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NJF Seminar 495 **4th Organic Conference**

ORGANICS for tomorrow's food systems

Mikkeli, Finland, 19–21 June 2017

NJF Seminar 495

4th Organic Conference

Proceedings

**ORGANICS for tomorrow's
food systems**

Mikkeli, Finland, 19-21 June 2017

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Editors

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Finnish Cultural Foundation



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Preface

Dear reader

I am delighted to present to you this book of ORGANICS for Tomorrow's Food Systems seminar papers. All papers have been carefully reviewed and revised and will be presented as speeches or posters at the NJF 4th Organic Conference and 495 seminar in Mikkeli. The papers have been divided into four tracks examining the organic sector from different viewpoints. Track 1, titled 'Tuning up Sustainable Organic Production' focuses on the development of organic cultivation techniques in soil management, weed and pest control; all of them representing central topics in organic farming practices. Track 2, titled 'Organic Food, Human Health and Wellbeing' considers the progress in organic food and feed research and the linkages of organic nutrition to animal and human health. Track 3, titled 'Organics in Our Society' focuses on the function of organic supply-chains and the societal factors affecting the development of the organic sector. Track 4, titled 'Organics – the Next Step', looks to the future in a holistic way assessing the role of organic methods as agents of change.

The NJF 4th Organic Conference and NJF seminar 495 is coordinated by the Finnish Organic Research Institute and is organized in collaboration with EPOK – the Centre for Organic Food and Farming, ICROFS – the International Centre for Research in Organic Food Systems, NORSØK – the Norwegian Centre for Organic Agriculture, the Estonian University of Life Sciences, the Latvia University of Agriculture, the Lithuanian Institute of Agrarian Economics and MUC – the Mikkeli University Consortium. I want to express my gratitude to all members of the Scientific- and Organizing committees for their tireless efforts related to this conference. Special thanks to Dr. Carina Tikkanen-Kaukanen, chair of the Scientific Committee for her great work in building the seminar programme in collaboration with other members of the Scientific Committee. I also want to thank Jaana Huhtala at the Ruralia Institute for editing the seminar report.

Finally, you are all warmly welcome to Mikkeli, Finland. The conference will be held during the Midsummer week. This special time of the midnight sun creates a unique atmosphere for inspiring discussions about organics for tomorrow's food systems.

On behalf of the NJF seminar 495 committee,

Sari Iivonen
Chair of the Organizing Committee
Director of the Finnish Organic Research Institute

Conference topics: Organics for tomorrow's food systems

Organic agriculture has been recognized as a driver towards more sustainable agricultural practices and food systems. However, there is a need for progress to meet tomorrow's agricultural, environmental and societal challenges, to be vital for public health and wellbeing and to have a major impact on global food systems. Research plays a fundamental role for the next step. The aim of the conference is to share and discuss recent research outcomes within organic food and farming and its societal interactions. Dialogue and cooperation between stakeholders are necessary for implementation of research and we welcome participants working in different parts of our food systems.

The conference is organized along four transdisciplinary tracks:

Track 1. Tuning up sustainable organic production

Recent reviews suggest that organic agriculture is beneficial to the environment and promotes e.g. animal welfare in a wide context. However, there are still a number of sustainability challenges concerning organic agricultural and horticultural systems of today and organic farming is criticized for its, in many cases, lower yield performances. In this track we welcome research on all kinds of organic systems that contributes to solutions for more productive and sustainable organic farming.



Photo: Brita Suokas, Ruralia Institute



Photo: Juho Hämäläinen, Ruralia Institute

Track 2. Organic food, human health and wellbeing

The knowledge of compositional differences between organic and conventional food is increasing. So far, the studies have focused on contents of essential nutrients, a few bioactive compounds like phenolic compounds, and toxic heavy metals. Less is known of other components like microbiota, hormones, growth factors, cytokines, etc. Health effects have been studied only in short term clinical studies; studies covering whole lifetime or several generations are still missing. This track deals with the link between food and health and wishes to bring light on research results contributing to fill in the knowledge gaps. The track covers also other innovative organic product development.

Transparency, clean ingredients, benefits of careful processing technologies like ferments and the identifying of new sources of proteins are also examples of topics fitting in to this track. Functional foods for target populations is another example.

Track 3. Organics in our societies

For further development of the organic food chain, larger comprehension of its interaction with communities is needed. This requires multidisciplinary and multi-actor approaches in research. Transformation of organic principles shall promote sustainability in the whole food system. This track aims to discuss food politics, economy and governmental programs, including topics about legitimacy of organic in our societies: in decision making process, legislative process and politics within different fields. What is the position of organics in our societies and food systems? How is both environmental sustainability and profitable businesses enhanced?

Track 4. Organics – the next step

Organic food and farming had a successful role to date in sparring the mainstream food systems to become more sustainable. Currently, the population is rapidly growing and the planetary boundaries are in several cases transgressed. Inequity and social unrest set unprecedented, inter-related challenges to the sustainability of food systems today and in the future. A radical change in global food systems is needed to meet the challenges. Is Organics able to make the leap to show the way forward again? This track focuses on research with systems approach, contributing to the development of tomorrow's food systems.

KEYNOTE SPEAKER

Professor John P. Reganold

speech on 19th of June 2017 at 15.30-16.30

Dr. John P. Reganold has shaped his career by his interest in agriculture and the environment, receiving his M.S. in Soil Science from UC Berkeley and his Ph.D. in Soil Science from UC Davis. He joined Washington State University in 1983 and is currently Regents Professor of Soil Science and Agroecology.

He has spent 30-plus years bringing a blend of innovative research and teaching on sustainable farming systems into the mainstream of higher education and food production. His research has measured the effects of organic, integrated, and conventional farming systems on productivity, financial performance, and environmental quality on four continents.

He has 185 publications in scientific journals, magazines, and proceedings, including *Science*, *Nature*, and *Scientific American*. He has taught more than 3,500 undergraduate students in soil science courses. His former graduate students are on the front lines of sustainability around the world, bringing food security to sub-Saharan Africa, adapting quinoa to salty soils, and turning wastes into resources in Haiti.



KEYNOTE SPEAKER

Professor Lotta Rydhmer

speech on 19th of June 2017 at 16.30-17.30

“Tuning up sustainable organic production”

Lotta Rydhmer, Dept of Animal breeding and genetics, SLU, is Professor in animal breeding. She conducts research on animal breeding and genetics, mainly breeding for sustainable production, performs studies of genotype-environment-interactions and breeding for organic production and traits in farm animals important for welfare and traits related to environmental impact.

She works with data from commercial herds, SLU's research-herd, breeding organisations' recording schemes and simulation studies. Currently professor Rydhmer is also working with sustainable agriculture and food production in SLU's interdisciplinary research platform “Future Agriculture -livestock, crops and land use”.



Photo Viktor Wränge

KEYNOTE SPEAKER

Professor Carola Strassner

speech on 19th of June 2017 at 18.00-19.00

Organic food systems: Do they produce healthy diets?

Carola Strassner is Professor of Sustainable Food Systems and Nutrition Ecology at FH Münster University of Applied Sciences. She specialises in food systems sustainability, a whole systems approach to sustainability in the sphere of food and nutrition, especially the out-of-home (horeca) context and alternative food networks. Dr. Strassner works specifically with the subsystems institutional catering, school meals, and the organic foodsystem. She is managing partner of the business company a'verdis – Sustainable FoodService Solutions.

Our most recent initiative within we can study many varying issues of sustainable food systems is the Organic Food System Programme (OFSP) <https://organicfoodsystem.net/>

The Organic Food System Program (OFSP) is conceived as a holistic global food system approach to production and consumption patterns.

The scope is to identify, understand and describetransformation processes towards sustainable food systems and make lessons learned available in a globally systematized and contextually- applicable way.

Organic food systems provide a set of unique experiences to learn from as they consist of well-defined principles and practice, as well as regulations and certifications, in different environments as well as providing abundant sets of data for modelling and testing in different geo-climatic and socio- economic regions around the world.

Furthermore, the organic sector is actively evolving into manifestly encompassing a full spectrum of sustainability issues, beyond what is sometimes seen as a limited scope focused on certification requirements.

OFSP will use the organic food systems as models, grounded in real-world examples, to understand issues in the transition to sustainable food systems.

Professor Strassner has produced a wide range of publications for chefs, kitchen staff and disseminators and is a regular contributor to text books for professionals in the food industry. She initiated and managed an international network 'Organic Out Of Home' for ten years.



KEYNOTE SPEAKER

Professor Dr. Gerold Rahmann

speech on 21st June 2017 at 10.30-11.30

Prof. Dr. Gerold Rahmann was born 1962 on a small dairy farm in East Frisia, Germany. He studied agricultural economy and made his PhD in Rural Development at the University of Göttingen, Germany. In 1999, he did his Professorship in agricultural ecology at the Faculty of Organic Agricultural Science at the University of Kassel in Witzenhausen, Germany.

Rahmann became founding director of the German Federal Thuenen-Institute of Organic Farming in 2000. He wrote more than 18 monographies and 450 articles, 52 are peer-reviewed. In 2015, Rahmann took a two-year sabbatical in Ethiopia to establish the Green Innovation Center as part of the German special initiative One World no Hunger.

Rahmann is board member of Fibl Germany, president of the International Society of Organic Farming Research (ISOFAR) and world board member of the International Federation of Organic Agricultural Movements (IFOAM). He is editor-in-chief of the scientific Journal of Organic Agriculture and associated editor of the Journal of Applied Agriculture and Forestry Research.



4th NJF Organic Conference, NJF Seminar 495 June 19-21, 2017 in Mikkeli, Finland

Day 1. Monday 19 th of June Mikkeli University Consortium (MUC) Campus, building Unica (address: Lönnrotinkatu 5)	
13.00	Registration begins
15.00-19.00	Opening session (Unica building, auditorium) Moderator: Sari Iivonen
15.00-15.30	Opening ceremony: Dr Sari Iivonen, Chair of the Organizing Committee, Director of Finnish Organic Research Institute; and Dr Carina Tikkanen-Kaukanen, Adjunct Professor, Chair of the Scientific Committee, Ruralia Institute, University of Helsinki, Finland.
15.30-16.30	Organic Agriculture in the 21st Century Keynote speaker, John P. Reganold, Regents Professor of Soil Science and Agroecology, Washington State University, USA.
16.30-17.30	Tuning up sustainable organic production Keynote speaker, Lotta Rydhmer, Professor of Animal breeding, Dept. of Animal breeding and genetics, Swedish University of Agricultural Sciences (SLU), Sweden.
17.30-18.00	Break, refreshments at MUC campus restaurant
18.00-19.00	Organic food systems: Do they produce healthy diets? Keynote speaker, Carola Strassner, Professor of Sustainable Food Systems and Nutrition Ecology, FH Münster University of Applied Sciences, Germany.
19.15 - 22.30	Get-together (organic and local buffet) at MUC campus restaurant



Day 2. Tuesday 20th of June

08.30-10.00

ORAL parallel sessions

	TRACK 1A (MUC campus, Unica building, auditorium) Cover crops and weed management	TRACK 1B (MUC campus, Unica building, Room 116) Nutrient management in organic systems	TRACK 2 (MUC campus, Unica building, Room 117) Organic dairy – from farm to milk	TRACK 3 (Cultiva building, Room 1003, Lönnrotinkatu 7) Perceptions of organic farmers and organic farming
Moderator:	<i>Sari Iivonen</i>	<i>Maria Wivstad</i>	<i>Raija Tahvonen</i>	<i>Jaakko Nuutila</i>
	<p>Salonen, Jukka and Zarina, Livija : Potential of cover crops for weed management in organic cropping.</p> <p>Madsen, Helena; Talgre, L.; Ereemeev, V.; Alaru, M.; Mäeorg, E. and Luik, A.: Winter cover crops decrease weediness in organic cropping systems.</p> <p>Hofmeijer, Merel A.J.; Melander, B.; Krawczyk, R.; Salonen, J.; Verwijst, T.; Zarina, L. and Gerowitt, B.: Problematic weed species in spring sown cereals around the Baltic Sea - an expert database.</p>	<p>Seuri, Pentti: Evaluation of nutrient (nitrogen) efficiency - the concept of primary nutrients.</p> <p>Hakalehto, Elias; Kivelä, J.; den Boer, E.; Heitto A.; Pesola, J.; Schwede, S.; Thorin, E.; Laatikainen, R.; Dahlquist, E. & Jaakkola, K. : Microbial interactions in soil improvement, circulation bioprocesses and health promotion.</p> <p>Andersen, Heidi Maj-Lis; Kongsted, A.G. and Jakobsen, M.: Integrated production of tree biomass and piglets - Effect of paddock design on sow excretory behaviour.</p>	<p>Puhakka, Laura; Jaakkola, S.; Kokkonen, T. & Vanhatalo, A.: Blue lupin as an alternative protein supplement for dairy cows fed grass silage-based diets.</p> <p>Adler, Steffen A. and Steinshamn, Håvard: Equol and enterolactone – two mammalian phytoestrogens with estrogenic potency found in organically produced milk.</p> <p>Tupasela, Tuomo; Tahvonen, R.; Marnila, P.; Vilkki, J. and Viitala, S.: Milk - new research and product development innovations (Milk-Inno).</p>	<p>Lähdesmäki, Merja and Siltaoja, Marjo: Pioneer organic farmers as institutional entrepreneurs in the agricultural context.</p> <p>Mikkola, Minna: Theoretical framing of the (heroic and rebellious) actors in the struggle for organic food and farming.</p> <p>Ma, Fanyi; Liu, X.; Tikkanen-Kaukanen, C.; Särkkä-Tirkkonen, M. and Mynttinen, S.: Perception of food and locality among Chinese tourist experiences in Finland.</p>



Day 2. Tuesday 20th of June (continued)

10.00-10.30	Coffee at MUC campus restaurant
10.30-12.00	POSTER sessions. There will be two parallel poster workshops divided in two sessions. 1A and B: Track 1 poster workshops, and 2A and B: Workshops on organic agriculture and research in Nordic and Baltic countries. It is possible to stay or to switch between the 45-minutes sessions. The workshop posters and other posters can also be viewed at any time during the conference.
10.30-11.15	1A Cover crops and weed control Toom, Merili; Lauringson, E.; Talgre, L.; Tamm, S. and Narits, L.: Finding new cover crops for Estonian conditions. Talgre, Liina; Madsen, H.; Eremeev, V.; Alaru, M.; Reintam, E.; Kahu, G.; Loit, E. and Luik, A.: Winter cover crops improve soil properties in organic cropping systems. Lötjönen, Timo: How to intensify bare fallow strategies to control perennial weeds?
11.15-12.00	1B Suitable crop varieties for organic systems Hakala, Kaija: How to find a good crop variety for organic farming? Zute, Sanita ; Vicupe, Z. and Bleidere, M.: Evaluation of different oat varieties to identify prospective breeding lines for organic agriculture. Hiltunen, Lea H.; Vorne, V.; Virtanen, E.; Degefu, Y.; Korhonen, K.; Muilu, T. and Tausta-Ojala, M-L.: Promoting production and use of organic potatoes in Northern Ostrobothnia, the northernmost agricultural area in Europe. Zarina, L. and Alekse, I.: Genotype and environment interaction on field pea cultivars in organic cropping system.
10:30-11:15	2A Organic agriculture and research in Nordic and Baltic countries Presentations from Finland, Estonia and Denmark
11:15-12:00	2B Organic agriculture and research in Nordic and Baltic countries Presentations from Sweden, Latvia, Lithuania and Norway.
12.00-13.00	Lunch at MUC campus restaurant



Day 2. Tuesday 20th of June (continued)

13.00-14.30	ORAL parallel sessions			
Moderator:	<p>TRACK 1 (MUC campus, Unica building, auditorium) Cropping designs and soil quality <i>Atle Wibe</i></p>	<p>TRACK 2 (MUC campus, Unica building, Room 117) Health impacts of organic food <i>Carina Tikkanen-Kaukanen</i></p>	<p>TRACK 3 (Cultiva building, Room 1003, Lönnrotinkatu 7) Development of organic food and farming <i>Merja Lähdesmäki</i></p>	<p>TRACK 4 (Cultiva building, Room 1030, Lönnrotinkatu 7) Platforms for sustainability and knowledge transfer <i>Elen Peetsmann</i></p>
	<p>Himanen, Sari ; Saarnia, M.; Lehtinen, H.; Mäkinen, H. and Savikko, R.: Intercropping can support ecological intensification in organic agriculture. Lepse, Liga and Jansson, Inga: Influence of Agricultural Service Crops on the fluctuations of the soil mineral composition. Mattila, Tuomas; Rajala, J.; Mynttinen, R. and Väisänen, H-M.: OSMO - Knowledge and tools for resource-efficient soil health management in a collaborative network. Short poster presentation: Mattila, T.; Rajala, J.; Mynttinen, R. and Väisänen, H-M. OSMO - Knowledge and tools for resource-efficient soil health management in a collaborative network.</p>	<p>Kneifel, Wolfgang: Raw milk and allergy prevention – a possible feature for organic milk? Tahvonen, Raija: Health effects of organic food – what can we say?</p>	<p>Siiskonen, Pirjo and Nuutila, Jaakko: Development of Organic Food Production in some European Countries. Viitaharju, Leena; Kujala, S. and Törmä, H.: Economic Effects of Organic Production in Finland. Nuutila, Jaakko: A Path of Actions to Develop Organics in the Finnish Food Chain.</p>	<p>Savikko, Riitta ; Himanen, S.; Rimhanen, K. and Mäkinen, H.: How to find pathways towards climate-smart agriculture - Views of farmers, educators and advisers in Finland. Wivstad, Maria and Röö, E: Organic 3.0 in Sweden – gathering perspectives through stakeholder dialogue Rasmussen, I.A.; Jensen, A.L.; Jørgensen, M.S.; Kristensen, H.; Conder, M.; Micheloni, C. and Moeskops, B.: OK-Net Arable online knowledge platform. Short poster presentation: Minin, Vladislav; Ustroe, A.; Mbaiholoie, E. and Subbotin, I.: Technical provision of organic farming in Russia: problems and prospects.</p>



Day 2. Tuesday 20th of June (continued)

14.30-18.00	Excursions Excursions to organic farms Siiriäinen (Excursion 1), Kalliola (Excursion 2) and Tea-House of Wehmais with an organic farm (Excursion 3).
19.00-23.00	Dinner Conference Dinner at Kenkävero vicarage. Kenkävero is at walking distance from the center of the city; 1 km from Hotel Vaakuna and 1.5 km from Hotel Cumulus. More information at http://www.kenkavero.fi/home .



Day 3. Wednesday 21st of June

08.30-10.00

ORAL parallel sessions

	TRACK 1 (MUC campus, Unica building, auditorium) Challenges for organic horticultural crops	TRACK 2 (MUC campus, Unica building, Room 117) Health and well-being from organic food	TRACK 3 (Cultiva building, Room 1003, Lönnrotinkatu 7) Organic food supply chains	TRACK 4 (Cultiva building, Room 1030, Lönnrotinkatu 7) Increasing organic farming sustainability
Moderator:	<i>Kaija Hakala</i>	<i>Elias Hakalehto</i>	<i>Pirjo Siiskonen</i>	<i>Ilse Rasmussen</i>
	<p>Kivijärvi, Pirjo ; Hannukkala, A.; Haapalainen, M. and Iivonen, S.: Onion seedlings versus onion sets in organic onion production.</p> <p>Koort, Angela and Vangdal, Eivind: The effect of organic fertilizers and thinning methods on quality parameters and the yield on apple cultivars 'Aroma' and 'Discovery' in Norway.</p> <p>Wibe, Atle: Progress in pest management in organic strawberry production.</p>	<p>Sturite, Ieva; Kruma, Z.; Tomson, L. Åsveen, M.; Kronberga, A.; Straumite, E. and Galoburda, R.: Effect of organic and conventional farming system on the total phenolic content and antioxidant activity of oats and barley grains.</p> <p>Partanen, Birgitta: Organic wild collection in forests.</p> <p>Obey, Jackie; Ngeiywa, M.; von Wright, A.; Kauhanen, J. and Tikkanen-Kaukanen, C.: Antimicrobial activity of Finnish organic honeys against human pathogenic bacteria.</p> <p>Toivanen, Marko; Huttunen, S.; Riihinen, K.; Obey, J. and Tikkanen-Kaukanen, C.: Natural product based anti-adhesion therapy- innovative prevention against bacterial infections.</p>	<p>Skulskis, Virgilijus and Girgzdiene, Vilija: Potential for raw milk in Lithuanian organic dairy supply chain.</p> <p>Väisänen, Hanna-Maija and Iivonen, Sari: Value creation in a successful organic potato supply chain from grower to professional kitchen.</p> <p>Korhonen, Kirsi; Muiilu, T.; Hiltunen, L.H.; Vorne, V.; Virtanen, E.; Degefu, Y. and Tausta-Ojala, M-L.: Demand for organic potato in professional kitchens and new production potential in Northern Ostrobothnia, Finland.</p> <p>Shamekh, Salem: Sustainable cultivation of truffles in rural regions of Finland.</p>	<p>Kuisma, Miia ; Mäkinen, H. and Kahiluoto, H.: Transition towards circular economy in dairy farms.</p> <p>Koppelmäki, Kari ; Hagolani-Albov, S.; Parviainen, T.; Virkkunen, E. and Helenius, J.: Palopuro Agroecological Symbiosis – Increasing sustainability in organic farming.</p> <p>Kreismane, Dzidra ; Popluga, D.; Berzina, L.; Naglis-Liepa, K.; Lenerts, A. and Rivza, P.: Organic Farming as a GHG Emission Mitigation Possibility in Latvia.</p>



Day 3. Wednesday 21 st of June (continued)	
10.00-10.30	Coffee at MUC campus restaurant
10.30-12.15	Closing session (MUC campus, Unica building, auditorium) Moderator: Ilse Rasmussen
10.30-11.30	Organics - the next step Keynote speaker, Professor Gerold Rahmann, Thünen Institut für Ökologischen Landbau, Faculty of Organic Agricultural Science, University of Kassel, Witzenhausen, Germany.
11.30-12.00	Conclusions of the tracks, track leaders
12.00-12.15	Closing of the Conference: Maria Wivstad, Director of EPOK–Centre for Organic Food and Farming, Swedish University of Agricultural Sciences (SLU), Sweden and Sari Iivonen, Director of Finnish Organic Research Institute, Finland.
12.30-13.45	Lunch at MUC campus restaurant

Organic Agriculture in the 21st Century

J.P. Reganold¹

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Implications

With only 1% of global agricultural land in organic production (Willer & Lernoud 2015), and with its multiple sustainability benefits, organic agriculture can contribute a larger share in feeding the world. Although organic agriculture has an untapped potential role in global food and ecosystem security, no one farming system alone will safely feed the planet. Rather, a blend of organic and other innovative farming systems, including agroforestry, integrated farming, conservation agriculture, mixed crop/livestock, and still undiscovered systems, will be needed for future global food and ecosystem security. Significant barriers exist to adopting these systems, however, and a diversity of policy instruments will be required to facilitate their development and implementation. Moreover, realizing food and ecosystem security requires more than just achieving sustainable farming systems worldwide. We need to reduce food waste, improve food distribution and access, stabilize the human population, eliminate the conversion of food into fuel, and change consumption patterns towards a more plant-based diet.

Conference track: I. Tuning up sustainable organic production

Background and objectives

Organic agriculture has a history of being contentious and is considered by some as an inefficient approach to food production (Pickett 2013). Skeptics argue that organic agriculture relies on more land to produce the same amount of food as conventional agriculture and that adopting organic agriculture on too large a scale could potentially threaten the world's forests, wetlands, and grasslands (Emsley 2001, Trewavas 2001). Yet the number of organic farms, the extent of organically farmed land, the amount of research funding devoted to organic farming, and the market size for organic foods have steadily increased (Willer & Lernoud 2015). Moreover, recent international reports recognize organic agriculture as an innovative farming system that balances multiple sustainability goals and will be of increasing importance in global food and ecosystem security (IAASTD 2009, De Schutter 2010, National Research Council 2010). Here, the objective is to compare the performance of organic and conventional farming in light of four key sustainability metrics: productivity, environmental impact, economic viability, and social wellbeing.

Key results and discussion

The performance of organic farming systems in the context of four major sustainability metrics indicates that they better balance multiple sustainability goals than their conventional counterparts. Based on present evidence, although organic farming systems produce lower yields compared with conventional agriculture, they are more profitable and environmentally friendly, and deliver equal or more nutritious foods with less to no pesticide residues. In addition, initial evidence indicates that organic agriculture is better at enhancing the delivery of ecosystem services,

other than yield, as well as some social sustainability benefits. In general, these results reported in Reganold & Wachter (2016) are similar to findings by Seufert & Ramankutty (2017).

Equal adherence to all four sustainability goals of production, environment, economics, and social wellbeing does not limit but encourages farmers and researchers to innovate. The challenge facing policymakers is to create an enabling environment for scaling-up organic and other innovative farming systems to move towards truly sustainable production systems. This is no small task, but the consequences for food and ecosystem security could not be bigger. To make this happen will require mobilizing the full arsenal of effective policies, scientific and socioeconomic advances, farmer ingenuity, and public engagement.

How work was carried out?

According to a US National Academy of Sciences report (National Research Council 2010), any farm, be it organic, conventional, integrated, or other, can only be deemed sustainable if it produces adequate amounts of high-quality food, enhances the natural-resource base and environment, is financially viable, and contributes to the wellbeing of farmers and their communities. With the rise of organic farming, especially in the past two decades, hundreds of research studies comparing different aspects of organic and conventional farming systems have been published. Based on the recent paper by Reganold & Wachter (2016), here 40 years of scientific studies comparing organic and conventional farming are reviewed and assessed in the context of these four major sustainability metrics: production, environment, economics, and social wellbeing. Much of the analyses relies on data that have been synthesized in published meta-analyses and reviews of sustainability metrics, such as crop yield, energy efficiency, and financial performance.

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Tuning up sustainable organic animal production

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Implications

In this report, within the track “Tuning up sustainable organic production”, we highlight sustainability assessments and the choice of breeding goals as opportunities for improvement. We also discuss goal conflicts and small-scale effects of organic production.

Goal conflicts

An engine can be tuned up to run most efficiently. But organic production is not an engine; there is not one single “most efficiently”. When striving for a more sustainable organic production we need to consider many different sustainability aspects and we encounter many goal conflicts. Examples of goal conflicts are: Good working environment vs Low production costs; Low climate impact vs High animal welfare; Low use of toxic substances vs High yield; High profit in a short-term economic perspective vs High animal welfare. The last example was shown in an evaluation of 15 different pig production systems in Europe, performed by Bonneau et al (2014). In production systems with high pig welfare the farmers’ economy was, in general, worse.

How can we improve the ability to handle goal conflicts? The first step is to admit them. And to admit that some of them cannot be solved scientifically; they need political decisions. Scientifically, it is difficult to compare the value of an improvement in working environment with the value of an increase in biodiversity. As researchers, we can highlight goal conflicts and provide a scientific base for political decisions. It can be done by investigating the frequency of accidents among farm workers or the number of species per m³ soil. Remember, however, that different values underlie the choice of monitored parameters and that many assessments lack social aspects (Slätmo et al, 2017).

Production system perspective

As animal geneticists we are proud of the genetic progress leading to lower climate impact of animal production. With an ongoing genetic increase in milk production, the greenhouse gas emissions per kg milk decreases substantially. It is, however, necessary to see this improvement in its context. In the Nordic countries, a high proportion of the consumed cattle meat is a ‘by-product’ of milk production (80 % in Finland, Niemi & Ahlstedt, 2013). If the demand is constant, a breeding work resulting in more efficient cows with high milk production leads to less number of cows and thus less meat. If we still want to consume the same amount of cattle meat we have to increase the number of beef cows. In general, animal production with beef cattle has a larger climate impact than animal production with dairy cattle. This example, discussed by Kokko (2017), illustrates the importance of studying whole production systems. Furthermore, agriculture production should be studied together with food consumption (see for example Rööös et al, 2016) when aiming for a more sustainable development.

In general, breeding has resulted in high producing plants and animals that are specialised on production systems with high input of external resources, as discussed on the workshop “Visions for genetic diversity in Swedish organic agriculture (Nilson et al, 2015). The less traits included in the breeding goal the faster is the progress in single traits and different breeds have been developed for different products, e.g. separate breeds for egg production and chicken meat production. This development can be problematic from an ethical point of view; for example male Jersey calves are neglected due to their low economic value and male chickens are killed after hatching. Selection for specialised breeds can also be questioned from a production system perspective, as shown by Kokko (2017). She concludes that “combined milk and beef production would likely be the most viable and sustainable way to achieve self-sufficiency in beef while maintaining sufficient milk production in Finland.” Her simulations show that a higher selection pressure on growth rate in dairy cattle would improve the profitability of combined milk and beef production systems (Hietala and Juga, 2016).

In organic production, dual-purpose breeds seem to have a key role. The Organization for Organic Livestock Breeding in the Netherlands is testing a small-scale poultry production system where the breeding for a dual-purpose hen is integrated into the commercial egg and meat production. Their breeding goal is a hen with a minimum laying output of 250 eggs per year that is genetically predisposed to be meatier, so that the cockerels can be raised for slaughter (Biologische fokkerij, 2017). Further selection of dual-purpose breeds and their evaluation from a production system perspective could strengthen the development of organic animal production.

Contrasting production systems

“The organic production” is sometimes discussed as if it was one homogenous system. Within the Core Organic project OrganicDairyHealth, an inventory of organic production systems in 7 European countries has been performed (Wallenbeck et al, 2016). It shows a huge diversity, ranging from systems with on average less than five cows and below 4000 kg milk per cow and year to systems with on average more than 150 louse housed cows and production levels close to 10000 kg milk (Wallenbeck, pers comm). Different organic production systems have different challenges and their farmers probably need different advisory support and research results from different kinds of scientific studies to improve. Two organic systems were included in the sustainability assessment of pig production systems (Bonneau et al, 2014) and both got better than average ‘sustainability scores’ for animal welfare and working conditions, whereas one got better than average scores for environmental impact and market conformity and the other for meat safety. It could be questioned whether the organic movement has room for all kinds of different production systems or whether ‘tuning up’ would mean focusing on a lower number of organic production systems.

Organic production and efficiency

The production level in many organic production systems is lower than in many conventional production systems and organic production is criticised for being inefficient (exemplified by Savage, 2015). This difference in production level influences the outcome of Life Cycle Assessments (LCA) and LCA reported per kg product rank production systems differently as compared to LCA reported per hectare land use (Meier et al, 2015). The review by Meier et al (2015) also shows that many LCA comparing organic and conventional systems do not differentiate the specific characteristics of the systems and often a rather limited number of aspects are assessed. Garnett (2014) describes three different perspectives on sustainable food security: Efficiency oriented, with focus on appro-

appropriate production techniques and strategies to reduce emissions; Demand restraint, with focus on decreased consumption of high impact foods; and Food system transformation, with focus on production and consumption and imbalanced relationships among actors in the food system giving rise to problems of both excess and insufficiency. Garnett (2014) states that “Everybody wants ‘sustainability’ and an end to hunger – but not everyone has the same vision of what the solution - the good life - might look like.” A better understanding of what underlies these different perspectives could maybe help the organic movement to handle critique related to lower production levels and lead to more constructive discussions around LCA comparisons of organic and conventional production.

Breeding goals for organic production

Differences in environment and management (more roughage, outdoors, later weaning etc), costs (higher feed price etc) and revenues (higher product price) could motivate different breeding goals for conventional and organic production. ‘Organic breeding programs’ are rare (although poultry and cattle are selected for organic production in the Dutch Organisation for Organic Animal Breeding, see Biologische fokkerij, 2017), but alternative breeding goals have been studied in several simulation studies. An interactive web questionnaire to dairy and pig farmers showed that when the farmers decide their breeding goal, farmers with organic production put higher weight on health traits as compared to farmers with conventional production (Wallenbeck et al, 2016b).

Slagboom et al (2016) performed a preference study among Danish dairy farmers. They identified four clusters of farmers that put most weight on Health and Fertility; on Production and Udder Health; on Survival; or on Fertility and Production. A higher proportion of farmers with organic production were found in the production-based clusters and farmers with organic production ranked production traits higher than other farmers. In organic production, milk yield and disease incidences were lower (compared to conventional) and this may explain the high ranking of milk production and the low ranking of disease traits made by farmers with organic production (Slagboom et al, 2016).

Slagboom and co-workers have created a breeding goal based on farmers’ preferences and compared that breeding goal to the current breeding goal for conventional milk production and to an organic breeding goal based only on economic calculations (Slagboom et al, 2017). These breeding goals are used in simulations to compare the genetic change. In the next step, Slagboom used the four organic principles on Health, Ecology, Fairness and Care (IFOAM, 2017) and asked dairy farmers, advisors, researchers and breeders which goal traits they think are important to select for in order to follow these principles. The traits getting the most ‘votes’ were disease and mortality traits for the principles on Health and Care; roughage consumption and feed efficiency for Ecology and mortality traits for Fairness. The associations between goal traits and organic principles will be used to construct an additional breeding goal that will be used in Slagboom’s simulation study. Creating special breeding programs for organic production, or at least special sets of weights for the goal traits, could be one way to ‘tune up’ the organic production (see Nilsson et al, 2015 for a discussion).

The problem of being an alternative

Being a minor alternative, counted in size of production, hinders development of a production system in general, since there are less stakeholders that can share the development costs. In

animal breeding there is also a direct negative effect of small scale. With less records the accuracy of breeding values decreases, leading to lower genetic progress. Furthermore, to run a breeding program is complicated and expensive. The sustainability assessment of European pig production systems showed that small breeding organisations had less technical and human resources and were more vulnerable (Rydhmer et al, 2014). The negative scale effects could motivate cooperation between organic producers in Europe; to create a population large enough for a special breeding program. This may, however, be in conflict with the definition of organic agriculture which states that organic agriculture is a production system that ... relies on ecological processes, biodiversity and cycles adapted to *local* conditions (IFOAM, 2017). With a population spread over many regions and countries, the breeding goal may become "less local".

Sustainability assessments

Regardless of differences between organic and conventional production systems, the organic movement should strive for continuous improvement and sustainability assessments can thus be useful. LCA of organic animal production has been performed (e.g. Thomassen et al, 2008) but they usually do not include social aspects. As shown by Raworth, agriculture production systems should be developed within the area framed by planetary and social boundaries, the so-called Doughnut (Raworth, 2012). In a new EU project entitled Sustainability of pig production through improved feed efficiency (SusPig, coordinator W Rauw), both environmental and social LCA of current and improved production systems will be performed. The social aspects will be identified through stakeholder workshops. Our experiences from SusPig project may be useful when evaluating organic production systems in the future.

The long term aim of organic production

IFOAM is revising the organic standards. Looking at organic production as a marketing strategy (added value), it may make sense to strive for keeping a gap between organic and conventional production. Then "tuning up" could mean more and more complicated rules for organic production, resulting in an exclusive but small production of highly valuable niche products. This point of view could maybe justify a ban of sexed semen or artificial amino acids in feed regardless of opportunities for decreased environmental footprints. Seeing organic production as a way to sustainable development on a larger scale, complicated rules for organic production may be counterproductive since they limit the number of organic farms. "Tuning up" could be to adapt the rules for organic production in accordance with new scientific results, not letting the precautionary principle lead to dead ends. The choice between these future roads for organic production ought to be discussed within the organic movement, keeping the organic principles in mind.

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Organic Food Systems: Do they produce healthy diets?

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Implications

European studies show that people who prefer organic food also follow overall healthier diets, i.e. they eat more fruits and vegetables, more whole grains, less meat, with an apparently lower environmental impact. This interplay of organic food preference and dietary patterns needs more attention. National or regional nutrition surveys in planning could include questions designed to collect data on the nature of organic consumption and even food literacy in order to verify or refute these first observations. Addressing the question of healthy diets requires epidemiological studies and connects with public health nutrition considerations. In turn this links with the Principle of Health, one of four guiding Principles giving orientation to the organic sector.

However, the organic product range is growing especially in the convenience and snack categories, which are typically associated with increased levels of processing, trans fats, salt and sugar content. At the same time dietary guidelines are shifting from a nutrient-based approach towards a wider approach linking both food product and food production processes. Food-based Dietary Guidelines (FBDG) are including such aspects restrictively. A critical appraisal of the organic assortment seems indicated. Foodstuffs that come from a food system in alignment with natural cycles should give rise to a healthy and sustainable diet. If not, we should be looking for disruptions.

Background and objectives

When considering the question of health in organic food and farming, the focus has largely been on comparing individual products produced according to organic or conventional practices. However, health is the product of diet i.e. the pattern of foods eaten over a longer period of time, and diet is one of many health determinants. Hence the search for evidence of better health outcomes in the organic food system also needs to be considered at the diet level and even at the social practice level.

Key results and discussion

Even though no “Organic Diet” with the customary characteristic of food-based recommendations or prohibitions can be identified in popular science style books on alternative diets, the organic market is growing in many countries. These markets afford access to consumers that may consume a significant amount of organic produce on a regular basis. In two such national markets (France and Germany) national nutrition surveys including organic consumption data exist. Analysis of regular consumers of organic products in both cohorts shows that organic consumers exhibit a better dietary pattern (more plant food-based) and a food choice that better fits food-based and nutritional recommendations. Additionally, in the German cohort a positive relationship between healthy dietary patterns, nutrition knowledge and a healthy lifestyle was also found. Furthermore, they are markedly less overweight and obese, have a higher level of physical activity, follow a non-smoking regimen and have healthier life-style profiles.

A further field for exploration of this may be provided by school meal systems. Studies show that schools with a healthy-food policy also support organic food; alternatively said, an organic school policy can promote healthy eating. This may underline the importance of organic food in public procurement for the education sector.

Organic food consumption patterns seem to be close to both recommended healthy dietary patterns as well as sustainable diet patterns. The association between dietary patterns and food choices seems of great importance and therefore needs further study.

How work was carried out?

Representative consumer studies such as national nutrition surveys with stratifiable data on organic consumption were investigated and selected for study.

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Going towards Organic 3.0

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Implications

Organic 3.0 discussions have released a discussion about the future development of the Organic sector (Rahmann et al. 2016). There are many think tanks started ideas (Arbenz et al. 2017). Most of the ideas are very rough and not with practical visions for research. But there should be no time lost, that Organic takes the leadership for innovations, that helps to tackle with the future challenges, to design clear pathways to be more sustainable: food supply and to have ownership for the definition of ecology, health, care, fair and quality.

Back grounds and objectives

Organic can help to prevent hunger, reduce farm land degradation and losses in biodiversity, mitigate climate change, income and jobs, and supply healthy and enough food with a low-external-input / medium output farming strategy. The Organic 3.0 approach is the basis for this contribution.

- Feed 9 to 11 billion people in the next 30 to 80 years with enough, affordable and healthy food.
- Protect environment like soils, water, air, biodiversity and landscapes in increasing intensification strategies.
- Mitigate greenhouse gas emissions and adapt on climate change in all farming systems and value chains.
- Incorporate novel ethics, food habits, demographic and lifestyles in the food chains.
- Produce food on limited farm land and fossil (non-renewable) resources efficient and profitable.

Key results and discussion

The "Organic 3.0" approach is the basis for this contribution. What has to be done that Organic is fit to contribute to tackle the future challenges? There are two time dimensions: the next 35 years till 2050 and the time from 2050 up to 2100. In 2050 we will have approximately 9 billion people and 1 ha agricultural farm land per capita. In 2100 we will have 11 billion people and only 0.7 ha per capita. This discussion and challenge is the same like for conventional agriculture: limited resources needs to intensify (factor-factor relation) and be more productive (output-factor relation) and be more efficient (factor-output relation).

How work has to be carried out?

Conventional can learn from Organic: The production must be more and more sustainable. That means: ecological sound, high ethical standards (e.g., animal welfare, fair trade), profitable and social acceptable. There is a need to change the industrial production strain of conventional and be back to local acceptable farming systems, where farmers can have a good income and the price is affordable for everyone. The external costs of production needs to be included into the price of products.

Organic can learn from Conventional: Efficiency and productivity with limited resources, e.g., agricultural land. Organic needs to be more productive to be accepted in societies with limited land and food quantities. Not all farm inputs are bad. Clear criteria are needed to incorporate good conventional strategies into Organic: e.g., synthetic amino acid if all feeds are produced on the farm. Mineral fertilizers, if produced with renewable energy and in a quantity, which does not pollute the environment and products.

Scale-up Good Organic Farming Practice: Good Farming Practice is necessary to fulfil the consumer and public demands as well as be more efficient with limited resources. Both, organic and conventional have to train and trigger their farming systems on the track of better practice. In future we cannot effort spoiling and inefficient farming practices. Capacity building and training needs to the support of research, mainly via socio-economics: How can we transfer Good Organic Farming Practice to all farms as a permanent process?

The food production needs more close links to the consumer: Consumer must accept, that in the coming future not everything will be always and everywhere for a cheap price available. It will be not possible and producible in the coming future that everyone on the earth will consume like the western world today. We need to avoid wasted food, reduce livestock and utilize novel food sources. Additionally, the consumers need to bring back valuable nutrients back to farming: clean and efficient.

Farming has to change from “commodity related” towards “needs related” production: Ecological Food First means also that non-food production is second and needs alternative - not farm related - production bases. Community Supported Agriculture needs to be improved and scaled-up.

Less livestock and changed animal husbandry systems: Numbers of livestock needs to be reduced by a significant number, from ethical point of view probably even towards zero (in specific cultures and regions). That needs improved food consumption skills (e.g., avoiding malnutrition with vegan diets). Invention of novel protein food resources based on insects and sea food are necessary.

Local versus global food chains: The transport of food from one place to another place on the earth will be not as easy as today. Fossil energy and probably limited space will need new farming and food distribution systems. Probably people have to go to food areas and not food to people areas as today. Migration and better distribution of humans and food have to be initiated.

Land-less food production: Organic farming likes soil and prohibits soil-less food production. But: soil is scarce, probably degraded, polluted or sealed and therefore not avail for healthy food production. Food can be produced on sealed surface (urban agriculture, in-door/household, on roofs etc.). Aquaponics is a chance to link water and land related food production. Last but not least inventions should be done to substitute some food ingredients from agriculture towards reactor production.

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Potential of cover crops for weed management in organic cropping

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Implications

The occurrence of weeds can be reduced with successful choice of cover crops which are grown together with the main crop. Cover crops compete against weeds and, moreover, leguminous cover crops leave nitrogen for the subsequent crops in the rotation and thereby improve their competitiveness against weeds. Weed management with cover crops should be built into a sustainable integrated weed management strategy which enhances both the weed control and the biodiversity in crop stands.

Background and objectives

In Northern Europe, the current crop rotations in arable fields are often too short and dominated by spring-sown annual crops. In consequence, some weed species become highly abundant and hamper crop production. With systematic choice of cover crop species and their mixtures we could control weed growth without significantly impeding the crop growth. However, the crop–cover crop–weeds interplay is sensitive to cropping measures and weather conditions. Need for studying the most feasible cover crop practices is evident.

Key results and discussion

Red clover (*Trifolium pratense*), white clover (*Trifolium repens*) and timothy (*Phleum pratense*) have a good potential of preventing weed growth. In the sowing year, the cover crops are too slow to effectively hamper the emergence and early growth of annual weed species but later in the growing season they interfere with weeds. The competition continues after harvest and therefore the tillage should be delayed until late autumn or even to the next spring. The long-term effect was demonstrated in Latvian experiments one year after the cover crops; the weed density in cover crop plots was significantly lower than in the plots without cover crops (Zarina et al. 2015). Based on the promising results on cover crops in Finland, farmers are encouraged to sow catch crops also in winter cereals early in the spring. Short-growing clover species do not cause significant yield reductions to the main crop. Tall-growing clover species (*T. resupinatum* and *T. incarnatum*) and *Melilotus alba* were too competitive to the crop. Italian ryegrass (*Lolium multiflorum*) can also be too aggressive when sown at the same time with the spring cereal. Delayed sowing is recommended particularly in light soils.

How work was carried out?

Field experiments with cover crops in cereals were carried out both in Finland and Latvia. Selected plant species (legumes and grasses) were undersown as cover crops either alone or as mixtures. In Finnish experiments altogether 16 species in mixtures were evaluated. Benefits of cover crops

were assessed by measuring weed growth and crop yield. In Latvia, the subsequent effect was measured one year later in grassland.

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Winter cover crops decrease weediness in organic cropping systems

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Implications

By inserting cover crops into organic cropping systems, the number and biomass of weeds decreased. Winter cover crops clearly have a suppressive effect on weeds by providing competition for light, water and space.

Background and objectives

In organic farming one of the most important issues is to maintain soil fertility and to reduce the influence of weeds on the main crop yield (Melander et al. 2016). Since infestation with weeds results in competition for nutrients, water and sunlight and thus is the main reason for considerable crop loss, it is important to control weediness (Robaccer et al. 2015). Drilling winter cover crops after the main crop harvest can improve soil characteristics, when incorporated into the soil, and prevent leaching. Growing cover crops provides agroecological services by preventing water and winter erosion, improving chemical, biological and physical soil properties and suppressing weeds by providing competition or by releasing allelopathic chemicals from either living or decomposing plant tissue (Melander et al. 2016). The aim of the study was to investigate the influence of different winter cover crops and their combination with composted cattle manure on weeds in three organic farming systems during the period of 2014–2016.

Key results and discussion

During the experimental period it became evident that the introduction of winter cover crops to a five-year crop rotation (Org I system) and in combination with cattle manure (Org II system) depressed weediness in comparison with the control system (without cover crops, system Org 0). In spring before the incorporation of winter cover crops into soil, the weed dry mass was statistically highest in system Org 0 (51.5 g DM m⁻¹), where no winter cover crops were used and the soil was bare. In the systems Org I and Org II the weed dry mass did not differ from each other but it was significantly lower than in system Org 0. These results correlated with the weed density – in Org 0 system the number of weeds was the most abundant and it was much lower in Org I and II systems. Different cover crops depressed weeds differently. Winter rye and a mixture of winter rye and winter turnip rape were better suppressors of weed dry biomass and weed density compared to winter turnip rape. There were no significant differences in weed species composition between cultivation systems. Before the incorporation of the cover crop, the dominant weed species was *Matricaria inodora* in all systems. The weed species also often found were *Viola arvensis* Murr., *Capsella bursa pastoris*, and *Chenopodium album* L. There was a tendency, that the number of weed species was higher in Org 0 and lower in winter rye as cover crop in Org I and II systems.

These results indicate clearly, that autumn sown cover crop establishes a sufficient living plant mulch covering the soil before winter. In early spring the cover crop is able to resume its vegeta-

tive state and thus suppresses weediness by competition (Hollander et al. 2007). Also winter rye exhibits allelopathy and thus inhibits weeds by releasing natural toxins.

The use of cover crops reduced the weed pressure during the cover crop cycle. But the effect was not permanently significantly obvious in the subsequent cash crop. In cash crops before harvesting the suppressing effect of winter cover crops was strongly influenced by climatic conditions and significant differences between systems appeared only in 2015.

It can be stated, that winter cover crops have a suppressing effect on weeds. From the cover crops used the winter rye was the best weed suppressor. Beside of suppression of weeds, winter cover crops have multiple positive effects on different soil properties (Luik et al. 2014)

How the experiment was carried out?

The five-field crop experiment with three different organic systems was started in 2008. The crops grown in succession were as follows: barley (*Hordeum vulgare* L.) undersown with red clover (*Trifolium pratense* L.), red clover, winter wheat (*Triticum aestivum* L.), peas (*Pisum sativum* L.), and potato (*Solanum tuberosum* L.). The control System (Org 0) followed this rotation. Winter cover crops were used as green manure in System Org I: mixture of winter turnip rape and winter rye after winter wheat, winter turnip rape after peas and winter rye after potato. In System Org II winter cover crops were used as green manure and in spring composted cattle manure – 20 t ha⁻¹ for potato, 10 t ha⁻¹ for winter wheat and for barley was applied. On average, the dry matter of composted cattle manure contained 138 g C kg⁻¹, 9.7 g N kg⁻¹, 4.6 g P kg⁻¹, 8.6 g K kg⁻¹. The average dry matter content was 44.8 percent. The experiment was established in four replicates, each plot (60 m²) situated in a systematic block design. The field is the property of the Department of Field Crop and Grassland Husbandry of the Estonian University of Life Sciences. The field's location is near Tartu (58°23'N, 26°44'E). The soil type was sandy loam Stagnic Luvisol according to the World Reference Base classification (FAO 2014). The cover crops were sown right after the harvesting of the main crop and in next spring at the beginning of May they were ploughed into the soil. In cereals, potato and peas mechanical weed harrowing was used to control weeds. All data regarding the five-field crop experiment was collected according to TILMAN-ORG Handbook of Methods (Cooper et al. 2012). Total dry mass and density of weed species were measured in the end of April before the cover crops were ploughed into the soil and three weeks before harvesting the rotational crops. All measurements were carried out in four replications per each plot with a 25 x 25 cm frame. All weed samples were collected and counted by species. Total biomass was weighted using only aboveground biomass after the weed samples were dried (80 °C) to a constant weight.

Statistical analyses were performed by using the Statistica software package (version 11.0). Significant differences between cropping systems, winter cover crops and experimental year were tested by Tukey's least significant difference test. The statistical significance level was set at p<0.05.

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Problematic weed species in spring sown cereals around the Baltic Sea – an expert database

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Implications

Specific annual and perennial weeds are a perpetual challenge in the process of tuning up sustainable organic production. To utilize the perspective of agro-biodiversity would both improve crop yields and conserve the ecosystem services of organic production. The successful use of crop diversity strategies provides an additional tool for the farmers, giving them a) an overview of problematic weed species and b) the opportunity to plan their crop diversity based weed management for the future.

Background and Objectives

Weeds remain to be the main constrain on organic crop productivity (Penfold et al. 1995, Clark et al. 1998, Turner et al. 2007) However, they serve multiple ecosystem services and only a few species prove problematic for both the crop and in the farmers' perception. The international PRO-DIVA project studies the effect of crop diversity strategies on the diversity of weed communities, hypothesizing that by increasing the weed diversity, the development of problematic weeds will be mitigated. Before this can be studied, an inventory of the 'problem' species should be compiled, to be able to target these species within the proceedings of the project. The findings are made available to local stakeholders.

Key results and Discussion

On basis of the international literature review we proposed five weed types. The "Bodybuilders": annuals that develop high biomass and are highly competitive. The "Early Birds": annuals that rely on a quick establishment in spring, also includes the more flexible and opportunist annuals. The "Plebeian": annuals that can occur in high densities, but rarely have a competitive impact. The "Indestructibles": perennials that have strong root systems and are extremely resilient, hard to control and very competitive. The "Grassland": perennials that are common weeds in grassland systems (See Table 1). The majority of the most problematic weeds stem from the categories of "Bodybuilders" and "Indestructibles", likely due to their high competitiveness and amount of control measures required. This is coherent with the sentiment expressed by farmers in the study of Turner (2007). Species belonging to these two weed types are mentioned to be 'problematic' in the majority of countries. The country specific species are often members of the Early Birds or the Plebeians or even the Grassland species.

This is probably caused by the distribution of weed species and their specific adaptation to their local environment, such as climatic conditions and soils. We have to consider that the competitiveness of weeds relies heavily on local conditions as well, but the similarities are noteworthy.

Table I: Problematic weed species most often mentioned in national literature and by local extension services. Divided into annuals and perennials. Germany (DE), Denmark (DK), Sweden (SE), Finland (FI), Latvia (LV) and Poland (PL).

Latin Name	DE	DK	SE	FI	LV	PL	Weed type
<i>Annuals</i>							
Chenopodium album	x	x	x	x	x	x	Bodybuilder
Polygonum spp.	x	x	x	x	x	x	Bodybuilder
Centaurea cyanus	x	x	x		x	x	Bodybuilder
Galeopsis spp.		x	x	x	x	x	Bodybuilder
Raphanus raphanistrum	x					x	Bodybuilder
Sinapis arvensis		x	x				Bodybuilder
Galeopsis tetrahit			x			x	Bodybuilder
Alopecurus myosuroides	x						Bodybuilder
Avena fatua				x			Bodybuilder
Brassica rapa ssp. Campestris		x					Bodybuilder
Stellaria media	x	x		x		x	Early bird
Galium aparine	x		x			x	Early bird
Matricaria inodora		x				x	Early bird
Apera spica-venti	x				x		Early bird
Lamium purpureum				x	x		Early bird
Viola arvensis				x	x		Early bird
Anthemis arvensis						x	Early bird
Papaver rhoeas	x						Early bird
Galinsoga parviflora						x	Early bird
Thlaspi arvensis			x				Early bird
Spergula arvensis			x	x			Plebeian
Erysimum cheiranthoides				x			Plebeian
Fumaria officinalis					x		Plebeian
Anchusa arvensis	x						Plebeian
Matricaria discoidea			x				Plebeian
Myosotis arvensis				x			Plebeian
Veronica arvensis					x		Plebeian
Amsinckia micrantha		x					Plebeian
<i>Perennials</i>							
Elytrigia repens	x	x	x	x	x	x	Indestructibles
Cirsium arvensis	x	x	x	x	x	x	Indestructibles
Equisetum arvense		x	x	x	x	x	Indestructibles
Sonchus arvensis		x	x	x	x		Indestructibles
Rumex spp.	x		x	x			Indestructibles
Tussilago farfara		x	x	x			Grassland
Ranunculus repens			x	x			Grassland
Taraxacum officinale			x	x			Grassland
Artemisia vulgaris		x			x		Grassland

Methodology

A preparatory study was carried out to list the most problematic weed species in spring sown cereals in the countries involved with PRODIVA (DE, DK, SE, FI, LV, PL). For this a literature review was conducted in all participating countries, collecting local sources including grey literature. This was combined with the opinion of local extension services and other weed experts. From this a list of 10 most problematic weeds was deduced for each country.

Furthermore, the weed species were divided into five types loosely based on the categorization of character traits from Holzner and Glauning (2005), so to make identification as a 'problematic' weed species more comprehensive.

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Evaluation of nutrient (nitrogen) efficiency – the concept of primary nutrients

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Implications

A method to evaluate nutrient utilization initially described by Seuri (2002, 2013) was improved. The system boundary was set covering the total target system including also the “invisible” processes outside the target system. The substitutive method is presented in the case of missing data of processes outside the target system. This study underlines the importance of understanding the total system instead of trying to improve single sub system.

Background and objectives

The concept of primary nutrients and primary nutrient efficiency, $P(\text{eff}) = Y/P = C \times U$; Y = nutrients in yield harvested in the system; P = primary nutrients ; C = circulation factor, $(P+M)/P$; M = secondary nutrients ; U = utilization rate, $Y/(P+M)$; was presented by Seuri (2002, 2013). The system boundaries were set around the target system (farm) in such a way that some of the processes and nutrient flows were not included directly in the target system. Main processes not included were a) crop production of purchased fodder and seeds, b) production of purchased manure (crop and animal production), c) crop production of sold manure. The main reason to exclude those processes previously was the lack of data about those processes. However, ignoring those processes distorts the actual nutrient efficiency of the target system. The aim of this study was to improve the initial concept of primary nutrients and present a new method to evaluate nutrient efficiency of the whole target system including the processes outside the target system as well. The substitutive method is presented in the case of missing data of processes outside the target system.

Key results and discussion

The method of “shadow farms” was developed. In the reality many of the processes and nutrient flows in modern agriculture are run outside the target farm, $F(\text{target})$. However, the functioning of the evaluated target system is fully dependent on those processes, i.e. these processes are an essential part of the evaluated system. Since these processes are not “visible” at the evaluated system, they can be named as “shadow” processes, and the external sub systems of the target system can be called “shadow farms”. Missing data of nutrient utilization can be replaced with constant ratios (nitrogen only). Constant ratios indicate average figures in Finnish agriculture.

Following “shadow farms” were identified and defined (analogous with processes above):

- a) $F(\text{pf/s})$, the “shadow farm” where purchased fodder/seed is produced to the target farm; constant ratio: 1 kg primary nitrogen equals 2/3 kg nitrogen in yield (67% utilization rate of primary nitrogen on the field,)
- b) $F(\text{pm})$, the “shadow farm” where purchased farm yard manure (FYM) is produced to the target farm; constant ratios: 1 kg primary nitrogen equals 2/3 kg nitrogen in yield, furthermore equals 1/3 kg nitrogen in sold FYM (50% of nitrogen in fodder ends up in FYM)

- c) F(sm), the “shadow farm” where manure sold out from target farm is used in crop production; constant ratio: 1 kg nitrogen in sold manure equals 1/5 kg nitrogen in yield (20% utilization rate of secondary nitrogen on field).

In order to evaluate the primary nitrogen efficiency, $P(\text{eff-N})$, in the total system (S), nutrient flows and yields must be aggregated from all of the sub systems: $S = F(\text{target}) + F(\text{pf/s}) + F(\text{pm}) + F(\text{sm})$. Primary nitrogen flows (P), secondary nitrogen flows (M) and yields (Y) are identified and defined in table 1. Minor flows (e.g. bedding materials, own milk for calves, atmospheric deposition) are ignored for this purpose.

Table 1. Specification of primary and secondary nitrogen flows and yields at all of the sub systems (Farm). Purchased/sold/own from F(target) point of view. Note, that nutrient flows and processes are not necessarily happening at same sub system, e.g. when purchased manure is used on F(target), manure itself has been produced on F(pm).

Farm	Primary nitrogen (P)	Secondary nitrogen (M)	Yield (Y)
F(target)	p(fertilizers) p(biol. N-fix)	m(own manure, own fields) m(sold manure) m(own seed)	y(fodder, own animals) y(cash crop) y(own seed)
F(fp/s)	p(fertilizers for seed) p(fertilizers for fodder)	m(purchased seed)	y(purchased seed) y(purchased fodder)
F(pm)	p(fertilizers for fodder)	m(purchased manure)	y(purchased manure)
F(sm)			y(sold manure)

As it can be seen from table 1. it really doesn't make any sense to evaluate any of the classic nutrient balances (farm gate balance or surface balance) or efficiency (nutrient utilization efficiency, NUE) for the target farm, F(target), if “shadow farms” are not included; at least the result doesn't indicate the efficiency of the total system.

The principle of this new method is useful in any system approach. If there are several successive processes (e.g. crop production, animal production, new crop production process in different system, new animal production process in different system), there is a huge risk for wrong conclusion if the system boundary has been set between any of these successive processes. Evaluation must not be begun excluding previous processes or later processes if the target process is dependent on those others. The lack of data cannot be the excuse.

How work was carried out?

There is a serious lack of tools to evaluate nutrient utilization in agricultural systems. Seuri (2002, 2013) has pointed out the weakness of farm gate balance, surface balance or NUE methods for evaluation; they can't identify the difference between primary and secondary nutrients (Fixen et al. 2015). The concept of primary nutrients and primary nutrient efficiency has been developed to evaluate specially the systems where nutrients are recycling (integrated crop and animal production systems). Original method was used for about 100 animal farms in South-Savo region in Finland through the years 2012–2014. It was noted, that especially for the farms with low self-sufficiency of fodder and selling out the manure for neighbouring farms, get results with higher pri-

mary nutrient efficiency than others. Closer analysis indicated, that those farms avoided the losses in evaluation which originated from production of purchased fodder and usage of sold manure. Therefore, the evaluation method had to be improved.

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Microbial interactions in soil improvement, circulation bioprocesses and health promotion

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Implications

Microbiological communities form inner balances between their member strains. Their natural interactions can be used for producing various fermented foods, organic preservation strategies, and means for maintaining human or animal health by pre- and probiotic products. The microbiomes of soil, foods and their supplementations, animal feed as well as in our digestion form a continuum, which can be monitored and adjusted during the entire production chain. This includes also the recycled biomass, which is returned to the food and feed production.

Background and objectives

Undefined Mixed Cultures (UMC) were used together with some industrial GMO-free strains for the processing of food and agricultural wastes, such as chicken litter from the ecological hen-house and abattoir in Sweden (Schwede et al. 2016), potato industry waste and sorted biowaste in Poland (den Boer et al. 2016), or bovine rumen contents in Finland (del Amo and Hakalehto 2015, Hakalehto et al. 2016), could facilitate circulation loops from the industries to the agriculture. The results from various bioprocesses indicated that the processing strategies with natural microbes could form a basis for the implementation of novel ecological production units, cultivation means and health-promoting organic goods.

Microbiological composition of the process broth had been studied by the PMEU (Portable Microbe Enrichment Unit) in a simulation of the microbial interactions together with prebiotic flax and some other organic raw materials (Hakalehto and Jaakkola 2013). The joint effects of the fibres and probiotic bacteria were to get further investigated to indicate the balancing effects that could help in maintaining intestinal well-being and health. It also seemed possible to achieve such balances between moulds and bacterial species in the production process (Hakalehto and Hallsworth 2017).

Key results and discussion

The management of the organic product and its microbiome should start from the primary production, and continue during the processing phase being combined with the return of the process side streams. We added the productivity in the greenhouse cultivation by about 50% by using the Aurobion™ microbiological supplementation of organic fertilizers produced out of the side streams.

In the waste management, the strong inherent microflora could compete out harmful strains, thus also hygienizing the process broths. The probiotics could attenuate as additions with the

crushed flax seeds the enterobacterial growth up to 100-fold in the simulation of the intestinal conditions. This offers means for supporting the Bacteriological Intestinal Balance (BIB) of the individuals along the digestive tract. Consequently, the intestinal disorders could be relieved by the microbiological approach. The present findings support the view that the microbial strains tend to form a balanced community on all phases of the succession (Hakalehto et al. 2008, 2010).

With a holistic approach to the organic raw materials, microbial strain supplementation, production process, product hygiene, circulation of side streams and health implications, we could establish production strategies which will improve the productivity, sustainability and healthiness of the organic goods and their manufacturing. The microbial loads at all stages were studied with emphasis on their interactions.

How work was carried out?

The testing of the microbial interactions was carried out in a simulation experiment. Some probiotic bacteria were cultivated together with intestinal microflora, such as *Escherichia coli*, *Salmonella* sp., *Klebsiella* sp., and *Staphylococcus aureus* in the PMEU (Portable Microbe Enrichment Unit) equipment, together with some organic additives, such as crushed flax seeds and antioxidants from various berries. The growth curves were obtained from the cultivation, and could indicate the interactive effects. They could be effectively monitored by this method, combined with the NMR analysis (Nucleic Magnetic Resonance) for the screening of the metabolites.

The field trials were conducted at the greenhouses of the Helsinki University Viikki campus. During three month cultivation period the growth of Chinese cabbage, Rye grass and Water grass was measured by dry and wet weight of the plants.

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Integrated production of tree biomass and piglets - Effect of paddock design on sow excretory behaviour

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Implications

In order to reduce nutrient losses in systems with an integrated production of trees and piglets it is important that the lactating sows are motivated to urinate and defecate adjacent to the trees. In the present study, adding poplar trees in one end of individual pasture-based paddocks did not motivate the sows to choose the area with trees for elimination, which was independent of paddock design. The location of feed and hut influenced the sows' excretory behaviour and the effect differed between the different combination of feed and hut location. Future work should be focused on overall paddock design to optimize nutrient uptake and to ensure an outdoor system that is sustainable from both a welfare- and environmentally point of view.

Background and objectives

Free-range pasture systems for organic pigs comply well with the organic principles and the organic consumers' expectations to organic livestock production. However, the systems as practiced in the Northern countries are associated with high risks of nutrient losses. This is caused by high inputs of concentrated feed combined with poor vegetation cover due to the pigs' rooting behaviour (Eriksen et al. 2006). There is a need for further development of free-range systems to reduce the environmental footprints of organic pork production.

An integrated production of tree-biomass and pork in pasture-based systems is expected to reduce nutrient losses compared to pasture systems without trees. Well-established trees like e.g. poplar are more robust to the pigs rooting behaviour and have deep root systems with nutrient uptakes across a long growing season compared to grass (Jørgensen et al. 2005). This will reduce the risk of nutrient leaching in pasture systems.

It is crucial that pigs are motivated to deposit the majority of urine and faeces close to the trees. The sustainability of an integrated system therefore depends on the ability to control excretory behaviour of pigs. Previous studies have shown that feed and hut location do affect choice of elimination area (Eriksen & Kristensen 2001). In addition, it seems that pigs prefer to excrete near to trees or near to high vegetation areas (Horsted et al. 2012). The objective of the present study was to investigate the effect of spatial arrangements of trees, hut and feed on lactating sows' excretory behaviour in a pasture-based system with four rows of poplar trees.

Key results and discussion

Based on previous studies by Horsted et al. (2012), it was assumed that the pigs would prefer to eliminate in the tree zones. As a consequence, this preliminary and first part of the analyses focused on the distribution between the grass zones (zone 1-3) and the tree zones (zone 4-5). Across paddock design, the sows in average were observed to deposit 35% and 52% of urine and faeces, respectively, in the zones with trees, which constituted 34% of the total paddock area.

Regarding effect of paddock design, for the distribution of faeces a three-way interaction was found between zone, hut and feed location ($p < 0.05$). If the hut was located in zone 3 (closest to the trees) and the feed in zone 1 (farthest away from the trees), the sows defecated mainly in the tree zones. Whereas if both the hut and the feed was located in zone 3, only 34% of the defecation was observed in the tree zone. Taking into account the difference in zone size, it means the distribution per unit area were similar in the two zones. The same was observed if the hut was located in zone 2 and feed in zone 3. For the urination, the highest proportion of urination was for all treatments observed in the grass zones ($p < 0.05$). The lowest proportion of urination (26%) in the tree zone was observed if the hut was located in zone 1 and feed in zone 3, whereas the highest proportion (43%) was observed if both hut and feed was located in zone 3, but no significant effect of treatment ($P = 0.11$) was found.

In accordance with the result reported by Stolba & Wood-Gush (1989), Salomon et al. (2007) and Watson et al. (2003), no urination or defecation was observed in the 1m zone around the hut, feed and water troughs. In addition, no elimination was observed in the wallow in accordance with the results reported by Sambraus (1981).

Our results could not fully confirm the results reported by Horsted et al. (2012), that the pigs prefer to eliminate in the trees. However, the elimination behaviour seems to be affected by the location of the feed and hut, which has also been reported by Eriksen & Kristensen (2001) and Salomon et al. (2007). Preliminary results from the present study indicate that sows can be motivated to eliminate in the tree area if the hut is located nearby the trees, and if the feed trough is located at the opposite end than the trees. Locating both resources nearby the trees should be avoided. Next step is to analyse if the distribution of urine and faeces in the paddocks is related to the resting and foraging behaviour. This includes looking more closely on the distribution in the individual paddock zones (1-5).

How work was carried out?

The experiment was carried out during spring and autumn 2016 on an organic pig farm in Denmark. It included twenty-four Landrace X Yorkshire sows housed in individual farrowing paddocks (36x13m). Each paddock was divided into five zones. Zone 1-3 consisted of grass clover and zone 4-5 each included two rows of four poplar trees. In all paddocks, a wallow was located in zone 2. The sows were randomly allocated to the six treatments: Feed trough located in zone 1 (farthest away from the poplar trees) or in zone 3 (closest to the poplar trees), and the hut located in zone 1, 2 or 3. Each sow was observed from sunrise to sunset, one day in the third- and the sixth week of the lactation. The sows' location and activity (e.g. lying, standing, grazing and rooting) was observed by scan sampling with 10 min. interval. Urination and defecation was observed by all occurrences observations. The effect of paddock design on the proportions of faeces and urine (e.g. number of defecations in the tree zone as the proportion of total defecations in the whole paddock per sow) were investigated by a binomial model using the glm procedure in R. The model included the following: zone, hut and feed location.

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Finding new cover crops for Estonian conditions

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Implications

Cover crops are essential in fallow periods of cropping systems to protect the soil from erosion and loss of plant nutrients through leaching and runoff (especially in winter). Experiments with potential cover crop species were carried out to evaluate their suitability to the local climate. The biomass production of tested cover crops in the two year experiment depended on the length of the growing seasons.

Background and objectives

In the last decades, organic farming has received great attention due to environmental and health-related concerns. Using cover crops in crop rotations is a promising option for sustainable agricultural production in both organic and conventional farming systems. Selection of cover crops depends mainly on the suitability for the local climate. In northern climate, the growth period of winter cover crops remains short, therefore the selection of species is limited.

In Estonia, interest in using cover crops for autumn and winter periods has grown in the recent years. Typical cover crops are white mustard (*Sinapis alba* L.), winter rye (*Secale cereale* L.), winter oilseed-rape (*Brassica napus* L. ssp. *oleifera* var. *biennis*) and winter oil turnip rape (*Brassica rapa* L. var. *oleifera*). Experiments with new cover crop species were carried out to find varieties that are capable of producing large biomass and binding great amounts of nutrients in the northern climatic conditions. More options for winter-hardy cover crops, especially cold tolerant legumes are also needed.

The potential new cover crops for autumn and winter include a brassica species tillage radish (*Raphanus sativus* L.) and leguminous crops berseem clover (*Trifolium alexandrinum* L.) and hairy vetch (*Vicia villosa* Roth).

Results and discussion

The weather conditions in 2015 caused a late harvest of cash crop and the cover crops tillage radish and berseem clover were drilled at the end of August. The growth period of the cover crops remained short – only 42 days, with an effective temperature sum (ETS, >+5 °C) of 323 degrees. Biggest biomass was produced by tillage radish - about 950 kg dry matter (DM) ha⁻¹ and it bound 25 kg of nitrogen (N) ha⁻¹. Tillage radish does not survive the winter in our climate, but when established early it produces quite large taproot and therefore is capable of scavenging the nutrients from deeper soil layers. Nutrients absorbed by the taproot are readily available to the following crop because the taproot decomposes quickly, releasing the nutrients almost immediately. We recommend the tillage radish for no-till farming systems because it leaves root channels, so the soil dries and warms up faster in spring.

The biomass DM yield of berseem clover was only 100 kg ha⁻¹. Berseem clover is also winter-killed in Estonia. In autumn it needs earlier establishment before cooler temperatures slow the growth.

The number of growing days for the cover crops tillage radish, berseem clover and hairy vetch was 68 in 2016, with an ETS of 534 degrees. Earlier sowing and more favourable weather conditions resulted in considerably higher biomass yields compared with 2015. The total biomass DM yields varied from 2500 kg ha⁻¹ for tillage radish to 1400 kg ha⁻¹ for hairy vetch and berseem clover. N accumulation by cover crops depends on the total amount of biomass produced and the percentage of N in the plant tissue. Several researchers found non-leguminous cover crops to be very effective in taking up mineral N from the soil during autumn-winter time (Kramberger et al. 2010; Thorup-Kristensen, 2001). Tillage radish bound 70 kg N ha⁻¹. The legumes that are able to bind nitrogen from air as well, bound about 30 and 50 kg N ha⁻¹. Hairy vetch bound more N than berseem clover because of greater N concentration in biomass.

Hairy vetch may be a promising cover crop option for Estonia, because it has potential for surviving the winter and therefore gives an opportunity to scavenge more N. The results of Power and Zachariassen (1993) show that hairy vetch had higher N uptake than other legumes at low temperatures. When accounting for the seed cost, legumes are recommended for seeding in mixture with other species.

Additional research with these new species is needed to evaluate the biomass production and nutrient binding capacity in Estonian conditions.

How work was carried out?

A field experiment at Estonian Crop Research Institute (58°44'59.41" N, 26°24'54.02") was conducted in 2015 and 2016. The cover crop species in the first year were tillage radish and berseem clover, in the second year hairy vetch was included. The soil type in the experimental area was Cambic Phaeozem (Loamic) soil (IUSS 2015). The sowing dates of cover crops were August 25 in 2015 and August 3 in 2016. Cover crop aboveground biomass samples were collected from four randomly placed squares of 0.25 m² in each plot in both years during the last week of October. Plant samples were oven dried at 65 °C for 72 h and weighed. N concentrations of the biomass were determined in Soil Science and Agrochemistry laboratory at Estonian University of Life Sciences.

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Winter cover crops improve soil properties in organic cropping systems

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Implications

An introduction of winter cover crops (wcc) into the crop rotation had a positive impact on soil quality in organic cropping systems. Wcc alone and in combination with composted manure enriched soil with organic matter, activated soil life (increased number of earthworms and soil microbial activity - FDA), increased soil pH value, and supported nutrient cycling and soil formation.

Background and objectives

To achieve a more sustainable production it is important to establish growing systems with appropriate crop rotations to ensure fertile and biologically active soils that are providing good crop yields in the long-run. One way to improve soil is to grow winter cover crops as green manure in crop rotations. The interest among farmers for using wcc in the crop rotation is high, especially in organic farming. Therefore, the long-term effects of wcc management need to be evaluated. The aim of the present research was to investigate the impact of winter cover crops on different soil properties in organic cropping systems in comparison with supply of mineral fertilizers in a conventional system.

Results and discussion

Winter cover crops (Org I) and wcc in combination with composted cattle manure (Org II) had significantly positive impact on soil properties. Soil organic carbon (C_{org}) content increased due to use of cover crops and composted manure. In the organic systems C_{org} content was on average 11 percent higher ($p < 0.05$) than in conventional system, where mineral fertilizers instead of cover crops were used (Conv II). Earthworms play an important role in the humification of organic matter in arable soils (Scullion et al. 2007). Higher content of C_{org} is achieved by higher input of organic matter from wcc and manure and by greater number of earthworms. On average, the highest number and biomass of earthworms were in the Org II. This could be explained by the higher amount of added organic matter in the system (food supply for earthworms). The number of earthworms was lower in both conventional systems, however, the non-fertilized (Conv I) and fertilized system (Conv II) did not differ. Pesticides could also contribute to long term negative influence on soil life (Pelosi et al. 2014).

Soil organic matter is the energy source for microbial processes. Microbial activity was higher in organic systems than in conventional ones (Table 1). The lowest microbial activity occurred in Conv I and Conv II, evidently because of low input of organic matter, usage of pesticides and soil low pH.

Different fertilization practices resulted in significant differences in pH among the systems. In the organic systems soil pH value increased during the experimental period with use of winter cover crops as green manures ($p < 0.05$). This can be explained by a positive effect of added organic matter (wcc and composted manure) on the soil buffer capacity (Sánchez de Cima et al., 2015).

In conventional systems repeated application of mineral fertilizers decreased the soil pH. Plant available P, K, Ca, Mg, contents decreased with time in the ploughing layer of the conventional systems, even in Conv II with addition of mineral fertilizers (Table 1). The changes in soil chemical and biological properties were correlated by changes in soil physical parameters. The highest bulk density, lower percentage of water permeability and lower air filled pores fraction was found in Conv I compared with the other systems (Sánchez de Cima et al., 2015).

Table 1. Average soil properties of different cropping systems in 2012–2015

	Cropping systems				
	Org 0	Org I	Org II	Conv I	Conv II
pH	5.92c	6.02cd	6.05d	5.77a	5.65b
FDA*(μg fluorescein g^{-1} soil h^{-1} oven dry soil)	53.1b	54.7c	56.4d	46.6a	52.5b
P (mg kg^{-1})	113.5b	112.5b	113.5b	80.4a	85.7a
K (mg kg^{-1})	123.6c	125.4c	133.9c	88.3a	104.4b
Mg (mg kg^{-1})	179.9b	190.2b	211.6c	75.1a	83.2a

Means followed by a different letters indicate significant influence ($P < 0.05$) of cropping systems (Tukey test). * Average of 2012–2014.

It is possible to conclude that winter cover crops in crop rotation, especially in combination with manure, have significantly positive impact on soil biological, chemical and physical properties in organic systems in comparison with mineral fertilizing in conventional systems.

How work was carried out?

The effects of different crop managements on soil properties were studied in Estonian University of Life Sciences in 2012–2015. The soil type of the experiment area is sandy loam Stagnic Luvisol according to the World Reference Base classification (FAO 2014). In a crop rotation experiment, barley undersown with red clover, red clover, winter wheat, pea and potato were grown in succession. There were two conventional farming systems without winter cover crops: Conv I as control (no fertiliser use) and Conv II (with mineral fertilizer - winter wheat and potato 150, barley undersown with red clover 120 and pea 20 kg ha^{-1} N) and three organic farming systems: Org 0 without winter cover crops (as control), Org I with winter cover crop and Org II with winter cover crops plus composted manure (40 t ha^{-1} (on average, the dry matter of composted cattle manure contained 138 g C kg^{-1} , 9.7 g N kg^{-1} , 4.6 g P kg^{-1} , 8.6 g K kg^{-1} , average dry matter content 44.8%). In Org I and Org II the wcc were used as follows: mixture of winter oilseed-rape and winter rye before pea; winter oilseed rape before potato and winter rye before barley. Since 2014 winter oilseed rape was replaced with winter turnip rape. Conventional systems were treated with pesticides (herbicides, fungicides, insecticides).

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Efficiency of different bare fallow strategies to control perennial weeds

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Implications

Effective control of perennial weeds in organic farming can be achieved with shortened bare fallow with proper machinery and timing. Probably, shortened fallow is better for farmer's economy and environment compared to the whole summer lasting bare fallow.

Background and objectives

Bare fallow can occasionally be needed in organic crop rotations to control perennial weeds (e.g. *Elymus repens*, *Cirsium arvense*, *Sonchus arvensis*). However, the whole summer lasting bare fallow is expensive for the farmer, it can be harmful to the soil structure, and it can lead to nutrient leaching (Bond & Grundy 2001). Therefore it is needed to intensify the fallowing strategies to shorten the fallowing time. In practice, bare fallow can be implemented by at least five different strategies (estimated duration of fallow period at northern latitudes in parenthesis): 1) brief fallow in spring before crop sowing (2 – 4 weeks), 2) fallowing during May – June followed by sowing green manure crops (2 months), 3) harvest one silage yield and fallowing after that (late summer fallow) (3 months), 4) bare fallowing the whole summer (5 months) and 5) stubble cultivation after cereal harvest (1 – 2 months) (Håkansson 1995).

In our studies, three of these strategies were tested. The main objective in a *E. repens* experiment was to find out the most effective tillage methods in late summer fallow when old ley is broken up (strategy 3). The target in *C. arvense* and *S. arvensis* experiments was to explore efficiency of the new type cultivator in May – June bare fallow (strategy 2) and in stubble cultivation after cereal harvest (strategy 5).

Key results and discussion

In *E. repens* experiment the Kwick-Finn (KF) weed-cultivator destroyed *E. repens* effectively; on average 5% of *E. repens* remained alive compared to untreated control in the barley crop in the autumn of the following year. After use of ordinary cultivators 10%, spade harrow 25% or frequent mowing 50% of *E. repens* remained alive. As a result of effective *E. repens* control, barley yield was about 1000 kg ha⁻¹ higher than without any fallow.

In *C. arvense* and *S. arvensis* experiments, after three passes of the KF-cultivator in May – June, only 3% of *C. arvense* and 1% *S. arvensis* remained alive compared to untreated control in the next autumn. Barley yield was nearly 400 kg ha⁻¹ higher after effective perennial weed control. Respectively, after stubble cultivation 21 % of *S. arvensis* remained alive.

Fallowing strategy 2 is advisable, since it makes it possible to sow green manure crops after the treatment. The green manure will then produce nitrogen to the soil and suppress weakened weeds. At least here, the strategy seemed to work. It is clear that strategy 5 (stubble cultivation) was not as effective as strategies 2 and 3, at least in case of *S. arvensis*, which is expected to fall into

dormancy early in the autumn (Fogelfors et al. 2003). However, strategy 5 allows cultivating cereal crops during following years, which is not possible in other strategies.

It is known that including frequently mowed perennial leys in the crop rotation helps to control *C. arvense* and *S. arvensis*, but *E. repens* often tends to proliferate in old leys (Graglia et al. 2006, Vanhala et al. 2006). However, most organic farms without livestock cannot utilize the yield of perennial leys, so the crop sequence mainly consists of annual crops. This often leads to increasing problems with perennial weeds and strategies of bare fallow are needed.

The Kvik-Finn weed-cultivator is a fairly new type of machinery, specially designed to lift roots of perennial weeds up to the soil surface. The KF-cultivator effectively reduced perennial weeds in all three experiments, although the weather conditions were not optimal with frequent rain during the experiments. It seems that three passes with KF-cultivator during May-June bare fallow was enough to achieve sufficient effect against *C. arvense* and *S. arvensis*. This is significantly less than in "traditional" whole summer bare fallow (strategy 4), which often requires 6 – 7 passes per summer (Vanhala et al. 2006).

How work was carried out?

E. repens experiment were conducted at the Luke Ruukki Research Station and other experiments in organic farm in Sievi in Central Finland. Soil types were: *E. repens* experiment: peat/organic soils, *C. arvense* experiment: silty clay soil and *S. arvensis* experiment: coarse sand soil. Procedure in all experiments was the following: in first year different fallow treatments were carried out and in second year the whole experimental area was fertilised with manure and drilled with cereal. In *C. arvense* experiment green manure mixture consisted of common vetch, rape and rye-grass.

Weed samples were taken just before cereal harvest by using a 0.25 m² frame (2 – 3 samples per plot). The experimental design was a randomized complete block with four replicates in every experiment. More details about *E. repens* experiment can be found from Lötjönen & Salonen (2016).

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How to find a good cereal variety for organic farming?

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Implications

Many field crop varieties bred for conventional farming are good also for organic farming. However, success in organic farming requires traits that are not selected for in breeding for conventional farming. These are e.g. good competition ability against weeds and ability to uptake nutrients from sparingly soluble sources. Because of this crop varieties should be tested and also bred under organic conditions. At present, EU offers financing for the efforts to develop and test superior varieties for organic farming market.

Background and objectives

The main problems in organic farming are inadequate mineral nutrition, poor competition with weeds and susceptibility to yield failure due to pests and pathogens. Choice of production methods such as good crop rotations, sowing and harrowing technologies and specific fertilizers per crop (Hakala 2013) are required for successful production. The choice of a crop variety suitable for local conditions may introduce better nutrient use efficiency, suppression of weeds and higher resistance and tolerance to pests and pathogens to the system (Hoad et al. 2008, Wolfe et al. 2008). Reliability of yield production in local climatic conditions can also be improved by choice of variety (Hakala et al. 2012, Kahiluoto et al. 2014). There is a large array of varieties bred for conventional agriculture, but a severe lack of crop varieties bred or even tested in organic conditions. EU aims at 100% organic production, including organically produced propagation materials. To increase the incentive to buy more expensive organically produced seed, the farmers should get benefits from using the seed. One way to show the benefits is to offer the farmers seed of superior crop varieties. To do this, we have to find out what are the key traits that improve success in organic farming. We should also study the effects of production in organic environment on the seed and whether the effects are carried on with the seed and affect the production of yield (epigenetic traits).

Key results and discussion

Some projects and breeding institutions have already identified a set of key traits for a superior cereal variety for organic farming (Wolfe et al. 2008). The key traits are: weed suppression, earliness (date of germination, date of heading, date of maturity), nutrient use efficiency, root depth, disease resistance, yield quantity, stability and quality and lodging resistance. Weed suppression has been identified to coincide with higher straw length to a certain extent, with increased nitrogen use efficiency following from reduced competition with weeds (Gooding et al. 2012). However, recent field trials show no positive correlation between straw length and root volume. On the contrary, shorter straw usually means more roots and better water and nutrient extraction capacity (e.g. Hoad et al. 2001). Shorter straw also results in higher NUE, as less minerals are required for shoot growth. Modern varieties are often superior not only in conventional high input conditions, but also in low input conditions (Rajala et al. 2016). Because of the overwhelming inputs and success of breeding for conventional farming, the conventional varieties may have valuable qual-

ities that cannot be overlooked in organic farming. However, qualities such as weed suppression through longer straw, early vigor, more horizontal leaf angle, may not have been focus targets in conventional breeding businesses, as chemicals for weed control are routinely used and shorter straw in conventional conditions results in better yield. Pest and pathogen resistance on the other hand are also selected for in the conventional breeding programs, as their control by chemicals is expensive and epidemics difficult to predict. When selecting superior varieties, the tests should contain both modern varieties and older varieties, to answer to challenges of organic farming.

How work will be carried out

Selection and breeding of superior crop varieties for organic farming can only be done in organic conditions. EU has launched a Topic "Organic breeding – Increasing the competitiveness of the organic breeding and farming sectors" in Horizon2020 call H2020-SFS-2016-2017 "More resilient and resource-efficient value chains". A minimum of three projects with a total funding of 20 million euro will tackle the problems in availability of organic sowing seed of suitable varieties for organic conditions. The work will be going on in 2017-2021. Variety tests will be arranged throughout Europe and information about the key traits will become available for EU, Europe and beyond. One of the consortiums is led by Luke.

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Evaluation of different oat varieties to identify prospective breeding lines for organic agriculture

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Implications

Different oat breeding lines prospective for organic agriculture showed significant variations in several quality traits. These traits such as grain size, test weight (TW), grain grades, groat percentage, groat yield and damaged groats are important for grain processors. In addition, the present study showed the possibility to develop improved oat varieties that possesses requirements to obtain qualitative organic oat products..

Background and objectives

Oat (*Avena sativa L.*) is one of the most popular cereal grains among organic cereal farmers. These growers aim producing high-quality products of consistent quality that are most desired by commercial grain processing companies. However, one of the main challenges for organic oat producers is that organically produced grains have to fulfil the same grain quality requirements like those of conventional origin.

Evaluation and breeding of oat varieties for organic agriculture started in Latvia in 2009. Today organic oat breeding trials are underway as part of several ongoing projects. In the last years, effort has been made in assessment of traits important for grain processing. This has been carried out in collaboration between several grain processing companies such as Dobeles Dzirnavniesks Ltd, 'Rigas Dzirnavniesks Ltd, organic farm 'Kanepites'. They are the main stakeholders in Latvia involved in the production of organic oat products. The aim of present the study was to evaluate different oat varieties to identify prospective breeding lines for organic agriculture. The oat varieties were evaluated according to physical grain quality traits, particularly important for grain processing.

Key results and discussion

The oats are usually processed as a whole grain. To operate oat mill at maximum efficiency, oats are divided into different sizes to separate oats with similar weights (Decker et al. 2014). Significant differences were observed among oat breeding lines according to all investigated traits. The proportion of grain size fractions between 1.8 and 3.5 mm sieve varied from 93-97% (Table 1). To ensure the quality of the total harvest and optimal outcome of grain processing fractions it is considered that 1000 grain weight (TGW) should be of 35-40 g. Results showed that there were possibilities to select oat lines that meet this criterion. All investigated oat genotypes formed test weigh (TW) higher than 480 g L⁻¹ that is the national standard requirement for this trait in Latvia. Test weight is important for grain processing industry because of high correlation with the groat/grain size ratio as in accordance with the results of Doehlert et al. in 2006.

The oat groats of mature grain is covered by a hull. The kernels enclosed by two hulls are worthless for grain industry. This characteristic is environmentally as well as genetically determined

(Decker, et al. 2014). In 2016 the grains with two hulls were found in all oat samples that could be the main reason of heightened hull proportion (>25%) for most genotypes. According to these both traits the best result was observed for the variety 'Peppi' that showed also the highest dehulling efficiency (88.3%). According to results under organic management conditions the best oat genotype is '32553' showing good grain quality characteristics required for food industry: test weight 530 g L⁻¹, dehulling efficiency – 79.7%, groat yield 92.5%.

How work was carried out?

Six oat genotypes from Latvian oat breeding program with potential adaptability to organic farming were tested at the AREI Stende Research Centre in 2016: 34482 (Dakot/Ivory), 34495 (Kirovec/Ivory), 34513 (STH-110/Katri//Abel), 34525 (PI 53118/Stmara//Belinda/3Polonez), 34525 (PI53173/Skakun//Hecht/3Ivory), 32553 (Tomba/Fuch). Latvian oat variety 'Laima' (occupies large areas in Latvia) and Finish oat variety 'Peppy' were used as standards. Trials were established in the fields certified as organic. Oat harvest was cleaned on sieve 1.8x2.0 and subjected for grading. Grain physical traits 1000 kernel weight/TGW (g) was determined by ISTA method, test weight/TW (g L⁻¹) by automatic grain analyzer Infratec Analysis 1241. Dehulling efficiency (%) was determined mechanically by small-scale grain dehuller (Heger, Germany) calculated as the ratio between the weight of dehulled kernels (both whole and damaged) and initial weight of the sample (25 g). (Grain moisture was 10 – 11 % before hulling). Groat yield, the proportion of damaged (dark coloured and broken) groats was determined as a percentage by weight of dehulled groats. Hull content (%) was determined by manual dehulling. All analyses were carried out in duplicates. Grain proportion (%) above 1.8-3.5 mm screen was evaluated for oat field harvest.

Table 1. Grain physical characteristics for oat genotypes grown under organic conditions

Genotype	TGW,g	TW, g L ⁻¹	Grains, 1.8-3.5 mm, %	Grains with two hulls, %	Hull content, %	Dehulling efficiency, %	Groat yield, %
34482	39.6a ¹	521.0b	97.0a	2.0b	24.8bc	83.1ab	78.2c
34495	37.1b	523.5b	97.5a	1.8b	26.8b	76.3c	89.6ab
34513	35.9c	522.0b	96.9a	1.9b	27.3a	81.9b	87.4ab
34525	35.4c	508.0c	95.0bc	7.4a	26.1b	74.3c	87.2ab
34541	35.4c	523.5b	94.9c	2.0b	27.6a	81.8b	90.7a
32553	34.0d	530.0ab	96.5a	2.5b	25.0bc	79.7bc	92.5a
Peppi	33.4ed	522.0b	93.1c	0.1c	23.8c	88.3a	84.7b
Laima	32.4e	509.5c	95.5b	2.4b	27.1a	75.9c	90.8a
LSD	1.16	12.45	0.81	0.77	1.96	6.21	5.01

¹Different letters in each column indicate significant differences between genotypes ($p < 0.05$).

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Promoting production and use of organic potatoes in Northern Ostrobothnia, the northernmost agricultural area in Europe

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Implications

The results produced in this on-going study will help to develop more effective cultivation methods for organic potato production especially in northern climate conditions and, consequently, promote the production and use of organic potatoes. The study contributes to solutions for more productive and sustainable organic farming (Track 1).

Background and objectives

The demand for organic products is increasing in Finland. The aim of the governmental development programme launched in 2013 is to increase the area under organic production to 20 % by the year 2020 (Ministry of Agriculture and Forestry 2014). Potato is an important part of the Finnish diet with around 60 kg of potatoes per person consumed annually. The demand for organic potatoes and potato products is also increasing. However, currently only around 1

% of the potato crops are grown organically (Luke 2017), and neither the volume nor the quality meets the expectations of the consumers and professional kitchens. Organic potato production faces many challenges including lack of suitable cultivars and fertilisers and difficulties with disease control, all of which may contribute to low yields in organic production (Varis et al. 1996; Finckh et al. 2006). Northern Ostrobothnia, the northernmost agricultural area in Europe, has excellent natural conditions for potato production despite the short growing season. It has a long history in production of seed and table potatoes, but produces only small amounts of organic potatoes. The main objective of this work is to promote the production and use of organic potatoes in Northern Ostrobothnia.

Key results and discussion

The project started in 2016, and hence, only preliminary results are available. In the first year of the project, data was collected from two field experiments carried out in organic potato farm in Northern Ostrobothnia. The growing season was warm and wet. As the weather conditions were conducive to late blight (*Phytophthora infestans*) infections, first symptoms were detected early, only 50 days after planting. Late blight epidemic developed rapidly, and foliar blight reached 100% 30 days after first appearance on the most susceptible cultivar tested. Total yields varied between cultivars from 5 to 14 t/ha, whereas the average for the area was 11.6 t/ha (Luke 2017). The marketable yield ranged from 60 to 80 %, and was mostly reduced due to small tuber size (< 30 mm), quality defects such as greening and symptoms of late blight and black scurf (*Rhizoctonia solani*). None of the biological control products tested for control of soil- and seed-borne diseases other than late blight affected the quantity or quality of the crops. Although late blight was not in the focus of this work, the weather conditions conducive to the infection lead to an early

onset of the epidemics and together with excessive rainfall had a detrimental effect on yield. This emphasizes the vulnerability of the organic potato production in northern latitudes and calls for methods that can make the best use of the short growing season efficiently.

According to the kitchen survey, over 80% of the professional kitchens in the area (n=33) are interested in using organic potato products of some kind. However, availability and price limit the use of these products at the moment. The preliminary results from the farmer survey indicated that farmers are especially concerned about issues on plant protection, fluctuations in yield quantity and quality as well as pricing.

How work was carried out?

The project is implemented in four work packages:

- 1) New cultivars and different types of fertilisers potentially suitable for organic potato production are introduced and their effect on yield quantity and quality tested in growers' fields.
- 2) The impact of diseases besides late blight is assessed and the efficacy of different biological control products for control of these diseases is investigated in organic potato production. In addition, methods for early detection of pathogens latently present in the seed potato are optimised.
- 3) The factors limiting the use and production of organic potatoes in Northern Ostrobothnia and willingness of growers to convert to organic production are investigated through surveys to professional kitchens and growers.
- 4) The interest towards production and use of organic potatoes is raised by organising field and kitchen demonstrations, which are open to professionals and the general public alike.

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Genotype and environment interaction on field pea cultivars in organic cropping system

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Implications

Globally, grain legumes like the field pea are important sources of plant proteins for both food and feed (De Ron, 2015). In addition, their cultivation have also a positive effect on soil fertility (Stagnari et al, 2017). However, there are some challenges in their production such as pests, diseases and unstable yields. Species diversity and the selection of appropriate cultivars are important factors for the stability of agricultural systems, especially in organic farming. When growing legumes as the field pea in mixture with cereals, choosing the appropriate pea genotype can enhance stable yields through environment changes.

Background and objectives

This work was done in the frame of EU FP7 project EUROLEGUME (Enhancing of legumes growing in Europe through sustainable protein supply for food and feed). The objective of this study was to contribute to improvement of sustainability of field pea crops in terms of yield parameters through efficient cultivation systems. As sub-objective was to introduce the new genotype- Estonian cv 'Kirke' in local cropping systems.

Key results and discussion

The pea genotype cv 'Kirke' showed stable yields in all three experimental years. However, for one year (2015) a significant difference in the yields between cv 'Kirke' and the genotype cv 'Bruno' was observed. In 2015 it was very hot and dry weather conditions in the period of forming of the seed-pots and cv 'Kirke' was more successful than the other, indicating cv 'Kirke' to be more adapted to changing conditions. However, for both genotypes there were no correlation between total rainfall during the growing season (473, 613, 842 mm) and the mean yields (3.9, 4.0, 4.4 t ha⁻¹ for cv 'Kirke' and 3.4, 3.4, 4.5 t ha⁻¹ for cv 'Bruno'). For both genotypes cv 'Kirke' and cv 'Bruno' mean yields were higher in pure sowings compared to the yield levels in mixtures with cereals oat, barley or wheat. Among the mixtures highest yield was obtained when the field pea was sown with wheat.

How work was carried out?

Three years field experiment with field pea-spring cereals mixtures were carried out in Latvia. Cv 'Bruno' and cv 'Kirke' were sown alone and in mixtures with oat 'Laima', spring barley 'Rubiola' and spring wheat 'Uffo'. Pea crops were evaluated on plant morphology (beginning of emergence, flowering initiation, duration of growing period, plant height at biological maturity, pods per plant at biological maturity, and harvesting date), grain yield potential (seed yield, number and weight of pods and grains per m²), resistance to local diseases and pests.

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Intercropping can support ecological intensification in organic agriculture

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Implications

Intercropping (IC) combines the temporal and spatial dimensions of crop diversification and offers a variety of ways to shape agroecosystem ecology and productivity. It has been most used with forage legumes for biological nitrogen fixation, but it might deliver also other, less known benefits such as buffering from weeds, pests and abiotic stresses, support for beneficial biota and greater yielding per acreage. Productivity gains are imperative for developing organic agriculture. We found that legumes added as intercrops had a positive impact on both a cereal and an oilseed co-crop yield under low fertilization, indicating that IC can support ecological intensification. Both additive and replacement IC designs resulted in overyielding. IC works well in line with the key principles of organic farming: utilizing and sustaining beneficial ecological interactions and biodiversity. It may support climate change adaptation as well (Himanen et al. 2016). In addition, it should be experimented more as a method to reduce reliance on external inputs and develop more sustainable conventional agriculture. Technological development and improved understanding on the mechanisms potentiating overyielding can help designing optimal IC using differential row, strip or mixed IC set-ups.

Background and objectives

Ecological intensification has been raised as one strategy for agriculture to operate more sustainably while aiming to meet the growing demand for food and feed. It entails, as stated by Bommarco et al. (2013), "replacement of anthropogenic inputs and/or enhancement of crop productivity by including regulating and supporting ecosystem services management in agricultural practices". IC, growing two or more crops together in space and time, has been suggested as one central method to support ecological intensification (e.g. Bedoussac et al. 2015).

The use of IC can aim for an increase in main crop yield or for gaining a higher total yield. In the former case, associative crops with low sowing density and an additive IC design can be used to facilitate improved yielding of the main crop. In the latter case, replacement IC designs are often used. The lower competition between the intercrops and complementary use of growth resources can result in higher and more stable total yield per acreage.

The objective of our research was to determine whether the addition of legume intercrops with ecologically important crop traits (biological nitrogen fixation and nectar provision) in additive and replacement designs supports ecological intensification, i.e. leads to higher yielding per acreage under low fertilization. Two crop systems were studied in field experiments established in organic field plots in Karila, Mikkeli, Finland): 1) *Brassica rapa* ssp. *oleifera* (spring turnip rape) - *Vicia faba* L. (fava bean) – *Vicia sativa* L. (common vetch) mixed IC, and 2) *Hordeum vulgare* L. (barley) - *Vicia faba* L. mixed IC and row IC.

Key results and discussion

Turnip rape-common vetch-fava bean additive IC design yielded circa 15 % higher turnip rape seed yield than the turnip rape sole crop. In barley-fava bean IC with replacement design (50 % sowing density for both barley and fava bean used compared to the sole crop plots), barley gave 89 % and 77 % of the yield of sole crop plots in mixed IC and row IC, respectively. Fava bean yielded 45 % and 37 % of the sole crop fava bean plot yield in mixed IC and row IC, respectively. Land equivalent ratio exceeded 1 (indicating overyielding per acreage) both in mixed IC and row IC of barley and fava bean.

The results showed that adding of a legume intercrop resulted in ecological intensification, i.e. overyielding per acreage under low fertilization, both when using an additive IC design (for turnip rape) and a replacement IC design (for barley and fava bean). Our results are in line with earlier research reporting that cereal-grain legume IC benefits the cereal component yield (Bedoussac et al. 2015). There is little earlier research on IC of oilseeds and legumes in northern organic agriculture. Reduced competitive pressure for barley in replacement IC benefitted its yielding, whereas fava bean yield was suppressed by barley. Turnip rape benefitted from the presence of the legume intercrops in additive IC design, while it is difficult to state why. The flowering legumes may have impacted its root environment and nutrient availability, pests and their natural enemies, or the abundance of pollinators. Analyses on nutrient dynamics, insect abundance, and allocation of biomass in sole cropping versus IC might help reveal the underlying mechanisms.

How work was carried out?

Experiment 1 (2015): 6 kg ha⁻¹ of spring turnip rape ('Cordelia'), 10 kg ha⁻¹ of common vetch ('Ebena') and 120 kg ha⁻¹ of Fava bean ('Kontu') were sown in the mixed IC treatment and 6 kg ha⁻¹ of spring turnip rape ('Cordelia') in sole cropped treatment in four 34 m² replicate plots. Three replications in time (three sowing times in 2015) were conducted. Fertilization with 60 kg N ha⁻¹ (NPK 4-1-2, organic fertilizer Arvo, Novarbo Oy, Finland) was added prior to sowing in both treatments. Seed yield of turnip rape at full maturity was measured from 0.25 m² areas per plot. Experiment 2 (2016): 167 kg ha⁻¹ of sole cropped barley ('Wolmari') and 167 kg ha⁻¹ of sole cropped fava bean ('Kontu'), 83.3 kg ha⁻¹ of both crops in row IC and 83.3 kg ha⁻¹ of both crops in mixed IC were sown in four 30 m² replicate plots. Fertilization with 40 kg N ha⁻¹ (NPK 4-1-2, organic fertilizer Arvo, Novarbo Oy, Finland) was added prior to sowing in all treatments. Seed yields were measured separately for barley and fava bean from 0.25 m² areas per plot. Soil type in both experiments was fine sand. Land equivalent ratio (LER) was calculated as: (barley seed yield in IC plot/barley seed yield in sole crop plot)+(fava bean seed yield in IC plot/fava bean seed yield in sole crop plot).

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Influence of Agricultural Service Crops on the fluctuations of the soil mineral composition

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Implications

Sustainable agricultural production is becoming more actual not only for organic production, but also for integrated production approaches. Especially it is important in vegetable production, where fresh commodities are consumed and often their chemical-biochemical composition is directly influenced by the soil agrochemical composition. Usage of organic fertilizers and agricultural service crops (ASC), e.g. green manure (GM), catch crops, living mulch, are the main tools to ensure soil fertility to obtain high quality organic vegetables. From the one season results we can conclude that green manure crops (winter rye and rape) have some positive influence on the maintenance of mineral nutrients balances in vegetable cropping systems. The differences between vegetables influence on the soil mineral composition were stronger expressed – cabbage notably reduced nitrate content in the soil, whereas onion did not.

Background and objectives

Agricultural service crops are the crops which are not yielding a cash crop (in our case - vegetable crops), but they have indirect influence on the yield by improving the soil properties and increasing availability of nutrients for following crops in a sustainable way. The main task of these crops in the relatively cool and moist climate of North Europe is to prevent leaching of mineral nutrients from the soil during the winter-early spring period, when precipitation exceed evaporation and low temperature slows down vegetation (Canali et.al., 2010; Canali et al., 2014). Efficiency of ASC crops under Latvia agro-ecological conditions for vegetable growing has not been investigated till now. Therefore field trials were established in the Institute of Agricultural Resources and Economics during the season of 2015/2016 in Dižstende, with the aim to clarify the influence of ASC on cabbage and onion crops and compare with traditional soil management systems.

Key results and discussion

Establishment and overwintering conditions for ASC crops were good, and the canopy of ASC crops was developed well in the spring before GM incorporation. The DM biomass of incorporated plants was quite high, 2.64 t ha⁻¹ for rape and 7.01 t ha⁻¹ for rye. It had recognizable influence on the dynamic of the soil mineral nutrient contents (Table 1).

From the soil analyses data we found that P₂O₅ and K₂O were reduced, except for K₂O in the manure treatment, during the winter period – leached or taken up by ASC. The results were most pronounced with rye GM and for P₂O₅ also in the non-fertilized control treatment. A decrease of these two elements in the soil may have been caused by the ASC plants root activity if these elements were solved by the root exudates and became plant-available and taken up by ASC

Table 1: Soil mineral nutrients composition in three different periods of the trial, 2015/2016

Variant	P ₂ O ₅ , mg/kg			K ₂ O, mg/kg			N/NO ₃ , mg/kg DM			N/NH ₄ , mg/kg DM		
	9.2015.	5.2016.	10.2016.	9.2015..	5.2016.	10.2016.	9.2015.	5.2016.	10.2016.	9.2015.	5.2016.	10.2016..
Control onion	223.00	119.6	205.7	164.00	122.2	126.8	3.20	1.30	2.40	1.50	4.60	3.40
Control cabbage	223.00	119.6	183.7	164.00	122.2	121.8	3.20	1.30	0.80	1.50	4.60	3.10
Rye GM-onion	201.00	91.20	173.9	145.00	95.65	167.5	3.10	0.90	3.60	1.20	4.30	3.30
Rye GM-cabbage	201.00	91.20	152.9	145.00	95.65	134.9	3.10	0.90	0.70	1.20	4.30	3.60
Rape GM-onion	178.00	138.75	160.6	126.00	119.9	143.6	2.90	1.30	2.30	1.30	4.00	3.30
Rape GM-cabbage	178.00	138.75	140.6	126.00	119.9	104.4	2.90	1.30	0.40	1.30	4.00	3.20
Cow manure-onion	208.00	167.35	197.00	148.00	189.00	185.6	6.20	1.50	3.50	2.20	4.30	3.50
Cow manure - cabbage	208.00	167.35	165.2	148.00	189.00	168.1	6.20	1.50	0.50	2.20	4.30	3.80

plants and/or subjected to leaching (Wang et al, 2010). The NO₃ and NH₄ relation in the soil had seasonal character – higher NO₃ concentration was detected in the autumn than in spring, but for NH₄ – vice versa. It can be explained by the soil processes influenced by temperature – in autumn when soil is still warm from summer, nitrification takes place more intensively in comparison to the cold conditions in spring (Brauer et al, 2002). There was no sharp difference in agrochemical parameters between treatments. The differences between vegetables were more clear – cabbage reduced nitrate content in the soil, whereas onion did not. It can be explained by plants nutritional particularities – cabbage demands more nitrogen in comparison to onions (Thorup-Kristensen K., 2007).

From the one season results we can conclude that ASC crops have some positive influence on the maintenance of mineral nutrients balances in vegetable cropping systems, but more investigations are needed to find particular regularities.

Methodology

Six soil treatments were compared for each vegetable crop: two GM treatments when ASC biomass of a) winter rye (*Secale cereale* L.) and b) winter rape (*Brassica napus* L.) was incorporated in the soil in the spring; two roller crimper (RC) treatments in which a) rye (*Secale cereale* L.) and b) rape (*Brassica napus* L.) was flattened by a roller-crimper before vegetable planting to create a mulch layer. These four ASC treatments were compared with: control 1 (no ASC, with soil tilled before crop planting) and control 2 (cattle manure ploughed into the soil before vegetable planting). Soil agrochemical analyses were performed before sowing of ASC in the autumn of 2015, in the spring of 2016 when ASC was incorporated and in the autumn after vegetable harvest. Average soil sample per treatment was collected and analysed. The lack of replications for soil analyses does not allow us to perform statistical analyses, but the major tendencies are inferable. Due to severe infestation by perennial weeds in RC plots, mostly by field horsetail (*Equisetum arvense* L.) and perennial sow-thistle (*Sonchus arvensis* L.), both roller-crimper variants were excluded from the trial. All the other treatments (both controls and chopped/incorporated green manure) were

evaluated in the trial. Fluctuations of organic matter, P_2O_5 mg kg⁻¹, K_2O mg kg⁻¹, C mg kg⁻¹, NO_3 mg kg⁻¹ and NH_4 mg kg⁻¹ are referred in the paper.

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OSMO - a collaborative network testing knowledge and tools for resource-efficient soil health management

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Implications

Soil and knowledge are the most important resources for agriculture. In order to create new knowhow on managing soils, collaboration between research, advisory services, product development and farmers is necessary. The Finnish OSMO –project (2015-2018) has provided these opportunities in farmer learning groups, workshops and field trials (Mattila and Rajala, 2016). Based on the first year of results it is clear that soil health is a complex system, where different aspects interact. Many of the problems observed as nutrient deficiencies can be sourced to compaction from machinery or lack of drainage. On the other hand, deficiencies and excesses of nutrients may affect soil structure, especially in terms of the amounts of Ca and Mg (Dontsova and Norton, 2002).

The current hypothesis is that each field has its own set of problems. Soil health can be improved only by identifying the crop yield reducing factors, determining their causes and planning for effective ways to remedy them. Currently there are several methods for analyzing various properties of soil, but a lack in communicating the results and developing the findings into management options. Decision support tools for farmers and advisors could fill the gap between analysis results and management actions.

Identifying and remedying soil problems have a large potential for increasing the productivity of both organic and conventional agriculture.

Background and objectives

Agricultural soils are under increasing pressure globally. During the last decades crop rotations have become simplified, annual crop areas have increased and machinery has become heavier. At the same time the progress in crop yields has stagnated (FAO, 2017).

Compared to the potential yield productivity (solar radiation and water availability) (Sylvester-Bradley and Wiseman, 2005), crop yields are very low (FAO, 2017), especially in organic agriculture (LUKE, 2017). At the same time, variability between farms, fields and field parts is high. It is unclear why some fields have low yields while other adjacent fields have very good yields, although measurements such as water infiltration seem to give good correlations (de Paul Obade and Lal, 2016; Keller et al., 2012).

The concept of soil health is an emerging paradigm for looking at soil as a system. It appreciates the interconnections between components of soils and different views on problems (i.e. chemical, physical and biological)(Kibblewhite et al., 2008).

The objective of the OSMO -project is to apply new knowledge on soil quality and health and to test the applicability in practice on farms. This is done through improving knowledge on soil testing, farmer know-how on soil health management and developing tools and study materials. Methods for analyzing and repairing soil problems are tested on 8 experimental problem fields,

with adjacent good fields serving as the reference. The approach has been problem-oriented, and analysis methods and tested techniques have been tailored to each problem field. The aim is to identify and overcome barriers to better productivity and soil health and to test how (and if) the approach works.

Key results and discussion

The project has been running since 2016 and most of the work is still ongoing. Final results for the test farms will be available in 2018. For now, five regional learning groups are running in western part of Finland, each with ca. 20 farms. These have included a six month intensive period of soil management education and application of skills to on-farm work. The separate tools for soil management have been assembled into a soil management planning toolbox, which is being refined based on user experience.

Several problems have been identified in the test farms and trials have been run to test for potential solutions. Soil structure has been improved through vetch based cover crop mixes and subsoiling. Gypsum applications have been targeted to remedy Ca:Mg ratio problems and manganese, potassium and boron fertilizers have been tested to remedy common nutrient deficiencies. In 2017, new methods for identifying and solving drainage and compaction issues are being tested.

The interaction between researchers and farmers has been valuable. In the intensive six month courses, researchers developed science based decision support spreadsheet tools and the farmers have applied them on their farms, providing valuable feedback. Receiving rapid feedback on their applicability and being able to redevelop them into tools has provided useful tools for soil management.

How work was carried out?

The core of the project was five learning groups with ca. 20 farms in each. The groups were mixed organic and conventional farmers. There were about 30-50 % organic farmers in each group.

Each group held regular meetings and online lectures on the main aspects of soil health (chemical, physical and biological). The participants also had access and guidance on using tools for managing soil fertility, compaction, drainage and crop rotations. The participants filled in an online soil management plan for their farm during the course and reported on their own trials and tested solutions for managing soil health. In addition, several in-depth work-shops were arranged on special topics. The scientific work focused on the 8 test fields. Their status was quantified through different soil tests (ammonium acetate extraction (Vuorinen and Mäkitie, 1955), Mehlich 3 (Mehlich, 1984), Soil Health Tool (Haney et al., 2010)), physical soil evaluation (visual evaluation of soil structure (Ball and Munkholm, 2015), soil cover (Laflen et al., 1981), earthworm counts (Lawrence and Bowers, 2002) "container-title": "Soil Biology and Biochemistry", "page": "549-552", "volume": "34", "issue": "4", "source": "ScienceDirect", "abstract": "Earthworm densities in soil are difficult to quantify. Part of the problem is that they are incorporated closely into the soil structure, which makes their extraction tedious and time consuming (Edwards, 1991, water infiltration (Burgy and Luthin, 1956)) and plant tissue nutrient testing.

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Onion seedlings versus onion sets in organic onion production

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Implications

The results of field experiments and on-farm trials comparing onion seedlings and onion sets indicate that the onions produced from seedlings are healthier than those produced from sets. Yield losses caused by *Fusarium* rot could potentially be reduced by using onion seedlings instead of sets. However, further research is needed to develop appropriate and economical cultivation techniques for producing onions from seedlings, to obtain high yield and high quality crop.

Background and objectives

Fusarium basal rot of onions causes severe losses in Finnish organic and conventional onion production (Avikainen et al. 2013, Kuivainen et al. 2015, Kivijärvi et al. 2016). Our recent studies showed that some lots of onion sets imported to Finland were highly contaminated by several *Fusarium* species (Haapalainen et al. 2016). The *Fusarium* problem is more severe in organic than in conventional onion production, because chemical fungicide treatment of onion sets against *Fusarium* is not permitted in organic production. In contrast, the lots of onion seeds examined in this and earlier studies have been almost free of pathogenic fungi. Therefore, producing onions from seedlings grown in the greenhouse could be a solution to reduce onion crop losses caused by *Fusarium* species, both in the field and during storage.

The objective of this study is to find onion varieties that are suitable for seedling cultivation and high-yielding in our relatively cool and short growing season. In addition, the yield quantity, quality and long-term storage durability of onions produced from either seedlings or sets are compared. Rot incidence and composition of pathogen populations in diseased onions is monitored during the growing season and long-term storage. The field experiments and on-farm trials will be carried out in 2016–2018.

Key results and discussion

In 2016, the yield of and disease development in onion crops produced from seedlings of six different cultivars were studied. Cultivars Hybing, Hybound, Hylander and Hytech represented yellow onion and Red Baron and Retano red onions. The average yield was quite low for all of the varieties. Hytech produced the highest marketable yield (dried and graded), 3.018 kg/m², and the second best was Hybing, 2.690 kg/m². The lowest yields were obtained from the red cultivars Red Baron and Retano, 2.234 and 1.847 kg/m², respectively. During the growing season and at harvest the proportion of diseased onions was very low, from 0 to 0.7%, in all cultivars. The disease incidence slightly increased during the drying process, but remained within 0.5 to 1.1% range. *Fusarium oxysporum* and *F. proliferatum* were only detected in low frequencies in cultivars Hylander, Hytech and Red Baron.

The dried onions were stored at room temperature (18 °C) for three months. Considering the high storage temperature, the storage durability was excellent for all the cultivars: in the end the proportion of marketable onions was still over 90%. Also, despite disease favorable storage conditions, the disease progress was slow. The proportion of diseased onions was less than 5% in all cultivars. In this study cv. Hytech seemed to be more susceptible to *Fusarium infections* than the other cultivars, while Hybing was most susceptible to grey mold, *Botrytis cinerea*.

In 2016, four on-farm trials were carried out at organic farms in Eastern Finland to compare the yield of and disease development in onions produced from either seedlings or sets in actual farm conditions. The average dried and marketable yield produced from seedlings was very low and varied from 0.778 kg/m² to 1.923 kg/m², depending on the farm and the cultivar. There are many possible reasons for the low yield, like sparse planting density, short growing time, planting too deep or too close to the surface, weeds, and downy mildew (*Peronospora destructor*). However, only few rotten onions were found during the growing period.

The yield produced from onion sets was also low, but higher than that gained from seedlings. The average dried and marketable yield from sets varied between 1.430 to 2.888 kg/m², depending on the variety and the farm. Red Baron gave the lowest yield, due to serious weed problems. On one of the other farms, very severe yield loss for cultivar Setton was caused by an early and severe downy mildew epidemic. During the growth period, rotten onions were found slightly more in the crop produced from onion sets compared to the seedlings.

At harvest time, the proportion of diseased onions was 10% on average in the crop produced from onion sets, and only 5% in the crop produced from seedlings. During the drying process and long term-storage the difference in the disease incidence between the onions produced from sets and seedlings increased. In March, the proportion of diseased onions in the onion set yield was over 40%, while in the seedling yield only 15% of onions were diseased. In most cases the main causal agent of rot was *F. oxysporum*. Towards the end of the storage period the incidence of grey mold increased and the incidence of *Fusarium* species declined.

There was considerable variation in the composition of the pathogen populations in diseased onions between different farms. The most common species in all the farms was *F. oxysporum*. There were clearly more rots caused by *Fusarium* species as well as grey mold in the onions produced from sets than in the crop produced from seedlings. The results indicate that yield losses caused by *Fusarium* can be reduced by producing onions from seedlings. However, as these results are only from one year, more research is required before any recommendations for onion production can be given.

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The effect of organic fertilizers and thinning methods on quality parameters and the yield on apple cultivars 'Aroma' and 'Discovery' in Norway

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Implications

The novelty of this work was to find out how does different organic fertilizers and the thinning methods influence the quality parameters and the yield of apple (*Malus xdomestica*) cultivars 'Discovery' and 'Aroma' grown in Norway, Hardanger region.

Both fertigation type and thinning method showed significant effect on weight and quality analyses of both cultivars. The thinning method had stronger effect on apple weight and the fertigation type influenced more the apple quality parameters.

Background and objectives

In Norway, apple growers are focusing in medium sized apples suitable for 6-pack consumer packages. 'Aroma' can have an excessive and uneven fruit set and therefore there is a growing need to find out method to reduce the fruit size of 'Aroma'. 'Discovery' is rather small-fruited cultivar, hence more even and bigger fruit size is desired. In our study, different thinning methods with two different types of organic fertilizers were used to influence the fruit size and the yield. Our hypothesis was that organic fertilizers provide optimal nutrient ranges during the growing season to both cultivars and have a positive effect on the yield and quality parameters. However, organic fertilizers tend to have slow nitrogen release in the beginning of the season, while synthetic fertilizers can provide optimal levels of nutrients. In our experiment, two different organic fertilizers with two fertigation levels were used: pelleted fertilizer Marihøne Pluss 8–4–5 (chicken manure, meat bone meal and vinasse) and liquid fertilizer Pioneer Hi Fruit 4–1–5 (organic plant material, natural minerals, extracts of sugarcane and potato).

Key results and discussion

Both organic fertilizers and the thinning methods had significant effect on the weight and on quality parameters on both cultivars 'Aroma' and 'Discovery'. Since there was clearer tendency with cultivar 'Aroma', its results on fruit quality parameters are mainly discussed here. There was significant effect on weight with the strong thinning in the 'Aroma' orchard rather than fertigation type in 2016. Pelleted fertilizer Marihøne Pluss 60 kg N/ha with strong thinning gave highest results in weight (337,6 g per fruit) when compared to same fertigation type's weak thinning (290,1 g), to Pioneer Hi fruit 60 kg N/ha weak thinning (273,9 g) and to 30 kg N/ha Marihøne Pluss with weak thinning (248,3 g). Same trend was followed in 'Discovery' orchard in 2016, where most of the strong thinning replications had heavier apples compared to weak thinning. Thus, highest weight in 'Discovery' orchard was with Marihøne Pluss 30 kg with strong thinning (152,4 g per fruit) when compared to other weak thinning results in the trial, except with Pioneer Hi Fruit 30 kg N/ha with weak thinning (139,3 g).

I_{AD} index was highest with the liquid fertilizer Pioner Hi Fruit 60 kg N/ha (Pioner 60 in Table 1) with both thinning types (I_{AD} index 1,28 for both) when compared to the control's weak and strong thinning results (I_{AD} index 1,0 and 0,90; respectively) in the 'Aroma' orchard in 2016 (Table 1). Similar trend was observed with starch results where Pioner Hi fruit 60 kg N/ha strong thinning had significantly higher starch content (8,5 in 1–9 scale) when compared to control's weak thinning starch content (7,2 in 1–9 scale). Marihøne Pluss 30 kg N/ha with strong thinning (Marihøne 30 strong in Table 1) had firmer apples (6,21 kg.cm⁻²) when compared to control's strong thinning (5.55 kg.cm⁻²) and to Pioner Hi Fruit 30 kg N/ha (5.67 kg.cm⁻²) (Pioner 30 strong in Table 1). There was no significant difference in soluble solid content (SSC) between the fertigation types neither with thinning. Although, there was higher titratable acid (TA) with Marihøne Pluss 60 kg N/ha (1,02) when compared to control's weak thinning results (0,82%). I_{AD} index and starch content concludes that Pioner Hi Fruit 60 kg/ha apples were less ripen compared to the control.

Table 1. Effect of different fertigation types and thinning methods on cultivar 'Aroma' quality parameters (2016).

	I_{AD} index	Starch (1-9 scale)	Firmness (kg.cm ²)	SSC (% °Brix)	TA (%)
Control weak	1.00 bc	7.20 bcd	6.15 ab	12.93 a	0.94 ab
Control strong	0.90 c	8.05 abcd	5.55 b	12.63 a	0.82 b
Marihøne 30 weak	1.05 bc	7.58 abcd	6.21 a	12.83 a	0.94 ab
Marihøne 30 strong	1.03 bc	7.35 cd	5.87 ab	13.25 a	0.91 ab
Marihøne 60 weak	1.12 b	8.05 abcd	5.88 ab	12.56 a	0.88 ab
Marihøne 60 strong	1.17 ab	7.26 d	5.89 ab	13.08 a	1.02 a
Pioner 30 weak	1.14 ab	8.13 abcd	5.86 ab	12.98 a	0.92 ab
Pioner 30 strong	1.12 b	8.20 abc	5.67 b	12.38 a	0.93 ab
Pioner 60 weak	1.27 a	8.36 ab	5.86 ab	12.70 a	0.99 ab
Pioner 60 strong	1.28 a	8.49 a	5.84 ab	12.42 a	0.90 ab

Means followed by different letters within the same column are significantly different at $p < 0.05$.

How work was carried out?

Experiment was carried out in 2015-2016 in Ullensvang municipality, where most of the inhabitants live in narrow coastal mountainsides and valleys along Hardangerfjord. The most popular apple cultivars in the area, 'Aroma' and 'Discovery' were selected to the study. Apple trees 'Aroma'/M9 were planted in autumn 2010 with 4,5x1 m spacing in the Lofthus village, Hordaland (60°19'12.8"N 6°39'12.7"E). Pollinizer tree in 'Aroma' orchard was cultivar 'Kobenza' and area classifies as a flat. 'Discovery' field situates in the steep area in the Jåstad village (60°20'36.7"N 6°37'16.3"E). 'Discovery'/M9 orchard was planted 2011, with planting space 3,5x0,9 m. Fertigation was carried out twice a week two weeks before blooming (apples start to bloom in the middle of May in Norway). Ground fertilizer was pelleted organic fertilizer Marihøne Pluss 8–4–5 with the fertigation rate 30 kg N/ha. Thinning method used in the trial was strong (15 cm between the fruit) and weak thinning (15 cm after 1 or 2 fruit). Fertilizers used in our trial were organic pelleted fertilizer Marihøne Pluss 8–4–5 (chicken manure, meat bone meal and vinasse) and organic liquid

fertilizer Pioner Hi Fruit 4–1–5 (organic plant material, natural minerals, extracts of sugarcane and potato). In 2015 the fertigation rate was 15 and 30 kg N/ha with both fertilizers. In 2016 the N rate was 30 and 60 kg N/ha. Control did not have any additional fertigation in both years. Experimental design was a randomized complete block with four replications. Firmness was determined by penetrometer (Fruit texture analyser Güss 84 Jennings, South Africa) on opposite sides of each fruit and results were expressed as kg.cm⁻². Chlorophyll absorbance index (absorption difference between 670 and 720 nm) indicating chlorophyll content I_{AD} was measured by DA meter (Model FRM01, Forli, Italy). Soluble solid content SSC was measured by a refractometer (Atago, Japan) and were expressed as °Brix. Titratable acid TA was analysed by titration of fruit juice as malic acid with 0.1M NaOH to pH 8.1 (Radiometer-analytical titrationmanager TIM865 with sample changer SAC850, Germany) and the results were expressed in %. Starch score was assessed in an iodine solution and let stand more than 1 minute before evaluation and it was expressed in 1–9 scale, where 1=full staining, 9=free of starch. Statistical analyses were done by One-way analysis of variance (ANOVA). Statistical significance was considered at $p < 0.05$ using Tukey's test by using Minitab 17.2.4.0 (Minitab Ltd., State College, PA, USA).

Progress in pest management in organic strawberry production

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Implications

For tuning up sustainable organic strawberry production new measures in pest management need to be developed. Both pest insects and pathogenic fungi reduce fruit yields and quality. The present study shows that mass trapping of strawberry blossom weevils by using plant volatile and insect pheromone baited traps is not an efficient measure in an established field. However, in a new study traps will be combined with fencing of the field with an insect net. There will also be a study on the effect of using ozonated water as a measure to prevent the fungus related disease grey mould to develop.

Background and objectives

In strawberry production, several pests have negative impacts on plant health and fruit yields.

One of the major pest insect is the strawberry blossom weevil (*Anthonomus rubi*). This weevil deposits eggs into flower buds and then severs the stems of the buds. Because of this weevil, some farmers have more than 70% yield loss. To manage this pest insect, several studies on using traps baited with volatiles have been conducted. It has been shown that a mixture of a plant volatile and insect pheromones attract strawberry blossom weevils to traps (Wibe et al 2014). In 2016 we carried out a mass trapping study, where the objective was to investigate if it was possible to reduce weevil damage by using traps baited with this volatile mixture (Wibe and Sjøberg 2016). To strengthen the management of this pest insect, a new project in 2017 will combine traps and fencing with insect net to exclude weevils from a strawberry field.

Another challenge for strawberry production is the disease grey mould caused by the pathogenic fungus *Botrytis cinerea*. This fungus infects both the flowers and fruits, and can greatly reduce yields. It is considered as one of the most damaging diseases of strawberry. In viticulture, there are also challenges with pathogenic fungi. However, at some vineyards they had success with spraying the vines with ozonated water (Bhadra 2015, Wood 2014). The ozone kills the fungi without having any negative impact on the plants or the grapes. Therefore, in a new project in 2017, a strawberry test field will be given the same treatment as the vineyards, to study the effect of ozonated water on grey mould on the strawberry plants.

Key results and discussion

In the mass trapping study of strawberry blossom weevils, altogether 5361 weevils were trapped. In the first four weeks, 159 weevils were caught by the traps. The number of weevils caught the next four weeks was 985 and for the last four weeks 3913. The weevils caught in the first period had been overwintering and were among those who performed damage on the strawberry plants. The weevils caught later were among the new generation of weevils that would breed the next year, thus not doing any damage on the strawberry plants the present year. When comparing damage caused by the weevil (number of cut buds on each plant) in the test field with a control field, no significant differences were found. There was neither found any difference in the yields

between the test and control fields. This led to the conclusion that it was not possible to reduce the damage caused by the strawberry blossom weevil in a two-year-old strawberry field using this method, since too few weevils were caught in the beginning of the season. By fencing a new established strawberry field with insect net, the strawberry blossom weevil will be excluded from the field. If this is combined with insect traps on the outside of the fence, weevils attracted to the field will be stopped by the fence and can be caught by the traps. Combining these measures will reduce the risk for weevils entering the field and less damage is expected.

Treatment of a strawberry field with ozonated water will hopefully reduce the disease outbreaks caused by the pathogen *B. cinerea* and increase the strawberry yields without having negative impacts on the fruit quality or the environment. Ozonated water for pest management is still not organically certified. However, since the half time of ozone in water is short (20-30 min) and it will not provide any residues (only O₂), the use of this treatment has a potential to become a new measure in organic plant protection.

How work was carried out?

In the mass trapping study of strawberry blossom weevils, 200 funnel traps were mounted in a two-year-old strawberry field (0.32 ha). The traps were mounted in ten rows (20 traps in each row) at a distance of five meters. Each trap was baited with a lure containing a specific plant volatile and the aggregation pheromones of the weevil. The lures were exchanged in the middle of the growing season. All traps were controlled and emptied every four weeks. In addition to the number of caught weevils, also insect damage and yields were recorded.

In the new project, combining traps and fencing with insect net, the measures will be mounted in a new established strawberry field of 0.8-1 ha. The fence will be about 2.5 m high, sealed closely to the ground and having a short fold on the top, pointing outwards. Outside the fence, traps will be mounted every 5 m to catch weevils stopped by the fence. The effect of these combined measures will be followed in the same field during three years.

For treating strawberry in a test field with ozonated water, an ozone generator will be mounted on a tractor. On this tractor there will also be a mounted a regular field sprayer with a water tank. Ozon gas will be lead from the generator into the water and sprayed onto the strawberry plants. The effect of the treatment will be compared with areas which have been treated with just water and areas with regular conventional pest management with fungicides.

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Blue lupin as an alternative protein supplement for dairy cows fed grass silage-based diets

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Implications

We examined the effects of substituting rapeseed meal with blue lupin (*Lupinus angustifolius*) on production and metabolism of cows fed grass silage-based diets. The results show that dry matter (DM) intake and milk production increase when cereal grain is substituted with blue lupin (BL) but decrease when rapeseed meal (RSM) is replaced with BL. Owing to its high energy and protein content BL is a potential home-grown feed for supplementing forage-based dairy cow diets.

Background and objectives

Cultivation of grain legumes such as lupin has beneficial effects at the farm level including among others N fixation and other direct and indirect positive effects for subsequent crop yields (Stoddard et al. 2009). In Northern areas some varieties of BL can be grown and the seeds harvested successfully (Stoddard et al. 2009). Owing to its relatively high crude protein (CP) content BL is a potential substitute for conventional protein sources such as soya bean meal (SBM) or RSM in dairy cow diets. The aim of this study was to examine the effects of substituting RSM with BL on production and physiological responses of dairy cows.

Key results and discussion

Protein supplementation increased grass silage DM intakes (+1.1 kg DM/d) and yields of milk (+2.9 kg/d) and milk constituents compared to control. However, the substitution of RSM with BL decreased total DM intake (-0.7 kg/d), and yields of milk (-2 kg/d), protein (-80 g/d) and lactose. Though, the energy corrected milk yield was unchanged as the milk fat content increased (+3.5 g/kg) with BL in comparison to RSM. Substitution of RSM with BL had no effect on the concentrations of rumen volatile fatty acids (except for increased ammonia) or plasma energy metabolites but decreased those of essential amino acids. Earlier research shows that SBM can be completely or partly substituted by lupin as protein source (White et al. 2007) but comparisons with RSM are scarce.

How work was carried out?

The experiment was designed as a replicated 4 x 4 Latin square with 4 intact and 4 rumen cannulated multiparous Finnish Ayrshire cows (111 days in milk, SD 29.3) and 4 experimental periods of 21 d. The treatments consisted of cereal based concentrates given either with no added protein (Control, CP 121 g/kg DM), or in isonitrogenous amounts (CP 185 g/kg DM) of RSM, BL or a 1:1 mixture of RSM and BL as protein sources. Concentrates were fed at a rate of 12 kg/d and silage (digestible organic matter 658 g/kg DM) made from 2. cut timothy-meadow fescue sward was given *ad libitum*.

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Equol and enterolactone – two mammalian phytoestrogens with estrogenic potency found in organically produced milk

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Implications

Cows fed high proportions of red clover yield milk with high concentrations of the isoflavandiol equol, a phytoestrogen with high estrogen potency that may have beneficial effects in prevention of osteoporosis and breast cancer. Soy products have much higher content of isoflavones than milk, but not all humans are able to produce equol from isoflavones. In cows many plant lignans can be metabolised to enterolactone, and milk concentrations tend to be higher during grazing season than indoor feeding season. Therefore, milk produced on feed containing red clover and milk produced on pasture may be considered as functional food. However, more documentations on possible effects in humans, including unwanted side effects are needed.

Background and objectives

Phytoestrogens are a group of non-steroidal plant compounds with structural similarities to mammalian estrogen (17- β estradiol). Phytoestrogens and their mammalian metabolites can bind to estrogen receptors in animals and humans, and provide a weak estrogenic or anti-estrogenic effect. In sheep, intake of phytoestrogens may impair fertility, whereas effects in cattle are not consistent. In humans, favourable effects of phytoestrogens have been reported related to osteoporosis, different types of cancer and cardiovascular disease. Isoflavones and lignans are metabolised to equol and enterolactone in the rumen. Human gut microbiota can metabolise plant lignans to enterolactone in the intestines, but only 30-50% are able to produce equol. Equol has a higher estrogenic potency than its precursors, whereas that of enterolactone is weak, but it may also exert biological effects by non-estrogenic mechanisms. The objective of this paper is to present the relationship between intake of forage legumes and milk content of equol and enterolactone in organically managed dairy cows.

Key results and discussion

Organic dairy farms with short-term grassland in mid Norway produced milk with higher concentrations of equol (241 $\mu\text{g}/\text{kg}$) than organic farms with long-term grassland (65 $\mu\text{g}/\text{kg}$) (Adler et al., 2015b). Grasslands on the farms with short-term grasslands contained on average 17% red clover at first cut and the farms with long-term grassland 9%. Pastures had only small amounts of red clover, and equol concentrations in milk from organic short-term grassland farms were lower in the grazing period than in the indoor feeding period. Enterolactone concentrations did not differ between the two farm types, but the concentrations were highest during the grazing period. In a grazing experiment, red clover-grass pasture (28% red clover) was compared with a botanically diverse pasture (Adler et al., 2015a). In milk, concentrations of equol (1,199 vs. 86 $\mu\text{g}/\text{kg}$) and enterolactone (165 vs. 120 $\mu\text{g}/\text{kg}$) were higher when red clover-grass rather than botanically diverse pasture was grazed.

In two silage feeding experiments red clover-grass silages (31-34% red clover in the dry matter) were compared to silages of birdsfoot trefoil-grass (16% birdsfoot trefoil) or botanically diverse

silage (Höjer et al., 2012). Milk equol concentrations were higher for the red clover treatments (716-1,494 µg/kg) than for the other treatments (84-145 µg/kg). For enterolactone the effect was opposite, birdsfoot trefoil-grass silage (226 µg/kg of milk) and botanical diverse silage (133 µg/kg) resulted in milk with higher concentrations than the red clover-grass silages (51-108 µg/kg of milk). However, huge individual differences were observed between cows. Steinshamn et al. (2008) found that red clover silage yielded milk with higher equol concentrations than white clover silage. Concentrate intake decreased isoflavone and increased lignan levels in milk. In a metabolism study with red clover-grass and botanically diverse silage, isoflavones and lignans were extensively metabolised in the rumen to mammalian phytoestrogens (Njåstad et al., 2014). The phytoestrogens and their mammalian metabolites were further metabolised in the intestine, but to a lesser extent than in the rumen. For lignans the authors suggested that a high amount of precursors has not been detected as the amount of mammalian lignans that escaped the rumen was larger than the intake of known precursors in the feed intake.

This paper confirms the findings of Antignac et al. (2003) and Mustonen et al. (2009), who found elevated levels of equol in milk produced organically or with high red clover proportion in the diet. The following equation was found: Equol concentration in milk (µg/kg) = $2.56 \times$ red clover proportion in total feed intake (g/kg of dry matter) + 76.61 ($R^2 = 0.52$). For white clover no correlation was found in the present study. Birdsfoot trefoil was only included in one feeding experiment, but resulted in milk with the highest concentration of enterolactone in milk in the present study. Average enterolactone levels in the 6 studies were 150 µg/kg of milk (SD = 22.5) in grazing and 68 µg/kg milk (SD = 56.4) in indoor feeding situations. Compared to soy products, such as raw tofu containing roughly 0.2 g of total isoflavones per kg, milk produced on red clover rich diets has a low content of equol. However, considering the high estrogenic potency of equol and that not all humans are able to produce equol, further studies on possible health effects of consuming milk based on red clover rich feed are needed. Accordingly, enterolactone in milk produced on pasture may have positive health implications. Further studies must also focus on unwanted side effects.

How work was carried out?

Forage intake, red clover proportion, milk yield, phytoestrogen content in feed and milk from 6 feeding experiments from Norway with dairy cows in organic farming were included in this study.

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Milk - new research and product development innovations (Milk-Inno)

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Implications

The aim of Milk-Inno research is to investigate the effect of biological and non-biological factors on milk composition, particularly on bioactive components, as well as health effects.

Background and objectives

Milk production is the most significant industry in Finnish agriculture and milk production is a major sector of the food export in Finland. In the 20th century development of a trend, where the producers create customized and quality assured raw materials for processing industry begun. The development of specialized products intended for specific target groups still continues. The general tendency is to create add-value to food production and food technology export. This trend covers also milk production and processing. To ensure the competitiveness of the whole dairy production chain through the changes will require a better understanding of the impact of different production and processing systems along the whole chain.

Key results and discussion

The research has started late 2016. Milk samples have been collected and all the analyses are going on. Data analyses will be done during 2017-2018.

How work was carried out?

The project is divided to three parts which concentrate on feeding, processing and health. Research is conducted using state-of-the-art methods. The milk is collected from another research project, where cows go through three different types of diet: i) low-energy "low-input" -diet with grass silage with a high proportion, ii) organic feed like a diet, where the share of the domestic source of proteins (red clover) is a large and iii) a high-energy "the high-input" -diet with the cereal-based compound feed with a high proportion.

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Raw milk and allergy prevention – a possible feature for organic milk?

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Background and objectives

Having its roots in the late 1980ies, a series of recent reports connected with the so-called hygiene hypothesis have indicated some possible involvement of raw milk as a protective agent against asthma and allergies. From an epidemiological viewpoint, there is an inverse correlation between raw farm milk consumption by infants during early childhood and the development of such diseases or disorders during later life, especially in rural populations. Besides this general observation, further studies support the assumption that even more criteria might play some role as interacting criteria. For example, the confrontation with non-infectious microbes including some of their fragments, rural environment involving the direct exposure to domestic animals, but also the intestinal microbiota as well as the immune system of the individual obviously possess some significance. However, from the viewpoint of public health, the preventive approach of drinking raw milk is hazardous for microbiological reasons. Hence, national and international regulatory requirements do not generally allow raw milk distribution, and in order to guarantee safe milk, pasteurisation is implemented as an obligatory step in milk processing. Although modern dairy technology can be regarded as a pacesetter for the production of highly nutritious food and also ensures microbiological safety as well as a certain shelf-life, it is well-known that conventional dairy technology has some impact on heat-sensitive milk ingredients.

Key results and discussion

To date it remains unclear whether single compounds or a cocktail thereof are of relevance as an anti-allergic agents in raw milk, but it seems to be clear that they are heat-sensitive, maybe even technology-sensitive. This review aims to give some update on the role of raw milk and/or its constituents in allergy prevention, also considering possible advantages of organic milk in such a context. In addition, challenges and strategies will be discussed to control and maintain safety of a raw milk-based formula product.

How was the work carried out?

This work presented is based on several experiences collected through the past twenty years and hence represents an amalgamate of own laboratory research with literature review. Within a former EU project (Gabriel), farm milk samples from different areas in Europe were examined for their status (native vs. heat-treated) and for compositional details relevant for exerting immunological effects. In another study, possible technologies for the collection and separation of relevant milk fractions were investigated and optimized.

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Health effects of organic food – what can we say?

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Implications

Debates on health effects of organic food arise from time to time. However, there are not enough scientific clinical studies to give fair objective statements.

Background and objectives

Recent review articles and meta-analyses show, that contents of certain nutrients as well as some phenolic compounds are slightly higher in organic than in conventional products. However, a healthy conventional diet contains enough essential nutrients and a slightly higher intake may not have any clinically significant impact. Only a small number of pesticides (some biocides and pyrethrins) and 48 food additives are allowed to be used in organic production, and thus there are fewer pesticide residues and less food additives in organic than in conventional products (more than 300 food additives allowed in conventional products). All pesticides and food additives allowed in conventional production are tested for safety and re-evaluated regularly, and also their use is regulated so that the contents existing in foods should be on safe level. Some conventional products contain more cadmium than organic products, as phosphate fertilizers contain cadmium. Both organic and conventional products may contain environmental toxins.

Comparing health effects of conventional or organic diets is not easy. The golden standard of clinical studies is a randomized controlled cross-over study, but that type of study is not valid for substances affecting also epigenetic regulation. In prospective studies aiming to investigate epigenetic effects multigenerational studies are needed. Pesticides and food additives may also affect indirectly, like via microbiota. There are also large individual differences between the sensitivity to adverse effects.

The objective of this study was to do a literature search of clinical studies comparing health effects of organic and conventional diets and recent reviews of pesticide toxicology to find gaps in research.

Key results and discussion

So far there are only few prospective multigenerational studies comparing the effects of organic and conventional diet. According to Brantsæter et al. (2016) there is a general consensus that the scientific evidence from human studies is insufficient to conclude whether organic foods are more beneficial for health in some respects than are conventional foods.

However, several research groups have aroused concern of areas that should be investigated thoroughly.

- 1) Pesticide mixtures can interact in various manners (Rizzati et al. 2016)
- 2) Cumulative exposure during embryonal and fetal stage should be studied carefully (Mitro et al. 2015, Strazzullo and Matarazzo 2016). Russ and Howard (2016) suggest, that prenatal exposure to endocrine-disrupting chemicals (EDCs) may contribute to the development of metabolic diseases in children. DDT exposure in utero has been connected

also with breast cancer (Cohn et al. 2015) and transgenerational inheritance of obesity (Skinner et al. 2013).

- 3) Some environmental pollutants (including pesticides) and some food additives affect both animal and human microbiota either indirectly or directly, and more studies should focus on the relationship between environmental pollution, gut microbiota, and human health (Jin et al. 2017)
- 4) Polymorphism in several genes may increase sensitivity to pesticides. Effects of polymorphism of ApoE (Richardson et al. 2014), PON-1 (Marsillach et al. 2016, Nam et al. 2016) and CYP2B6 (Lind et al. 2017) on pesticide levels in clinical samples and their connections with life-style diseases have been studied recently.
- 5) Current knowledge of the impacts of pesticides on human thyroid function is still limited and the quality of some earlier studies not valid. Especially exposure during critical windows of brain development and in agricultural population should be evaluated (Campos & Freire 2016).
- 6) Maternal or paternal exposure to pesticides has been linked with autism and ADHD (Mostafalou & Abdollahi 2017).
- 7) The methods used in safety evaluations at present are not up-to-date and do not take into account the chemicals combined in commercial products (Vandenberg et al. 2017)
- 8) A recent large prospective study found a negative association between high frequency of organic food consumption and risk of overweight and obesity (Kesse-Guyot et al. 2017)

How work was carried out

A literature search was done first for the recent clinical studies comparing organic and conventional diets and then recent literature concerning genetic and epigenetic effects of pesticides and food additives.

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Effect of organic and conventional farming system on the total phenolic content and antioxidant activity of oats and barley grains

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Implications

Oats. Total phenolic content (TPC) and radical scavenging activity was higher in hull-less oat varieties cv Stendes Emilija and cv Bikini compared to the other tested varieties independently from the production system. However, part of oat varieties produced significantly higher content of the tested parameters in organic farming conditions than in conventional farming conditions. Significant difference in TPC and radical scavenging activity for the all tested varieties was found in the field experiments including four different climate conditions.

Barley. The highest TPC and radical scavenging activity was detected from the grains of hulled barley variety cv Tyra and hull-less barley variety cv Pihl. There was no significant difference between farming systems in general, but the significant interaction between the genotype and the farming system was found. For barley varieties environment and genotype interaction was also stronger than for oat varieties, except of 2,2'-azino-bis 3-ethylbenz-thiazoline-6-sulfonic acid (ABTS) scavenging activity, which was significantly higher in all the barley grain samples grown in Priekuli (Latvia).

Background and objectives

Cereals are the main source of carbohydrates, but the most of beneficial properties have been attributed to bioactive chemical compounds, commonly named phytochemicals (Acosta-Estrada et al. 2014). Phenolic compounds are the secondary metabolites found in almost all plants at various concentrations and the investigations are carried out because of their diverse health benefits. Natural antioxidants such as phenolic compounds may prevent chronic inflammation, cardiovascular diseases, cancer and diabetes (Masisi et al. 2016) possibly as a result of their free radical scavenging activity. As consumer knowledge on the health benefits from grain constituents increases, barley and oats are becoming more attractive both for researchers and producers. The objective of the current study was to assess the total phenolic content and radical scavenging activity in grains of hulled and hull-less varieties of oats and barley depending on production system and climate conditions.

Key results and discussion

Total phenolic content and antioxidant activity in oats and barley was affected by a variety, production system and climate conditions (growing location).

Oats. Overall, the highest TPC and DPPH scavenging activity was measured in grains of hull-less variety cv Stendes Emilija and the lowest activity – in hulled variety cv Laima. The highest ABTS scavenging activity was recorded in grains of hull-less variety cv Bikini while the lowest in grains of the variety cv Laima. It is well documented that oats contain phenolic acids, flavonoids and a group called avenanthramides. Several studies have shown strong antioxidant capacity of these compounds (Yang et al. 2014) thus it possibly would explain high DPPH radical scavenging activity established in our study. It is known that phenolic compounds are strongly related to radical scavenging activity. We also found a strong correlation between TPC and DPPH scavenging activity ($r = 0.75$) and a very strong correlation between TPC and ABTS scavenging activity ($r = 0.85$). The significantly higher TPC, DPPH and ABTS scavenging activity was measured in oat grains cultivated in the organic farming comparing to the grains from conventional farming system. All the tested varieties grown in Priekuli (Latvia) had significantly higher TPC and DPPH scavenging activity compared to the same varieties grown at Stende, Apelsvoll, and Kvithamar. Thus, the content of phenolic compounds was strongly affected by growing environment.

Barley. For barley varieties the highest TPC and the highest DPPH and ABTS scavenging activity was measured in grains of hull-less variety cv Pihl and hulled variety cv Tyra, whereas the lowest content was measured in hull-less variety cv Kornelia. Barley varieties showed significantly higher TPC content compared to the tested oat varieties. However, a moderate correlation was established between TPC and DPPH scavenging activity and TPC and ABTS scavenging activity in barley. Generally, the farming system had no significant effect on TPC and DPPH scavenging activity of barley. The relationship between genotype and growing environment was observed indicating the importance of a particular growing climate. It seems that organic farming system is more stressful for the plant growth and therefore could result in a higher content of bioactive substances, which was partly confirmed in the current study. Higher content of phenolic compounds and higher antioxidant activity were measured in oats from organic production system, suggesting that oats might be more sensitive to the management conditions than barley. For barley only some genotypes had similar response. It seems that relationship between environment and genotype is more pronounced for barley cultivars than oats.

How work was carried out?

Spring cereals of barley and oats were grown at four locations: two in Norway – Apelsvoll (N 60.7°, E 10.9°), Kvithamar (N 63.5°, E 10.9°) and two in Latvia – Stende (N 57.1°, E 22.3), Priekuli (N 57.2°, E 25.2°). At all locations, the crops were grown in conventional as well as organic production systems. Fertilizers and chemical pesticides were applied according to the agronomical practice of the respective country. Five oat and five barley genotypes were included in the field trials –hull-less oat varieties cv Bikini, cv Nudist (both originated from Norway), cv Stendes Emilija (Latvia) and hulled varieties cv Odal (Norway) and cv Laima (Latvia); hull-less barley variety cv Phil (Norway), cv Irbe and cv Kornelija (both Latvia) and hulled barley varieties cv Tyra (Norway) and cv Rubiola (Latvia).

Extraction and analysis of phenolic compounds and evaluation of antioxidant activity was done according to the methods described by Kruma et al. (2016). Experimental results presented are the means of three replicates. Analysis of variance (ANOVA) and linear correlation analysis were performed.

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Organic wild collection in forests

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Implications

The wild collecting products from the nature are favorable, sustainable raw materials, because they grow without inputs. In addition being nourishment, they will be a source for innovative raw materials for, among others, the welfare products and cosmetics. The wild forest raw materials and products are allowed to market as organic when the whole production chain follows the organic supervision.

Background and objectives

In Finland there is about 26.2 million hectares of forestry land (Metsäntutkimuslaitos 2014)-where berries, mushrooms, herbs and other non-wood forest products (NWTP) can be collected. Nearly half of the area, about 13 million hectares, are certified as organic picking area. In future the organic forest area can be increased by double, because of the extremely low use of chemical fertilisers or pesticides in Finland.

In Finland lingonberry (*Vaccinium vitis-idaea*), bilberry (*Vaccinium myrtillus*) and cloudberry (*Rubus chamaemorus*) are the most important commercial berry species (Kurppa et al. 2015). Only a few species of mushrooms are collected commercially. The commercial collecting of berries and mushrooms is registered statistically (Maaseutuvirasto 2016). Many other wild collecting products, such as wild herbs, birch sap and resin could be collected and used as native products and for further product development in considerably higher amounts.

At the moment the bulk of the organic picking area is located in the Northern Finland. The growth and productivity of berry crops vary greatly during different years depending on the growth area (Turtiainen et al. 2011). It is important to bring more organic picking areas also to the southern part of Finland in order to fill the possible gaps in the supply of the organic products. Organic certification label in collecting products is appreciated especially in the export market. It guarantees the quality and the origin and its significance will further increase with emerging food forgeries.

The present study produces information concerning the significance of the organic certification of collecting of the wild collecting areas. It also compares different operation models and clarifies the opportunities for cooperation with companies and forest owners based on organic certification.

Key results and discussion

The study is at the initial stage and the results will be available in future. Inquiries, focus group- and expert interviews will be used as research materials.

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Antimicrobial activity of Finnish organic honeys against human pathogenic bacteria

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Implications

Research on antimicrobial activity of organic honeys is a novel approach (Oinaala et al. 2015) and may lead to unknown antimicrobial mechanisms and factors (Cooke et al. 2015) and it also represents sustainable development. In the present study we show that Finnish organic honeys have antimicrobial activity against the growth of human pathogenic organisms *E. coli*, *S. typhi*, *P. aeruginosa*, *K. pneumoniae*, *B. cereus* and *S. epidermidis* responsible for various human diseases. Moderate concentrations of the studied organic honeys were active against most of the pathogenic organisms and thus could have applications *in vivo* in order to control infections caused by the studied pathogens. The determined minimum inhibitory concentrations (MIC) of the organic honeys were significant, when considering applications to medical practice. The impact of this study fits in to the theme "Organic food, human health and wellbeing".

Background and objectives

Recent years have seen substantial improvements in life expectancy and access to antimicrobials, especially in low-income and lower-middle-income countries, but increasing pathogen resistance to antimicrobials threatens to roll back this progress. Alternative methods and solutions for fighting against infectious diseases are urgently needed. Honey has been used as a traditional medicine for centuries (Zumla & Lulat 1989) and its antimicrobial properties have been revealed in several *in vitro* studies against wide variety of human pathogenic bacterial species, including antibiotic resistant strains (Kwakman et al. 2010). Our previous studies have shown that Finnish monofloral honeys possess significant antimicrobial activity against important human respiratory pathogen *Streptococcus pneumoniae* and MRSA (Huttunen et al. 2013). We have also shown that Finnish organic honeys have antimicrobial activity against food poisoning pathogen *Clostridium perfringens* (Oinaala et al. 2015). In the present study, five organic and one conventionally produced Finnish honeys were tested for their antibacterial activity against six important human pathogenic bacteria causing variety of human infections such as wound infections, diabetic foot ulcers, urinary tract infections, diarrhea, septicaemia, food poisoning, gastroenteritis, enteric fever or upper respiratory tract infections.

Key results and discussion

The results from the present study show that antibacterial activity was dose dependent and the activity increased with the increased honey concentration, regardless of the honey sample. When compared to antibiotic controls, which induced zones of inhibition of 19-22 mm, the highest inhibition was achieved by organic honey sample F against *S. epidermidis* (15-16 mm), followed then by *E. coli* and *P. aeruginosa* (14-15 mm). Organic honey samples B, D and E showed moderate

activity against all the bacteria tested. Organic honey A had low activity against *E. coli*, *S. typhi* and *P. aeruginosa*, but no activity was detected against *K. pneumoniae* and *S. epidermidis*. Nonorganic honey C had the lowest activity, showing moderate activity only against *E. coli* and *S. epidermidis* but no activity against *S. typhi*, *P. aeruginosa*, *K. pneumoniae* and *B. cereus*. The lowest MICs (12.5% except 25% against *B. cereus*) were detected with the organic honey F and with the organic honeys E and D (12.5-50%).

The organic honey A and the nonorganic honey C were active only at the 80% honey concentration and induced low zones of inhibition.

How work was carried out?

Laboratory strains of the pathogenic bacteria used in the study were obtained from the Department of Medical Laboratory Science, University of Eastern Africa, Baraton, Kenya. The bacterial organisms were *Escherichia coli*, *Salmonella typhi*, *Pseudomonas aeruginosa*, *Bacillus cereus*, *Staphylococcus epidermidis* and *Klebsiella pneumoniae*. After cultivation the bacterial concentrations were standardized to 1.0×10^8 cfu/ml and used in the antimicrobial assay. Honey samples were purchased from the major supermarkets in Helsinki, Finland. They were labelled from A to F. Five of the honey samples (A, B, D, E and F) were organic and honey C was non-organic. Honeys were diluted in sterile deionized water to achieve concentrations of 80, 50, 25, 12.5 and 6.25% (w/v). In the study the control antibiotic against *K. pneumoniae*, *B. cereus* and *S. epidermidis* was gentamycin (10ug) and against *E. coli*, *S. typhi* and *P. aeruginosa* ciprofloxacin (10ug). The antimicrobial activity of the honeys and the MIC values were determined by the agar well diffusion method (Oinaala et al. 2015). Nine replicates of each honey sample were pipetted into wells with diameters of 6 mm. For MIC analysis five honey concentrations, 80, 50, 25, 12.5 and 6.25 % (w/v) of each honey were used. The artificial honey, positive and negative controls were studied in parallel with honeys against each of the organism tested.

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Natural product based anti-adhesion therapy- innovative prevention against bacterial infections

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Implications

Antimicrobial resistance (AMR) resistance, similar to climate change, is a shared global problem (Gelband & Laxminarayan 2015). AMR threatens the effective prevention and treatment of an ever-increasing range of infections. There are plenty of resistant bacteria that cause common infections such as urinary tract infections and pneumonia. In addition to causing death, disability and suffering AMR has huge economic impacts. The alarming increase in drug-resistant bacteria means that there is a need for novel means of fighting against bacterial infections. One feasible approach is to use agents that interfere with the ability of the bacteria to adhere to the tissues of the host, the initial stages of the infectious process. Our research project deals with milk oligo-saccharides, wild berry and herbal bioactive polyphenols in prevention of bacterial attachment to human nasopharynx. We have focused on major human respiratory pathogenic bacteria. By employing several in vitro techniques we have shown that wild berry molecular fractions inhibit the binding of the serious human pathogen *Neisseria meningitidis*, associated with fatal invasive infections, meningitidis and septicemia. Anti-infective properties of wild berry fractions against different Streptococci causing human respiratory infections, newborn meningitis, animal diseases and associated with dental caries have been detected as well. Inhibitory activity of the berry material has been extracted especially from wild *Vaccinium* berries (bilberries, cranberries, and lingonberries) and from crowberries. Bioactive wild berry polyphenols represent organic products from wild forests subjected under organic certification.

Background and objectives

The prevention by anti-adhesion is directed to the initial attachment of the bacteria to human cells in the first step of microbial colonization and pathogenesis. Antiadhesive prevention can reduce the spread of the bacteria from person to person or from contaminated food. With anti-adhesion therapy bacterial infections could also be reduced by affecting on the amount of the healthy carriers. In anti-adhesion therapy components isolated from natural products such as berries, milk and herbs can be employed. Plants produce several bioactive compounds in response to environmental stress found in berries. Berry phenolic compounds can act against plant pathogens and may also cross-react with human pathogens. These substances can be curing or preventive. A well-known example is the use of cranberries to protect against *E.coli* urinary tract infections. The idea of present research was to investigate the ability of Northern wild berry bioactive components to prevent bacterial attachment to human respiratory mucosa and to prevent bacterial coaggregation associated with dental caries.

Results and discussion

We found anti-infective milk, wild berry and berry juice, and Chinese herbal molecular fractions and that inhibited the binding of pathogenic *Neisseria* bacteria causing serious human meningitis and septicemia (Hakkarainen et al. 1995, Toivanen et al. 2009, 2011, Huttunen et al. 2016). Anti-infective properties of berry fractions against different *Streptococci* causing human respiratory infections, newborn meningitis or animal diseases and against oral pathogens was detected as well (Huttunen et al. 2011, Toivanen et al. 2010, Riihinen et al. 2011). Inhibitory activity of the wild berry material has been revealed especially from *Vaccinium* berries and is associated with polyphenols, mainly with proanthocyanidins and/or anthocyanins. Today we aim to develop innovative anti-infective organic food products, which will be submitted to controlled clinical trials. We are also studying antimicrobial activity of wild natural products against food poisoning bacteria (Obey et al. 2016). The food products based on our research results are aimed to be consumed both in developed and developing countries against bacterial infections. Bioactive wild berry and other organic natural products provide a great future potential in controlling infectious diseases both in anti-adhesive and antimicrobial way. They can be utilized in their natural form or in functional food development to protect healthy consumers. The product development could also be directed especially to risk groups, to newborns, elderly people, military servants and immune compromised patients.

How work was carried out?

The studied berries and berry juices were fractionated into molecular weight fractions using centrifugal devices and for solid phase subfractionation C-18 SPE cartridges were employed. Molecular characterization of the bioactive berry and berry juice fractions was carried out by using NMR and HPLC-mass-spectrometry technologies. Several in vitro anti-adhesion techniques were used including hemagglutination inhibition, microtiter cell binding and dot binding assays, antiaggregation assay, cell culture studies and pilot clinical trials. Antimicrobial activity was tested in microtiter broth microdilution assay or by disc diffusion method. The studied bacteria were submitted to the experiments as vital whole bacterial cells or using their isolated adhesive pili structures.

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Pioneer organic farmers as institutional entrepreneurs in the agricultural context

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Implications

The present study advances two lines of academic discussion. First, our study adds to the existing literature on organic farming. Even though previous literature on pioneer organic farmers has identified the attitudes among conventional farming community and social stigma as barriers to organic conversion (e.g. Rigby et al. 2001), it has not addressed the ways how pioneer organic farmers were coping with the social stigma. By demonstrating pioneer organic farmers as institutional entrepreneurs who challenged the existing institutional order by overcame the stigmatizing cultural categories at the time. Second, our paper further contributes to stigma management literature by demonstrating how stigmatization can be understood as an empowering condition, thus enabling institutional entrepreneurship. Thus, we argue that the fact that pioneer organic farmers did not accept the legitimacy of stigmatizing attributes of organic farming is an important, but not a sufficient precondition for mainstreaming the idea of organic farming.

Background and objectives

The break-through of organic agriculture can be best described as an institutionalization process in which organic farming was promoted by numerous initiatives originating in different parts of society (Michelsen 2001). At the local level, farmers experimenting with innovative sustainable solutions played an important role in spreading a more sustainable forms of agriculture (Ingram 2015; Padel 2001), thus acting as institutional entrepreneurs. Since institutional entrepreneurs initiate changes that break with existing institutions, they may come across specific challenges arising from other actors' institutional embeddedness and possible political opposition (Battilana et al. 2009). Accordingly, the pioneers of organic farming often faced social challenges typical to institutional entrepreneurs as their innovative ideas on agriculture not only encountered opposition in the mainstream farming community but led to processes in which organic farmers were stigmatized as social deviants (e.g. Duram 2010; McGreevy 2012; Padel 2001; Strohlic and Sierra 2007; Sutherland 2013; Wheeler 2008). Our study is thus motivated by the following research question: how pioneer organic farmers managed their stigmatized identities to become successful institutional entrepreneurs?

Key results and discussion

The empirical results describe the identity management processes that the pioneer organic farmers used to reject their stigmatized identities in order to transform them into something that is valued and desirable. This process of identity disclosure consisted of two sub-strategies which we named as purification and distinction. Purification singled out the stigmatizing attributes by challenging the legitimacy of stigma communicators and transferring the stigmatizing features to other actors. Purification thus aims to normalize organic farmers and their farming decisions by cleaning of tainted self. The process of differentiation, on the other hand, aims to portray organic

farmers as specific social group by emphasizing the difference between them and conventional farming through socially valued identity blocks like innovativeness and entrepreneurialism. Accordingly, through differentiation, the pioneer organic farmers aimed to redefine their place in society by strengthening their sense of belonging to a valued in-group different than the group of conventional farmers.

How work was carried out?

This research is based on interviews with 13 organic farmers. The interviewees were contacted through organic farming associations, while the selection of the interviews was based on purposeful selection method (Patton 2002). In other words, we decided on two criteria for the interviewees on which the selection was based. First all the interviewed organic farmers had engaged in organic agriculture before governmental support for organic farming was launched in 1990. Second, the interviewed organic farmers had also experiences from conventional farming, i.e. before starting organic farming, they had been using conventional farming methods. Accordingly, by setting these two criteria we were able to focus on those farmers who were pioneering organic farming methods in Finland, and thus could be described as institutional entrepreneurs in the context of agriculture.

The data analysis method applied in this study was discourse analysis which examines how social reality is created by historically and contextually situated discourses (e.g. Alvesson and Kärreman 2000). Discourse analysis helps to shed light on how the pioneer organic farmers, embedded in definite social contexts, use available discursive resources to manage the social stigma attached to organic farming and produce alternative narratives of themselves (see Zajicek and Koski 2003).

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Narrative framing of the (heroic and rebellious) actors in the struggle for organic food and farming

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Implications

Collaborative projects for more sustainable food systems, including researchers and practitioners, would benefit from increased clarity regarding the ways the project has (or has not) reached its aims. This clarification is here suggested to lean on a meta-theoretical approach, which can relate the aims, activities, roles and positions of actors as well as their competences which they deploy for their goal attainment. This paper appreciates the well-known and insightful Dutch construct of transition management as a successful meta-theory for socio-economic and environmental change. However, the change, as a very complex phenomenon, could also be analyzed as rich, extensive and intensive as well as more unstable and open-ended process. Therefore, the paper proposes that research and innovation projects could benefit from the theoretical approach embedded in the narrative scheme particularly when the work is carried out by multiple actors, some of who are researchers and some practitioners. The paper proposes the narrative scheme (Greimas, 1966; Prince, 1987) as a valid meta-theory which links actors' roles, positions, activities, competences and contradictory aims into the plot which makes the wonder of socio-economic and environmental change visible.

Background and objectives

Social change is an extremely important and challenging phenomenon to be understood. Obviously, due to its risks and benefits, its management would be highly desirable. The research of action for social change, understood as transformation of large socio-economic systems entailing environmental impacts, often means collaboration between research and practice. This research needs a 'red thread' for planning, communication, implementation and dissemination for successful delivery. This paper reads transition management theory as an excellent account about technological and industrial change, which knits well strategic planning, development of progressive policies and public as well as private funding (Vellema, 2011). To add more social richness and open-endedness, as well as contradictory features as "drama" (Buurma, 2011), this paper explains how narrative scheme would be a support for research and innovation projects with multi-level developments with very different actors and actor groups.

Key results and discussion

Transition management theory is deployed in several Dutch case studies as a basic meta-theoretical resource (Vellema, 2011). The theory depicts change through three levels. The uppermost level is the "landscape" reflecting global trade and its consequences for socio-economic activities. The middle level is the "regime" which depicts the 'play of the game' in the mainstream socio-economic activities. Finally, the "niche" represents the source for change through technological and socio-economic innovations, assumed to expand competitively within the mainstream devel-

opments of the regime. However, here the levels and their 'roles' are 'pre-defined', and the actors' voices focused on innovation activities whereby other social aspects and actors seem somewhat damped. Buurma (2011) also notes how the weakness of the regime may enable changes to occur, rather than the niche only; furthermore, the author recognizes there is "drama" in the dynamics of change. These views suggest the whole meta-theoretical construct could be enriched by more flexible and nuanced ways.

This paper proposes the narrative scheme (Prince, 1987) as a generic and 'dramatic' theoretical approach which would more visibly connect the different levels with various actors' simultaneous dealings across the levels in active pursuit of their goals, often stemming from contradictory interests and expectations.

The narrative scheme, initiated by Propp (1973) and elaborated by Greimas (1966) as actantial model presents a scenery whereby the subject has an object, the achieving of which is motivated by the sender; the plot builds around the subject's efforts for the object while the opponent works to hinder the subject from achieving the object. Here both the subject and the opponent may have competences and helpers, agents, which support their efforts. Finally, if achieving the object, the subject is rewarded and if not, the opponent gets its way as a reward. The theory is flexible in the way that the same actor in the scenery may represent different actor-positions simultaneously; the position of the sender and the receiver are available for the subject, who is committed to the task and looks for reward. However, typically there are several actors on the scenery. Furthermore, actors may also present ambiguity towards the subject's and the opponent's efforts and aims.

The narrative framing emphasizes both the narrative structure and the narrative plot – the relation between actors, the events unfolding and the activities and competences by which the goal is attained. As it often seems, organic food and farming are in contradictory terms with conventional agriculture; thus, the narrative framing shows the struggle of the organic movement in proper 'heroic and rebellious' light as fits for the subject, the organic actors. As a trace from folktales, the farmers can adopt the heroic role of the subject as they struggle in the clutches of the establishment and its legal requirements in challenging conditions of global trade. Intriguingly, the narrative scheme can present the actors in more nuanced ways. They can be both self-serving (organic farmers interested in economic achievements) and broadly altruistic (showing the other regarding behavior). Thereby farmers may also contribute both to the sending role and receiving one too. Furthermore, actors can vacillate between the roles as they change sides, for instance by turning from conventional to organic agriculture and vice versa. In a useful role in the theory are the competences, which may range from technology to nature to legal devices to consumer campaigns in actors' use. This helps to put on one plane very different matters such as technologies, biological features, legal documents, administrative bodies and social movements in support or resistance of the subject's efforts. Finally, the conditions of the narrative scheme are as broad and deep as to accept other social scientific and technological (working) theories as well as practices (both quantitative and qualitative) to meet the needs of the project.

How work was carried out?

The work is a result of a long-term acquaintance with social scientific theoretical sources and exercises made in their application for several projects, both domestic, Nordic and Horizon 2020.

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Perception of food and locality among Chinese tourist experiences in Finland

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Implications

The study applies qualitative methods to reach a more in-depth understanding of Chinese tourists' relations to food during their visit to Finland. The main interest is to find out how they perceive food and tourism, local food, environmentally friendly food and organic food during their trip. The preliminary results show that the Finnish food and food culture is not familiar among Chinese tourists and they have difficulties to identify the local food in holiday destinations. Concept of organic food was better understood than environmentally friendly food. Attributes like healthy, safer, natural, green, expensive and luxury were associated to the organic food. Additionally, organic food was considered to fulfill high quality standards.

Background and objectives

The Chinese tourists have showed a growing interest for travel to the Nordic countries and the number of Chinese overnights has almost tripled since 2010. Especially the winter season has been quite popular (Wu, 2016). Chinese tourism expenditure in Finland has increased by +56 % in 2015 and an average Chinese tourist spends ca. 656 euros during their trip in Finland (Visit Finland, 2016). According to the recent reports, Chinese groups will be looking into in-depth travel and spend more time in one country/destination instead of multi countries/destinations as it has been so far (Lai, 2016). There will be more interest in good quality tours such as living better, eating better, seeking more fun and spending more time in exploring attraction sites. Chinese travelers also seem to be willing to experience the daily life of the locals and know more about local customs and cultures. The focus in this study is to gain understanding of Chinese tourists' relations to food during their visit to Finland.

Key results and discussion

According to this preliminary study the Chinese interviewees had money but no time to spend during their holidays in Finland. This phenomenon seem to be quite typical (Visit Finland, 2016). The lack of time affected e.g. what kind of food or meals they chose. Different kind of snack products were preferred or they made an easy choice to save time and visited Chinese or Japanese restaurants. Naturally this has an effect on the perception of the local food or on the Finnish food. Some of the snacks, like noodles, were even purchased in order to prevent homesickness. However, some of the respondents described that "traditional and original food" would be the first choice and preferred in the holiday destination. Traditional food, restaurants and small local food shops were seen as symbols of the Finnish culture in general. Especially younger interviewees trusted information and recommendations of local food found via internet or websites and used online

travel advisers. In general locality was described “growing here and sold here” and most of the interviewees were willing to try local food products when travelling in Finland.

When asked about the meaning of the food itself, it was regarded to provide energy and nutrition and to maintain the health of the body. Importance of the water was pointed out and it was considered as food as well. On the other hand, attention was paid on the appealing appearance and how attractive way the dish was served. E.g. one interviewee mentioned experience with local fish meal, which was served in unpleasant way.

Environmental friendly food was not well understood by the Chinese interviewees. However, food waste and plastic food packages were brought out in this context. Concept of organic food was better understood. Attributes like healthy, safer, natural, green, expensive and luxury were associated to the organic food. Additionally, organic food was considered to fulfill high quality standards.

As a conclusion it can be stated that the Chinese tourists are not familiar with the Finnish food and they have difficulties to identify the local food in holiday destinations. However, the Chinese tourists are skilled in using online travel advisers and seek for recommendation and additional information there. This kind of services were considered trustful and informative.

How work was carried out?

A qualitative method was chosen as the main research approach for this study, in order to get more in-depth understanding of Chinese tourists’ perceptions of local food. The research material consists of fifteen semi-structured in-depth interviews. The thematic interviews were used to understand the perceptions of Chinese tourist on four themes, including food and tourism, locality, environmentally friendly food, and organic food. Interpretation of the interview data was analyzed using qualitative content analysis. Further, the meanings of the perceptions, the possible similarities and also the differences between the conceptions were analyzed. The interviews were coded using Atlas.ti 7 qualitative data analysis software (Atlas.ti 7, Version 7.5.10).

The interviews took place in hotels, lounges, cafeterias and online. 15 interviewees were participated in the separate interviews held during August 2016 to October 2016. The ages of the interviewees ranged from 18-60 years (12 females and 3 males). The interviews were conducted in Chinese by native Chinese interviewer, and took about 1-2 hours. All interviews were recorded, then transcribed and subsequently translated into English. Most of in-depth interviewees were found as travelling for leisure purpose, and some of them were interviewed using e.g. Skype after their trip in Finland.

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Development of Organic Food Production in some European Countries

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Implications

There are differences between countries in the development of organic food production, consumption and national organic food production policies. The main result was that there are possibilities to increase both production and consumption. The most effective tools were the national policy actions; diversification of subsidies, national development programs and pricing policy. Also consumers' actions can be effective e.g. by the demand of a larger assortment or a bigger share of organic food in public kitchens.

The farm size has no effect, if the national policy is to increase the organic food production (Austria). Municipalities may have an important role in promoting and increasing the use of organic food in schools, daycare centers and elderly people's homes (Denmark and Sweden). Consumption of organic products can be increased by active and open information of the pesticide residues found in food products (Denmark).

Background and objectives

The aim of the study was to compare the development of organic food production in eight European countries: Austria, Denmark, Estonia, France, Finland, Germany, Norway and Sweden. The comparison was done between years 1998 and 2014. The Ministry of Agriculture and Forestry named the countries and the research was done by FORI (Finnish Organic Research Institute) researchers. The main objective of the study was to get information of the best practices for promoting and developing organic food chain.

Key results and discussion

Many countries have set similar targets for organic agriculture: the most general for the production is 20 % of the field area before year 2020. Austria as the first European country has already reached it, but it had an earlier start for the organic development. Best practices to increase production are better targeted subsidies, national development programs with precise goals and proper actions to reach them and co-operation between farmers and research.

Best countries in consumption of organics are Denmark, Sweden and Austria. The best methods to increase the consumption in Denmark were providing information to the consumers (pesticides, when found) and efficient marketing campaigns. The municipality level programs to enhance the welfare of the nature and humans by including organic food into public catering were effective especially in Denmark and Sweden. The diversification of production has been made possible with policy actions and national level decisions to better target subsidies e.g. for plants and products that need an increase in production (Austria, Estonia, Finland, France, Germany, Sweden).

The reasons for the differences pointed out, are basically cultural. In some countries organic food production is more generally accepted and promoted (Austria, Denmark, Sweden) than in others. In some countries consumers are actively demanding organic food (France, Denmark, Sweden). If the conventional production is considered good enough by the citizens, national food policy is targeted to that more than to organic production (Norway, Finland).

How work was carried out?

The main data was statistical and collected from Eurostat, Faostat and IFOAM statistics. Literature on legislation, research reports and expert interviews were used as well. The collection and analysis of the data was executed in 2016.

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Economic Effects of Organic Production in Finland

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Implications

Money is usually one of the strongest reasons influencing decision making when choosing between organic and conventional production or usage, both in case of producers and decision makers of municipalities. The results of the survey directed to organic producers in Finland implied that the contribution to profitability of organic farming would be the most effective way to get more farmers to make the decision to convert from conventional to organic production. Naturally there are also many other reasons that affect the decision to make the conversion, for example environmental and health issues. According to the survey targeted to municipalities' decision makers, municipalities would use more organic products if they had more financial resources in use.

The model calculations showed that the economic impacts of organic production in Finland are already meaningful and the impacts will increase while the share of organic production rises. However, the increase in organic production would lead to minor negative economic effects as the share of conventional production would simultaneously decrease. Nevertheless, it would be useful, for example, to increase the efficiency of organic production so that the conversion from conventional to organic production would be more beneficial to the society from the economic point of view.

Background and objectives

The Finnish government has set a goal to increase the share of organic production to 20 % of area under cultivation by 2020 (Ministry of Agriculture and Forestry, 2013). In year 2015, the share was 9.9 % of the cultivated area, so there is still some catching up to do in order to reach the goal. Globally compared, Finland was the 13th in the share of organic production in 2015. For example, the share of organic production is higher in Sweden (16.4 %) and Estonia (16.2 %). In Finland, approximately 350 million euros are used every year in public procurement to buy food stuffs. Only a few per cent of that sum is used for organic products.

The main objective of this study was to produce new information about regional and national economic effects of organic production. New information about organic production and its impacts on economy helps for example politicians to make decisions concerning organic production.

Key results and discussion

According to the organic farmer survey, the most important reason for converting to organic production was lower costs or improved profitability. Therefore, the change seems to have been market-driven in many cases. In addition, such concepts as higher price and demand from customers, as well as growing organic markets are other sides of the same coin. Environmental and health concerns were also important motivators for the change.

The producer survey addressed also the geographical division of sales. The responses showed that around two thirds of the organic production in Finland was sold within the own NUTS2 region, and only 1 % was exported. In many regions, there were no exports at all. Almost half of the respondents (46 %) believed that the value of their organic production would be roughly the same in 2020 as it was in 2014. A third (36 %) believed that the value of production would grow. The rest 18 % foresaw a decrease in their production value. The respondents' view on the future could be translated as a growth of 3 % from 2014 to 2020. Thus, such a growth would not be enough to reach the national goal set up by the Finnish government.

Most of the respondents of the decision maker survey considered organic food products as a good alternative for public kitchens, but the municipal budgets are so tight nowadays and therefore the procurement is usually directed to conventional food products. Domestic origin is often the most important procurement criteria in food stuffs, but there are municipalities in Finland that have put organic in their procurement strategy. Even though the decision makers of the municipalities usually have a rather positive attitude towards organic products, their low value-added was regarded as a hindering factor. Contemporary public kitchens need products that have a high value-added. Thus, the width and suitability of the assortment of organic products alongside with the price will set the pace for the increase of the usage of organics in the public sector.

According to the calculations, the economic effects of organic production in Finland are approximately 3 400 person-years and 680 million euros. Almost half of that concerns crop production, about one-fourth milk production, about one-fifth meat production and about 5 % horticultural production. The regional economic effects are the biggest in western Finland. The growth of 3 % (estimated by the respondents) in organic production would make a small change to current situation. The employment would grow by 50 person-years and the GDP by 15 million euros between years 2014 and 2020.

When the RegFinDyn model is set up to grow the share of organic production according to the stated national goal (20% of the cultivated land used for organic production), it itself has positive effects to the economy. However, the land of organic cultivation cannot grow if the conventional agriculture does not decrease by the same amount. A reduction of conventional agriculture leads into losses in employment and GDP. The combination of these two changes leads into a small decrease in Finland's employment (-0.02 %) and GDP (-0.04 %) by year 2020. Still for many farms, the organic production seems to be more profitable than conventional when examined on a farm level.

How work has carried out?

A central part of the data collection concerned two surveys: one directed to the organic producers in Finland and the other to decision makers of the Finnish municipalities. Altogether 840 organic farmers (20 % of the total) and 280 decision makers completed the questionnaires. Organic producers were approached in spring 2015 with an email survey, which was complemented with phone interviews and later in autumn 2015 with a postal survey. The survey to municipalities' decision makers was carried out during the spring and summer 2016.

The other central method of this study was the use of a regional computable general equilibrium (CGE) model called RegFinDyn (for more information, see Törmä et al., 2015 and RegFin, 2017) of the Ruralia Institute to evaluate the regional economic effects of organic production now and in 2020. CGE models are economic models that use actual economic data to estimate how an economy might react to different changes. RegFinDyn is a dynamic model that takes into account the time dimension.

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A Path of Actions to Develop Organics in the Finnish Food Chain

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Implications

The Finnish Government has set development goals for organic food chain (MMM 2014). Following the actions presented in this paper, it is possible to develop the organics in the Finnish food chain holistically and comprehensively to reach the goals. The increase in production and consumption will have proven positive impact to the wellbeing of people, nature and animals (Rahmann 2016). Arctic and safety features of Finnish food will enhance the export possibilities of organic food to partly correct the current negative trade balance. The development is possible when organic values are incorporated to the Finnish food chain supported by the Nordic welfare model (Nuutila 2016).

Background and objectives

Organic production and consumption in Finland is lagging behind the neighbouring countries like Sweden and Denmark although the Finnish stakeholders and consumers find organic food healthy and safe and its production ethical and ecological (Nuutila 2015). The Finns find conventional equal to organic because of the lack of objective official information of the negative externalities of the conventional system (Nuutila 2016). Information plays important role in decision making (Aertsens et al. 2011). The communication between the stakeholders is not efficient and the centralized retail and food industry cause the uneven division of power and that partly prevents the collaboration (Nuutila & Kurppa 2016). It is important to analyse organics as part of the Finnish food system, recognize the obstacles that prevent its development and find solutions crossing the stakeholder, disciplinary and political boundaries.

Key results and discussion

According to Nuutila (2016) the Finnish food chain can be developed to accept organic growth by following a path of actions: 1) to include organics as part of studies in all school levels, 2) to ensure high quality internationally active organic research, 3) to provide objective information to the Finnish society about the food chain, 4) to set taxes on synthetic pesticides and nitrogen fertilizers, 5) to execute a national organic school meal project, 6) to reduce VAT on certified organic products, 7) to strengthen the activities of the Organic Food Association to unite the stakeholders, and 8) to support organic entrepreneurship and to promote Finnish organic produce abroad.

Education and knowledge form the foundation of a Nordic welfare society and Finns have succeeded well when comparing the learning leading to good results on innovation and entrepreneurial activity (Miettinen 2013) therefore it is well argued that education has a great importance in organic acceptance. The negative impacts of pesticides and unsustainable fertilizers have been proven scientifically and there is environmental taxation for those in several countries (Pearce & Koundouri 2003). It is often a practice to target the money collected into a contradictory action (OECD 2011), in this case for school meals and lower VAT. The strategic 2016 goals of the Finnish

government (TEM 2015) supports the presented actions: 1) to improve health and wellbeing, 2) to improve competence, 3) to renew education and knowledge system, 4) to enhance the bioeconomy, and 5) to change procedures e.g. by reducing bureaucracy and regulation.

There are several good examples of a fruitful collaboration between national authorities and organic food chain actors. E.g. in Italy the government strongly promotes Italian produce (Santucci & Antonelli 2004) and in Denmark, after some environmental scandals, the politicians and government made organic food chain one of the best examples in the world (Holm & Ingeman 2006). The globalized food markets have increased the price margin and it is crucial to find alternative marketing channels. Organic food produced, processed and sold most often in unconventional channels provides an alternative to maintain a fairer and local food chain. (Nuutila & Kurppa 2016b) It is important to further analyze the contradictions in and between the different parts of the food chain to better enable the realization of the aforementioned actions. Organic food system is an innovation itself and it earns to get a better legitimacy in the Finnish society.

How work was carried out?

This study is a result of a Survey of the Finnish food chain actors' opinions on organic food and its production, a focus group study about the collaboration and power relations in the Finnish food chain, and an extensive analysis of the Finnish food chain and the status of organics in it. The analysis was done using the cultural historical Activity Theory as the frame work for the food chain, Co-creation theory as a guiding agent for the collaboration and Economy of Common Good to support and fortify the organic values. The resulting modified Finnish food chain model was discussed with the Nordic welfare model and the Finnish innovation politics. The work was carried out during years 2013 and 2016 resulting to a dissertation with three peer-reviewed papers and one conference paper.

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Potential for raw milk in Lithuanian organic dairy supply chain

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Implications

The results of analysis on Lithuanian organic dairy supply chain considering the changes in raw milk production in farms, raw milk processing into dairy products and their realization lead to the conclusion about a considerable potential for the growth of dairy products market. Larger amounts of organic raw milk could be achieved by improving its purchase process; the analysis shows existence of quite a large “free” amount of organic raw milk that is used as conventional milk. A wider range and more active application of promotional measures could encourage dairy enterprises to use better available organic raw milk reserves.

Background and objectives

Organic food products are still considered to be niche products, but the benefits of organic farming in the context of sustainable development does not raise doubts, and positive changes in the attitudes of the EU consumers as well as support for agricultural producers consistently increase the market of organic products. Over the past decade, the global market of organic dairy products has grown considerably (compound annual growth rate in 2007–2013 was 3.7%, in 2012–2013 reached 6.2%) and in 2013 accounted for about 11% in the total world market of organic food and beverages.

The objective of the research is to analyse the organic milk supply chain in Lithuania and to obtain the potential for organic raw milk.

Key results and discussion

According to the data of certification body “Ekoagros”, in the beginning of 2016, in total 2.9 thou. entities were certified in organic production, processing, trade, etc. in Lithuania, of which in the stage of production 2.7 thou. of entities engaged in primary production; the total certified land area amounted to 220.2 thou. ha, number of cows reached 14.6 thou. (including land area and cows in conversion).

In the stage of processing only 7 entities engaged in raw milk purchase and processing: cooperatives „EKO tikslas” and “EKO Žemaitija”, AB „Pieno žvaigždės” subsidiaries „Kauno pienas” and „Panevėžio pienas”, AB „Rokiškio sūris”, AB-F “Šilutės Rambynas”, AB “Žemaitijos pienas”. In the stage of trade a few companies were certified only for wholesale of organic food products (e. g. UAB “Eko123”, UAB “Sanitex”, UAB “Varėnos pienelis”, UAB “Nestle Baltics”, AB “Žemaitijos pienas”, etc.) as well as a number of entities were certified for trade and storage (e. g. UAB “MAXIMA LT”, UAB “Rimi Lietuva”, UAB “Lidl Lietuva”, etc.).

As concerns the final stage of the chain – consumption, 43.9% of consumers of organic products in Lithuania realize the importance of healthy food, 21.3% are interested in a healthy lifestyle, 15.9% recognize the significance of physical activity to health, 11.8% take care of their health consuming organic products (Klupšas & Vanagienė 2010).

Part of the organic milk produced is consumed on farms; however, the data on this consumption are insufficiently accurate due to a lack of official data. The authors' calculations revealed that 0.5–0.7 thou. tons of organic milk per year was consumed by farmers' families for their own needs. Considering scientific recommendations for well-balanced feeding of calves and heifers, especially those for breeding, calculations showed that 3.1–4.9 thou. tons of milk per year was used on organic farms to feed calves. In 2004–2014 the conventional dairy farms each year 2.4–6.0% of the milk produced sold directly to consumers. With reference to the data of conventional dairy farms, it is estimated that organic farms each year sold 0.9–3.2 thou. tons of milk directly to consumers.

Due to various reasons such as the problems in raw milk purchase process (e. g. not daily collection of raw milk from small farmers; milk after cow treatment with chemical medicines does not meet the requirements of organic milk, etc.), farmers part of organic milk sell to processors as conventional milk.

According to the data of „Ekoagros“ (data provided by farmers), in 2013–2015 the entities engaged in milk purchase and processing from the Lithuanian milk producers purchased 21.9, 21.5 and 19.0 thou. tons of organic raw milk (of natural fatness) per year that accounted for 41.6%, 50.4% and 47.8%, respectively, of the total amount of organic milk produced in Lithuania. With reference to the data of Agricultural Information and Rural Business Centre, in 2013–2015 the amounts of raw organic milk bought from Lithuanian producers were increasing. In 2015 as compared to 2014 and 2013 the amounts purchased by Lithuanian milk processors increased by 5.5% and 14.3%, respectively. In 2013–2015 Lithuanian milk processors purchased and processed 16.9, 18.2 and 19.2 thou. tons of raw organic milk (of natural fatness) per year, but only 73.1%, 62.4% and 61.9%, respectively, of the total amount of purchased raw milk processed to organic dairy products.

In January 2016 the share of organic butter (fat content not more than 85%) accounted for 0.01% of the total amount of butter produced in Lithuania, sour milk – 0.03%, fresh cheese – 0.14%, sour cream – 1.2%, drinking milk – 1.9%, cottage cheese – 4.7%, yoghurt with additives – 9.4%, natural yogurt – 60.1%. Most of these products were sold in the domestic market: drinking milk – 81.5%, sour cream – 83.9%, flavoured yogurt – 94.3%, yogurt without additives – 99.0%, cottage cheese – 99.99%. Sales of organic dairy products are slowly declining; it is likely that the main reasons behind the decrease are: the country's purchasing power limits consumption of organic products, and the demands for organic dairy products in Lithuania are already almost satisfied.

Due to differences in data collection, different information sources provide different data about organic raw milk purchase, therefore, the amounts bought and the shares of the total milk production are also different. It should be noted that in recent years significant steps are made in order to gather the best possible information on the organic raw milk production, purchasing and processing, but the authors faced a lack of data and their reliability problem. This implies the proposal consistently from the methodological point of view to improve both the collection of data and the assurance of the integrity and consistency of these data publication.

How work was carried out?

The calculations were based on scientific recommendations for animal feeding in organic farms; the input-output methodology was applied. Statistical analysis refers to the data of certification body „Ekoagros“, Agricultural Information and Rural Business Centre, Statistics Lithuania. The analysed period covers the 2013–2015 period.

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Value creation in a successful organic potato supply chain from grower to professional kitchen

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Implications

Successful supply chains create value for not only consumers, but also for the other partners in the supply chain. When marketing organic products, the organic certificate alone is often not valuable enough: in most cases the organic product must also contain other properties that are valuable to the consumer. For a successful organic potato supply chain, many other value dimensions are required: both the supplier (farmer) and the end-user (kitchen) must perceive that the benefits outweigh the sacrifices. The crucial point in a successful organic potato chain is the mutual understanding of the meaningful values for each partner in the supply chain. The whole idea of sustainability is more than the use of organic products in itself; it is also how the kitchen operates – how to make food from the ingredients. From the sustainability viewpoint in an organic potato chain, the whole concept of sustainability is also worth considering. One issue, for example, is the necessity of processing; the unpeeled potato is also serviceable. Leaving potatoes unpeeled also reduces energy and water consumption as well as waste compared to processed potatoes. Perhaps the next step in the value creation of an organic supply chain is to create shared value, which means creating economic value in a way that also creates value for society.

Background and objectives

Nowadays, the quality of being organic is a natural part of food selection in Finnish professional kitchens. About 15% of catering sector kitchens use organic products daily, and the share is increasing. Over one-third of kitchens are considering increasing the usage of organic ingredients (Food Service Feedback, 2015). The most required items are processed organic vegetables, for example, washed and peeled potatoes and carrots.

Potato is a common and traditional ingredient in the Finnish catering sector. But the use of the organic potato is still quite complex. The barriers preventing the more extensive use of the organic potato can be found on both the kitchens' and the growers' sides. The rationalized production and hygiene requirements in kitchens promote the use of semi-manufactured and processed foods. On the other hand, organic potato growers are reluctant to start processing because of the necessary expensive investments and the low price of the processed potato (Koivisto et al., 2016). Thus far, organic potatoes are sold mainly as washed in the catering sector.

In business, it is essential to be able to create value for buyers (Porter, 1985). The supplier needs to offer value to the customer but also needs to gain benefits from the customer at the same time. For the survival of the business, suppliers need to understand how value can be created (Walter et al., 2001). To build a successful supplier–customer relationship in business, it is important to create value for each partner.

In this survey, the buyer–seller (kitchen–potato grower) relationship is examined to understand the perceived value of both business partners (professional kitchens as well as the growers) in the

organic potato supply chain. A better understanding of the value creation of both the supplier and the buyer will enhance successful organic supply chain development.

Key results and discussion

The value of the organic potato in a professional kitchen consists of quality attributes, use/functional criteria and signalling value. Professional kitchens most often mentioned values related to quality, such as freshness, taste, the right size of the tubers and a suitable variety for dishes. In the category “use/functional value” it was revealed that some kitchens appreciate peeled potatoes, whereas for some kitchens the unpeeled potato has a meaningful value. Those kitchens used hardly any processed or semi-manufactured ingredients. On the other hand, the usage of unpeeled potatoes might be regarded as a concession to the producer. However, in this case the value creation benefits both sides, even though the type of values differed (profit value for the grower; quality, use and signalling value for the kitchen). Organic potatoes also have a signalling value: the organic potato is an ingredient in “better” menus or served to certain customers.

In turn, the value of the organic potato for growers consists of profit value, quality and use/functional value. Growers as suppliers seem to highlight profitability-related issues, which is meaningful for the success of their businesses. The promotion of quality (referring to taste, safety, suitable varieties) is a normal method of gaining a competitive advantage in the catering sector. Growers seemed to consider their own delivery and the reliability of delivery to be a part of value creation (functional value).

The results point out that besides an organic label, the organic potato needs to meet other requirements of the end-user. The catering sector considers taste, ethicalness and environmental friendliness as the most important reasons to use organic products (Food Service Feedback, 2016). For a successful organic potato supply chain, other value dimensions are also required: both the end-user (kitchen) as well as the supplier (grower) must perceive that the benefits outweigh the sacrifices. The value creation elements of both supply chain partners are partly in line. The crucial point in the successful organic potato chain is the question of realizing and understanding the meaningful values of the others.

How was the work carried out?

The organic potato supply chains and business relationships were investigated by (semi-structured) interviews of the partners in an organic potato supply chain. Altogether fifteen organic potato suppliers (growers and wholesalers) and end-users (professional kitchens belonging to the Step to Organic scheme) were interviewed. The kitchens represented small-scale (30–90 lunches per day) and large-scale production (400–900 lunches per day). The potato area of the grower was in most cases between 1–3 hectares. The interviews were recorded, transcribed and analysed to identify the value-related issues. The different types of value were categorized, and their frequencies were measured.

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Demand for organic potato in professional kitchens and new production potential in Northern Ostrobothnia, Finland

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Implications

There is increasing demand for organic food. However, improving its availability requires actions within the whole food supply chain. Understanding of different price requirements that producers and professional kitchens have, regarding to organic potato for instance, must be improved. Consumers and especially professional kitchens need more information about why organic food is more expensive than conventional products. Potential producers in turn need better knowledge about organic farming, but above all improved availability of organic seed potatoes and new and more profitable cultivation methods. Also new market channels, especially export, should be considered while thinking about the opportunities to cultivate organic potato.

Background and objectives

Local and organic foods have been on the political agenda in Finland especially since 2010. In 2013, the Ministry of Agriculture and Forestry published *Local Food – But of Course! Government Programme on Local Food and development objectives for the local food sector to 2020* (Finland's 72nd government 2013a) and *More organic! Government development programme for the Finnish organic product sector and objectives to 2020* (Finland's 72nd government 2013b). These programs aim at developing markets for local and organic food and increasing their production. The objectives for the organic product sector include *greater diversity in the supply of domestic organic foods* and *improving the access to organic food through trade and institutional kitchens* for instance. Organic production is also among the priority issues in the EU programming period 2014–2020.

There is increasing demand for local and organic food products among professional kitchens (see. Korhonen & Muilu 2015), and potatoes and potato products are among the most commonly used locally produced food stuffs. However, the supply of organic potato is quite low. In 2016, the production of organic potatoes was 7.2 million kilograms and its share was only 1.2 % of the total yield for potato (Luomusatotilasto 2016), despite the largest harvest in the decade.

The aim of this study was to find out the present situation concerning the use of locally produced potatoes and potato products in professional kitchens in Northern Ostrobothnia and their interest and need for organic potatoes and potato products. In addition, the potential of increasing organic potato production was studied.

Key results and discussion

Over two thirds of all kitchens (n=33) under study said they use potato products produced in Northern Ostrobothnia and the most important factors for choosing products were quality, flavor and flexible delivery. Over half of the respondents also told to use organic potato products - most commonly unpeeled or peeled potatoes. Although the amounts used were rather small, most of

the kitchens were interested in using organic potato products. Currently, the poor availability restricts the use of organic potato products considerably. Previous studies also show (see. Korhonen et al. 2013, Korhonen et al. 2014, Kotavaara et al. 2014) that availability of organic potato products is very low compared to availability of nonorganic local potatoes.

The aim of the study was also to investigate, if there are new potential organic potato producers among nonorganic potato producers in Northern Ostrobothnia. All organic farmers in the region were also under study. A survey was sent to these producers to find out which factors prevent their transition to organic potato farming and whether or not they have interest in it. The preliminary results indicate that farmers are especially concerned about plant protection, fluctuations in yield quantity and quality as well as pricing. However, about 20 % of potato producers (n=57) and 11 % of organic farmers (n=46) had clear interest towards organic potato production and even greater amount were interested to some extent.

How work was carried out?

An electronic survey was sent to professional kitchens in the Northern Ostrobothnia area in spring 2016. Total of 33 responses were received from private and public operators. The second survey was sent to nonorganic potato producers in December 2016. However, due to a small number of responses a supplementary survey was needed. The third survey aimed at all organic farmers was executed during the spring 2017.

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Sustainable Cultivation of Truffles in Rural Regions of Finland

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Implications

Truffles are rarely found in Finland, in spite of recent breakthroughs. In 2006, we initiated an effort to explore the possibility, and feasibility of truffle cultivation in Finland. This effort started by establishing the first truffle orchard in Juva. By 2016, we planted roughly 10 000 tree seedlings in 33 orchards. The results of our work indicated that even a boreal Finnish area is suitable for the sustainable organic production of truffles, and it appears that *Tuber aestivum* is a promising truffle species for future truffle orchards in northern conditions. Our results also show that restrictions caused by the Finnish winter climate and low soil temperatures can be overcome with proper soil and winter protection management. In conclusion, the selection of proper tree species and provenances is needed to obtain positive results from cultivating truffles in Finland as a future, sustainable and organic crop for the benefit of rural Finnish areas' economy and prosperity.

Background and objectives

Truffles can be defined as hypogeous fungi of the genus *Tuber*, which grow in symbiosis with several trees. In comparison with the Mediterranean region, truffles are less documented in Fennoscandinavia. Interestingly, truffles are considered the most expensive edible fungi in the world. Economically, the two most highly renowned truffle species are *Tuber melanosporum* Vitt., and *T. magnatum* Pico. Finland is not a traditional truffle-producing location, nor are truffles a part of the traditional Finnish kitchen. Nonetheless, truffles have a long history in Finland, despite several truffle species (*T. maculatum*, *T. scruposum*, *T. foetidum* and *T. anniea* excluding) having only been recently identified (Shamekh et al. 2009; Orczán et al. 2010; Wang et al. 2013). Over the last decade, we have established the first truffle orchards in Finland in order to study oak seedling survival, growth, and truffle ectomycorrhiza development in a boreal environment with long winters and low winter soil temperatures. To overcome these environmental restrictions, a combination of different orchard adaptations and management methods were applied and studied (Shamekh et al. 2014). Interaction of truffle mycelium with the host plant involves the excretion of extracellular enzymes. The ability of *T. maculatum* mycelia to produce an extracellular cellulase during submerged fermentation was demonstrated for the first time worldwide (Bedade et al. 2017). Producing chanterelle mycelia was successfully performed in Juva Truffle Center recently for agro-forestry industry applications. The goal of this study was to provide a new and sustainable crop and income for forest and land owners in Finnish rural areas.

Key results and discussion

The effect of the applied protection methods was noted in examining the soil temperature and survival of the tree seedlings inoculated with truffles. The soil temperature at a depth of 15 cm dropped below 0 °C (−0.25 °C to −8.1 °C) at all measured sites during the winters of the study. The lowest temperatures (below −5 °C) were recorded on the sites where no additional protection was applied, or only a thin layer of sawdust was used during the winter. Morphological and molecular investigations of the root samples taken from the grown oak trees showed that truffle

ectomycorrhiza was present in root samples at all studied sites. In October 2012, the first truffle crop was harvested from two orchards which were established in 2006. Since 2012, the truffle crop of the Finnish orchards was harvested yearly. Our experimental results showed that further studies on purification and characterization of extracellular enzymes of truffle mycelia is needed in order to explore their potential for commercial and industrial applications. The optimal enzymes production pH is well in line with the pH of Finnish forests (Sippola & Yli, 2004). This pH level can be applied in establishing orchards for Finnish wild truffles which is lower than the pH of the soil orchard of Italian and French truffle species. It is noteworthy that the Finnish harsh winter is challenging both for truffles and ectomycorrhiza host trees. The results of this work indicated that even a boreal area is suitable for the sustainable production of truffles, and it appears that *T. aestivum* is a promising truffle species for orchards in northern conditions. Our results show that Southern European oak seedlings and *T. aestivum* can adapt to the Finnish climate and ecological conditions. Our results also show that restrictions caused by the northern climate and low soil temperatures can be overcome with proper soil and winter protection management. In conclusion, the selection of proper tree species and provenances is needed to obtain positive results.

How work was carried out?

Thirty-three of organic truffle orchards were established over 2006–2014 in Finland. Seedlings were planted in rows with 3–5 m between plants to ensure good future shading with canopies and access to harrowing machines. The soil between the rows was ploughed, harrowed, or weeded mechanically. The soil properties were determined for all truffle orchards prior to the first liming and planting, as well as in the years following planting. The soil temperature was measured by a data logger for each orchard at two differently exposed points of 15 cm depth. Different mulching and winter protection methods were applied to find out which one was suitable for the boreal climate. To assess the survival of truffle ectomycorrhiza on the roots of oak seedlings, root samples were taken randomly from each orchard for morphological and molecular identification. The truffle crop (organic) was picked by the help of trained dogs in every October since 2012.

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How to find pathways towards climate-smart agriculture – Views of farmers, educators and advisers in Finland

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Implications

Pursuing climate-smart solutions at farms can be thought of as being part of strategic farm management in the context of sustainability and adapting to the future. When preparing for climate change, not only the environmental dimensions matter but all aspects of sustainability (ecological, economic, social and cultural) should be considered in tailoring climate-smart solutions for one's own farm. Knowledge sharing, co-operation and long-term strategic thinking skills can support developing more sustainable and resilient agriculture and help farmers find and develop their own optimal climate-smart solutions that fit their development targets and pathways. Also many common practices of organic agriculture such as nutrient cycling and biological nitrogen fixation can help to develop climate-smart agriculture.

Background and objectives

Climate change is one of the most important drivers of change in agriculture (Lacey et al. 2015). In the global context, climate change is already threatening food security and causing major changes in e.g. the availability of water and tillable soil (IPCC 2014). Climate-smart agriculture can be defined as an approach for transforming and reorienting agricultural systems to support food security under the new realities of climate change, it aims to increase the adaptive capacity of farmers as well as increase resilience and resource use efficiency in agricultural production systems (Lipper et al. 2014).

Agriculture has also many different roles in relation to climate change: it is a victim of the impacts, on the other hand it is also causing greenhouse gas emissions and thirdly, agriculture has a role as climate change problemsolver, because it creates soil carbon sinks and has possibilities to produce renewable energy (Ollikainen et al. 2014). Farmers know the importance of climate and weather for their work and livelihood and already see a need for more climate-smart solutions, but they may lack information on the practical solutions suitable for their own farms (Ollikainen et al. 2014).

Climate change can be defined as wicked problem, concept used in social sciences for situations characterised by combination of high complexity, uncertainty and divergence (Head 2008). Wicked problems are series of interlinked problems and they have many stakeholders (Head 2008; Collins & Ison 2009). Solving of wicked problems needs social learning, which is based on the idea that knowledge is composed by sharing and doing with others and knowledge has contextual character, it is depended on situation, time and place (Collins & Ison 2009). To combat climate change, not only knowledge and technical solutions but also future-oriented strategic thinking skills, skills to cope with uncertainties and building of adaptive capacity are needed (Folke et al. 2010).

The objective of this work was to describe how actors (farmers, advisers and other rural stakeholders) jointly see the pathways and solutions to prepare for climate change in Finnish farms. The enabling and obstructing issues important for finding and taking climate-smart actions into practice were gathered based on views of workshops participants.

Key results and discussion

Developing climate-smart solutions at farms was found to be an integrated part of farm development, rather than a separate issue to deal with or a requirement for a technical investment. Research-based and experience-based information about practical solutions (not just information about climate change impacts), examples of good practices, excursions, and collaboration and discussion forums with colleagues were considered to be important means for capacity building on developing climate-smart solutions at farms.

The main obstructing factors recognized were the current low profitability of farming, farmers' feeling of inferiority in society, lack of smooth farmer co-operation, regionally divided location of cereal and domestic animal farms in Finland, and short-term and inconsistent farming and energy policies. According to participants, the current high workload and lack of time, lack of financial resources for investments and fears for increasing bureaucracy limit proactive climate work. However, methods creating multiple benefits for farmers, such as increasing carbon sinks while simultaneously improving soil quality, ensuring yields by utilizing high quality research and knowhow, and producing on-farm renewable energy, were seen as concrete and inspiring means towards climate-smart agriculture.

Based on our workshops, farmers value that also familiar agricultural practices and management choices, can support preparing for climate change. These include e.g. taking care of soil organic matter and soil structure, enhancing biodiversity on fields, using crop rotation and growing nitrogen-fixing-plants. In win-win-situations, farmers can find climate-smart solutions as economically and ecologically beneficial but also motivating factors for their work and work identity. E.g. soil conservation, crop rotation and enhancing biodiversity on fields were seen to be based on honouring the value of agricultural field and soil, traditionally seen as the most important basis for whole agriculture.

How work was carried out?

The Climate Change and Countryside-project (www.ilmase.fi) organised 12 workshops for farmers, educators of farmer students, rural developers, decision-makers and researchers around Finland during the years 2012-2014. Workshops had altogether app. 300 participants, of which 120 were farmers. Workshops lasted 7 hours each, including presentations by researchers, rural developers, farming advisors and forerunner farmers to provide information followed by facilitated group discussion using "me-we-us" method and applied SWOT-analysis on the main theme of the workshop (for methods see Himanen et al. 2016; Hogan 2003; Knierim & Nowicki 2010). In each workshop, there was also a written questionnaire to gather the views of the participants on possibilities and challenges of climate change mitigation and adaptation. Results are based on qualitative analysis of these group discussions and questionnaires. The Climate Change and Countryside-project was run by MTT Agrifood Research Finland and funded by EAFRD and Finnish Ministry of Agriculture and Forestry.

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Organic 3.0 in Sweden – gathering perspectives through stakeholder dialogue

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Implications

By capturing ideas through stakeholder dialogues of different ways to improve the production and environmental performance of organic agriculture we can contribute to engagement for developing a more sustainable organic agriculture in Sweden.

Background and objectives

Organic production has shown to be successful in a number of ways; environmental and health benefits by avoiding synthetic pesticides, lower nitrogen losses per hectare and higher energy efficiency compared to conventional agriculture (Tuomisto et al. 2012, Reganold & Wachter 2016, Seufert & Ramankutty 2017). Organic management also promotes biodiversity (Tuck et al. 2014) and results in higher organic matter contents in soils (Gattinger et al. 2012). It generally improves animal welfare by e.g. providing preconditions for animal natural behaviour. Some studies also conclude that the economic viability is better on organic farms (Reganold & Wachter 2016). However, at the same time organic agriculture have sustainability shortcomings; often lower yields and productivity compared to conventional production, especially in a European context (including in Sweden), shortages of nutrients in arable cropping systems, and sometimes high leaching losses per amount produce (Tuomisto et al. 2012, Seufert & Ramankutty 2017). In order for organic agriculture to contribute to more sustainable farming and food systems as a whole it needs to improve and grow. Sustainable solutions and agricultural methods also need to be spread outside the organic sector (Arbenz et al. 2017).

EPOK initiated stakeholder dialogues in Sweden with the aim to gather ideas and ways to develop the Swedish organic farming sector in a sustainable way. One main objective was to identify research needs to support this development. An international discussion about the concept Organic 3.0 on the next steps to be taken for organic agriculture was formulated in a discussion paper by IFOAM (IFOAM 2016), a paper by Arbenz et al. (2017) and at an International Society of Organic Agricultural Research (ISO FAR) symposium “Organic 3.0 is Innovation with Research” in Republic of Korea in late 2015 (Rahmann et al. 2016). These discussions form the background of the EPOK initiative.

Results and Discussion

The results still need to be processed, e.g. different ideas sorted into themes and profoundly described, but here we give examples of issues being discussed in the dialogues. As stated above, organic agriculture has achieved recognition for being an environmental friendly farming system in a number of ways, but still there is a long way to go to build sustainable organic farming systems. A common theme in the dialogues was the appropriateness and the insufficient flexibility

of the organic regulation, the European Council Regulation (EC 2007), which also forms the basis of the Swedish KRAV standards. According to the organic regulation the possibilities for nutrient recirculation between urban and rural areas are strongly restricted as any sewage product are forbidden to use. For a long-term sustainable nutrient management in organic farming changes are needed, both in the regulation and by conducting research and development work to find new solutions for safe and resource efficient recycling of these products. Greater availability of nutrients in organic production would give opportunities for growth and may also increase yields and productivity. Another theme concerned strengthening efforts in research on animal and crop breeding adjusted for organic systems, to achieve both productivity and animal welfare improvements, which were judged important for building more resilient organic agricultural systems in the future. A major challenge for agriculture as a whole is the dependence upon fossil fuels and the importance of organic agriculture contributing to solutions was stressed in some of the dialogue groups. One big part of the discussions was how different stakeholders looked at the role of organic agriculture as driver for sustainable agriculture. Should organic farming develop to be the mainstream agricultural practise? Or should organic agriculture also in the future be a niche production having the role of being a forerunner and an innovation system for agriculture as a whole? Another theme in the discussions was about building stronger bridges and confidence between producers and consumers and promote shorter food systems chains. Producer-consumer associations could be an alternative to certification of the production according to regulations.

How work was carried out?

Seven dialogues with the following stakeholders were conducted: 1) Organic Sweden (Swedish umbrella organization for stakeholders in the organic sector), 2) Swedish Society for Nature Conservation, 3) The board of KRAV, 4) KRAV staff, 5) The board of Swedish Organic Farmers' Association, 6) Swedish authorities (Swedish Board of Agriculture, Swedish Environmental Protection Agency, National Food Agency, Sweden, Swedish Chemicals Agency), 7) Researchers at SLU.

The dialogues were not structured in detail as we aimed for an informal discussion where all opinions and ideas could be freely expressed. However, we used an EPOK brochure about Organic 3.0 as background material (EPOK 2016 (a summary of the IFOAM discussion paper mentioned above, supplemented with adjustments for the Swedish context)). The dialogues have been finalized and we will now sort out the main ideas on future possible pathways for organic agriculture development in Sweden. In the end of year 2017 EPOK will arrange a stakeholder forum where the results of the study will be discussed and important future actions and research needs summarized.

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OK-Net Arable online knowledge platform

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Implications

The complexity of organic farming requires farmers to have a very high level of knowledge and skills, but exchange on organic farming management techniques remains limited. The thematic network OK-Net Arable under Horizon 2020 has the aim to improve the exchange of innovative and traditional knowledge among farmers, farm advisers and scientists to increase productivity and quality in organic arable cropping in Europe. An online platform for knowledge exchange has been created, offering innovative education and end-user material as well as communication opportunities between actors. A number of specific tools – providing information about how to put existing knowledge from research and practice into use – have been chosen. They are presented on the platform with the possibility to find solutions, evaluate them, comment and discuss them or ask questions about them and to suggest new tools to be shown on the platform.

Background and objectives

Closing the yield gap is one of the most important challenges in organic arable farming in Europe (EIP-AGRI Focus Group Organic Farming 2013). The thematic network OK-Net Arable under Horizon 2020 has the aim to improve the exchange of innovative and traditional knowledge among farmers, farm advisers and scientists to increase productivity and quality in organic arable cropping in Europe. This contributes to helping farmers and advisors to become more innovative and improving towards best practices. Reducing the yield gap in organic arable farming will also make organic agriculture more sustainable.

Key results and discussion

The OK-Net Arable project under Horizon 2020 created a platform (farmknowledge.org/) aimed at filling the gap in the exchange of information about organic arable farming between farmers and advisers across Europe. The platform can be translated into the ten languages of the project partners, including English: Bulgarian, Danish, Dutch, Estonian, French, German, Hungarian, Italian and Latvian. Originally, this was planned to be carried out by Google Translate (translate.google.com/), however, as translation was varying from acceptable over confusing to wrong, all texts on the platform itself have been translated by the project partners.

The platform contains a “toolbox” of “tools”: existing knowledge in a form easily accessible to users, described with metadata. The metadata includes information about the problem, the tool addresses, the solution(s) it offers, a description of the tool, the theme(s) it addresses, the language(s) it can be found in, the year it has been released, the country of origin and information about the issuing organisation. The tools themselves as well as the metadata about the tools are translated by Google translate, and thus use of their recommendations in other than the original language

is not always practical. The users can rate the tools with one to five stars, and the mean rating and number of rates a tool has received is shown, helping others to see whether previous users have found a certain tool relevant.

The metadata of the tools and, if possible, the tools themselves are stored in Organic eprints (orgprints.org), the world's largest archive with publications about research and development in Organic Agriculture. In order to accommodate this, Organic Eprints had to be adapted to be ready to include this metadata. This was carried out by ICROFS, the administrator of Organic Eprints.

In order to accommodate discussion about the themes and tool, a module from DISQUS (disqus.com) has been integrated on each theme and tool page. Users have to login to give comments, they can login with existing accounts for Facebook, Twitter or Google Plus or create an account in DISQUS, and users can share the theme and tool pages on their own social media streams. The discussion is moderated continuously by IFOAM EU, and it is made sure that all questions are replied by relevant experts.

Users can search for tools on a specific topic using either the themes, the specific keywords chosen to be relevant for organic arable farming or free-text search. As the specific keywords have been translated into the 10 languages, a user searching for "ukrudt" in Danish, for example, will also find tools in Latvian with the keyword "nezales". The users can also search for specific tool types, e.g. videos, tools in certain languages, and tools from a certain country of origin.

Organic farmers and advisers know that a lot of knowledge exists about organic arable farming, but it can be difficult to find and in many cases it is difficult for them to use e.g. research results directly in their daily work. The online platform farmknowledge.org offers tools in the sense that the resources shown there present scientific and practical knowledge "digested" for use by practitioners. In addition, it offers the possibility for users to comment, discuss and ask questions about important themes and specific tools.

How work was carried out?

Based on the final report by the EIP-AGRI Focus Group on Organic Farming (2013) as well as on work in the project (Niggli et al., 2016), the most prominent factors contributing to overcoming the yield gap between organic and conventional arable farming were chosen for themes on the online platform created by OK-Net Arable. These are the five themes: Soil quality and fertility, Nutrient management, Pest and disease control, Weed management and Crop specific solutions.

A list of more than 200 different resources providing knowledge, decision support, education or update on relevant issues for these themes was collected by scouting websites and contacting research and advisory organisations within the field. The term "tool" was defined as "formatted information used as a mean for circulation of knowledge among farmers and advisors" (Micheloni, pers.comm.), and tools for knowledge exchange were grouped into 1) tools providing knowledge, 2) tools for decision support and 3) tools for education/updating. The tools were in many different formats: web platforms & websites, videos, educational resources such as webinars & e-learning, leaflets & guidelines/fact sheets, calculation tools & decision support systems, books & reports and audio/podcasts. A subset of the 200 tools was chosen for the first version of the platform. In addition, "Practice abstracts" that in very short form (2 A4-pages) describes a problem and a suggested solution, have been developed within the project. These are based on the common format for interactive innovation projects developed by EIP-AGRI (<http://ec.europa.eu/eip/agriculture/en/content/eip-agri-common-format>).

In a re-iterative process, the platform and its contents were designed, commented by project partners, re-designed, tested by farmers and advisers, improved etc. Farmers' needs were taken into account at every stage of development among others by involving Farmer Innovation Groups (Cullen et al., 2016) in the participating countries in order to make it easy for them to use.

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Technical provision of organic farming in Russia: problems and prospects

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Farmers that currently are starting to engage in organic crop production are mostly oriented to conventional technologies, making small changes, and use the available agricultural tools. However, the crop environment in the organic field is characterized by physical, chemical and biological properties, which differ from more intensive farming. These conditions should be reflected in the selection of appropriate technological operations, which in turn fit into certain limitations.

Research on the adaptation of basic crop cultivation technologies to the requirements of organic production has started to carry out in the IEEP in 2015. The aim is to form a database of information on the processes taking place in organic agro-ecosystems under the influence of agricultural technologies and on this basis to develop the software system "Organic farmer assistance", which will contain modern knowledge concerning organic crop production practices and will provide highly skilled remote support to farmers.

Sources of information include: special field experiments, laboratory experiments, as well as scientific literature.

The software system will allow to keep a record of the state of the farm and events, and on this basis to carry out activity planning. The state of the farm is the information about the condition of the soil, plants, weather; events are performed operations and state changes of farm objects. The system receives data in manual and automatic modes.

Based on the data on the state of the farm, planned activities and weather conditions, the system generates recommendations on timely measures aimed to improve the plant conditions and, as a result, increasing the yield (Picture).

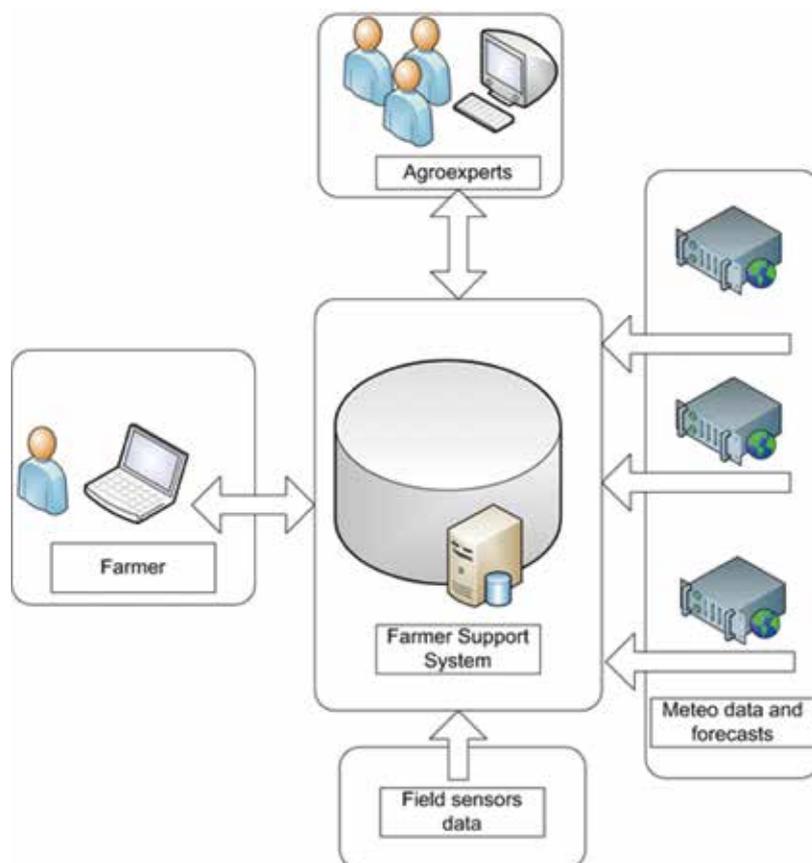
To implement the system, an algorithm is necessary to respond to changing weather conditions and farm conditions and to suggest adjusting planned activities and adopting unplanned measures. The construction of such an algorithm is possible by creating a knowledge base and its "learning" by experienced agro experts. At the initial stage, decisions are made by agro-experts and the system, studying their reaction to various events, eventually forms a knowledge base of rules (knowledge base of rules), which, in the future, is able to make decisions on the formation of recommendations to the farmer.

For this purpose, the set of field experiments was established on the IEEP Experimental station. The design of the experiments will allow to collect the needed information to fill in the software.

Particular attention is given for following operations, which are important for organic crop production: mechanical tillage, application of organic fertilizers, weed and pest control.

We use tillage system with different depths for organic crop rotations: cereal crops - at depth of 12 - 16 cm, for vegetable crops and potatoes at depth of 22 - 24 cm by mould board plough. In the presence of strongly marked "subsoil layer" or waterproof horizon the subsoil shattering is conducted to a depth of 45 cm by chisel cultivator. Fall tillage is an effective way to control weeds, diseases and pests.

Promising is the use of technical means for the local application of solid manure in the furrow.



Picture.
Software system
“Organic farmer assistance”.

A particularly important task in organic agriculture is weed control. In addition to crop rotation, the previously developed and then half-forgotten cultivation of root crops in which was used ridge system and rotary harrows was used to handle the ridge slopes during the growing season. In the conditions of field experiments, the effectiveness of the use of the rotary harrows is estimated. In cooperation with scientists from the Russian Research Institute of Plant Protection the biological crop protection practices are investigated on the field experiments, also. In 2017 cooperative research on the IEEP Experimental Station is continuing.

Conclusions

There are a number of problems in the cultivation of organic agricultural plants, which restrain the production of agricultural products.

To solve these problems, efforts of representatives of different sciences should be combined, and the results of these efforts must be presented on the experimental field.

A good tool for organic farmers can be a Software that will collect and systematize the necessary knowledge, including practical results obtained in field experiments.

Is there transition going on towards nutrient recycling and renewable energy in dairy farming?

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Implications

We concluded that there are barriers towards change in nutrient recycling and utilisation of renewable energy in dairy farms which prevent and retard the transition towards circular economy. Any barriers appearing, including institutional barriers such as formal and informal rules and economic environment as well as barriers concerning farmer's producer identity, habits, knowledge and skills were considered.

Background and objectives

The agricultural production in Europe is heavily dependent on external inputs, especially on fossil energy and energy-consuming synthetic fertilisers that exert also negative environmental impacts. Therefore, food and feed production are sensitive to energy market volatility and to rapid changes in policies. During the past 10 years fossil energy price has increased and fluctuated a lot driving prices of other inputs also, exemplified by price peak of synthetic fertilisers in 2008. This development has contributed to the increasing vulnerability of both farmers of developed and developing countries (Piesse and Thirtle 2009). Consequently, independence from external inputs, e.g., in terms of mixed farming, has been debated as a means to enhance farm resilience (Niggol Seo 2010, Rufino et al. 2011, Himanen et al. 2016). Independence from turbulent input markets can be enhanced through circular economy by recycling of nutrients, biological nitrogen fixation, and increasing the use of on-farm residue energy. Despite their potential in farm profitability and resilience enhancement, the use of such measures appears to be rare except in nutrient economy in organic agriculture.

In organic agriculture nutrient management in crop production is regulated and is based on recycling nutrients, but the general principles concerning energy use (IFOAM 2008) are not enough to promote the circular economy. Utilisation of residue-based or other renewable energy and saving and efficiency in energy use are not yet integral part of the practices in organic agriculture, except the refusal of synthetic fertilisers. Previously, observed changes in fertilisation practices of Finnish farms were found to be driven by changes in the internal elements (new materials, e.g. machinery), new competencies (such as the ability to observe the soil condition) and new meanings (such as organic agriculture and legal changes) of fertilisation practises, and their connections and relations with other practices (Huttunen & Oosterveer 2016). Transition towards circular economy on dairy farms, as transitions in socioecological systems generally, are not linear processes. Barriers, such as economic, but especially systemic, have been identified in the transition of nutrient economy in Finnish food system (Kuokkanen et al. 2017).

The aim of this study was to investigate the changes, and the reasons behind the changes, in nutrient and energy use on dairy farms in the North-East Europe from farmers' perspectives. We investigated, if the dairy farmers had tried to increase farm resilience to market volatility such as turbulent and increasing input prices by increasing independence through transition to circular economy, and what the main factors driving to and preventing from that were.

Key results and discussion

Our results showed that the changes in nutrient economy were policy-driven and the changes in energy use were market-led. Organic dairy farms based more often on renewable energy compared to conventional ones. In dairy production, there exist buffers against the higher input prices, e.g., substantially high and stable producer price of milk, and agricultural subsidies and growing productivity of cows. We identified barriers to change which prevent and retard the transition towards circular economy, such as institutional barriers, e.g., formal and informal rules and economic operations environment, and barriers concerning farmer's producer identity, habits, knowledge and skills.

How work was carried out?

We studied by qualitative approach the dairy farmer's perceptions of nutrient and energy use on the dairy farming, including current situation, experienced and expected changes, implemented changes, impacts of changes and factors promoting or hindering changes and coping. The 13 in-depth interviews in conventional and organic dairy farms in Finland and 8 in dairy farms in North-West Russia were conducted in 2013 and 2014. Both continuing farms and those that had quit dairy farming were included. The range of farms was founded on our hypotheses: Concerning the nutrient economy the farms differentiated in terms of the origin of nutrient inputs (primary or secondary (recycling) nutrients) and concerning the energy economy in terms of the origin of the energy inputs (non-renewable or renewable energy). All the interviews in Finland were tape-recorded and transcribed and in North-West Russia either tape-recorded and transcribed or manually recorded. The data was analysed by coding and structuring into themes for answering the research questions.

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Palopuro Agroecological Symbiosis – Increasing sustainability in organic farming

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Implications

Agroecological symbiosis (AES) is a novel system that aims for better sustainability in agriculture. A case study of the first AES in Finland (<http://blogs.helsinki.fi/palopuronsymbioosi/>) indicates that productivity of an organic crop farm has the potential to be increased through production of biogas from green manure leys, fallows and other locally available biomasses. At the same time, this farm becomes a net-energy producer instead of being an energy consumer. Combining the food processing, crop production, energy production, and closer interaction with consumers increases the overall sustainability of the local food system

Background and objectives

AES is a model which is based on the theory of industrial symbiosis and industrial ecology (Koppelmäki *et al* 2016). Industrial ecology describes a production model in which nutrient and energy flows resemble those in natural ecosystems (Graedel 1996, Graedel & Allenby 1996). Industrial symbiosis refers to operations which are spatially situated in close proximity allowing co-evolution and increased resource efficiency (Chertow 2000).

The first functional incarnation of the AES concept is actively forming in Palopuro village, near the city of Hyvinkää in Southern Finland. A symbiosis exists between three organic farms, a bakery, a biogas company, and community members. The center of Palopuro AES is Knehtilä farm, an organic cereal farm (360 ha). The feed production and manure management of a neighboring organic hen house is integrated with Knehtilä's production. In the future, the produced grain will be milled and baked by the bakery which will establish its operations on the farm. Energy for the grain drying, farm machinery, food processing, and sales will be produced in a biogas plant; operated in cooperation with local actors and a local energy company.

The aim of this paper is to study, from a biophysical and social perspective, the overall sustainability of a symbiotic model by using the first AES pilot as a case study. From the biophysical side the objective is to measure how the biogas production from locally available biomasses impacts the nutrient and energy flows. From a social perspective, the lived experiences of the producers and consumers will be investigated through ethnographic and other qualitative inquiry.

Key results and discussion

Based on the participating farms current crop rotation plans AES will produce renewable energy from green manure leys and manures (gross energy of 2,440 MWh) and shifts the farm from consuming energy to producing energy. The produced energy replaces the fossil energy used in the bakery, grain drying and partly in the farm machinery. The major part (over 60 %) of the energy will be sold for transportation use.

The nutrient-rich digestate will increase the productivity by supplying more soluble nitrogen for the crops compared to traditional use of green manure leys (Seppälä 2014). The risk of nutrient leaching is reduced because the plant material is not left to decompose on the ground in the field (Uusi-Kämpä 2012)

There is a huge potential for farm-scale biogas production in Finland. There are ca. 105000 ha of green manure leys and other non-cultivated areas which would be available for biomass harvesting (Niemiäinen *et al.* 2014). Producing biogas from biomasses that are not competing with food production can be a sustainable way to produce bioenergy. At the same time, nutrient use efficiency is enhanced in organic farms without cattle.

In addition to producing farm scale biogas, AES reconnects farmers, food producers and consumers through a (re)localization of food production. The benefit of local food and producing renewable energy has the potential to improve rural livelihoods.

In summary, the AES-model has the potential to yield higher self-sufficiency for energy and nutrient resources, in addition to the potential of strengthening social capital in rural areas through reintroduction of the producer and consumer and peer-to-peer interaction in the social space provided by the main farm participating in the AES system.

How work was carried out?

The biophysical aspects are assessed using nutrient flows and energy production which are modelled as if the biogas plant were already in operation. The actual data was collected from the farms. The area of green manure leys and other fallows in the crop rotation plan was used as an available area for biogas production. The energy potential of the biomasses and nutrient content of the digestate was derived from the literature (Seppälä 2014).

To assess the social sustainability and viability of the model we will employ participatory mapping (Corbett *et al.* 2006), surveys, semi-structured interviews, and participant observation to capture the lived experience of the actors in the system which include the producers, processors, and consumers, and other users of the social space at the farm. Our research interrogates the levels of “locality” present in creation of a (re)localized food system.

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Organic Farms and Agricultural GHG Emissions in Latvia

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Background and objectives

In Latvia there can be observed rapidly growing interest of farmers to engage in organic farming – from 2012 till 2015 number of certified organic farms has increased by 4%, but utilized organic agricultural land area – by 18%. At the same time after the Paris Summit on Climate Change held at the end of 2015, Latvia has agreed on the need for reduce global greenhouse gas (GHG) emissions as soon as possible and joined to the initiative to scale up its efforts and support actions to reduce emissions, which in the agricultural sector shows constant increase (in 2015 agricultural GHG emissions have increased by 10% compared with 2010). Application of organic farming methods in agricultural production is one of the possibilities to reduce GHG emissions. This research aims to characterise role and contribution of organic farms in agricultural GHG emissions in Latvia.

How work was carried out?

The present research designed a typology of agricultural farms, which allowed identifying farming systems typical for the conditions in Latvia and clarifying role of organic farming systems in total agricultural production and GHG emission generation. The typology of agricultural farms was based on statistical data from the Farm Accountancy Data Network (FADN). Cluster analysis, which was based on 22 indicators, was employed and the SPSS program (IBM SPSS Statistics 22) were used to design the typology. The cluster analysis identified three different farm clusters that, depending on their characteristics, represented the following farm types: Cluster 1 – Intensive indoor fodder based livestock farms; Cluster 2 – Intensive cereal farms; Cluster 3 – Mixed specialization and pasture based livestock farms.

Given the fact that the FADN farms were represented only by economically active, commercial farms and produced their products for the market and the number of such farms was equal to approximately 36 808 or 45% of the total farms in Latvia, the three FADN farm clusters did not fully reflect the situation in the country. For this reason, two more clusters were added to the farm clusters identified in the cluster analysis, which gave more complete insight into the situation on farming systems in Latvia: Cluster 4 – Organic farms; Cluster 5 – Small farms.

Statistical data from FADN, EUROSTAT, Central Statistical Bureau of Republic of Latvia, organic farming certification bodies were used to describe the clusters; yet, the databases lacked data on farming practices in the context of GHG emissions. For this reason, the present research performed a survey of farms, which involved 50 farms (10 from each cluster). The questionnaire for the purpose of the survey were developed, which included questions about farming practice and activities affecting GHG emissions. Obtained data were used to calculate GHG emissions, where calculation based on a methodology prescribed in the Guidelines of the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2006).

Key results and discussion

Characteristics of identified farm clusters are given in Table 1, where organic farms are represented by Cluster 4. Preformed farm typology and obtained indicators characterizing performance of different farming systems were used to determine role and contribution of organic farms in agricultural GHG emissions in Latvia (Table 2).

Table 1. Characteristics of identified farm clusters in Latvia

Indicator	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Number of farms	286	110	20797	3473	57130
Used UAA, % from total	15%	9%	46%	10%	20%
Average UAA per farm, ha	992	1552	41	54	7
Agricultural animals, % from total					
Non-dairy cattle	25%	0%	33%	30%	12%
Dairy cattle	65%	0%	22%	7%	5%
Swine	82%	0%	14%	1%	3%
Poultry	93%	0%	6%	1%	0%
Other animals	0%	0%	55%	28%	17%
Utilization of UAA, % from total					
Meadows and pastures	3%	0%	66%	13%	19%
Permanent crops	0%	0%	42%	13%	45%
Arable land	22%	14%	55%	3%	7%
Synthetic N fertilizers, % from total	14%	28%	54%	0%	3%

Research results show very different GHG emission intensity which is significantly higher in intensive farms (Cluster 1 and 2) compared to organic farms (Cluster 4) and small farms (Cluster 5). These differences can be explained by a series of factors which differs among the clusters: type of market strategies, agricultural machinery availability, information about soil quality and properties, availability of financial sources for purchase fertilizers, livestock keeping and feeding practices, etc.

Table 2. Agricultural GHG emissions and its division by farm clusters in Latvia

Indicator	2013	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Total agricultural GHG emissions, kt CO ₂ _{eq}	2570.33	877.71	307.62	1048.10	184.54	152.35
Average GHG emissions per farm, t CO ₂ _{eq} per farm	31.42	3068.92	2796.58	50.40	53.14	2.67
Average GHG emissions per UAA, t CO ₂ _{eq} per ha	1.37	3.09	1.80	1.21	0.99	0.41

Research results also indicates that organic farms comprises 7% from total agricultural GHG emissions and comprises relatively small GHG emissions per utilized agricultural area (UAA) – 0.99 t CO_{2eq} per ha, which means that further development and increase in organic areas can be used as one of the GHG emission reduction tools. Similar findings regarding role of organic farms in GHG emission reduction can be found in other studies (Bos et al., 2007; Cooper et al. 2011). Results of this research will serve as background for broader research which aims to identify GHG emission reduction possibilities in Latvia.

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