solutions for those challenges, it can also devote to destroy weak balances and to push them towards new solid balance. Digitalisation and ecologisation could be considered as enablers to worthy transformations. Thusly, the most relevant research challenges concern: data collection and dissemination from various sources and associated governance issues which include devices to assist farmers (decision support), sensory (acquisition and spreading of knowledge) and physical levels (digital tools: platforms, mobile Apps, etc.).

Introduction

Reasearch on organic agriculture found on using digital tools requires a methodical perception for digitalisation of the sector, specific research focus on reducing environmental impact, food systems resilience and increasing of farmer's autonomy. First and foremost, digital technology has considerable potential to improve food security around the world. The purpose is to enhance the relevance of using available digital tools in an effective and sustainable way in agriculture. In this context fits the project "Knowledge Center for Organic Agriculture in Africa KCOA". This project establishes a continental digital knowledge platform which consists of a database and a website for self-promotion, networking and inspiration. This paper deals with the importance of the KCOA platform as a digital tool promoting organic agriculture in Africa. It will give a brief overview of the knowledge management system that is currently being settled and used in the field.

Results

"KCOA" Knowledge management system and the digital knowledge platform "DKP"

Digital technologies are playing an ever more important role in the lives of millions of individuals around the world. The "Kowledge Center for Organic Agriculture in Africa KCOA" is a development project financed by the German Federal Ministry for Economic Cooperation and Development (BMZ) and implemented by the German Corporation for International Cooperation (GIZ) GmbH, that contributes to and endorses the Principles for Digital Development, which are best practices for integrating digital technology into agricultural development projects. This project deal with two approaches: promoting agrocecology and organic agriculture and exploit of digital tools. Thus, ecologisation is defined as "the growing importance of environmental issues within agricultural policies and practices" (Lamine, 2011; Lucas, 2021). Digitalisation refers to the increasing use of digital technology throughout the economy and society in general (Lange et al., 2020). Furthermore, Digital tools could have an effective impact on each part of the organic farming value chain, including, planning, inputs, on-farm production, storage, post harvest, processing, transport and access to markets (USAID,

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2018). In more details, digital tools could help farmers in planning what, when to plant, tighten relationship with buyers and processors, adapting to climate change and providing data for farmers to make business decisions on cash flow, it could also, reducing costs and risks for buyers, increasing access to quality inputs, enabling sellers to know demand in advance. Additionally, using digital tools contributes to help extension services reach more farmers, to use behaviour change media to promote best practices among farmers, to improve links between farmers and processors, to reduce post harvest loss with digitally-enabled harvest loans, to monitor storage conditions, to reduce transport costs, as well as to increase ability of smallholder farmers to sell to larger markets by allowing buyers to track crops to source (USAID, 2018). In order to guarantee effectiveness and sustainability, the KCOA digital platform was founded in those purposes and was referenced to the nine principles of digital tools including: design with the user, understand the existing ecosystem, design for scale, build for sustainability, be data driven, use open data, open standards, open source, and open innovation, reuse and improve, address privacy and security and be collaborative.

As a consequence, "KCOA" Knowledge management system is a simple, effective, dynamic and participatory approach, while providing opportunity for self-presentation. The goal is to seek towards opportunity for users to creatively profile themselves and to share knowledge interactively. It is important that the KCOA Digital knowledge platform does not just be a solution in difficult but rare situations like a university library but to be something that can be part of the habits and that can cover trivial needs (eg. WhatsApp, daily news platforms). Platform users could contribute in feeding the database with relevant which make it more attractive.

Knowledge collection, validation and dessimination

Knowledge are collected from various sources ranging from farmers to scientific search engines. Both national and internationally relevant information will be collected. These sources will have various types of mediums where knowledge is recorded. Once the knowledge medium is obtained, it will be classified under several themes and sub-themes. The researchers then will summarize and translate (partially or fully depending on the size) knowledge medium into relevant Knowledge Product (KP). These summarized KPs are be uploaded into the user centric platform.

All knowledge products of the KCOA hubs are verified after collection and before entering them into the publicly available knowledge database. In order to ensure the accuracy of the data entered and that only high quality knowledge products are collected, there is a verification process in place and included in the tool. Afterwards, validated knowledge, strategies and good practices will be disseminated mainly by the virtual knowledge bank and social exchange among the stakeholders and the demonstration plots where innovations and trials will be showcased.

Discussion

Our analysis showed that there are important enablers that facilitate digital agricultural transformation. Digital key enablers of organic farming development and research are: the use of internet and smart phones, social media networks among farmers and agricultural extension officer, promoting digital skills among the rural population and digital engagement platforms. These processes are based on the use of a series of enabling technologies, divided into product-service and process innovations, which are of strategic economic importance. The objective goal of the KCOA project is to facilitate access to knowledge and to enable organic farmers all around Africa to participate. This vision intersects with the objectives of the KCOA project that promote for the effective use of digital tools to boost organic farming in Africa.

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Workshop 5: Novel organic and urban agriculture innovations for global food security?

Acronym: Novel food

Moderator: Prof. Dr. Gerold Rahmann (Germany)
Rapporteur: Dr. Wan Mohtar (Malaysia)
Date: Oct 2nd, 2022

	Impuls presentations by:
09:00 – 12:00	Off-Campus excursion
14:00 – 16:00	• Gerold Rahmann (Germany) • Wan Mohtar (Malaysia) • Daniel Grimm (Germany)
16:00 – 18:00	• Mahesh Ganesapillai (India) • Enno Sonntag (Germany) • Azizi Abu Bakar (Malaysia) • Zul Illham David Zulkiflee (USA) (online)

Organic and urban agriculture are both innovators of novel and innovative food systems. Organic is more rural and farming related, while urban agriculture is innovation with same targets (healthy and sustainable food production) and appart from farm land (in-door, balconny, vertical, container, hydro, roof, cellar, etc.). Both food chain innovations are rarely exchange ideas and results. The future challenges of food chains are limitations of farm land, sustainable food production, affortable food for all, production-consumption chains, philosophy of food culture and habits. Novel foods (mushrooms, invertebrate protein, algae) and food habits (vegan, vegetarian, etc.) are popular in urban agriculture. Urban agriculture is very efficient in space (yield per m^2) and nutrients (close systems). Organic can learn a lot about those ideas and results. Vis-a-versa, urban agriculture is limitated in mass production, usually high-tech related with a lot of energy and technology needs. Urban agriculture food is usually expensive and could learn a lot about food production and chains from Organic. The standards and regulations hinder joint action and marketing. Science can help to identify mutual concepts and joint structures for a modern urban and rural life and links.

Organic and Urban farming – two sides of a coin of future sustainable and circular food systems

GEROLD RAHMANN[1] , DANIEL GRIMM [1,2] AND ENNO SONNTAG [1,3]

Key words: urban farming, organic farming, circular food system, sustainability, food security

Abstract

Organic and urban agriculture are both innovators of novel and innovative food systems. Organic is more rural and farming related, while urban agriculture is innovation with same targets (healthy and sustainable food production) and apart from farm land (e.g. in-door, balcony, vertical, container, hydro, roof, cellar). Both of these food chain innovation are like-minded but rarely exchange ideas and results. Novel foods (mushrooms, invertebrates, algae) and food habits (vegan, vegetarian, etc.) are popular in urban agriculture. Urban agriculture is very efficient in space (yield per m^2) and nutrients (nearly 100%, closed systems). Organic can learn a lot about those ideas and results. Vis-a-versa, urban agriculture is limited in mass production, usually high-tech related with a lot of energy and technology needs. Urban agriculture food is usually expensive and could learn a lot about food production and chains from Organic. The standards and regulations hinder joint action and marketing. Science can help to identify mutual concepts and joint structures for a modern urban and rural life and links.

Introduction

The global food security and safety was, is and will be a challenge. Enormous increase of productivity in agri- and aquaculture in the last decades is able to feed more than 7,8 billion people (2022) nowadays. Nevertheless, hunger is still prevalent and malnutrition a severe issue in many countries. More than 800 mio people are facing hunger and more than 2 billion malnutrition (FAO 2019). And the challenges are getting bigger, with the global population set to grow up to 9 to 11 billion until the end of the century and the demand for resource-intensive livestock products like meat, eggs and milk increasing (Rahmann et al. 2017). Though a fairer global distribution of food would ameliorate these problems – there is after all enough being produced - an increase of productivity and production is necessary (Rahmann et al. 2021). Since land is more and more limited and land use change more and more difficult, intensification is needed: higher yields per hectare (Rahmann, Grimm, 2020). But this is only one side of the coin. Increasing productivity and production has resulted not only in more food production but also in more environmental damage, such as decreasing soil fertility, biodiversity losses, water pollution, climate impact and low animal welfare. How can this double challenge be solved: food systems, which produce and deliver enough, healthy and affordable food but are also sustainable? Two options and potential synergies of merging both will be discussed in this paper (Rahmann, Grimm, Kuenz, Engel 2021):

- Organic farming: horizontal farming, mainly in rural areas, practiced by farmers
- Urban farming: vertical farming, mainly in urban areas, practiced by non-farmers

Organic farming

Organic farming has led to major advance in terms of environmental sustainability and animal welfare (Sanders, Heß 2019). It is well established (standards and regulations, e.g. EU reg. 848/2018) and widely practiced (globally on about 70 mio hectare in about 130 countries and done by more than 3 mio farmers in 2020). Organic food has left the market niches in important markets like the US and EU (90% of the 120 billion USD sales) (Willer et al. 2022). On the other side, Organic farming is less productive (per hectare) compared to intensive conventional agriculture (round about 25-50% lower yields) (Rahmann, Böhm, Kuhnert 2022).

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Nevertheless, several governments, particularly in Europe (EU members) and Asia (e.g. India, Bhutan) have decided to increase the share of Organic farm land. For example, the EU green deal and the farm-to-fork strategy wants to achieve 25% Organic farm land by 2030 (from 8% in 2020). With the global food security problems due to the Russia-Ukraine war (since 24th February 2022), this target is under increasing scrutiny,.

Urban farming

Urban agriculture, though in principle an old concept, has in recent decades become a new trend, with a new image (Padilla 2018). Until today, most urban agriculture takes place in the form of backyard and homestead gardening, as well as intensive animal husbandry (indoor dairy, pigs, chicken husbandry without farm land) (Lee-Smith et al. 2019). But these "old fashioned" and in many cases unsustainable urban food systems are dying out due to bad image and decreasing policy support (emissions). But novel and disruptive new urban food systems arise. Usually, they are not driven by farmers and not supported by policies but done by activists, socio-ecological groups and start-ups, mainly in "Western" countries, like North America, EU, Japan, Australia, New Zealand and Korea. Nevertheless, there is potential for less developed areas as well (de Bon, Parrot, Moustier 2009) and particularly in food security crises (Gantner 2022).

Urban farming activists and start-ups invent and implement novel food production systems in urban, open spaces (organic backyard gardening) (Rahmann 2021), in or on private or commercial buildings and even in bioreactors and "food factories" (Castillo 2021). In-door, balcony, roof-top, cellar, container and wall-based food production has a positive image as sustainable and innovative. Large scale, fully automated food production factories are the latest innovations. Most of these new urban food systems produce mainly plant-based food, though there is an opportunity for integrating other organisms, such as fish, in the case of aquaponics, or mushrooms and algae. These approaches are highly space and resource efficient (nutrients and water), more circular than conventional and organic land-based food systems but, on the other side, capital intensive, as a lot of technology and energy is needed. Urban farming has not left the niche yet, but the market is there and the potential is high.

Indoor farming in factories can be very space efficient. E.g., an aquaponic factory near Copenhagen produces vegetables without any GHG emissions and nearly 100 % nutrient efficiency, with no water contamination. The production is 250 times more efficient in water and 200 times more efficient in space compared to farm land-based production in Denmark (Castillo 2021). Novel food like algae show even better results (Ullmann, Grimm 2021). Urban land use change towards increasing urban farming is on the go (Lohrberg 2001). Urban farming in-door has still production and technical challenges (disease control, ligthing systems, automatisation) as well as high costs.

Discussion

Organic and Urban farming are two sides of the coin of sustainable farming of the future. They have similar targets but different historical backgrounds, approaches and focus. While Organic farming is famers and rural based on sustainable land use, urban farming is start-up and activists generated novel food production without farm land. Both systems have their potential and appreciation by consumers. Organic is regulated and already has a large market. But urban farming is still heterogenous and without market relevance and regulations.

Both can learn from each other. Organic can give orientation in standards and the development of regulations, food quality and holistic approaches of food systems. Urban farming, thanks to its heterogeneity, is highly innovative and can open the mind to "think different" and "out of the box", producing food without farm land, in urban areas and with high or low technology. Both together would be an excellent chance to produce solutions for future food security and safety challenges. But there are still high walls of different opinions, resource efficiencies, strategies, knowledge, and markets. The scientific discussion can help to overcome those problems for an even better sustainable food systems in the future.

Table 1. Comparison of conventional, organic and urban farming

Parameter	Conventional farming	Organic farming	Urban farming
Space efficiency	medium	low	very high
Energy efficiency	medium	low	very low
Nutrient efficiency	low	medium	very high
Water efficiency	high	high	low
Capital intensity	high	low	very high
Labour intensity	medium	high	very high
Knowledge capacity	low	medium	very high
Skill capacity	high	high	very high
Ecological impact	high	medium	very low
Food security impact	high	medium	low
Food sovereignty impact	medium	high	low

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Mushroom bioreactor-biomass as bioactive protein source: Synergy of mushroom rural and urban cultivation

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Keywords: Mushroom biomass, Bioreactor, Protein, Urban cultivation, Landless food

Abstract

Mushroom rural cultivation consumes averagely 6-month period, while urban cultivation takes only 10 days or less. In this study, mushroom biomass was grinded and converted into a flour to produce mushroom-chicken patties using Lingzhi and Enoki. The inclusion of Enoki in chicken patties (10%, 20% and 30%) indicates higher consumer acceptance significantly ($p > 0.05$) compared to chicken patties with Lingzhi (10% and 20%). This analysis validated the concept of mushroom biomass as source of bioactive protein. On the other hand, 3kg dried mushroom-bioreactor biomass was produced using a heterotrophic 1m² fabricated-bioreactor, which answers the minimum requirement for protein content for 1 human per year. Together, these explain the significance of mushroom biomass in food security as a protein source and the synergy of mushroom rural-urban cultivation.

Introduction

The global wheat flour's price soars as a result of Russian's invasion of Ukraine, one of the major producers of wheat and heatwave in India, second global wheat producer, causing the crops' withering (Vethasalam, 2022). With the current concerning issues, wheat flour's shortage and occurrence of land's heatwaves, researchers are looking into solutions to generate food using landless environment with lesser time and cost consumption. Besides that, consumers concern about health and sustainability are driving changes from land use to ingredient supply chain. In addition, technology advancements are reshaping globally, and mushroom-bioreactor technology is designed to help to achieve higher yields and productivity without compromising mushroom's nutrients properties.

In recent studies, mushroom biomass has been used successfully as functional enhancers in various food products (Wan-Mohtar et al., 2018; Wan-Mohtar et al., 2020). In order to achieve fast cultivation time, the development of controlled cultivation has proven to produce mushroom biomass in 10 days or less (Supramani et al., 2019). Bioreactor-grown mushroom biomass, particularly Lingzhi, has been accepted as an alternative animal feed due to its great nutrients value such as protein (32.23%), dietary fibre (13.8%), carbohydrate (48.38%), ash (1.14%) and lipids (4.45%) contents (Wan-Mohtar et al., 2021). The high protein content warranted of using this biomass as a ''Novel Food'' development for human consumption.

Materials and methods

Preliminary study

Both fruiting bodies of Lingzhi and Enoki mushrooms were dried to prepare mushroom biomass. The biomass was grinded and turned into mushroom flour (MF) as shown in Figure 1. Next, the formulated mushroom-chicken patty samples; 10%, 20% and 30% Enoki, 10% and 20% Lingzhi, control and commercial chicken patty were assessed for appearance, colour, aroma, texture, taste, aftertaste and overall acceptability using a 9-point hedonic scale (1 = extremely poor, 2 = very poor, 3 = poor, 4 = bad,

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5 = average, 6 = fair, 7 = good, 8 = very good, 9 = excellent), by 30 acceptable panellists from Biotechnology Program, Universiti Malaya, Kuala Lumpur, Malaysia.

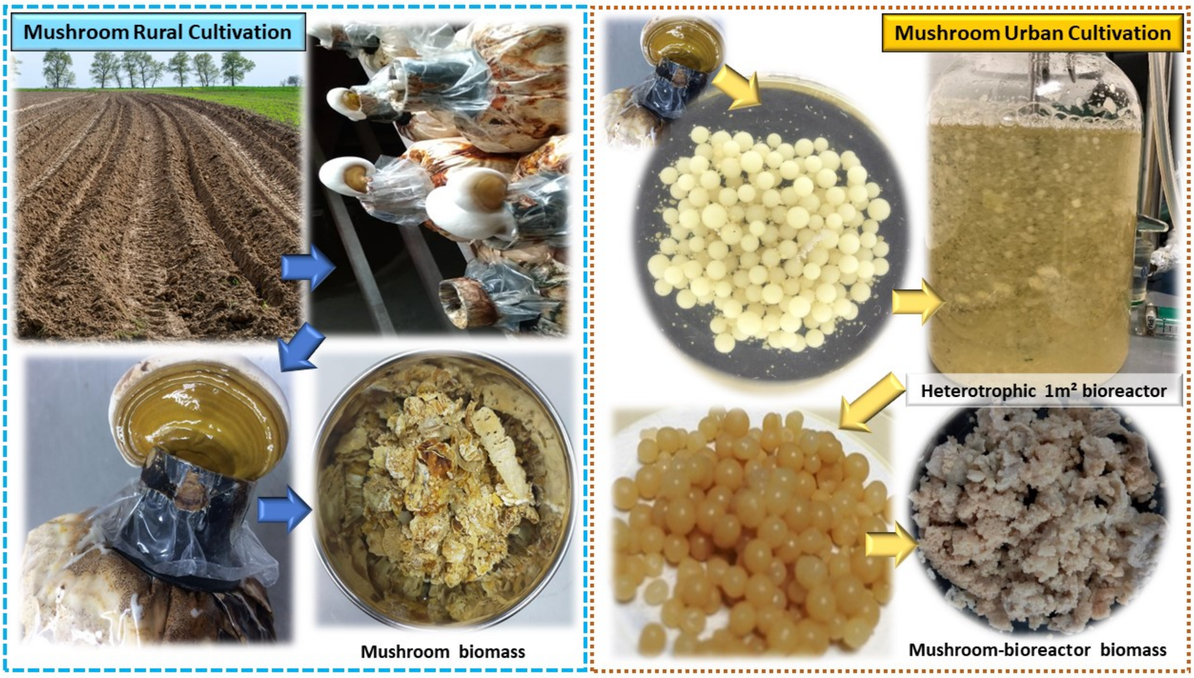

Figure 1. The preliminary study of the consumers' acceptance of mushroom-chicken patty.

Results

The radar chart showed in Figure 1 summarizes the panellists' scores for each attribute. The commercial chicken patties collectively obtained the highest scores in all sensory attributes. Regarding the chicken patties formulated with different concentration of mushroom flour, the 10% Enoki-chicken patty (6.73) showed a great acceptance by the panellists, and significant appearance (7.17), colour (7.20) and aroma (6.93) than the control chicken patty (6.73, 6.83, 6.60 respectively). Chicken patties with Lingzhi (10% and 20%), however, obtained the least attributes and acceptability scores.

Discussion

The incorporation of Enoki mushroom flour in the development of chicken patties showed a greater potency, whereas the chicken patties formulated with Lingzhi mushroom flour were less acceptable to meet the consumer's palate due to its strong unique flavour and an undesirable appearance in comparison to commercial chicken patty.

Mushroom biomass can be produced by both rural and urban cultivation (Figure 2). Rural production requires a big arable land in order to grow crops and accommodate a vast number of mushroom bags. Besides that, the production of rural mushroom requires a longer time (6 months) compared to urban cultivation (10 days or less) (Hanafiah et al., 2019). Meanwhile, an effective production of mycelial pellets or mushroom-bioreactor biomass by heterotrophic 1m² bioreactor has been proven by Usuldin et al. (2021).

The strategy, which in accordance with landless food concept by Rahmann et al. (2020), is to apply mushroom urban production to produce mushroom-bioreactor biomass using heterotrophic bioreactor for human consumption. Based on Figure 3, 3kg of biomass can be produced in 1 run resulting 0.966kg of protein. The protein value of biomass is calculated using ratio of the protein value (g/100g) by Wan-Mohtar et al. (2021). Furthermore, this mushroom-bioreactor biomass not only contain high protein value, but also consists of other vital nutrients for balanced diet such as carbohydrate, fibre and lipid (Wan-Mohtar et al., 2021).

Conclusion

In this study, synergism of mushroom rural to urban cultivation has been achieved. Lingzhi and Enoki mushroom biomass significantly affected the texture, colour, taste, aftertaste, and overall acceptability of the chicken patties. Notably, 10% Enoki-chicken patty indicates moderately higher consumer acceptability score (6.73) compared to chicken patties with 10% and 20% Lingzhi mushroom (3.03 and 2.10 respectively). In addition, 3kg mushroom-bioreactor biomass with 32.2% protein has been obtained using heterotrophic 1m² bioreactor. Therefore, with the present worldwide concerns of flour shortages and land heatwaves, this rapid and sustainable mushroom production will potentially promote the utilisation of mushroom-bioreactor biomass as future bioactive protein source.

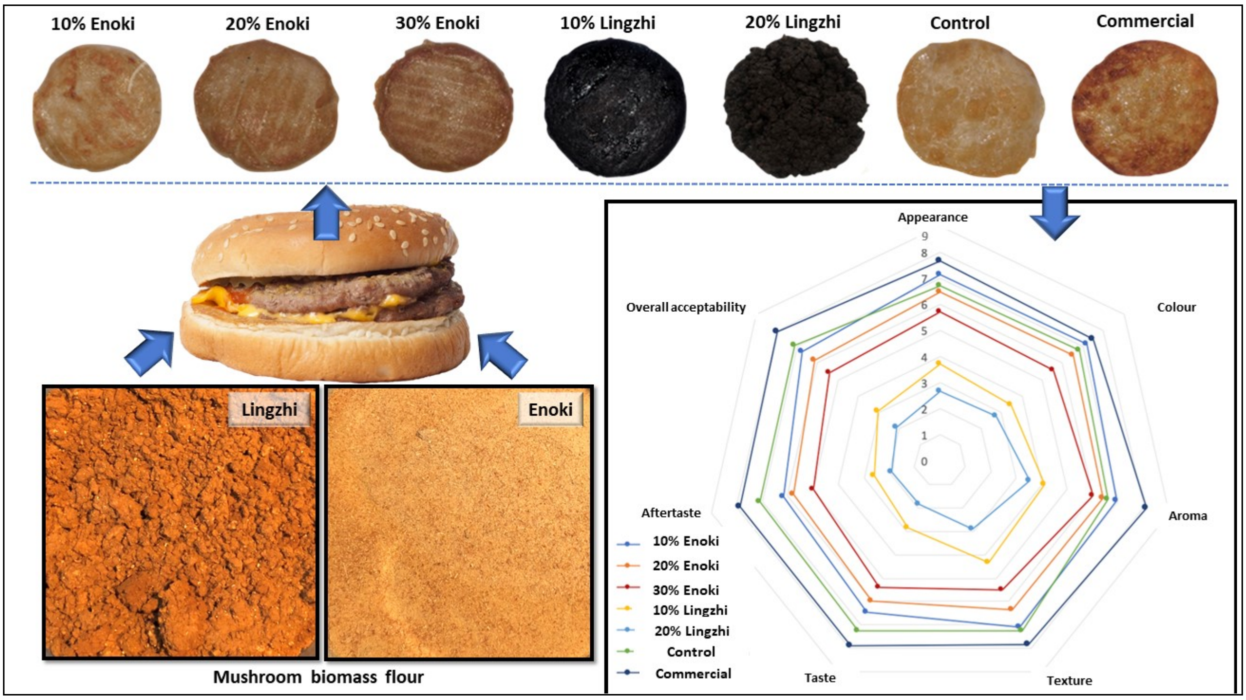

Figure 2. Mushroom rural cultivation and mushroom urban cultivation

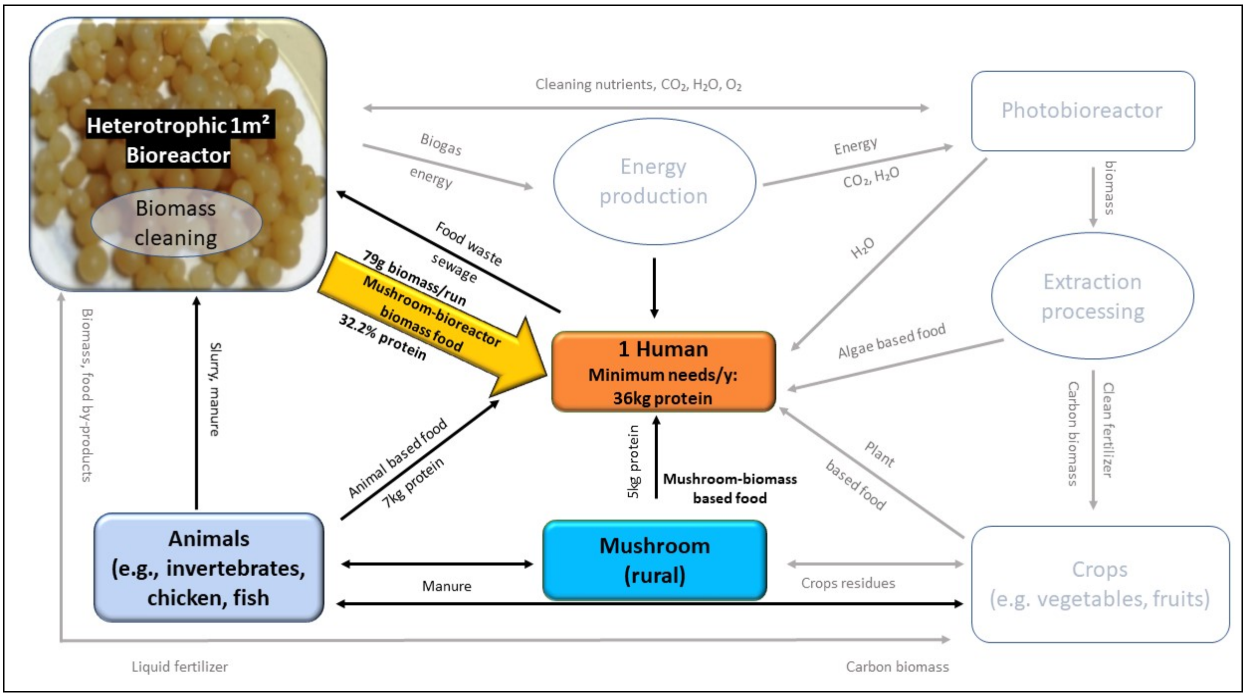

Figure 3. Mushroom-bioreactor biomass application in landless food concept.

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Mushroom cultivation and its challenges at different scales

DANIEL GRIMM[1,2], GEROLD RAHMANN[1], AND ENNO SONNTAG[1,3]

Key words: mushroom cultivation, organic farming, circular food system, sustainability, food security

Abstract

This text analyses the societal, ecological and economic advantages and disadvantages of mushroom cultivation at different scales, from a farming household, to a rural community, to an industrialized, commercial enterprise. For this we use SWOT analysis in three model-scenarios. The results of this analysis show increased productivity and product-diversity going from the small to the large scale, but mixed results in terms of ecological sustainability and societal benefit. The most sustainable and socially beneficial approach seems to be a rural community farm, although it is not as productive as a commercial enterprise.

Introduction

With the world population predicted to increase to 11 billion people by the year 2100, according to medium estimates of the United Nations (2017a), and most of this growth taking place in the global south, land scarcity will become a major problem in many regions of the world (Rahmann et al. 2020). According to the medium estimates, and assuming that available cropland remains the same, only 629 m2 of land for crop production will be available per person in Africa and in more extreme scenarios only 458 m2 would be available (Rahmann et al. 2021). Landless food production, such as mushroom cultivation, could play an important role in overcoming the problem of land-scarcity and help transition towards a circular economy, in which food is produced on crop residues without additional land use (Grimm et al. 2021).

While mushroom cultivation has a history of many centuries, the last four decades have seen the most significant scale-up, with a more than 30-fold increase in mushroom production (Royse et al. 2017). A large part of this growth has been driven by China, which in the years from 1978 to 2002 went from producing 5,2% to 70% of all mushrooms cultivated globally (Shu-Ting Chang 2005). In his account as a first-hand witness of that remarkable growth-period, Prof. Shu-Ting Chang remarks how mushroom production in the 1980s was taking place in rural areas at a small scale, while 20 years later it had moved to urban areas and was being done at an industrial scale. This development, he notes, was mostly due to improvements in technology, which also enabled the cultivation of a more diverse set of mushroom species. The development of markets and the productivity increase through economies of scale are likely to also have played an important role.

This leads to the question, how mushroom economies can and should be established in developing countries that currently produce very few mushrooms. Is a grassroots-approach, with workshops for small farmers and subsequent "organic growth" of the sector the right way, as it was done in China in the 1980s (Shut-Thin Chang 2005), or should these steps be left out, to move directly to industrialized production, since the technologies for this scale have already been developed?

To answer this, and to better understand which are the societal, ecological and economic advantages and disadvantages of mushroom cultivation at different scales, we perform a SWOT-analysis of three different model-scenarios: a household, a rural community and a commercial enterprise. In the discussion we compare the results of this analysis.

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Methods

We perform a SWOT-analysis of three different model-scenarios (table 1). The SWOT-analysis is a strategic planning tool used to evaluate the strengths, weaknesses, opportunities, and threats of a project (Paschalidou et al. 2018). The method begins with stating the project objective and then identifies internal and external variables that are favourable or unfavourable to achieving it.

To define the framework for the three scenarios, we use the boundaries defined by the LandLessFood project (Rahmann et al. 2020), focusing on the African continent and assuming an area of 500 m^2 of cropland per person.

For the first scenario we assume a household size of 7 people, which is in the medium to high range: an average household in Africa consists of 3.2 (South Africa) to 8.3 (Senegal) people (United Nations 2017b). In this scenario, a family of subsistence farmers produces mushrooms with the objective of producing food and some income by selling at local markets.

For the second scenario, we look at a rural community consisting of 500 such households (a village of 3.500 people), where crop residues from the village farm land are used for mushroom production in a special mushroom house, by specialized workers, with the objective of producing food and income for the community.

In the third scenario, we look at a commercial enterprise, which is not strictly limited to a certain area of farmland, but rather can buy substrate ingredients from farmers and food- or wood-processing industries as needed. The main objective of this enterprise is to make a profit by achieving high productivity.

A more detailed overview of the model-scenarios is given in table 1. Here we list differences in the cultivation set up, looking at

1. The mushroom species that can efficiently be cultivated at that scale,
2. The substrates that will be used,
3. The pasteurization or sterilization methods used,
4. The way mushroom spawn is obtained,
5. The way the production system is set up,
6. The labourers that do the work,
7. The markets where the mushrooms are to be sold and
8. Aspects of nutrient circulation

Table 1: The application of mushroom cultivation is described for three scenarios at different scales

Socio-Economic Information:	**Objective of Mushroom Cultivation:**	**Mushroom Cultivation Setup:**
Scenario A: Farming household		
7 persons, 0.35 ha farmland, subsistence farming. Mushroom production on self-produced straw. Low capital and low investment	Food and income for family and biomass for composting	**Mushroom species**: Oyster mushrooms **Substrates**: Grain and bean straw **Pasteurization/sterilization**: Hot water pasteurization **Mushroom-spawn**: bought from large supplier **Production system**: in small shack next to family house on shelfs, in plastic bags **Labour**: household members **Market**: local **Circularity**: spent mushroom substrate/compost for fertilizing household fields

Scenario B: Rural community		
500 households, 175 ha farmland, mainly subsistence farming. Mushroom and compost production: centralized with some market orientation, specialized workers, little capital & small equipment	Food and income for community and biomass for composting	**Mushroom species**: Oyster mushrooms and button mushrooms **Substrates**: straw, sawdust, chicken and horse/donkey manure **Pasteurization/sterilization**: Hot air pasteurization in oven **Mushroom-spawn**: G1 spawn bought from large supplier but increased by sterilizing grain in a small autoclave **Production system**: shelf and column systems in a specialized house with three cultivation rooms (one colonization room and one fruiting room for oyster, one room for button mushroom. Area outside for pre-composting button mushroom substrate. **Labour**: trained community members, outside experts for help and planning **Market**: local, national **Circularity**: spent mushroom substrate is composted for fertilizing village fields
Scenario C: Commercial enterprise		
Crop residues supplied by many farms other substrate ingredients from wood- and food processing industries. Mushroom production: highly centralized production for the market, expert workers, high capital & high-tech equipment	Profit. High productivity and efficient biomass usage.	**Mushroom species:** Large number of mushroom species **Substrates:** Cultivation on straw, sawdust, manure and side-products of food processing industry **Pasteurization/sterilization:** in large autoclaves **Mushroom-spawn:** self-produced spawn from self-kept and bred stem culture strains. Spawn also sold to other mushroom producers **Production system:** Shelf and column systems, many rooms **Labour:** trained, specialized workers and engineers **Market:** local, national, international **Circularity:** spent mushroom substrate is composted and sold. Not necessarily returned to the same fields from which the substrates came.

Results

Table 2: **Strengths** Analysis of the three different model scenarios

Farming household	Rural community	Commercial enterprise
Mushroom species: Only one, robust species which requires low skill level Substrates: No costs, no transport Pasteurization/sterilization: Easy method. Very low investment cost Mushroom-spawn: high quality Production system: cheap and simple Labour: some work, such as pasteurization, can be overseen while doing field work Market: not reliant on market but opportunity for extra income Circularity: Most nutrients in spent mushroom substrate returned directly to the field	Mushroom species: more than one species, tailored to available substrates Substrates: No costs, short transport Pasteurization/sterilization: More sustainable, energy and water-saving. Medium to high investment cost Mushroom-spawn: reduced cost by using spawn, which is bought, for producing more spawn on sterilized grains or sawdust Production system: good hygiene and climate conditions Labour: Well-trained and specialized on mushroom production Market: Profit from selling at markets can be invested in mushroom facilities or other community projects. Surplus production is distributed for free among community members. Circularity: Most nutrients in spent mushroom substrate returned directly to the fields	Mushroom species: wide range of species, some of which are more profitable Substrates: Wide range of substrate ingredients. These can be analysed in laboratory and mixed for maximum productivity Pasteurization/sterilization: highly reliable substrate sterilization Mushroom-spawn: self-reliant by using pure cultures, hight quality, low cost, opportunity to sell spawn and to breed and license new strains Production system: ideal hygiene and climate conditions Labour: specialized staff and experts with increased productivity through division of labour and through automation Market: nearby and distant markets, large and niche products, food and medicine, mushrooms and compost Circularity: compost can be sold to farmers or exchanged for substrates.

Table 2: **Weaknesses** Analysis of the three different model scenarios

Farming household	Rural community	Commercial enterprise
Mushroom species: oyster mushroom is a relatively low-profit species and there could be a lot of competition on the market Substrates: variable quality. Not analysed in laboratory and mixed accordingly. Dependent on seasons, no storage space Pasteurization/sterilization: uses a lot of fuel and energy. Substrate needs to drain after pasteurization, leaving time for pests to enter Mushroom-spawn: dependence on spawn makers and the prices they set Production system: low hygiene and no climate control Market: restricted access. Short shelf-life of mushrooms, no access to cooling Circularity: Plastic use for growing containers and high fuel use for pasteurization	Mushroom species: some species too difficult to cultivate Substrates: variable quality Pasteurization/sterilization: medium investment costs Mushroom-spawn: partly dependent on spawn makers Production system: medium investment cost. Limited number of cultivation rooms Market: restricted access Circularity: plastic use for growing containers and medium fuel use for pasteurization	Mushroom species: more expertise, more investment, more labour necessary Substrates: substrates are not for free and need longer transportation Pasteurization/sterilization: high investment, high energy need Mushroom-spawn: high cost of building and maintaining sterile work environment and specialised staff Production system: high investment costs Market: marketing and advertising costs Circularity: spent mushroom substrate is not returned to same fields from which it came. Transport of substrates leads to higher emissions. Plastic use for growing containers and medium fuel use for pasteurization

Table 4: **Opportunities** Analysis of the three different model scenarios

Farming household	Rural community	Commercial enterprise
Mushroom species: increasing demand Substrates: using substrates from neighbours Pasteurization/sterilization: buying a solar oven Mushroom-spawn: using spent mushroom substrate as spawn Production system: investing in better cultivation rooms, pasteurization and substrate chopping machinery Market: direct marketing to customers Circularity: investing in reusable cultivation containers, to reduce plastic pollution	Mushroom species: growing different species in different seasons, to optimize for weather Substrates: using substrates from neighbouring villages Pasteurization/sterilization: investing in solar panels to make pasteurization more climate-friendly Mushroom-spawn: become a spawn producer by investing in autoclaves and sterile work rooms Production system: investing in better climate control and Market: expand past local market Circularity: investing in reusable cultivation containers, to reduce plastic pollution	Mushroom species: Substrates: Pasteurization/sterilization: investing in solar-panels, to make sterilization climate-friendly Mushroom-spawn: become a spawn supplier to smaller mushroom cultivators Production system: investing in solar-panels, to make sterilization and other processes climate-friendly Market: export to other countries Circularity: investing in reusable cultivation containers, to reduce plastic pollution. Investing in greenhouses, to use air from mushroom facilities for CO2 fertilization and reduce emissions

Table 5: **Threats** Analysis of the three different model scenarios

Farming household	Rural community	Commercial enterprise
Mushroom species: none Substrates: bad harvests and pests Pasteurization/sterilization: fuel shortage (fossil fuels/timber) Mushroom-spawn: difficulty of obtaining quality spawn, rising spawn prices Production system: Hot and dry weather could stop production Market: competition driving down prices Circularity:	Mushroom species: none Substrates: bad harvests and pests Pasteurization/sterilization: rising energy prices Mushroom-spawn: difficulty of obtaining quality spawn, rising spawn prices Production system: Market: competition driving down prices Circularity:	Mushroom species: cheap imports Substrates: rising prices Pasteurization/sterilization: rising energy prices Mushroom-spawn: high demand for specialized staff Production system: worker shortage Market: competition driving down prices Circularity:

Discussion

As the SWOT-analysis showed, all three scenarios have their own strengths and weaknesses, opportunities and threats. Some of these have to do with the scale at which the mushroom cultivation takes place, some have to do with competition and other outside factors, so that in practice, mushroom cultivators at different scales are likely to affect each other business success. For the discussion we will have a short look at each scenario separately and then make a comparison.

Farming household:

Low investment and running costs the biggest advantages of this scenario. The household members can use straw and wood from their own land for mushroom cultivation and use the spent mushroom substrate for composting, which will in turn help maintain their soil fertility. Various activities of the farm can be interlinked with mushroom cultivation. For example, if the family has chickens or pigs, these could forage the compost for worms and even leftover mushrooms as feed. These sustainability factors are however somewhat undermined by the relatively ineffective hot-water pasteurization, which needs a lot of fuel and water.

Also, due to the lack of expensive machinery and specialized labour (the household has to perform all farming tasks, rather than only mushroom cultivation), the work hours that have to be put in per kilo of harvested mushroom are quite high. Chopping straw with a cheap leave cutter takes a lot of time, as does pasteurization and spawning. This, together with the fact that less hygienic and climate-optimized growing conditions reduce mushroom yields, means that the profit from selling mushrooms might be relatively low. Considering the cost-factor of spawn, which a family household cannot produce itself, reduce the possible profit-margin further. Using part of the spent mushroom substrate as spawn can reduce costs but cannot completely reduce spawn costs, as insect larvae, moulds and bacteria would accumulate in the substrate over time.

If the household is able to invest in better machinery and cultivation room, as well as reusable growing containers, the profitability and competitiveness might be enough to have success at local markets even if there are competing farmers. Otherwise, the main benefits at this scale are the mushrooms produced as food for the household members and the improved circularity of their farm, which reduces costs (such as for fertilizer and feed) at other points and keeps the farm fertile.

Rural community:

A mushroom farm run by a rural community can produce more mushrooms in terms of amount and number of species. In order to make an impact and be able to process large amounts of the ligno-cellulosic biomass that grows on the village land, some machinery for chopping and pasteurizing straw have to be bought and cultivation rooms have to be built. This means that several thousand Dollars have to be invested. A large-scale oven for pasteurization is cheap, compared to an autoclave, but expensive compared to a simple barrel for hot-water pasteurization. It also uses less fuel and water than either an autoclave or the hot-water method, which improves the circularity. Since in this scenario there would be specialized staff and better machinery, the efficiency of labour would be relatively high and the losses due pests relatively low. The cost of spawn could be partly reduced by sterilizing grain in a pressure cooker or small-scale autoclave and multiplying the stem cultures or spawn bought from a supplier. This would lead to some independence, though it also requires extra work and investment. There are many opportunities for circular agriculture that would benefit the whole community in this scenario. Dung from animals could be collected and co-composted with spent mushroom substrate. Some dung, such as horse or sheep manure, could also be used for growing button mushrooms. If wood is available, even species such as shiitake could be cultivated. However, all this depends on good cooperation within the village.

Commercial enterprise:

In this mushroom farm, the efficiency of the production process and of labour can truly be optimized. The amount of mushrooms produced, as well as the number of species, is greater than in other scenarios. This is however only possible due to large investments in machinery, cultivation rooms and qualified staff. To sell the mushrooms that are produced, marketing costs might also limit the profit margin. By investing in large-scale autoclaves and hygienic facilities, the pest load of substrate will be minimal, while the energy and water cost would be medium. By producing spawn and selling it to smaller cultivators, additional profit can be made and costs can be reduced. The transport of substrates over long distances reduces the sustainability, as does the fact, that spent mushroom substrates is not necessarily returned to the same fields where the substrates came from. The accumulation of large amount of substrate in a small area can lead to environmental problems such as eutrophication, if the waste disposal is not handled correctly. The amount of food produced per kilo of substrate is greatest here, especially if the substrate ingredients are mixed optimally after analysing their chemical composition. By investing in solar panels and greenhouses or photobioreactors into which the CO2-rich air from mushroom production is pumped, the circularity of the approach could be improved.

Conclusion

The trend towards larger mushroom production facilities that has been taking place for example in China, can be explained by the higher effectiveness and productivity due to scale-effects and better machinery and production facilities. However, only where there is a large enough market, large enterprises can cover the costs and make good on the high initial investment. Also, large-scale facilities need more transport of substrates as well as the products that are sold and can cause more environmental problems. The household scenario is relatively unproductive but, except for fuel and (depending on the local conditions) water-use in pasteurization is also sustainable. The more productive, as well as more sustainable rural community approach might however be the better one. In a country, where mushroom cultivation is not yet common, it might be best, to foster this communal approach to mushroom cultivation as a part of local recycling schemes. In this way the benefits of mushroom cultivation can be shared in the whole community. A crucial part of growing a mushroom economy in this way would be easily and cheaply available spawn and workshops to have trained labout. Other than this, few obstacles seem to be in the way. In the long term however, commercial enterprises could outcompete smaller farms. At this point it will be crucial to either make sure these enterprises make the necessary investments, to be sustainable despite the weaknesses of the large-scale approach, or to protect small- to medium scale mushroom cultivators from competition through government action.

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Recycling Human Waste: A Potential approach to Closed Loops in Sanitation and Agriculture

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Key words: Nutrient recovery; Water resource management; Human urine; Food security; Agricultural biomass

Abstract

The precipitous growth of population and simultaneous intensification of socio-economic activities has resulted in rapid deterioration of the environment. However, our current systems are designed to deal with problems in sanitation, health, water, and agriculture independently. Conventional linear solutions fail to address socio-economic developmental issues adequately, owing to the inseparable nature of our essential life-support systems. Sanitation, hygiene, food security and water resource management form a nexus of essential systems – it exhibits immense potential for the implementation of efficient solutions, particularly in sustainable agriculture. The following study highlights instances of potential strategies for attaining sustainable agriculture using sanitation and hygiene nexus.

Introduction

Owing to its inter-connected nature, sustainable development in the sanitation sector has taken primacy in this age of heightened environmental awareness. Existing solutions in this industry, however, are focused on specialization and fail to realize any synergistic advantages. Continuous use of fertilisers derived from fossil fuels has significantly benefited contemporary food production. In light of the rapid fall in synthetic fertilizer supply, long-term soil fertility must be maintained in order to support the agriculture industry. Incorporating source separation, concentration, and cycling of human wastes back to agricultural fields as crop fertilizers is a sustainable approach incorporating the sanitation and agriculture nexus. If agriculture (food security) is incorporated into the sanitation–water–health equation, conceptual complication and a circular systems approach can be achieved. Human urine is currently recognized as one of these waste-water streams having a high potential to boost agricultural output as a nutrient-rich source. The development and effective use of urine diversion toilets, on the other hand, in a variety of geographical contexts have facilitated large-scale separation and shown that urine diverting toilets perform better than conventional toilets in terms of both economic and environmental externalities. Few studies have been performed on nutrient recovery, particularly the recovery of urea, the main nitrogen molecule in urine, despite the fact that significant research has been done on the design and development of urine diversion toilets. Given the inadequacy of standard separation approaches for urea recovery, it is necessary to investigate additional viable solutions.

Methodology

Fresh urine samples were collected from source separated urine diversion toilets and refrigerated at -20°C for two days (to minimize eutrophication) before being analyzed for major composition (Köpping et al., 2020). The process is then followed by adsorption of plant essential nutrients such as NPK from human urine. The potential use of locally accessible biomass such as coconut shells, bamboo shoots, and walnut shells as adsorbent media was investigated. By varying the following process parameters, the influence of adsorbate flow rate, initial adsorbate concentration, and adsorbent loading on urea absorption was investigated: (i) adsorbate flow rate, (ii) initial adsorbate concentration, and (iii) adsorbent loading. The adsorption operation was repeated until equilibrium was reached. All of the above materials are mostly discarded into the environment as waste. Hence, using them as a potential source of adsorbent helps in creating a zero- waste generating process as the waste such as human excreta and bio-materials are treated and sent back into the environment as an organic product.

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Therefore, this study gives a holistic picture of the progress made with respect to nutrient recovery systems and provides the best adsorbent-adsorbate combination that would help in maximizing nutrient recovery from urine to aid in the enrichment process of the soil, ultimately increasing the crop yield.

Results

Effect of Adsorbent

The type of adsorbent media employed to carry out the process has a substantial impact on the determination of the amount of urea absorbed from urine. Microwave-activated Carboinsed Coconut Shell (MACCS), Walnut Shell (MACWS), and Bamboo Shoot (MACBS) were the three primary adsorbents employed in the investigation. Various experimental data on the nutrient adsorption capability of the adsorbents were obtained by batch studies. The two principal investigations consist of one with a constant temperature and the other with a constant adsorbent loading. Table 1 represents the information for the former, at 100% sorbate concentration, pH: 6.8, temperature: 30C, and agitation speed: 175 RPM, and the later, at 100 percent sorbate concentration, pH: 6.8, sorbate loading: 2g, and agitation speed: 175 RPM. In all cases, it was evident from the table that the adsorption rate (mmol/g) for the adsorbents follows the trend: MACBS > MACCS > MACWS. The quantity of urea absorbed by MACBS reduced with increasing adsorbent loading (1g to 2g) and temperature (30C to 40C), from 12.5 mmol/g to 4.61 mmol/g. The same pattern was also seen for MACCS and MACWS. A further factor contributing to the improved effectiveness of MACBS is the existence of a larger surface area and an abundance of mesopores, which leads to more particle settling at its surface. Among MACCS and MACWS, the predominance of other polar groups in MACWS prevented urea molecules from interacting with the surface. Since most of the studies were conducted in Vellore, Tamil Nadu, India which has a large supply of coconut shells due to its extensive coastline, MACCS was selected as the primary adsorbent since its adsorption rates are approximately identical to those of MACBS.

Effect of Adsorbent Loading

The quantity of adsorbent that is utilised has a substantial impact on two main variables; percentage adsorption and the amount of urea uptake from the concentrated urine solution. Therefore, it is of high importance to predict the range of values for the aforementioned parameters that will result in the greatest efficiency in terms of nutrient recovery. Within this range, one particular adsorbent loading brings about the maximum uptake capacity along with percentage adsorption, before which and after which it follows a decreasing trend. On experimentation using MACCS as the main source of adsorbent, the results gathered were based on varying the adsorbent loading from 1g to 2g (Table.1). It was found that increasing the adsorbent loading parallelly resulted in the increase of the surface area that is readily available to be occupied by the urea particles from the urine solution, thereby increasing the percentage adsorption. But on the other hand, the urea uptake was >300 mg/g for adsorbent loading ≤ 1.5g (Kizito et al., 2015). At loading above 1.5g, the number of active sides available for uptake increases significantly resulting in the decrease of mass transfer between the bulk liquid and solid phase (Ganesapillai et al., 2013; Pillai et al., 2014; Simha et al., 2019). Therefore, although the percentage adsorption increases significantly at adsorbent loadings > 1 g, the decrease in its urea uptake capacity overshadows its impact. Hence, 1 g was chosen as the most effective adsorbent loading for the MACCS samples used.

Table 1: Effect of adsorbent loading with MACBS, MACCS and MACWS

Adsorbent Loading (g)	Amount of urea adsorbed ($mmol.g^{-1}$)		
	MACBS	**MACCS**	**MACWS**
1	12.52	11.31	10.57
1.5	6.2	5.8	4.91
2	4.61	3.78	3.02

Effect of Initial Concentration

Initial urine sample concentration influences the mass transfer resistance of the adsorbent-adsorbate interaction. Maintaining the adsorbent loading of MACCS constant at 1.5g, the impact of increasing the initial concentration of urine (from 25% to 100%) was examined Figure 1. The adsorption capacity of urea increased from 25 mg/g to 140 mg/g when the urine concentration rose from 25% to 100%. At all concentrations, the urea adsorption capacity grew slowly with increasing adsorption duration and finally reached a nearly constant state (Mohan et al., 2002; Zabihi et al., 2009). This is mostly due to the fact that at this time, all of the active sites had become maximally occupied, and then the urea particle dispersed into the occupied active sites for extensive adsorption. It also indicates that the starting concentration has a substantial effect on the urea absorption capacity, but a little effect on the percentage of urea adsorption, since the trends followed by the various concentrations are almost identical (Ganesapillai et al., 2015; Simha et al., 2019). This is further demonstrated by the fact that the urea removal efficiency of all curves exceeded 90%.

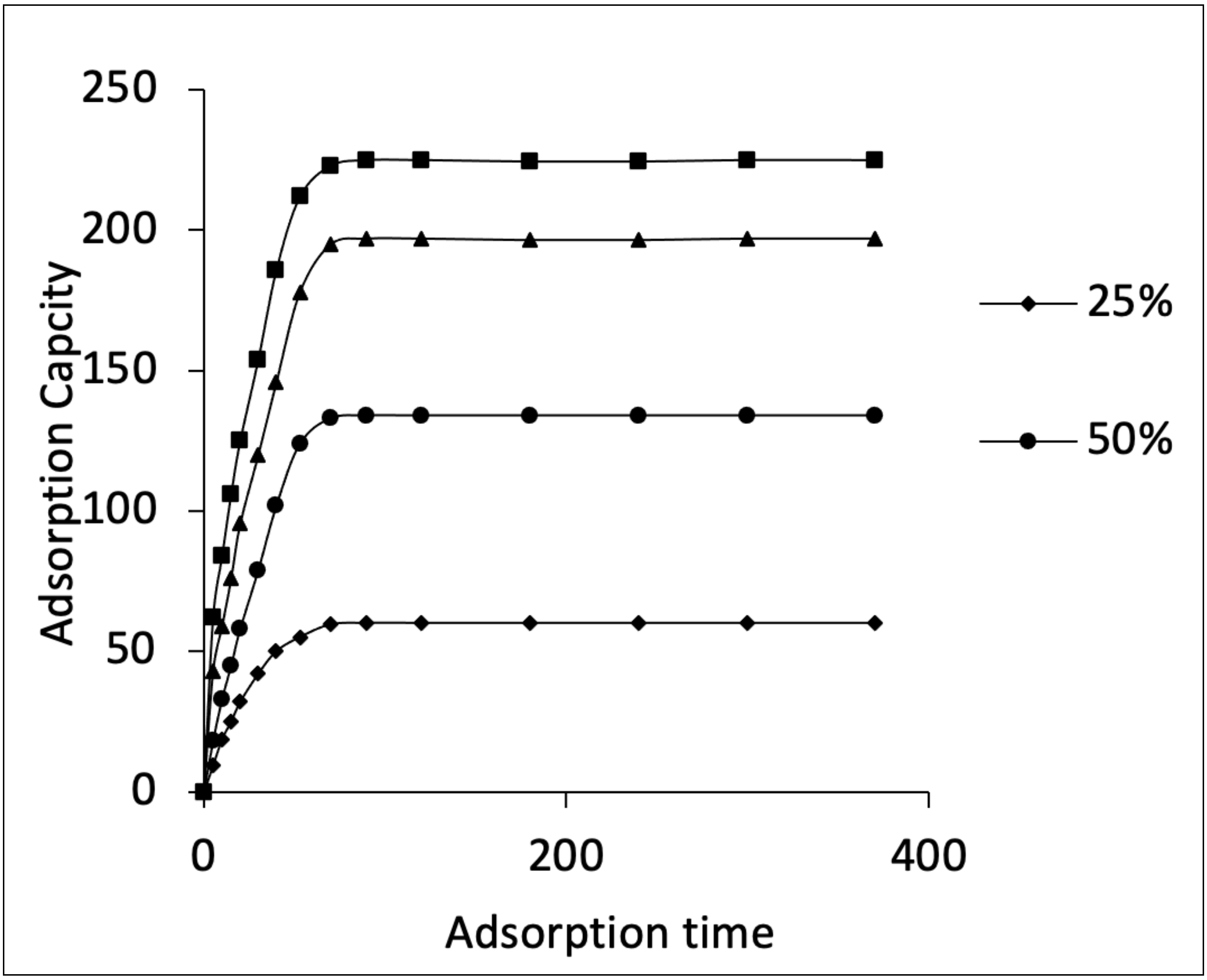

Figure 1: Effect of initial concentration with 1g MACCS loading and human urine

Effect of Adsorbate

The adsorbates employed in the investigations were human urine and cattle urine. Since nitrogen is regarded as the most essential element for agricultural soil, both human and cow urine underwent the Kjeldahl analysis. In the former, urea-N accounts for 85% of the total nitrogen content in urine, whereas in the later, urea-N accounts for 78.3% of the total nitrogen content, making human urine a better source in terms of its nutritional content (Ganesapillai et al., 2015; Pillai et al., 2014). Figure 2 depicts the adsorbed urea molecule from human urine onto the MACCS surface. Based on their increased nutritional contents, a comparison between the two was made for further research. A number of process variables are taken into account when comparing the rates of sorption onto the adsorbent for the two (carbon loading: 2 g; temperature: 30°C; pH: 6.8; shaker speed: 175 RPM)/(50 mL sorbate volume, 150 rpm shaker speed, 25°C, and 3 g MACBS loading). More than 90% of the urea was recovered at 100% original concentration with MACBS was used as an adsorbent to remove urea from cow urine (Prabhu and Mutnuri., 2014). While the same process parameters for the adsorption of urea from human urine showed that 87% of the urea at 100% concentration could be recovered. Therefore, it turns out that cattle urine is a better source of adsorbate for the chosen adsorbent.

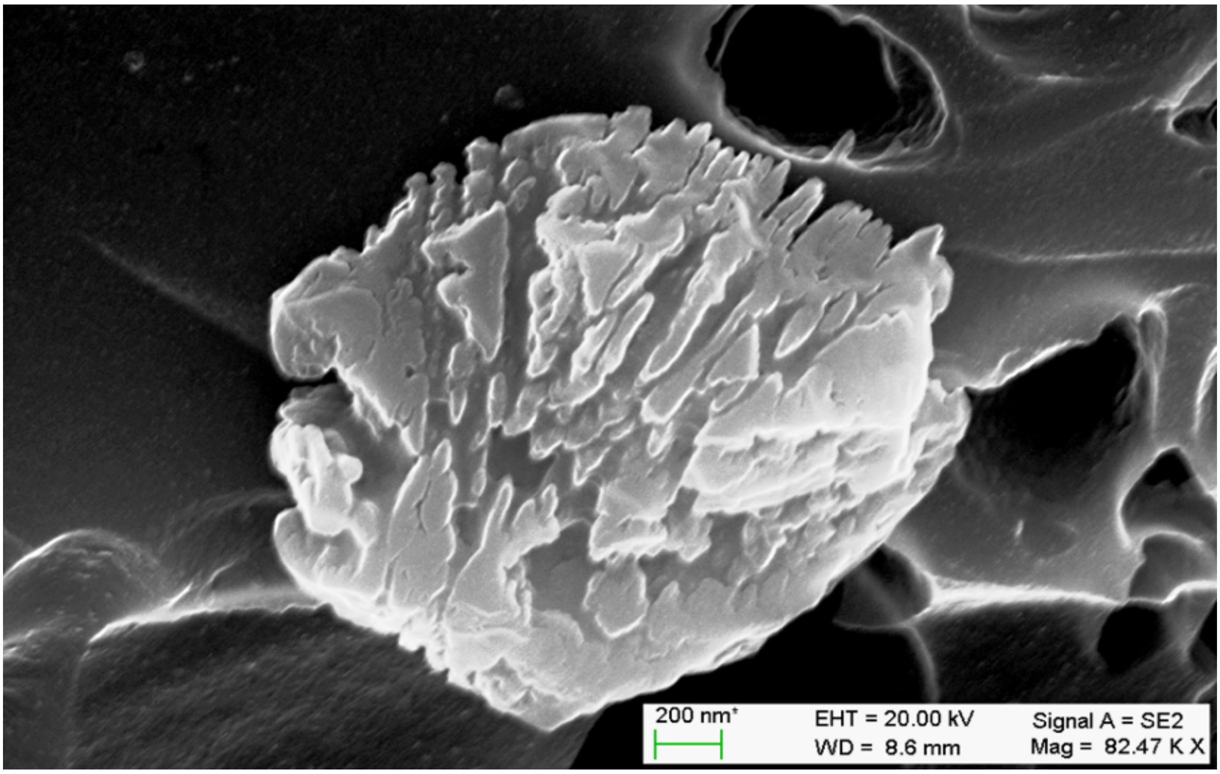

Figure 2: Scanning Electron Microscopy of MACCS surface post Urea adsorption

Equilibrium Isotherm Analysis

After checking fit with the different isotherm models as mentioned in Table.2, it was noticed that when the sorbent used was MACWS along with human urine, Freundlich model produced the highest R^2 value of 0.941. With MACCS and MACBS as the adsorbents used, highest R^2 values of 0.973 and 0.968 were obtained respectively with respect to the Dubinin–Radushkevich thereby proving it as the best fit. Since the Dubinin–Radushkevich model and the Freundlich model proved the best fit, the presence of heterogeneous adsorption sites on all the three adsorbents is proved (Vijayaraghavan et al., 2006). On the other hand, while considering MACBS as the source of adsorbent on cattle urine, as the adsorbate, it was observed that the highest R^2 value of 0.9435 was obtained with the Langmuir model combining with the R_L value at 0.43 which is supposed to be anywhere between $0<R_L<1$ (Weber et al., 1974). Therefore, for this combination, a homogeneous and monolayer uptake of urea by MACBS was proved (Pillai et al., 2014 ;Ganesapillai et al., 2015).

Discussion

Utilizing activated biomass as an adsorbent for urea recovery and recycling from urine was established by the current research. Analysis of the breakthrough curves revealed that the urea adsorption capacity is highly dependent on the adsorbate concentration, adsorbent dose, and solution inlet flow rate. Different adsorbent-adsorbate combinations were examined and studied to see which produced the greatest urea adsorption outcomes, and it was discovered that the combination of microwave-activated bamboo shoots and cow urine produced the best results. Therefore, this work is crucial in paving the way for the optimal use of resources for nitrogen recovery, which contributes to the sustainable improvement of soil. This study aims to recover the majority of soil nutrients that use the fewest resources and are the most biodegradable when applied to soil. To do this, samples of biomass were pre-treated to maximize nutrient recovery. Moreover, the nutrient-rich biomass may be utilized directly as a soil-enriching fertilizer in agriculture. This can bring about a lasting shift in the dynamics of organic agriculture. Pillai et al., (2022) featured a similar study by blending fecal matter and urine in various compositions and subjecting it to microwave pretreatment. Analogous results were attained in both studies - the energy of activation for drying was obtained to be significantly lower than in conventional processes. Hence, this upholds the need for microwave pretreatment as it alleviates the overall efficiency of the drying process.

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Vermiculture for Human Nutrition across Scales – Potentials and Limitations

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Key words: vermiculture, alternative protein source, human nutrition, circular food system, novel food

Abstract

With rapid population growth and limited land availability, food security is increasingly threatened in many parts of the world. To address these challenges, future food systems need to provide additional, affordable and healthy food, without adding pressure on limited resources, particularly farmland. A promising novel food that can be produced on little land are earthworms. They are traditionally consumed by different cultures around the world and recent studies support their value as a high-quality alternative protein source. Earthworms can be reared on organic wastes to produce protein-rich earthworm biomass and vermicompost, a high value organic fertilized, as a byproduct. Future food systems could utilize the ecological function of earthworms as decomposers to create economic value, food and fertilizer, from waste. However, the scale at which these benefits can be harnessed best is still unclear. Accordingly, in this study we performed a SWOT analysis to compare three model scenarios of vermiculture for human nutrition to elucidate the potentials and limitations present at different scales.

Introduction

Global population growth is expected to rapidly increase the demand for food in the coming decades and innovative and sustainable food systems will have to be developed in response. Current food systems rely largely on farmable land for food production. The area of farmland available per person, however, is drastically decreasing and agricultural productivity is furthermore jeopardized by climate change, soil degradation and biodiversity loss (Rahmann und Grimm 2021). Under these conditions, ensuring food security for all will be near impossible with today's primarily land-based food systems (Rahmann et al. 2020). To address these challenges, future food systems should produce affordable and healthy food, and reduce the environmental impact on land, water, biodiversity and the global climate, while restoring soil fertility (Willet et al. 2019).

The circular LandLessFood system has been developed as one approach to achieving these goals (Rahmann et al. 2020). It combines the following three steps to increase food production and nutrient cycling, while lowering land-use and environmental footprint: 1. Land-based agriculture produces staple foods and crop residues are removed at harvest as a resource for further food production. 2. Crop residues are utilized as a substrate for cultivation of edible oyster mushrooms and are partially degraded in the process. 3. Spent mushroom substrate is fed to earthworms to produce protein-rich earthworm biomass for human consumption. Residual vermicompost, a high-quality organic fertilizer, is returned to the field to improve soil fertility and agricultural productivity.

The present article focuses on the rearing of earthworms for biomass production, also known as vermiculture, in the context of the LandLessFood system. A number of recent studies have shown the potential of using spent mushroom substrate as feed for earthworm biomass production (Bakar et al. 2011; Nik Nor Izyan et al. 2009; Sailila et al. 2010; Sun 2003; Wang et al. 2019). Earthworm biomass is a valuable protein-source and has been traditionally valued as food by cultures around the world (Sun und Jiang 2017; Grdiša et al. 2013). Earthworms have a high protein content of 55 – 71 % dry weight (Sun et al. 1997), are rich in essential amino acids (Sun und Jiang 2017) and a good source of minerals and vitamins (Domínguez et al. 2017). Furthermore, vermiculture for human nutrition produces high-

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quality organic fertilizer as a by-product, which can be applied to improve soil fertility and crop productivity in the field (Dominguez and Edwards 2011, Lazcano and Dominguez 2012).

Vermiculture for human nutrition comes with varying potentials and limitations depending on the scale of application. Vermiculture can be practiced from small-scale, low-tech settings up to industrial-scale, high-tech facilities (Shermann 2018). It is currently unclear at which scale the use of vermiculture for human nutrition can most efficiently contribute to food system sustainability. In this study we therefore investigate potentials and limitation of vermiculture for human nutrition in three scenarios of different scale. Our main research questions with regard to these three scenarios are:

1. Is vermiculture technically feasible?
2. How does vermiculture contribute to food security?
3. How does vermiculture contribute to sustainability?
4. How does vermiculture create economic value?

Methods

Table 1: The application of vermiculture for human nutrition is described for three model scenarios of different scale.

Scenario A: Farming household	
Socioeconomy: • 7 people • 0.35 ha farmland • Subsistence farming • Vermiculture: low level of know-how, no or little capital & equipment	**Vermiculture Setup:** Earthworms are reared in small-scale vermibeds, open to the ground and surrounded by a low wall on the sides. Shade is provided by trees, a simple roof or net. Evaporation can be controlled by large leaves, a tarp or other cover. Feed is applied in the form of crop residues and food waste when available. Earthworm are utilized by controlled access of chickens or hand-picked for direct use in the kitchen. Vermicompost is directly applied to the field or kitchen garden.
Scenario B: Rural community	
Socioeconomy: • 500 households (7 people each) • 175 ha farmland • Mainly subsistence farming • Vermiculture: centralized with some market orientation, specialized workers, little capital & low tech equipment	**Vermiculture Setup:** Earthworms are reared in several large vermibeds with a cemented floor and surrounded by low brick-walls. Alternatively stackable boxes with ventilated lids can be used for more efficient space utilization. Shading and rain-protection are provided by a simple roof. Vermibed can be covered with tarps, large leaves or lids for evaporation control. Spent mushroom substrate and other organic community wastes are regularly added as feed in thin layers. Earthworms are harvested by sieving for direct consumption in community households or during application to the field by chickens. Vermicompost is stored and supplied to farmers when needed. Leachate, or vermitea is collected and can be used as a biostimulant.
Scenario C: Commercial enterprise	
Socioeconomy: • Large scale production facility linked to commercial mushroom production • Vermiculture: highly centralized production for the market, expert workers, high capital & high-tech equipment	**Vermiculture Setup:** Earthworms are reared in a box-system on multi-level conveyor belts with sensors for automated feeding, optimal humidity and temperature regulation and pH-control. Spent mushroom substrate and other N-rich organic wastes supplied regularly in thin layers for optimal earthworm biomass production. Mechanized harvest with trommel sieve for direct processing of fresh earthworms. Vermicompost is stored and supplied to farmers when needed. Leachate, or vermitea is collected and can be used as a biostimulant.

This study investigates the potentials and limitations of vermiculture for human nutrition at different scales, based on three model-scenarios. The three scenarios (Table 1) describe increasingly complex socio-economic situations within the LandLessFood framework (Rahmann et al. 2020). The availability of materials, investment capital and know-how to implement vermiculture increases from the level of a farming household (scenario A), over a rural community (scenario B) to a commercial enterprise (scenario 3).

Each scenario was subjected to a SWOT-analysis, a strategic planning tool used to evaluate a project (Paschalidou et al., 2018). Following this method identify internal and external variables that are supporting or inhibiting to the application of vermiculture for human nutrition.

Results

Table 2: The results of a SWOT-analysis are shown for the implementation of vermiculture for human nutrition in three scenarios of different scale.

	Scenario A: Farming household	Scenario B: Rural community	Scenario C: Commercial enterprise
Strengths	• No / low cost for building vermibed • No cost for feed materials • Low workload • Additional protein source • Easy harvest through chickens	• medium labour productivity of skilled workers • medium area productivity resulting from better rearing conditions and/or stacking of vermiboxes • regular availability of homogeneous feed • improved humidity regulation	• High productivity of labour, area and feed inputs • Automatization → reduced labour costs • Immediate processing → wide range of food- and medicinal products
Weaknesses	• Comparatively high land-use • Heterogenous feed quality • Seasonality of feed availability • Low level of know-how • Low humidity control • Hand-harvesting earthworms is work-intensive • Human consumption difficult with mineral particles in earthworm gut	• Medium investment costs • Labour cost of skilled workers • Organizational complexity / difficulties within the community	• High investment costs • High energy costs • Transportation costs • Automatization → high maintenance costs • Potentially reduced circularity if vermicompost is not returned to the source of crop residues
Opportunities	• Reduced need for fertilizer inputs • Improved soil health and crop productivity • Improved productivity in chickens • Commercialization of excess worms and vermicompost	• Reduced need for fertilizer inputs • Improved soil health and crop productivity • (Improved productivity in chickens) • Commercialization of earthworms and vermicompost • Reduced CO_2 emissions compared to burning of crop residues and traditional composting	• Access to new markets • Reduced need for fertilizer inputs • Improved soil health and crop productivity
Threats	• Damage by invading wild animals or insects • Drying out / flooding / overheating of vermibed • Possibility of nutrient leaching (= nutrient loss)	• (Damage by invading wild animals or insects) • Earthworm diseases • Lack of water	• Earthworm diseases / pests • Infestation with competing invertebrates • Economic competition for feed substrates • Energy shortage • Failure of equipment

Discussion

Is vermiculture technically feasible?

Technical feasibility becomes increasingly difficult and requires more financial resources from small to large scale vermiculture operations. While a simple vermibed (scenario A) requires almost no financial and material resources to implement and maintain, walled and cemented vermibeds (scenario B) require at least some degree of material inputs and financing to establish. Scenario B also requires some simple machinery for harvesting which could present challenges of maintenance. On a commercial scale (scenario C), vermiculture requires a larger amount of investment and, depending on the degree of automatization, may be difficult to maintain.

How does vermiculture contribute to food security?

In farming households (scenario A) direct consumption of earthworms by humans is difficult, but indirect utilization as chicken feed is a viable alternative. Vermibeds, which are open to the ground result in the presence of mineral particles from the soil in the earthworm gut. These particles create an unpleasant sensation to the teeth. Earthworms need to be kept for at least 24 hours in moist conditions without soil to empty their gut which complicates direct consumption of earthworms by humans. The indirect valorisation of earthworms as chicken feed is a practical alternative which eliminates the laborious hand-harvest of earthworms. Chickens are efficient at picking out earthworms when given controlled access to the vermibed. Alternatively, vermicompost containing earthworms can be applied to the field with access for chickens. This approach creates a synergy whereby the chickens harvest earthworms and spread the compost on the field.

In rural communities (scenario B) larger quantities of earthworms are produced and can be utilized either for direct human consumption or via chickens. The cemented floors of vermibeds allows to feed chickens with organic materials only, avoiding the necessity to empty the earthworm’s gut before consumption by humans. Earthworms can be harvested using simple hand or trammel sieves and distributed to households for processing as food. However, the time between harvest and processing needs to be as short as possible to avoid decay of earthworms and potential health risks. Alternatively earthworms can be sun-dried and preserved for later use as food or feed. Another alternative is the abovementioned application of vermicompost and earthworms to fields with access for chickens.

A commercial enterprise (scenario C) holds the greatest potential for utilization of earthworms for human nutrition. A well-controlled production process, mechanized harvest and direct processing ensures high quality and safety of earthworm biomass for human nutrition. Freeze-drying and removal of lipids can be applied to produce protein-powder with high storability, which can be used to improve protein content in a number of products, especially with regards to essential amino acids. The production of feed is still possible, but unlikely to be economically viable.

How does vermiculture contribute to sustainability?

In farming households (scenario A) resource use efficiency of vermiculture is likely to be comparably low. Organic wastes are not optimized for earthworm rearing but fed when available, resulting in seasonal variations in feed quality and earthworm production. Nutrients may be lost to leaching, possibly limiting the value of vermicompost as a fertilizer to improve soil fertility. However, application of this vermicompost is still preferable to commonly practiced burning of crop residues. Greenhouse gas emissions may be high due to limited control of humidity during the vermiculture process.

Rural communities (scenario B) are likely to show a higher degree of resource use efficiency due to a more controlled vermiculture process managed by trained staff. Feed materials can be stored and mixed for optimal rearing conditions resulting in high productivity of earthworm biomass. Optimal feed and prevention of leaching improve the value of vermicompost as a fertilizer. Vermicompost can be stored and redistributed to fields to strengthen nutrient cycling and maintain soil fertility in the community. Collection of leachate, or vermitea, provide an additional option for improving crop production in the community. Greenhouse gas emissions can be maintained at a low level when the vermiculture process is managed well.

A commercial enterprise (scenario C) will likely show the highest degree of resource use efficiency to optimize economic returns from organic wastes. Accordingly, feed materials will be selected and mixed, and the vermiculture process controlled for optimal earthworm biomass gains. Fertilizer value of vermicompost will be high and contribute well to soil fertility. However, a market driven distribution may lead to redistribution of nutrients to financially strong farms and therefore disrupt nutrient cycling. Leachate, or vermitea, is collected and can further improve crop production in farms with the financial capacity to purchase these products. Greenhouse gas emissions will be kept at a minimum and can even be captured and utilized, e.g. for CO_2 fertilization of greenhouses. However, the transport of organic waste to the production site and vermicompost back to farms is likely to produce more emissions than in the other scenarios.

How does vermiculture create economic value?

Farming households (scenario A) are likely to generate little economic returns from vermiculture, except for substitution of expensive chicken feeds. For these households the main benefit of practicing vermiculture may lie in the production of organic fertilizer as a low-cost substitute for chemical fertilizers. This could improve economic resilience and soil fertility.

Rural communities (scenario B) may benefit economically by efficient utilization of organic wastes for local production of protein-rich earthworm biomass and organic fertilizer. Selling of various products such as fresh or dried earthworm biomass, vermicompost and vermitea will generate a diversified income. Returns should be sufficient to make a profit after buying organic wastes at a low price and paying staff. A number of qualified jobs would be created.

A commercial enterprise (scenario C) would be able to generate the highest revenue from vermiculture due to high resource use efficiency and a diversity of products. A range of food, pharmaceutical and fertilizer products would help such a business to diversify its income options and contribute to economic resilience. Highly qualified jobs would be created. However, it is likely that returns would be privatized and not benefit the poorer population as much as in scenarios A and B. Processed food products would also be more expensive and may not be accessible for all.

Conclusion

While vermiculture is easily implemented at the level of a farming household, the potentials for food security, sustainability and economic value creation are not fully utilized. On the level of a rural community, vermiculture can be practiced at an efficient scale and contribute significantly to food security, sustainability and economic value creation. However, the needs for investment, communal organization and trained staff may hinder implementation. A commercial enterprise is likely to practice vermiculture most efficiently and generate the highest economic returns. However, needs in terms of investment, maintenance of facilities and highly qualified staff are potential barriers to implementation. While resources are efficiently used, circularity and benefits for low income populations are limited in this scenario. Overall, a medium scale vermiculture operation appears to produce the most convincing results.

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Vermiculture on spent mushroom substrate: an insight in food security and circular economy

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Key words: Biofertiliser, *Lumbricus rubellus*, *Pleurotus sajor-caju*, Spent Mushroom Compost, Vermicomposting

Abstract

An insight in food security and circular economy is viewed by connecting vermicomposting and vermiculture experience on spent mushroom substrate with the utilisation of Lumbricus rubellus. The experience of vermiculturing Lumbricus rubellus were briefly tabulated for physico-biological characteristics of the vermicomposting process and earthworms' palatability and dietary aspects. In food security dimensions, vermicomposting is part of the food stability pillar and able to always provide access for adequate food while not risking losing the food access. In a circular economy, vermiculture as part of the vermicomposting process is regenerating nature and conserving aquatic vertebrates and avian species. Potential of earthworms as alternative food with a commendable amount of protein source and its utilisation in the situation of extreme food scarcity is the way forward. So, this insight is to outline vermiculture as tolerable solutions in alternative realities and challenges while facing uncertain situations such as climate change.

Introduction

Our climate drastic changes in extreme weather trends, temperature and rainfall patterns significantly expose us to an alarming and serious threat to worldwide agri-food systems. This real climate change is undesirably affecting the food security dimensions at all pillars and yet abstain the redirection from linear economy to circular economy. Addressing the future food security issue –food availability– there is still lack of consideration for fresh earthworms or earthworm meal to be used as protein source for monogastric animals (Parolini et al. 2020). Although earthworms as a replacement meal for potential source of protein without contamination risk of heavy metals and infectious agents were significantly reported (Ding et al. 2019). Circular economy aspect –eliminating waste and pollution– building resilient and risk-free agrifood systems is the current need as echoed by the Food and Agricultural Organization of the United Nations (FAO), but lack of research is delaying the progress. In fact, the vermicomposting process bio-engineered by earthworms is a special conversion technology to treat pathogens and removes heavy metals from organic waste as this is a major challenge in waste to fertiliser conversion (Bhunia et al. 2021).

It is known that the vermicomposting process produces vermicast and from the process, the multiplication number of earthworms can be re-circular to the next cycle of organic waste bioconversion. In the aspect of earthworms breeding from vermicomposting process is commonly re-used as a protein source for animal feed (aquatic vertebrate and avian species) since most of the food chain are led back to earthworms. This eco-engineering system needs to be comprehended on its current application and future prospect so investment on its broadening potential can be harmonised at its optimal capacity.

In this vision paper, several perspectives of food security and circular economy are complimentary viewed with the experience of the vermicomposting process of spent mushroom substrate by utilising *Lumbricus rubellus.*

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Vermiculture of *Lumbricus rubellus*: aspect and condition

Vermicomposting process is a co-interaction process between microbes and earthworms in biodegrading biowaste at a faster pace as compared to composting. This eco-technology often utilises epigeic earthworms and requires a confined space created as vermireactors which provides an optimal condition for the bioconversion process or vermicomposting of biowastes to be conducted. Earthworms' palatability is the main factor ensuring the success of the vermicomposting process and it is approved based on our significant findings that the converted organic waste from agricultural industries have been successfully treated as nutrient-rich and lead to a decrease in heavy metal content in vermicast. Culturing earthworms or vermiculture is an integral part in the vermicomposting process because it is the main condition to predict the success of the bioconversion process of organic waste. Vermiculture aspect and condition for rearing earthworms' multiplication by utilising spent mushroom substrate for biofertiliser production and bioremediation is summarised in Table 1.

Table 1: Vermiculture aspect and condition on spent mushroom substrate (SMS) utilisation as feed material.

Vermiculture aspect	Vermiculture condition	
Physico-biological characteristics (process)	Vermibin / microcosm specification	Covered and (360 mm × 280 mm × 200 mm) artificially designed with a net (250 mm × 100 mm) covering the centre of the lid. (Cover is to prevent any interruption of pests and aeration net is to allow aeration and to imitate microclimatic conditions)
	Moisture	55 – 75 % (Constant moisture achieved by manual turnover of feed materials)
	Temperature	28 – 29 °C (Constant temperature for higher rate of earthworm's activity. The temperature range achieved after pre-composting period of 14 days of non-earthworm's introduction to feed materials)
	Texture	Finer texture of vermicompost (without being sieved) as compared to original substrate (SMS) texture. (In soil bioremediation treatment by utilising SMS, the soil texture after vermicomposting is sandy loam sand: 58 %; clay: 17 % and silt: 25 %)
	Colour	Darker colour of vermicompost (Due to mixture of SMS with bedding substrate goat manure / cow dung as compared to the original colour of the SMS)
	Odour	Odourless (Foul smelling substrate due to anaerobic condition or other than ruminant excreta will inhibit the process)
	Noise	Quite condition (Based on observation: if noise or vibration that causing unfavourable condition for earthworms will indicate with lowering number of clitelated earthworms – escape out from the vermibin)
	Other species	Enchytraeidae (white worms), isopods (sow bugs) and diplopoda (millipedes) (In soil bioremediation process, presence of *Allolobophora chlorotica* (green worm / morph) in the vermibin due to soil condition is highly organic and acidic. All the species are not outcompeted with the cultured earthworms for SMS as feed material)
	SMS proportion	1 kg of the feed material : 10 earthworms (The earthworms' species: *Lumbricus rubellus*)

Palatability and dietary (earthworms)	SMS granularity	Crunched as dry substrate in granular form (Positively impact on process productivity with optimum condition applied)
	Bedding type	Goat manure resulting higher multiplication of earthworms compared to cow dung: SMS (50 %) : GM (50 %) = + 394 % (multiplication; no. of clitelated) + 644 % (weight; gm) as compared to SMC (50 %) : CD (50 %) = + 57 % (multiplication; no. of clitelated) + 154.45 % (weight; gm)
	pH / acidity	pH 5 – 8, slightly alkaline to slightly acidic (Avoidance of highly acidic content (citrus), poultry and meats, and cooked food as feed amendments)

Vermiculture insight in food security

Resilient and formidable food system is needed in the current time of post-pandemic and climate change. Vermicompost or vermicast as a bioproduct from the vermicomposting process can be a substitute for soil medium in the agro ecosystem to feed the fast-paced development of urban areas which results in shrinking of available space for food production. In the food security dimensions – the four pillars, vermicomposting is part of food stability where vermicomposting is able to always provide access for adequate food while not risk losing food access from sudden shock or cyclical events to any individual or population. This is comprehensible from the role of vermicomposting process in transformation of organic waste to nutritious value of protein feed. This conception is encapsulated in Figure 1 as a visual connection of vermiculture with food security dimensions and circular economy pillars.

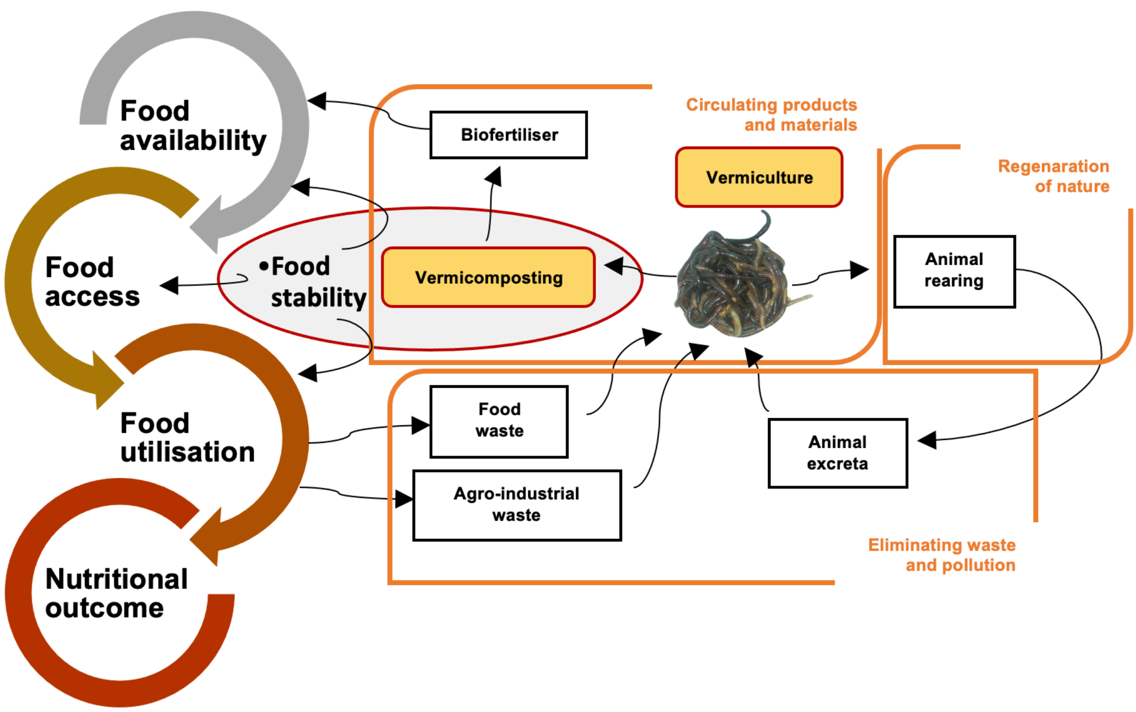

Figure 1. The food security dimensions (brownish outline) and circular economy pillars (dark-orange outline) in relation to vermitechnology concept application

Vermiculture insight in circular economy

Vermicomposting is known as a low-cost technology and environmentally friendly technique that contributes to minimisation of organic waste materials via bioconversion process for biofertiliser production. Product of the vermicomposting process, the vermicast is an efficient substitute to the chemical-fertilisers which is an efficient and alternative way in agro-industrial practice particularly in pollution prevention. In combating the issue of biodiversity loss as one of the effects of climate change, vermiculture as part of the vermicomposting process is regenerating nature and conserving the aquatic vertebrates and avian species. This application broadly taps on the circular economy pillars (Figure 1), i.e., circulating products and materials (vermicast), regeneration of nature (vermiculture), and eliminating waste and pollution (biofertiliser).

Figure 2. The spent mushroom substrate (SMS) from Pleurotus sajur-caju cultivation. Six-month-old of SMS grown in sawdust substrate utilised in vermicomposting after 4 – 5 times of mushroom harvest. Weight per bag: ~ 600 g (usually dumped in landfill or burnt in the farm)

Way forward: vermiculture potential

It is a need for alternative food with a commendable amount of protein source such as earthworm as a replacement meal due to the situation of extreme food scarcity in the effects of climate change and to sustain food demand of increasing human population with less liveable space available. Earthworms' meal could be safely consumed and act as a source of protein for monogastric animals including humans as this alternative food source of protein has been testified by Paoletti et al. (2003) with evisceration and smoke of *Andiorrhinus kuru n. sp.* and *Andiorrhinus motto* which contained large contents of protein (64.5 – 72.9% of dry weight), iron, calcium, essential amino acids, and notable quantities of other important elements that are critical to human health. Those species are edible invertebrates consumed by Yekuana indigenous people in Southern Venezuela. In this retrospective view that aligns with the suggestion of earthworms' species generally as alternative food, there is a need to consider the feeding materials consumed by the earthworms reared such as SMS (Figure 2) or other agro-industrial waste. This is crucial for nutrient content preparation and food safety in facing critical aspects of economic sustainability in aquaculture and poultry meat industry which later led to the demand on other new dietary ingredients by potential alternative and sustainable protein of human food source. In addition to address the lack of research issue, comprehensive nutritive values of common earthworm's species used in the vermicomposting process needs to be developed and its usability to the needy who are affected in the food security aspects or negatively impacted in the circular economy when tackling the climate risk.

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Malaysian Tiger Milk mushroom as functional superfood with high antioxidants

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Key words: peroxidase; polyphenol oxidase; antioxidant; phenol; mushroom

Abstract

A genus of fungi called Lignosus has proven to have beneficial therapeutic characteristics. Three different Lignosus species, generally referred to as "Tiger milk mushrooms", have been identified in Southeast Asia: L. rhinocerus, L. tigris, and L. cameronensis. The people of Peninsular Malaysia have traditionally employed all three as significant medicinal mushrooms. In this study, the antioxidant properties of L. rhinocerus sclerotial extracts from the wild type and a cultivated strain were compared. The sclerotial powder contains low fat and lots of carbohydrates. It's interesting to note that in comparison to the wild type, the cultivated tiger milk mushroom has higher levels of protein and water-soluble compounds. The extracts' capacities to scavenge 2,2-Diphenyl-1-picrylhydrazyl (DPPH) radicals per gram of extract ranged from 0.55 to 1.49 mmol Trolox equivalents (TE). The Ferric Reducing Antioxidant Power (FRAP) values ranged from 0.007 to 0.029 mmol TE/g extract, whereas the phenolic content of the hot-water, cold-water, and methanol extracts of the sclerotial powders ranged from 18.76 to 29.45mg gallic acid equivalents per gram extract. Similar to the standards, both strains showed substantial radical scavenging activity. Due to its strong radical scavenging activity and high antioxidants, the L. rhinocerus cultivar has a promising future as a functional superfood.

Introduction

The therapeutic qualities of *Lignosus* mushrooms, a species of fungi in the Polyporaceae family, are highly prized. Their potential as functional foods and biopharmacological ingredients have also been extensively studied. The species *L. dimiticus, L. ekombitii, L. goetzii, L. hainanensis, L. tigris*, and *L. sacer* are all recognised members of the genus. These mushrooms are primarily found in Australia, Southeast Asia, and Africa. The portion of the mushroom with advantageous biopharmacological characteristics and potential for use as a functional food is called the sclerotium. For instance, it has been discovered that L. tigris sclerotial extract has antihypertensive, anti-proliferative, immune-modulating, and antioxidant effects (Yap et al., 2014). Additionally, it has been discovered that the non-digestible carbohydrates isolated from the *Polyporus rhinocerus* sclerotium function as a novel prebiotic for gastrointestinal health (Gao et al., 2009). Common button (*Agaricus bisporus*), shiitake (*Lentinus edodes*), straw (*Volvariella volvacea*), oyster (*Pleurotus* sp.), winter (*Flammulina velutipes*), ear (*Auricularia* sp. and *Tremella* sp.), *Agrocybe aegerita*, and other edible mushrooms (*Dictyophora indusiata*, *Grifola frondosa*, *Hericium erinaceus*, *Tricholoma giganteum*, *Ganoderma lucidum*) primarily consumed in Asian countries (Cheung and Cheung, 2005). However, there are currently few papers addressing the bioactive qualities of *Lignosus* mushrooms, which are typically found in the forests.

The majority of the time, low-molecular-weight chemicals, in particular the phenolic fractions, are responsible for the antioxidant activities of mushrooms. So many of these potentially advantageous phenolic chemicals, including peroxidases and polyphenol oxidases, which are abundant in mushrooms, may act as natural substrates for these oxidative enzymes. Cell decompartmentalization and enzyme activation may be caused by bacterial infections, bumps and other tissue damage, improper handling

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and storage of fruiting bodies, or any combination of these factors. In these situations, phenolic chemicals might be quickly oxidised and broken down into brown melanins or other similar polymers, lessening the fruiting bodies' perhaps advantageous function. When *A. bisporus* cold-water extracts demonstrated a strong genoprotective activity against H_2O_2-induced oxidative damage, it was discovered that these enzymes may play a significant part in the antioxidant power of mushrooms (Ramírez-Anguiano et al., 2007). The presence of a thermolabile protein known as tyrosinase was associated with the protection (a polyphenol oxidase). All cultivated mushrooms have had their oxidative enzymes examined, but there is hardly any data available on wild species of edible mushrooms. Tyrosinases catalyse the oxidation of ortho-diphenols to ortho-quinones and the ortho-hydroxylation of monophenols (cresolase activity). The oxidation of lignin as well as a wider variety of monomeric and polymeric phenolic compounds can be accomplished by peroxidases and laccases through more intricate reactions involving electron transport or free radicals.

In this study, the radical scavenging activity of water and methanol extracts from *L. rhinocerus* sclerotial extracts is compared (wild and cultivated). As a preliminary study to identify the source of their radical scavenging activity, research was also focused on the low-molecular-weight (LMW) and high-molecular-weight (HMW) fractions of aqueous extracts. Additionally, it was suggested that their endogenous oxidative enzymes may have a role in their radical scavenging activity. To gauge the contribution of these molecules to their antioxidant activities and as substrates for the oxidative enzymes, total phenol levels were also assessed.

Material and methods

Tiger Milk Mushroom

The wild Malaysian Tiger Milk mushroom, *L. rhinocerus* strain ABI (WT-TMM), was discovered in the tropical rainforest of Lata Iskandar, Pahang, Malaysia (23–28 °C; 4.1949° N, 101.1923° E) (Usuldin et al., 2021). Cultivated sclerotium (C-TMM) was grown on a potato dextrose agar (PDA) plate from Sigma-Aldrich in Dorset, United Kingdom at Fuctional Omics and Bioprocess Development Laboratory Institute of Biological Sciences Universiti Malaya and incubated there at 30 °C in the dark. The strain was kept at 4 °C in storage and maintenance on PDA slants. Unless otherwise noted, all chemicals, reagents, and standards were sourced locally.

Culture Condition

The two steps of seed culture were included in the preparation of the fungus inoculum for cultivated sclerotium (C-TMM) in accordance with previously published procedures (Wan Mohtar et al., 2020). The mycelium was grown for ten days in the dark, with minor changes for the first seed culture, at an initial pH of 5, 150 rpm, and 30 °C. Using sterile scalpels, four mycelial agar squares (each measuring 1 cm by 1 cm) were cut from a ten-day-old plate culture and inoculated in a 250 mL Erlenmeyer flask (100 mL of medium). In order to develop more hyphal tips with consistent mycelium diameters, the first seed culture was then homogenised for 10 seconds with a sterile Waring hand mixer. As the inoculum for the second seed culture, the homogenised mycelial culture was transferred to a 500 mL shake flask (200 mL media) and incubated for 11 days in the dark on an orbital shaker at an initial pH of 5, 150 rpm, and 30 °C. Unless otherwise specified, the liquid culture medium of seed cultures contained potassium dihydrogen phosphate (KH2PO4) (0.046% (w/v), dipotassium hydrogen phosphate (K2HPO4) (0.1% (w/v), glucose (3% (w/v), yeast extract (0.1% (w/v), peptone (0.2% (w/v), and magnesium sulphate heptahydrate (MgSO4.7H).

Sclerotial Extracts Preparation

Using freeze-dried, sieved sclerotial powder, extraction was done at a mass to volume ratio of 1:20 (g/mL)., Hot water extraction (HW) was done at 95 to 100 °C for two hours, cold water extraction (CW) was done at 4 °C for 24 hours and methanol extraction (ME) was done by stirring at room temperature for the entire time. After that, Whatman grade no. 1 filter paper was used to filter the extraction mixture. Before analysis, aqueous extracts were freeze dried and then redissolved in Milli-Q water. Methanol extract was redissolved in 10% dimethyl sulfoxide (DMSO) after being evaporated to dryness at 37 °C.

2,2-Diphenyl-1-picrylhydrazyl (DPPH) Radical Scavenging Activity Assay and Ferric Reducing Antioxidant Power (FRAP) Assay

The DPPH radical scavenging activity assay and FRAP assay were modified from our earlier study (Hasni et al., 2017). Briefly for the antioxidant activity assay, 200 μL of a 50 μM DPPH solution in methanol were added to 40 μL of sample extracts at different concentrations. After giving the mixture a good shake, it was let to sit at room temperature for 20 minutes. In a photo-spectrometer, absorbance was measured at 517 nm. Ethanol was employed as the control, and ascorbic acid (5–80 μg/mL) served as the standard. Test results were reported as μg/mL and were carried out in triplicates (n = 3).

On the other hand, for FRAP assay, 20 μL of the methanol-based extracts were combined with 200 μLof the daily-prepared FRAP test reagent (5 mL of 10 mMTPTZ in 40 mMHCl, 5 mL of 20 mM FeCl3, and 50 mL of 0.3M acetate buffer (pH 4) in a micro-well plate reader). The incubation time lasted for 10 minutes. A 96-well microplate was used to measure the production of the TPTZ-Fe2+ complex at 595 nm in the presence of antioxidant chemicals, with methanol serving as the control. In order to calibrate the standard curve, iron sulphate (FeSO4) was used as the reference. The FRAP value was assessed using the linear regression line. The findings of the triplicated test were expressed as mmol Fe2+/g of dry extract after measuring the absorbance at 595 nm.

Total Phenolic Content Determination

The established Folin-Ciocalteu technique was used to determine the total phenolic content (Hasni et al., 2017). To 1 mL of 0.5 M Folin-Ciocalteu reagent, 100µl of sample extract was added, and the mixture was then agitated. After adding 1 mL of 75g/L sodium bicarbonate, the liquid was shaken once more for 30 seconds. The sample was incubated for two hours in the dark, and its absorbance at 765 nm was measured using a 96-well microplate. The standard used was gallic acid. Gallic acid's standard curve was used to calculate the total phenolic content, which was then represented as gallic acid equivalents (GAE) mg/g of dry extract.

Statistical Analysis

To assess whether there are any statistically significant changes between the samples that affect the oxidation activity, all the data were statistically analysed using SPSS. The outcomes shown as ± SEM (standard error mean). Application of the ANOVA test with P 0.05 was done statistically using the SPSS (Statistical Package for the Social Sciences) programme.

Results And Discussion

Antioxidant Activity of L. rhinoceros extracts

The ability of the antioxidants in the extracts to lower ferric ions and scavenge free radicals was assessed to evaluate the antioxidant activities of the mushroom extracts. In terms of the nutritional benefits of antioxidants, information on these activities is more pertinent than information on the chemical makeup of the antioxidants (phenolics and other secondary metabolites), as the antioxidants' protective effects on health are caused by their capacity to scavenge free radicals (Hasni et al., 2017). Trolox equivalent antioxidant capacity is used to express the free radical scavenging activity (TEAC).

DPPH Radical Scavenging Activity Assay

All of the *L. rhinocerus* sclerotial extracts' DPPH radical-scavenging capacity are at a range of 1 to 16 mg/mL, demonstrating a DPPH radical scavenging activity that is concentration-dependent up to a concentration of 8 mg/mL, at which point the reactions slowed considerably. Regarding TEAC, the DPPH radical scavenging activity of all of the extracts have much decreased, in comparison to quercetin and rutin, the positive controls (Table 1).

The extracts' ability to scavenge DPPH radicals declined in a sequence of ME>HW>CW for WT-TMM, and for C-TMM, ME>CW>HW. This suggests once more that various reducing chemicals may be present in ME, besides phenolics, which have a high capacity to scavenge DPPH.

Table 1: DPPH radical scavenging activity of *L. rhinocerus*

	WT-TMM			C-TMM		
Solvent	HW	CW	ME	HW	CW	ME
DPPH	0.88 ± 0.05*	0.56 ± 0.04*	1.18 ± 0.06*	0.55 ± 0.08*	0.87 ± 0.03*	1.49 ± 0.08*
Activity	Moderate	Low	High	Low	Moderate	High

Quercetin: 4.87 ± 0.02*, Rutin: 4.77 ± 0.01*
Values are described in Trolox equivalent antioxidant capacity (TEAC, mmol TE/g extract).
* significant at P<0.05

FRAP Assay

The ability of *L. rhinocerus* extracts to decrease ferric tripyridyltriazine (Fe3+-TPTZ) to the ferrous complex (Fe2+-TPTZ) serves as a measure of their antioxidant activity. The beginning rate of the ferric reducing capacity of *L. rhinocerus* extracts is shown in Table 2. In the first four minutes, FRAP values for all mushroom extracts were noticeably lower than those for the positive controls quercetin and rutin. In the course of the assay, the ferric-reducing abilities of the mushroom extracts increase steadily and according to a slow kinetic mechanism. This is consistent with a study on several commercial and wild *Agaricus bisporus* mushrooms, where the response was incomplete even after 30 minutes (*Agaricus* sp., *Boletus* sp., and *Macrolepiota* sp.) (Ramírez-Anguiano et al., 2007). Except for the ME of both the WT-TMM and C-TMM, all the mushroom extracts' antioxidant activity exhibits a pattern that is similar to their phenolic content (mg GAE/g of extract). Despite having more phenolic content than HE and CW, *L. rhinocerus* ME has a better FRAP value, which suggests the presence of additional less polar substances including tocopherols and flavonoids that may also contribute to their ability to reduce or donate electrons.

Table 2: FRAP assay of *L. rhinocerus*

	WT-TMM			C-TMM		
Solvent	HW	CW	ME	HW	CW	ME
FRAP	0.011 ± 0.02*	0.008 ± 0.05*	0.018 ± 0.01*	0.007 ± 0.02*	0.009 ± 0.02*	0.029 ± 0.03*
Activity	Moderate	Low	High	Low	Moderate	High

Quercetin: 4.87 ± 0.02*, Rutin: 4.77 ± 0.01*
Values are described in Trolox equivalent antioxidant capacity (TEAC, mmol TE/g extract).
* significant at P<0.05

Total Phenolic Content (TPC)

Phenolics are common secondary metabolites in plants, including mushrooms, and they often have strong antioxidant properties. Table 3 displays the overall phenolic content of the various *L. rhinocerus* extracts. Due to their high extraction yield, HW of C-TMM had the most phenolic compounds in terms of mg GAE/g sclerotial powder dry weight, followed by CW and ME of C-TMM. Although the concentration of phenolics in the extracts of WT-TMM were generally comparable to C-TMM in terms of mg GAE/g extract, the phenolic content was very low (0.26 mg GAE/g dry weight) when expressed in terms of mg GAE/g of sclerotial powder, possibly because of the low yield of the extracts.

Table 3: Yield and total phenolic content of *L. rhinoceros* extracts

	WT-TMM			C-TMM		
Solvent	HW	CW	ME	HW	CW	ME
TPC	28.12 ± 0.15*	27.02 ± 0.06*	18.76 ± 0.11*	21.45 ± 0.055*	28.15 ± 0.45*	29.45 ± 0.42*
Yield	4.2	7.6	6.8	210.2	105.4	32.5

Values for total phenolic content (TPC) are described in mg GAE/g extract.
Values for yield are described in g/kg dry weight.
* significant at P<0.05

Our findings demonstrate that the *L. rhinocerus* cultivated strain (C-TMM) sclerotia have higher levels of antioxidant capability than those of the wild variety (WT-TMM). These variations are not altogether unexpected. Wild type sclerotium is typically only collected once the cap has formed because, up until that point, it is hidden underground and undetectable. Sclerotium from the cultivated strain, on the other hand, is taken in the lab just as the stem and cap are developing, meaning that it is at an earlier stage of maturity.

Concluding Remarks

In comparison to the wild type (WT-TMM), the cultured strain's sclerotium (C-TMM) of *L. rhinocerus* has more antioxidant and potentially higher nutrient composition, suitable as a potential source of functional superfood or nutraceuticals.

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