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Nordic Association of Agricultural Scientists

SLU EPOK ICROFS

NJF Seminar 461

Organic farming systems as a driver for change

Bredsten, Denmark, 21-23 August 2013

NJF Nordic Association of Agricultural Scientists

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NJF Seminar 461

Proceedings

Organic farming systems as a driver for change

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The seminar was organized in collaboration with EPOK – Centre for Organic Food and Farming at Swedish University of Agricultural Sciences and ICROFS – International Centre for Research in Organic Food Systems

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Editors

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Nordic Association of Agricultural Scientists

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Preface

Dear reader

It is a great pleasure for me, chairing the planning committee of NJF seminar 461, "Organic farming systems as a driver for change", to present to you this book of seminar papers. They have all been carefully reviewed and revised, and almost 100% of the oral speeches and posters in workshops, that will be presented at the seminar in Vingsted, Denmark during August 21-23, are presented by a paper in this seminar report.

The seminar is the 3rd in a row of NJF seminars focusing on organic farming systems and being placed in time in-between the NJF congresses, which occur each 4th year. The first seminar in this row was NJF seminar 369, "Organic farming for a new millennium – status and future challenges", arranged in Alnarp, Sweden in 2005 with 140 participants from all the eight Nordic and Baltic countries. The second was NJF seminar 422, "Fostering healthy food systems through organic agriculture – Focus on Nordic-Baltic Region", arranged in Tartu Estonia in 2009. That seminar had 150 participants from 19 countries. For the seminar 461 we expect about 130 participants from 16 countries. For the first time we have participants from countries outside Europe.

NJF seminar 461 is organized in collaboration with ICROFS – International Centre for Research in Organic Food Systems and EPOK – Centre for Organic Food and Farming at Swedish University of Agricultural Sciences. Thanks to this support, and the dedicated work of the highly qualified committee members, we have been able to create a very broad and interesting program. I am very grateful, especially to Kirsi Partanen who has been the seminar secretary, and worked heavily on this matter for more than one year. The other committee members were Maria Wivstad, Karin Ullvén, Eva Salomon, Ilse A. Rasmussen, Margrethe Askegaard, Vibeke Langer, Peter Sørensen, Sirli Pehme and Anne-Kristin Løes. We had a very bad gender balance, but we have had a good time together in nearly 20 virtual committee meetings. The internet is a good thing for international cooperation. I also want to thank Grethe Hansen at ICROFS for editing the seminar report.

We structured the program in four tracks: Societal and economic viability; Transition to renewable resources; Nutrient sufficiency and management in farming systems; and Productivity and sustainable production levels in animal and crop production. Within each track, experts are involved to give plenary speeches and follow the track sessions. Output from these sessions will be merged in the final session discussion. We hope this will be an innovative way to structure the seminar program, and facilitate a discussion of how research can participate to solve problems in organic farming systems as well as conventional farming systems. Together with you, we want to utilize this seminar to get inspired, and reflect on how organic research contributes to change the many and serious challenges that we face to protect our environment and to ensure a satisfactory living for all.

On behalf of the NJF seminar 461 committee,

Anne-Kristin Løes, chair

Organic farming systems as a driver for change

Organic agriculture has grown to a sector with profound impact on the societal and agricultural development. This conference aims to reveal how organic research has contributed, or may contribute to change the many and serious challenges that we face to protect our environment and to ensure a satisfactory living for all.

Target groups

All researchers, advisors, teachers and other stakeholders with an interest in organic food and farming systems are welcome.

Four tracks

The program comprises four tracks, where well qualified track experts will follow the track during the whole conference. These experts will contribute to and lead sessions (together with session chairs). Their task is to make sure that discussions are focused on the overruling question: How can our research efforts contribute to a required change? The track experts will also give an introductory key-note speech and in the final plenary session, they will contribute to sum up major messages from the presentations and discussions during the conference.

Dr. Susanne Padel will be the track expert of track 1, **Societal and economic viability**. Susanne is principal researcher and team leader for socioeconomics and policy at The Organic Research Centre (ORC), Elm Farm in the UK. The socio economic work of ORC covers standards and certification systems, consumer attitudes to organic product and market development, policy support payments, profitabiliy as well as public benefits of organic farming.

Dr. Tommy Dalgaard will be the track expert of track 2, **Transition to renewable resources**. Tommy works at Aarhus University, Department of Agroecology in Denmark on the development of sustainable farming systems, with an emphasis on the reduction of non-renewable resource use in organic farming. His work includes methodologies for the assessment of energy and nutrient balances, potentials for bioenergy production, reductions in greenhouse gas emissions, and multi-criteria assessment of scenarios for the development of a more sustainable bioeconomy.

Dr. Christine Watson will be the track expert of track 3, **Nutrient sufficiency and management in farming system**. Christine leads the Soils Research Team at Scotland’s Rural College (SRUC) in the UK. Her research focuses on improving nutrient use efficiency in a wide range of agricultural systems including outdoor pig production, dairying, organic farming and agroforestry. She is particularly interested in the management of legumes in agricultural systems. Most of her research focuses on nitrogen and phosphorus although she has recently begun working on trace elements in farming systems.

Dr. Paolo Barberi will be the track expert of track 4, **Productivity and sustainable production levels in animal and crop production**. Paolo is Professor in Agronomy and Field Crops at Sant’Anna School of Advanced Studies in Italy, where he leads an Agroecology team and coordinates a Curriculum (Functional Biodiversity in Agroecosystems) in the International Doctoral Programme in Agrobiodiversity. His research focuses on 1) the optimisation of low-input and organic cropping systems through increased diversity, 2) functional biodiversity in agroecosystems, and 3) weed ecology and management.

21 AUGUST				
10:00-12:00	**REGISTRATION**			
12:00-13:00	**LUNCH**			
13:00-14:45	**CONFERENCE OPENING AND INTRODUCTORY PLENARY SESSION**			
	Welcome and instructions, *Anne-Kristin Løes*, Norway, Chairman of scientific committee			
	Opening speech: **Organic farming meets future food and environmental challenges**, *Elisabeth Gauffin*, dairy farmer and the president of KRAV - Swedish Association for Standards in Organic Agriculture and Food, Sweden			
	Track 1: Societal and economic viability **Organic farming as an European innovation system** *Susanne Padel*, The Organic Research Centre, Elm Farm, UK			
	Track 2: Transition to renewable resources **Energy balance comparisons of organic and conventional farming systems and potentials for the mitigation of fossil resource use**, *Tommy Dalgaard*, Department of Agroecology, Aarhus University, Denmark			
14:45-15:15	**COFFEE**			
15:15-16:15	**PLENARY SESSION CONTINUED** – *MODERATOR: MARIA WIVSTAD*, SWEDEN			
	Track 3: Nutrient sufficiency and management in farming systems **Long-term management of nutrients in organic farming – principles and practice,** *Christine Watson* and *Elizabeth Stockdale*, Scotland's Rural College, UK			
	Track 4: Productivity and sustainable production levels in animal and crop production **Is agroecology the most sustainable approach for all organic farming systems?** *Paolo Bàrberi*, Institute of Life Sciences, Sant'Anna School of Advanced Studies, Italy			
16:15-16:30	**BREAK**			
16:30-17:45	**ORAL PRESENTATION SESSION WITHIN TRACKS**			
	Track 1: Organic farming as a driver for the livelihood of small scale farmers?	***Track 2: Organic production systems mitigating climate change***	***Track 3: How can organic farming systems diminish the risk of nitrogen leaching?***	***Track 4: Challenges in clover production – is the nitrogen well running dry?***
Moderator:	***Vibeke Langer Denmark***	***Sissel Hansen Norway***	***Eva Salomon Sweden***	***Margrethe Askegaard, Denmark***
	Co-operative or coyote? Producers' choice between intermediary purchasers and Fair-trade and organic co-operatives in Chiapas, *A.B. Milford,* Norway **Conversion to organic farming; experiences from Punjab and Uttarakhand**, *A.M. Nicolaysen,* Norway **Productivity and growth in organic value chains in East Africa – potentials and challenges for accessing local high value markets**, *L. Andreasen,* Denmark	**How can organic agriculture contribute to long-term climate goals?** *C. Sundberg, E. Röös, E. Salomon & M. Wivstad,* Sweden **Multispecies grasslands for crop productivity and carbon storage**, *J. Eriksen, T. Mortensen & K. Søegaard,* Denmark **Nitrogen mineralization and greenhouse gas emissions after soil incorporation of ensiled and composted grass-clover as green manure**, *M.S. Carter, P. Sørensen, S.o. Petersen & P. Ambus,* Denmark	**Agronomical and environmental performances of organic farming in the Seine watershed, France** *J. Anglade, G. Billen & J. Garnier,* France **Nitrogen leaching from organic agriculture and conventional crop rotations** *M. Benoit, J. Garnier, G. Billen, B. Mercier & A. Azougui,* France **Management affects nitrate leaching from organic farms**, *M. Askegaard & J. Eriksen,* Denmark	**Clover fatigue – a reason for precaution in organic farming?** *G.L. Serikstad, A. de Boer, & C. Magnusson,* Norway **Plant parasitic nematodes – problems related to clover and organic farming**, *C. Magnusson & R. Holgado,* Norway **Opportunities and limitations in use of clovers as nitrogen source in organic farming systems in Norway**, *I. Sturite,* Norway

21 AUGUST (CONTINUED)			
17:45-18:45	**POSTER WORKSHOPS WITHIN TRACKS**		
	Track 3: Innovative strategies for sustainable plant nutrition	***Track 4: Improving the protein supply of animals***	***Track 4: Perennial weed control – emperor's new clothes?***
Moderator:	***Margrethe Askegaard Denmark***	***Niels Andresen Sweden***	***Ilse Rasmussen Denmark***
	Optimizing nitrogen utilization by ecological recycling agri-culture (ERA), *P. Seuri,* Finland **Contaminants in manure – a problem for organic farming?** *K. McKinnon, G.L. Serikstad & T. Eggen,* Norway **Ashes for organic farming,** *T. Kousa, M. Heinonen, T. Suoniitty & K. Peltonen,* Finland **The impact of conversion to ecological recycling agriculture (ERA) on farm nitrogen budgets and production levels,** *J. Kivelä & K. Westerling,* Finland **In crop rotation green manures as winter cover crops enhance ecosystem services of farming,** *L. Talgre, B. Tein, V. Eremeev, D. Matt, E. Reintam, D. Sanches de Cima & A. Luik,* Estonia	**Profitability of organic and conventional dairy production with different dietary propor-tions of high quality grass silage,** *M. Patel , E. Wredle, E. Spörndly, J. Bertilsson & K.-I. Kumm,* Sweden **Forage legume silage and cold-pressed rapeseed cake for dairy bull calves,** *B. Johansson & A. Hessle,* Sweden **Feeding value of red clover-grass, Persian clover and com-mon vetch for pigs,** *K. Partanen, J. Valaja & H. Siljander-Rasi,* Finland **Inclusion of mussel meal in diets to growing/finishing pigs,** *K. Andersson, M. Neil, N. Lundeheim & A. Wallenbeck,* Sweden **Feed intake and weight and body condition changes of 100% organically fed lactating sows,** L. Voutila, K. Partanen & H. Siljander-Rasi, Finland	**Control of perennial weeds based on weed biology and environmental considerations,** *M.G. Thomsen, L.O. Brandsæter, K. Mangerud & H. Riley,* Norway **Resource effective control of Elymus repens,** *B. Ringselle, L. Andersson, G. Bergkvist & H. Aronsson,* Sweden **Temperature effect on fructan storage and regeneration of Canada thistle (*Cirsium arvense* (L.) Scop),** *L. Nkurunziza & J.C. Streibig,* Sweden **Improved weed management in organic crop production** *B. Melander & J.E. Olesen,* Denmark
19:00-21.30	**WELCOME RECEPTION**		

22 AUGUST				
08:30-10:05	**ORAL PRESENTATION SESSION WITHIN TRACKS**			
	Track 1: Organic consumption and standards as drivers for change	***Track 2: Fossil fuel free farming – is it possible?***	***Track 3: Innovative strategies for sustainable plant nutrition***	***Track 4: Strategies for profitable dairy farming – inspiration for conventional farmers?***
Moderator:	***Egon Noe Denmark***	***Jørgen Eriksen Denmark***	***Peter Sørensen Denmark***	***Birgitta Johansson Sweden***
	Organic food prices and the consumer – a review of the evidence, *J. Aschemann-Witzel & S. Zielke,* Denmark **How can a private standard accelerate the development of organic production?** *E. Gauffin, L. Hällbom & K. Sjödahl Svensson,* Sweden **Transition to Organic Food in danish Public Procurement: Can a top-down approach capture the practice?** *N.H. Kristensen & M.W. Hansen,* Denmark	**Organic farming with-out fossil fuels – life cycle assessment of two Swedish cases,** *C. Sundberg, M. Kimming, Å. Nordberg, A. Baky & P.-A. Hansson,* Sweden **Embedded energy in dairy stables,** *M. Koesling, S. Hansen & G. Fystro,* Norway **Self-sufficiency of fuels for tractive power in small-scale organic agriculture,** *S. Johansson & K. Belfrage,* Sweden	**Long-term changes in soil nutrients and grass/clover yields on Tingvoll farm,** *M. Ebbesvik & A.K. Løes,* Norway **Estimating nitrogen supply and cereal crop yield in organic crop production,** *J.E. Olesen & P. Sørensen,* Denmark **Development of phosphatase and de-hydrogenase activities in soils of annual cropland and perma-nent grassland in an organic farm,** *M. Ohm, H.M. Paulsen, B. Eichler-Löbermann & G. Rahmann,* Germany **Effects of applying anaerobically digested slurry on soil available organic C and micro-biota,** *A. Johansen, R. Pommeresche, H. Riley & A-K. Løes,* Denmark	**Comparison of organic and conventional dairy farm economic and environmental perfor-mances throughout North West Europe,** *A. Grignard, D. Stilmant, J. Oenema, S. Tirard, L. Debruyne, S. Hennart, D. Jamar, J. Boonen & partners of DAIRYMAN project,* Belgium **Operational strategies for optimizing grazing when using automatic milking systems in organic dairy produc-tion,** *F.W. Oudshoorn & E. Spörndly,* Denmark **Long term farm study of organic milk pro-duction — moderate concentrate inputs and high milk yields on Tingvoll farm,** *T. Strøm & M. Ebbesvik,* Norway **Feeding toasted field beans to dairy cows** *K.F. Jørgensen, A.M. Kjeldsen & M. Askegaard,* Denmark
10:05-10:30	**COFFEE**			

22 AUGU1ST (CONTINUED)			
10:30–11:45	**POSTER WORKSHOPS WITHIN TRACKS**		
	Track 1: Research as a driver for change	***Track 2: Multifunctional use of farm resources – improved use of biogas digestate***	***Track 4: Developing cropping systems for a sustainable future***
Moderator:	***Atle Wibe, Norway***	***Mette S. Carter, Denmark***	***Margrethe Askegaard, Denmark***
	Importance of organic farming research in Sweden for innovations and increased sustainability in agriculture, *M. Wivstad, P. Fredriksson, S. Gunnarsson, R. Hoffman, B. Johansson, A. Mie, U. Nilsson, E. Röös, E. Salomon, C. Sundberg, K. Ullvén & A. Wallenbeck,* Sweden **The new tendencies in the scientific research of the organic food system in Finland,** *J. Nuutila,* Finland **Organic production and consumption in Norway – new knowledge through research and dissemination,** *G.L. Serikstad, A.-K. Løes, E. Brunberg, L. Grøva, H. Steinshamn & K. Sørheim,* Norway **Acquisition and transfer of knowledge within the organic sector in iceland,** *Ó.R. Dýrmundsson,* Iceland **Organic farming research in Estonia,** *S. Pehme, E. Peetsmann, D. Matt, A. Luik & E. Veromann,* Estonia **15 years of research in organic food systems in Denmark – effects on the sector and society,** *I. Ankjær Rasmussen & N. Halberg,* Denmark **Opportunities of Organic Agriculture in Albania,** *E. Leksinaj,* Albania	**Strategic management of nitrogen within an organic cropping system using digestate from biogas production of recirculated crop residues,** *T. Råberg, E. Kreuger, L. Björnsson & E.S. Jensen,* Sweden **Biogas nutrient management in organic cropping – not only a nitrogen issue,** *A. Gunnarsson & H. Asp,* Sweden **Post-harvest sown catch crops – results from two years of organic field trials,** *K.H. Madsen, I. Bertelsen & M. Askegaard,* Denmark **Management of forb species mixtures for high biomass production,** *T. Mortensen, J. Eriksen & K. Søegaard,* Denmark **Anaerobic digestion of manure – consequences for plant production,** *A.-K. Løes, A. Johansen, R. Pommeresche & H. Riley,* Norway	**Goal conflicts in long-term cropping system trials – the example of carrots,** *P. Modig, M.-L. Albertsson Juhlin, A. Gunnarsson & C. Gissén,* Sweden **Organic rapeseed production in Finland,** *K. Hakala,* Finland **Translocation of imidacloprid from coated rape (Brassica napa) seeds to nectar and pollen,** *T. Eggen, S.R. Odenmarck & A.-K. Løes,* Norway **Organic production systems in Northern highbush blueberries,** *S. Caspersen, B. Svensson, S. Khalil & H. Asp,* Sweden **COBRA: a new European research project for organic plant breeding,** *T.M. Pedersen, T.F. Döring, P. Baresel, A. Borgen, M.R. Finckh, S.A. Howlett, L. Ortolani, B.D. Pearce & M.S. Wolfe,* Denmark **Quantitative population epigenetics a catalyst for sustainable agriculture,** *R. Stauss,* Germany **Quantitative population epigenetics in screening and development of regulator-active factors of the farming system,** *R. Stauss,* Germany
12.00-18:00	**EXCURSIONS INCLUDING LUNCH AND COFFEE**		
	Excursion 1: Challenges in organic crop production.Visit to two very different organic crop producers	***Excursion 2: Livestock production and animal welfare: A tour to two organic livestock farms; an egg producer and a dairy farm***	***Excursion 3: Focus on climate, resources and food systems. Visit to two organic farms that focus on on-farm greenhouse gas reduction***
19:00-22:00	**CONFERENCE DINNER**		

23 AUGUST				
08:30-10:05	**ORAL PRESENTATION SESSION WITHIN TRACKS**			
	Track 1: Supporting development of robust and holistic farming systems	***Track 3: Shaping resource efficient management strategies for green manure crops***	***Track 4: Changes towards improved productivity and animal welfare***	***Track 4: New methods and designs for organic vegetable production***
Moderator:	***Sirli Pehme Estonia***	***Jørgen E. Olesen Denmark***	***Mikaela Patel Sweden***	***Birgitta Rämert Sweden***
	Impact of the dynamics of discourses on the development of organic farming in Flanders, *L. De Cock, J. Dessein & M.P.M.M. de Krom,* Belgium **Barriers for developing more robust organic arable farming systems in practice,** *E. Noe, P. Sørensen, B. Melander, J.E. Olesen & Erik Fog,* Denmark **Picture card tool for holistic planning in organic plant production,** *E. Fog, J.E. Olesen, E. Noe, P. Sørensen & B. Melander,* Denmark **Introducing trees in dutch dairy and poultry farms,** *M. Bestman & N. van Eekeren,* The Netherlands	**Utilization of nitrogen in legume-based mobile green manures stored as compost or silage,** *P. Sørensen, E. Kristensen, K. Odoko-Nyero & S.O. Petersen*, Denmark **The impact of nitrogen in red clover and lucerne swards on the subsequent spring wheat,** *Ž. Kadžiuliene, L. Šarunaite & L. Kadžiulis,* Lithuania **Effect of green manure management on barley yields and N recovery,** *S. Hansen, R.B. Frøseth, A.K. Bakken, H. Riley, K. Thorup-Kristensen & M.A. Bleken,* Norway **Effects of organic versus conventional farming on different chemical soil parameters in Estonia,** *D. Sánchez de Cima, E. Reintam & A. Luik,* Estonia	**Robust breeds for organic pig production,** *T. Serup, Denmark* **Associations between pig leg health and lean meat growth in commercial organic herds,** *A. Wallenbeck, C. Eliasson & M. Alarik,* Sweden **Low stress and safe handling of outdoor cattle – effective measures to improve work environment and avoid dangerous situations,** *Q. Geng, S. Atkinson & E. Salomon,* Sweden **Could a different management routine that strengthens the mother-offspring bond contribute to a more efficient organic piglet production?** *O. Thomsson, A.-S. Bergqvist, L. Eliasson-Selling, Y. Sjunnesson & U. Magnusson,* Sweden	**The effect of different compost applications in organic production of lettuce (*Lactuca sativa* L.),** *A. Kir, M. Tepecik & O. Abaci,* Turkey **The effect of companion planting on the abundance of pest complex and its parasitism rate on white cabbage,** *R. Kaasik, G. Kovács, S. Pehme & E. Veromann,* Estonia **The introduction of the new control method of plant viruses infection for organic farming,** *S.B. Kwon & J.S. Chung,* Korea **The influence of organic and conventional production on yield and quality of carrots,** *I. Bender & A. Ingver,* Estonia
10:05-11:00	**COFFEE AND POSTERS**			
11:00-12:30	**FINAL PLENARY SESSION FOR SUMMING UP CHALLENGES, CONCLUSIONS AND FUTURE RESEARCH**			
	Susanne Padel, Tommy Dalgaard, Christine Watson & Paolo Bàrberi. Discussion moderated by Niels Halberg, Director of ICROFS – International Centre for Research in Organic Food Systems			
12:30-13:30	**LUNCH**			

Organic farming as an European innovation system

S. Padel[1]

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Implications

The paper explores how organic agriculture fits into the framework of innovation systems that is becoming more widely accepted in supporting innovation also in agriculture which is faced with many societal challenges. The paper explores the need to better understand the role of different types of innovation and in particular the role of knowledge and how joint learning systems for sharing different types of knowledge can be developed.

Background and objectives

Innovation and agriculture have always gone "hand in hand" because working with dynamic geographic, climatic, market and political conditions requires constant change (EC SCAR, 2012). Today, innovation is also seen as the primary instrument for overcoming the future challenges for agriculture of food security, climate change and the conservation of natural resources. For example, the European Innovation Partnership for Agricultural Productivity and Sustainability was set up in response to these challenges (EIP, 2012).

Innovation is a broad concept. OECD defines it as the implementation of a new or significantly improved product (good or service), a new marketing method or a new organisational method in business practise, workplace organisation or external relations (EC SCAR 2012). The concept of innovation refers not only the invention itself, but also to the embedding of that idea in a relevant sector. The whole process has three stages of (1) invention, when ideas and concepts are developed or prototypes built, (2) innovation focussing on how to put ideas into practice and (3) diffusion with more widespread application of the innovation at different social and economic levels (Schumpeter et al., 1980).

In looking at how this applies to organic farming two possible perspectives can be adopted: (a) Organic farming itself can be seen as an innovation. I looked into whether conversion to organic farming can be interpreted as a typical example of the diffusion of and innovation by applying the adoption/diffusion model (Rogers et al., 1971) to organic farming. Based on a review of various studies I confirmed that to some extend farmers, who had converted organic farming, showed similar characteristics to innovators and early adopters in the model (Padel, 2001).

(b) Innovation in the organic food and farming sector also depends on the functioning of the innovation system as a whole (Häring et al., 2012). This systems perspective is becoming more widespread in designing innovation support also for agriculture, such as the European Innovation Partnership (EIP 2012). The focus of this paper is the relevance of this perspective to the organic sector, building on work in the EU funded SOLID project[1] (in particular "Innovation through stakeholder involvement and participatory research WP1)" and the technology platform TP organics[2].

The innovation system framework

The first problem to overcome is that in the context of agriculture, innovation is nearly always understood as being only technical, with most experts not sufficiently aware of social/societal innovations (Bokelmann et al., 2012) that could be particularly important for achieving societal and political goals. This is maybe not so surprising, given the long period during which progress in agriculture was understood is increasing the efficiency

[1] Sustainable organic and low-input dairy systems (EU-P7:266367) http://www.solidairy.eu
[2] Technology Platform TP organics, http://tporganics.eu

through using new technology. Morgan et al. (2000) describe this for the cropping sector in England in the post war period as follows: "*Efficiency came very quickly to mean the application of the new agricultural technologies which were beginning to emerge onto the market. Input companies were investing heavily in research and technology development*". During developing the chemical inputs in arable production, the farmers' "know-how" was replaced by know-what, i.e. what input to use and when.

The systems perspective describes innovation in a more process-oriented, interactive and evolutionary way, whereby networks of organizations, together with the institutions and policies that affect innovative behaviour and performance, bring new products and processes into economic and social use (Hall et al., 2005). It looks at innovation as an emergent property not only of science or the market, but of interaction among stakeholders that allows opportunities to develop (Röling, 2009). Innovation is seen as the application of knowledge (of all types) to achieve desired social and/or economic outcomes. This may be acquired through learning, research or experience, but it cannot be considered as an innovation until it is applied (Hall et al. 2005).

The importance of the system perspective and of different innovation is increasingly recognised in agriculture (e.g. Bokelmann et al., 2012, EC SCAR, 2012). In the EIP this is expressed as the need for forming partnerships, on using bottom-up approaches and linking farmers, advisors, researchers, businesses, and other actors in so called Operational Groups.

The relevance to the organic sector

In the Implementation Action Plan of TP organics, we also argued for a broad understanding including social/organisational as well as technology innovations (Padel et al., 2010). We called organic farms "creative living laboratories", because the restrictions in the standards force them to think outside the box in finding new solutions to common problems. We also introduced a category of "know how" innovations. This emphasizes the importance of the application or leverage of existing knowledge, for example through developing and prototyping management practices. We argued that know-how is crucial to the farmer's ability to respond effectively to new challenges, such as saving and protection of natural resources, and for improving the multi-functionality and sustainability of agriculture.

Knowledge is of course importance in any innovation systems, but for organic and low-input some innovations consist only of knowledge. Examples of such "know-how" innovation include finding ways to secure essential supply of vitamins and minerals in organic dairy production through natural sources (ECOVIT-project), the use of compost in plant protection or to encourage predators by supporting their habitats (e.g. flowering field margins) (Padel et al, 2010). With such a strong focus on knowledge comes shift to learning, i.e. active knowledge construction rather than more passive "technology transfer" (Koutsouris, 2012). Morgan and Murdoch (2000) argue that in industrialised conventional supply chains the farmers' knowledge tends to be rendered into codified and standardised forms (blueprints) while in the organic chain there is increased scope for local, tacit forms of agricultural knowledge.

All this is not new to the organic sector, which has long been characterised as one that replaces inputs with knowledge (Lockeretz, 1991). In response, learning partnerships, group extension, farmer-field schools, communities of practice, study circles, farmer networks have emerged and are widely discussed. These are not always successful and the process can be very frustrating for the participants, but there is a growing number of good examples. In the SOLID project, we included a whole work package on farmer led innovation where we collaborate closely with farmers and SMEs partners (mainly organic and low-input dairy buying groups and processors). In a first step, we consulted for research priorities (using on farm interviews about sustainability as well as workshops (see Leach et al., 2013). At present we are developing on-farm projects in several countries, with the aim to test ideas of farmers for relevance and feasibility and also for acceptability with various stakeholders.

Where next?

One problem for "know-how" innovation is that it is often difficult for projects to generate something that is useful beyond the actual participants. One reason might be the importance of tacid knowledge. This knowledge is un-codified and contextual and the user might often not even be aware that she/he possesses it (Morgan and Murdoch, 2000). So, if the user does not what they know, how can it be shared? Also there is an urgent need to reflect about different types of knowledge held by different participants (the lay-expert gap of Koutsouris, 2012), and the ownership of knowledge and associated conflicts between protecting intellectual property and open-access.

So, the challenge we face in organic farming is moving beyond recognising the importance of knowledge, but to remain innovative in how we work with this mixture of different and very diverse sources and types of knowledge in developing joint learning approaches for researchers, farmers and advisors. In this way, I believe we can achieve that novel approaches developed in organic agriculture become true innovations that are more widely applied and used.

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Energy balance comparisons of organic and conventional farming systems and potentials for the mitigation of fossil resource use

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Implications

Today, agriculture and food production has major implications for the use of fossil energy and other resources, and a sustainable development implies transition towards new systems, based on renewable resources (Dalgaard et al. 2011).
The reduction of external inputs to the farm through efficient management of materials and energy is a central part of the organic principles (IFOAM 2013), and in most countries standards are implemented in the form of nationally adapted, organic farming regulations, with significant implications for the potential energy and matter flows in- and out of the agricultural systems, and thereby the energy balance and the use of renewable resources.
Consequently, it is important to develop new and more resource efficient production systems mitigating organic farming's reliance on fossil resources, and to compare different pathways towards reduced resource consumption in agriculture.

Background and objectives

In the Danish strategy for development and growth in the organic sector (ICROFS 2008) reduction in the dependency of fossil fuels, together with the related reductions in greenhouse gas emissions and the import of non-organic nutrients has been identified among the most important research areas; which are also highly prioritized in other Nordic countries (Sundberg et al. 2013a, Løes et al. 2013).
As input to the track two discussions about "Transitions to renewable resource" during the NJF seminar no. 461 on "Organic farming systems as a driver for change" this paper presents examples from Danish research, where energy inputs and outputs are compared for organic and conventional farming systems. In these examples, it is quantified how conversion to organic farming effect both the direct and indirect fossil energy embedded in the inputs to agriculture, and how the organic farming regulation of input factors effects the output produced, and thereby the energy balance given as the fossil energy use per unit of product produced in organic and conventional farming, respectively. These results are presented in addition to the other track two studies presented during the seminar, including studies on organic agriculture's contribution to reach long-term climate goals (Sundberg et al. 2013a) and climate gas and nitrogen emission mitigation via increased grassland productivity and carbon storage (Eriksen et al. 2013) or new green manure management strategies (Carter et al. 2013). Other studies focus on reduced fossil fuel dependency in the whole food chain (Sundberg et al 2013b), in the fields (Johansson 2013) or the livestock housing systems (Koesling et al. 2013), and various aspects and potentials for synergies between different types of organic farming, and new higher biomass production systems, in combination with biogas production (Loes et al. 2013, Råberg et al. 2013, and Gunnarson et al. 2013 among others).
Based on this it is the aim to facilitate the discussion and make conclusions and recommendations for further research and development of more sustainable organic farming systems based on more renewable resources.

Key results and discussion

Scenarios for developments in the agricultural sector has shown significant effects of conversion to organic farming as a measure to reduce both the net energy use, the emissions of greenhouse gases, and nitrogen losses (Dalgaard et al. 2011, 2003; Halberg et al. 2007; Pugesgaard et al. 2013). For all major types of crops, the average energy use was lower for organic compared to conventional farming (Table 1), but the average yields were also lower (Dalgaard et al. 2001).

Table 1. Modelled average energy use in MJ/SFU* for the major crop types in Danish Agriculture (Dalgaard et al. 2001). *) 1 SFU equals the fodder value in 1 kg of barley

	Cereals	Grass/Clover	Row crops	Permanent grass
Conventional farming	2.7	2.4	2.4	1.0
Organic farming	2.2	0.9	1.8	0.7

For dairy livestock production we see the same overall tendency, where conventional farming show a higher production per ha, but at the same time an even higher energy consumption; especially with higher energy inputs embedded in feed and fertilisers imported (Figure 1).

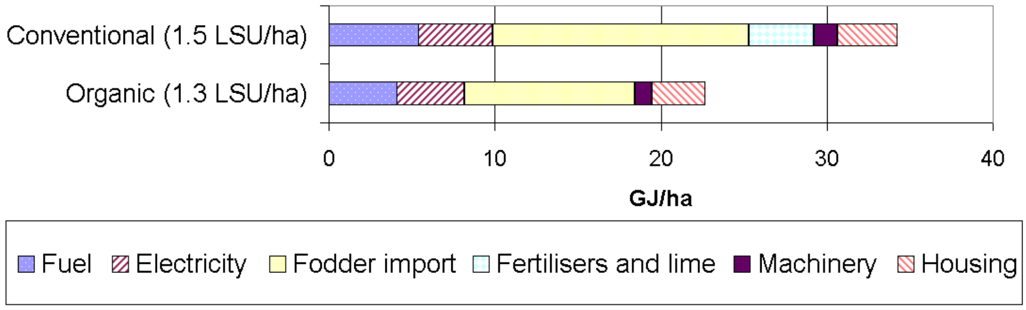

Figure 1. Average energy use per area in the organic and conventional dairy farm sector of Denmark (Dalgaard et al., 2003). 1 LSU equals one dairy cow of large race

In both organic and conventional systems there are significant potentials for energy savings in the range of 0-20% (Meyer-Aurich et al. 2013, Dalgaard et al. 2006), but to move the systems further towards fossil energy and climate gas emission neutrality, the inclusion of energy production in form of combined energy and food systems are needed.

It has been assessed that a positive fossil energy balance could be achieved for organic farming in Denmark via large scale implementation of Short Rotation Coppice (SRC) production, but on the cost of a potentially, relatively higher reduction in the food production (Jørgensen et al. 2005, Dalgaard et al. 2006). Therefore other possibilities, where energy production can be combined with the existing food production, have moreover been investigated. For instance, Christen and Dalgaard (2013) showed promising results for the use of buffer strips along water courses to catch nutrients, and harvest biomass for bioenergy; for instance in the form of SRC or Short Rotation Forestry (SRF) harvested for Combined Heat and Power (CHP) production, or green matter for biogas production.

In that context, Pugesgaard et al. (2013) evaluated a range of organic biogas production systems, and concluded that a significant surplus energy production in the form of heat and electricity could be produced (Figure 2). These systems also reduced the greenhouse gas emissions from between 4.2-4.4 Mg CO_2-eq./ha/yr in the reference situations (Ref. A and B) to respectively 2.9 Mg CO_2-eq./ha/yr and 2.8 Mg CO_2-eq./ha/yr in systems where biogas was produced from either grass-clover or silage maize harvested on 10% of the area (S1 and S2), compared to 0.8 Mg CO_2-eq./ha/yr and 0.6 Mg CO_2-eq./ha/yr in systems where either 20% of the area was harvested for grass-clover biogas production and the dairy production was reduced proportionally and substituted by a higher cash crop production (S3), or an additional 20% area with meadow grassland was harvested and added to the biogas production on top of the 20% grass-clover area harvested (S4).

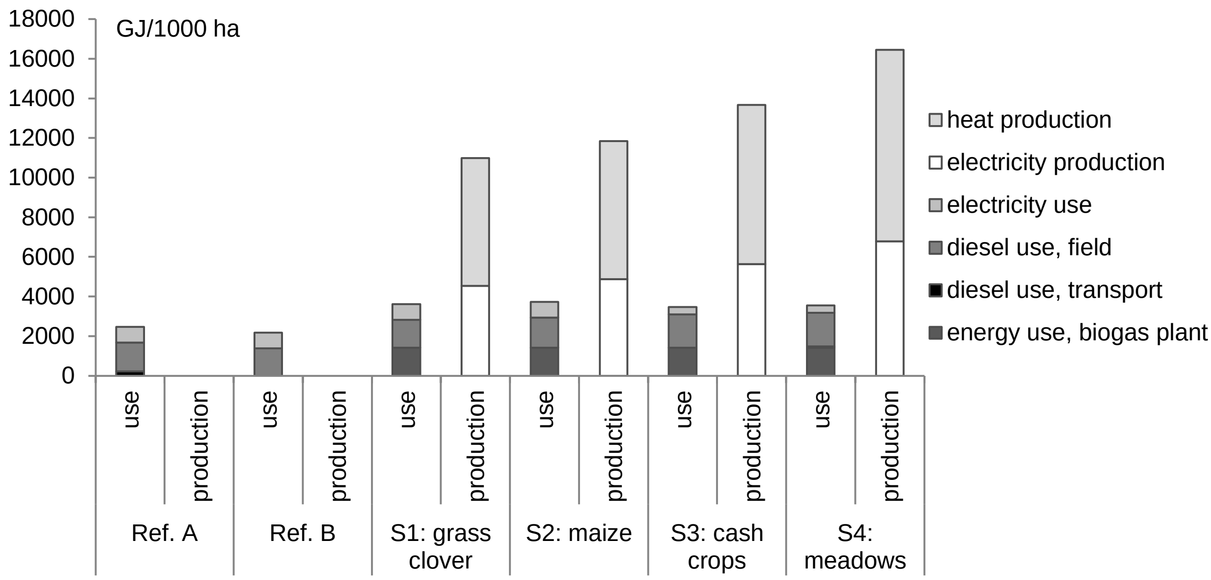

Figure 2. Comparison of energy use versus energy production on organic model dairy farms without biogas (Ref. A with slurry import, and Ref. B without slurry import), and three scenarios for conversion to organic farming with biogas production based on Grass Clover (S1), Maize (S2), increased cash crop production with maize for biogas, and reduced livestock production (S3), and biogas production based on imported meadow grass (S4). (Pugesgaard et al., 2013). *) Diesel use for transport includes solely external import of slurry and organic matter

Summary

Based on the presented examples and literature studies it is concluded that

- Typically, conversion to organic farming leads to a lower total fossil energy use. However, organic farming practices also result in a lower amount of production per area of agricultural land, another product quality, and eventually another product price than per unit of similar conventional products.
- In the examples presented, the reductions in the energy inputs were higher than the reductions in outputs from the production. Consequently, the energy efficiencies, defined as output per energy input, are typically higher in organic compared to conventional farming examples.
- A higher use of locally produced forage crops in organic dairy production may reduce the energy use via reductions in the energetically costly import of concentrates.
- The fossil energy use reductions lead to similar reductions in emissions of carbon dioxide (CO_2). This gas contributes with between one fourth and one third of the total greenhouse gas contribution from agriculture.
- There are high potentials for synergies between bioenergy production, improved nutrient cycling, and emissions of nutrients and other greenhouse gasses than CO_2.
- The potential for bio-energy production is higher in conventional than in organic farming. Fully utilizing this potential, conventional farming apparently has a more favourable energy balance and a lower net greenhouse gas emission than organic farming. However there are still many unanswered questions concerning possibilities for combined food-energy systems, which may change this conclusion.

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Long-term management of nutrients in organic farming – principles and practice

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Implications

Organic farming faces a number of challenges as it moves forward. It has become a part of the global agricultural industry and therefore organic products are traded not just between farms and regions but between countries and continents. Inevitably, large amounts of nutrients are exported from farms as part of this process. These farms can only continue to produce acceptable quantities of quality food if these nutrients are replaced. Soil has a finite capacity to supply crop nutrients unless they are replenished. The solution is perhaps easiest for nitrogen where biological fixation by legumes can be harnessed to provide the engine for crop production. For other major and micronutrients more consideration needs to be given to acceptable sources for organic production; in situ mineral weathering from soil parent materials will only rarely meet crop demand. In addition we need to understand and improve the recycling and management of all nutrients on farm to optimise crop and livestock production and quality while minimising losses.

Background and objectives:

The EU Regulation on organic food 834/2007 (EC 2007) sets a legal framework for practices which are considered acceptable within organic production. The regulation also aims to embody the principles of organic production set out by IFOAM (Health, Ecology, Fairness and Care) and states these principles within the regulation. A key concept within organic production is the idea of a balanced system (especially within the Health and Ecology principles) and to a limited extent the regulation addresses this issue by controlling the sources of external nutrients that can be imported to the farm. The regulation is mainly focussed on the farm as this is considered to be the main unit of control. However some wider scale issues are also addressed, e.g. the ability to import organic fodder from within the region. There is a vast body of research on nutrient management in organic farming carried out within Europe over the last 30 years but the majority of it focuses on nitrogen (N) and phosphorus (P) with fewer studies on potassium (K) and very rare consideration of secondary macro (Ca, Mg, S) and the wide range of micro-nutrients. Within this paper we address some of the options and challenges for improving the long-term management of nutrients in organic production with a consideration of both local and global scale issues. This is not a comprehensive review of nutrient management in organic farming but provides the opening for a debate on future issues in nutrient management in organic production.

Discussion

Recently there has been considerable controversy in the scientific literature with regard to quantifying and closing the yield gap between organic and conventional production (Reganold & Dobermann 2012; Seufert et al. 2012; Connor 2013). Increasing yields in organic farming will require an increase in both the total amounts of macro and micro-nutrients and their availability from acceptable sources. If higher yields are to be achieved sustainably, this requires a concerted approach from agronomists, soil scientists and plant breeders. Farmgate nutrient budgets for organic farms show both positive and negative results for macro and micro-nutrients e.g. Haas et al. 2007; Nesme et al. 2012; Watson et al. 2012. Many budgeting studies show balanced nutrient budgets (values close to zero) for P and K but studies are sometimes published from data collated for only one year. This may mask critical issues in organic production where practices may be planned on a rotational basis e.g. nutrient import in permitted fertilisers. Some crops export much larger quantities of nutrient per kg dry matter than others and this kind of detail can also be lost in budgets calculated for short periods. It is essential that nutrient budgets are estimated over at least one full crop rotation and that this information is used alongside soil analysis to allow useful interpretation whether for farm planning or policy-making.

Nutrient management in organic horticulture is perhaps a special case in relation to both the principles and practice of organic production. Within organic field-based annual cropping systems, the principles of organic farming suggest that use of crop rotation is key to the provision of nutrients to growing crops and that this can be supplemented by acceptable inputs of fertilisers and manures. However in protected cropping, where standards are currently under-developed, the use of crop rotation is more difficult issue as setting aside land for fertility building is generally not economically viable. As a result production in protected cropping systems may be more heavily based on imported nutrients than in field based systems, although total limits on applied N still apply. There is currently no requirement for field-based and protected cropping systems to be linked e.g. in the way that intensive livestock systems (pigs, poultry) are required to have a field-based element when produced organically.

Optimisation of the use of on-farm nutrient sources such as soils, crop residues and farmyard manure where available is critical in any approach to increase yields in organic production. However, in addition to these resources and selection of suitable plant species and varieties, locally available off-farm materials are an important option. While once viewed only as waste for disposal, materials such as food processing, kitchen and garden wastes can represent a valuable source of various nutrients (as well as potentially toxic elements). However, use of such soil amendments in organic farming requires these materials to be approved for use in organic farming and to be analysed prior to application so that they can be used appropriately with a rotational nutrient management plan, as well as in line with environmental legislation to protect agricultural land and the food chain (European Community and national regulations e.g. EC, 1986). Manures, composts and other organic materials as well as imported feed may contain both macro and micro nutrients which need careful scrutiny in the long-term. For example, high levels of copper have been found in manures due to contamination with waste from footbaths using copper salts (e.g. Jokela et al. 2010) and Zn from metal equipment or building materials in animal housing in also increased in manures (Öborn et al. 2005). Waste materials, and thus nutrients, from processing and/or consumption of organic products are not generally returned to organic farming systems potentially resulting in nutrient depletion of soils.

There are ongoing debates about whether the food system in Northern Europe can continue to rely on global transport of food; hence there has been an increased interest in relocalisation of the food system (Peters et al., 2008). Changing diets have been a major driving force in the spatial decoupling of consumption and production. This is not only the demand for "exotic" products which cannot be produced locally and year-round consumption of seasonal goods but also the changing patterns of meat consumption. The EU imports the equivalent of 37 million tonnes of soya bean, accounting for about 15 million hectares of land outside the EU and the largest cause of the EU net "virtual" land import (von Witzke and Noleppa 2010). This is increasingly pertinent for organic farming which now has substantial global trade and increasing numbers of countries requesting recognition of their organic standards by the EU. As a result of spatial decoupling of food production and consumption, macro and micronutrients are being exported not just from organic farms but from entire regions and replacement nutrient inputs acceptable to the organic standards will have to be found (ideally in the country of production) if soil fertility is to be maintained. There has also been increasing decoupling of crop and livestock production in Europe over the last 40 years and it is interesting to consider whether this has occurred in organic production to the same extent that it has in conventional production. From a point of principle there is an expectation that mixed farming will be more prevalent within organic production, with a degree of reliance on home produced feed and fodder.

The scale at which nutrient management is best considered to answer questions about long-term sustainability of organic farming in relation to nutrients is thus an interesting one. Nesme et al. (2012) question whether the farm is the correct scale to address nutrient balances in organic farming or whether groups of farms or regions are more appropriate. This larger scale would allow exploration of the issues about decoupling of livestock and crop production and also the appropriate uses of local soil amenders or "waste" products. Ultimately, returning human waste to organic farms is one way to help to "close the nutrient loop" although this is not currently allowed within the EU regulations. Issues over the use of globally traded commodities like rock phosphate within organic production continue to be up for debate. It is however very difficult to obtain figures which allow robust independent analysis of the reliance of organic production on the use of particular inputs.

Improving the management of nutrients in organic farming in the long-term will continue to challenge the research community. It undoubtedly will require a range of approaches both on farm and at a wider scale. However, in looking for economically viable solutions to on-farm and off-farm nutrient management challenges, it is essential to hold on firmly to the principles of organic production.

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Is agroecology the most sustainable approach for all organic farming systems?

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Implications

Analysis of very diverse Italian organic production systems through dedicated research projects revealed that all of them have ample margins of improvement in sustainability. The "multifunctional organic system" (small-scale farms, produce sold on local or regional markets, agroecologically-based management) must seek optimisation of production, cost reduction, and a better access/distribution of labour in peak times. The "specialised organic system" (medium-large farms, produce sold on supermarkets or abroad, input substitution-based management) should seek viable, more ecologically-based alternatives to input substitution to mitigate its high environmental impact. Literature suggests that this divergence between organic production systems is occurring in many countries. National and international organic standards should not only be more aligned towards their claimed sustainability objectives but also clearly distinguish from future integrated production standards. Incorporation of more agroecologically-based management options (e.g. functional biodiversity) should help keep organic farming duly identifiable by people, but practical solutions would need to be tailored to the specific production system.

Background and objectives

Agroecology can be considered a scientific discipline, a series of cultural practices and/or a social movement aiming at developing cropping and farming systems based on the best use and conservation of natural resources and the minimum use of external inputs (Wezel et al 2009). IFOAM and TP Organics Europe have defined a series of agroecological principles that are highly recommended for planning organic farming systems. These include: the optimisation of soil nutrient cycling, the increase in soil organic matter and fertility, the reduction of dependency on external inputs, and aspects related to socio-economic equity and sustainability (http://agro-ecoinnovation.eu).

Raising external and internal pressures demand an answer to the question: "Is organic farming really sustainable"? More specifically, are the three pillars of sustainability (environmental, economic and social) equally important in all organic farming systems? It is obvious that "organic farming" is not a monolithic category and that huge differences exist among different organic production systems, although this is rarely communicated to the larger public. In many countries there is a continuum of organic production systems ranging between multifunctional small-scale farms producing a plethora of produce for local or regional markets with agroecologically-based methods ("multifunctional organic systems") and specialised medium-large farms producing for supermarkets and the export with input substitution-based methods ('specialised organic systems') (Bàrberi 2010). In Italy, this divergence is particularly evident given the fact that in conventional agriculture mixed crop-livestock systems are uncommon, a structural problem which is difficult to overcome with conversion to organic farming.

The general objective of this paper is to evaluate the overall sustainability level of very diverse organic production systems (multifunctional *vs* specialised) typical of the Italian situation, through the results of four dedicated national or regional research projects (FERTORTOMEDBIO, SIMBIOVEG, ARIA and SATREGAS). The specific objective is to highlight the weak elements of sustainability for both organic production typologies and suggest possible solutions.

Key results and discussion

FERTORTOMEDBIO project. The SMS showed a lower total weed biomass at spinach harvest than PWC and PWC+LM thanks to the presence of the plastic mulch, but values were overall low (from 0.2 to 2.4 g m^{-2}). The biomass returned to the soil by PWC+LM was nearly double that in PWC, including 20 kg ha^{-1} of N provided by the subterranean clover living mulch. There was a significant negative association (r^2 = 0.44*) between living mulch biomass and weed biomass. Spinach yield and biomass $plant^{-1}$ were on average 31% and 33% higher in PWC and PWC+LM than in SMS. Total production costs were nearly threefold in SMS than in the innovative systems due to huge labour costs for manual transplanting (calculated based on standard salaries for non-specialised agricultural workers in the region). Actually, labour costs were not borne by the farmer because he employed disabled people thanks to a social agriculture project he was involved in. This was the only reason that made his production economically sustainable, otherwise he would have suffered a gross margin loss of >4000 € ha^{-1}. Despite the availability of low-cost labour, the farmer was unable to manage his summer crops (e.g. tomato) satisfactorily due to lack of management skills and labour mismanagement at peak times.

SIMBIOVEG project. Compared to optimum values, the 12 organic vegetable farms showed better values for indicators like average soil cover during the whole year (89.4%) and the most critical season (78.3%), genetic agrobiodiversity (45 cultivars, including an average of 3.68 traditional varieties $farm^{-1}$), species agrobiodiversity (crop rotation), and habitat agrobiodiversity (high richness and diversity of ecological infrastructures). However, critical values were shown for other indicators like soil NPK concentration [e.g. 408 kg NO_3^- vs an optimum value of <70 kg, too large, long and adjacent fields, and insufficient share of woodland (<4% of the total farm area)]. The most striking negative indicator was the energy balance (output-input), on average -4704 kg. It was clear that these farms were not fully environmentally sustainable, mainly due to excess reliance on external inputs, although they fully complied with the provisions of the EU Regulation on organic farming.

ARIA and SATREGAS projects. LCA analysis based on actual farm, processing and retail data showed a huge variation in the estimated CO_2 release from the different processing tomato production and retail systems. The lowest emissions (58.0 kg CO_2 kg $produce^{-1}$) were found for the organic open field production sold via box scheme and the highest (291.7 kg CO_2 kg $produce^{-1}$, i.e. fivefold) for the organic cold greenhouse production sold packed in supermarket. In the latter case, 51% of total emissions were due to the processing, delivery and packaging phases *vs* 3% in the former case. Noticeably, the production site (open field *vs* greenhouse) and the retail system had a much higher effect on CO_2 emissions than the production method (organic *vs* integrated). These results indicate that, for the same produce, there can be tremendous differences in the environmental impact of different organic production and retail systems, which is systematically much higher in "specialised organic systems" than in "multifunctional organic systems". This evidence may open roads to new voluntary certification schemes quantifying the contribution of a given typology of organic farming to the reduction of greenhouse gas emissions.

Results of these four projects show that both organic production systems should improve their sustainability. In the case of "multifunctional organic systems", the main priority is to increase farmers technical skills, which are often poor, resulting in sub-optimum farm management and yields and consequently in too high prices, unjustified for produce that are sold directly on farm or through local retail systems with reduced food mileage. In the case of "specialised organic systems", the main priority is to (re)introduce or optimise some agroecologically-based methods (e.g. agronomically-sound crop sequences, cover crops/living mulches, intercropping), which are often surprisingly considered a necessary evil. This would reduce dependence on external inputs, improve the environmental sustainability of these systems (a problem mainly in specialised organic vegetable production), and revert the trend towards "conventionalisation" of organic farming, which is being considered as one of the major threats to the whole organic sector (Best 2008; Darnhofer et al. 2010).

How work was carried out?

FERTORTOMEDBIO (2005-09): this was a national project aimed to improve soil fertility management in organic vegetable systems. Our activities were carried out in a vegetable farm (ca. 4 ha) representative of the "multifunctional organic system" typology. The standard farm management system (SMS), based on manual transplanting on plastic mulch, was compared with two innovative systems, one based on physical weed control (PWC), and one on its integration with a *Trifolium subterraneum* living mulch (PWC+LM). Data on total and weed biomass, spinach yield, production costs and gross margins are shown.

SIMBIOVEG (2005-09): this was a large national collaborative project aimed to develop innovative systems and methods for arable and vegetable organic crops and to test their effects on produce quality and environmental and economic sustainability. Here, data on several indicators of agri-environmental sustainability assessed in 12 vegetable farms, mainly representative of the "specialised organic system" typology, are reported. These indicators were classified in three categories: (1) soil and water, (2) landscape and biodiversity, (3) agronomy and energy.

ARIA and SATREGAS (2009-12): these were two regional projects aimed to analyse the environmental sustainability of various integrated and organic production and retail systems and the way to communicate it to the larger public. Here, data on estimated unit emissions (kg CO_2 kg produce^{-1}), as based on Life Cycle Assessment (LCA) analysis, are shown for 20 processing tomato systems, given by the combination of 4 production systems (integrated *vs* organic in cold greenhouse *vs* open field) and 5 retail systems (packed produce of extraregional *vs* regional origin sold in supermarket, unpacked produce sold in supermarket, unpacked produce sold in specialised shop, unpacked produce sold via box scheme).

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Co-operative or coyote? Producers' choice between intermediary purchasers and Fairtrade and organic co-operatives in Chiapas

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Implications

This study of organic and Fairtrade co-operatives in Mexico aims to find out why many coffee producers prefer not to join the certified co-operatives, despite their higher price offer. A study of costs of production of organic coffee concludes that it implies more work, but not necessarily higher yields. A main conclusion of the investigation is that the compulsory organic production methods deters many producers from entering the co-operatives, and that it is more attractive for producers with more free family labour, and less attractive for producers with very little coffee land. However, the study also shows that it is not only economic factors that influence the decisions of the producers on where to sell their coffee.

Previous studies have shown that Fairtrade and organic certification can bring higher incomes and more security into the lives of marginalized farmers (Bray et al. 2002, Martinez-Torres 2006, Jaffeee 2007) hence it is important to understand more about how these systems can achieve their aims. This study shows that although the smallest farmers are less likely to become a part of these systems, the farmers who do are also very poor and vulnerable. Also, co-operatives need to be economically viable organisations and the organic requirements ensure a market with a higher price for the product, while at the same time keeping the organization at a manageable size. It is therefore recommended to keep the organic production requirements as a criteria for producers entering the co-operatives.

Background and objectives

Many coffee producers in Chiapas, as well as in other parts of the coffee producing world, are in a situation where they can choose to sell their coffee to a Fairtrade and organically certified co-operative, or to a local intermediary purchaser. Knowing that the certified co-operatives receive price premiums for their coffee, it may seem like a paradox that many producers choose the private intermediary before the co-operative. One possible explanation is the requirement to produce organically, which is more time consuming and therefore makes the co-operative option less attractive. But it is also possible that personal preferences not based on economic deductions may influence the decision.

Several studies have found that organic coffee production implies more work than conventional (Jaffee 2007, Gliessman 2008, Gobbi 2000, Bray et al. 2002, Martinez-Torres 2006, Lyngbæk et al. 2001). Other studies have also found that it generates higher yields than natural production, which is production with neither chemical inputs nor specific organic methods (Martinez-Torres 2006, Bolwig et al. 2009). Some studies have found that coffee production with chemical inputs generates higher yields than production with organic methods (Martinez-Torres 2006, Kilian et al. 2006, Lyngbæk et al. 2001). According to Martinez-Torres (2006), organic farming, which is cash-cheap and labour intensive, is appropriate for the cash-poor families in Chiapas, where underemployment is high and opportunity costs for extra family labour is low. Hence smaller farmers are more likely to be organic and larger farmers are more likely to use chemical technology (Martinez-Torres 2006). The tendency for Fairtrade and organic co-operative members to have smaller coffee areas and a higher ratio of on-farm family labour per coffee hectare was also found in a more recent study from Nicaragua (Beuchelt and Zeller 2011). On the other hand, Bray et al. (2002) finds in their study of three organic coffee co-operatives in Chiapas that the members are predominately from the 2-5 hectares stratum, and not from the smallest producers with less than 2 hectares.

Key results and discussion

Coffee producers have a variety of reasons for not wanting to join certified co-operatives, despite their better price offer. The qualitative study from Chiapas finds that the most often mentioned reason is the requirements for organic production. This corresponds to the results of a household survey from the municipality of Jitotol, where many producers claim that they do not want to join the organic co-operative because of the extra work load. A study of work hours spent by co-operative members and non-members in the area shows that the members do spend more time in their coffee field than non-members. They particularly spend more time on making and applying compost, as well as renovating coffee trees. Also harvesting takes more time, since only the ripe berries are picked, and since they have to pick all the berries in order to avoid diseases from spreading. The requirements to work more, and the fixed costs in organic coffee production, indicate that membership should be more profitable for producers with more available work force in the family, and less profitable for producers with very little coffee production. This is confirmed in a probit analysis on the household data from the same area.

In order to increase the number of producers organised in Fairtrade and organic co-operatives, one could facilitate the producers' conversion to organic production methods, by information, training or financial support. But also non-economic aspects are important, such as the building up of trust in co-operative organisations in general. A lack of trust is due to corruption being too common in co-operatives, as it is in other firms and organisations in Latin America. Supervision of co-operative leaders, such as the one conducted by FLO, may thus have a long term positive effect on the attractiveness of these organisations. Another insight derived from this study is that for co-operative membership to be attractive it is important that the price offered by the co-operative remains at a higher level than that of the "coyote". A fall in the demand for labelled coffee which reduces the income of the co-operatives would make them less attractive. The work of those who promote labelled coffee is therefore of great importance.

How work was carried out?

Several methods were used for the study:

1. Qualitative study among coffee co-operatives and other stakeholders in Chiapas, Mexico. During a 10 month period interviews where recorded, transcribed and analysed with the software NVivo.
2. Survey of 38 organic co-operatives in Chiapas, asking questions about their structure, regulations and price policy. Used for summary statistics.
3. Survey of costs of production. 80 producers in Jitotol, Chiapas that were eithed organically certified, using chemicals, or neither. Used for summary statistics.
4. Household survey among 153 producers in Jitotol. Used for summary statistics and probit analysis.

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Conversion to organic farming; experiences from Punjab and Uttarakhand

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Implications

This research indicates that it is possible for farmers to convert from an intensive conventional system (Punjab) to organic farming, or to make a living on a smallholding in difficult terrain (Uttarakhand). Both alternatives can provide a good livelihood with sustainable methods. I also found that the organizations that assist the farmers in this transition are crucial, because they teach the farmers new methods and give practical and moral support during a time when they feel uncertain making such a large change in how they make their living. One of them is Navdanya, which has been working in Uttarakhand and in several other states in India for nearly three decades. The organization trains and supports farmers converting to organic practices and helps to improve the farming methods of those farmers who have been using traditional, natural methods all along. While a reduction in crop yield, especially during the conversion period, is seen in intensive production systems such as those in Punjab, traditional, low-input production systems as in Uttarakhand often see an immediate increase in the yields after converting to organic methods. This is because in organic agriculture, the farmers make use of a number of on-farm fertility sources including vermi compost, crop residue, and animal manure. Multi-cropping is also used to increase production on small plots and to reduce the risk of loss where there is drought or other difficult climatic conditions.

Background and objectives

This research was undertaken to learn more about conversion to organic agriculture among small farmers in India. I wanted to look at how organizations like Navdanya, Kheti Virasat and others teach small farmers about organic agriculture and biodiversity conservation. Even though a growing body of research indicate that the farmers using sustainable, organic methods are better off, both economically and in terms of health (Brandt and Molgaard 2001; Gala and Burcher 2005; Magkos, et al. 2003) little research has been conducted on the work that social movements like Navdanya have done in facilitating this conversion in India, and more importantly on how the local farmers perceive, and adopt or reject this "traditional", now called "alternative", farming philosophy and strategy.

Key results and discussion

In Punjab, a relatively minor number of predominantly small, but also some medium and a few large farmers have converted to organic farming methods, either independently or through cooperation with Kheti Virasat. The number is increasing. Farmers are converting to organic farming methods to become more independent in terms of seed and other farm inputs. The organic farmers use traditional seed brought in from nearby states, which they now grow and conserve in seed banks in Punjab, because local seed were lost during the GR. Those who convert to organic also cite ecological reasons for this change: to restore soil fertility or manage farming with less water and to avoid pollution of the environment and negative impacts on their health from excessive application of agrochemicals. Many farmers who converted were able to become economically independent in the years after the transition, as they could gradually repay their loans taken up in earlier years.

In Uttarakhand it is estimated that roughly eighty percent of the farming is organic by default in rainfed areas, and in the hills, ninety percent of the agricultural land is rainfed (Sitling, et al. 2008). Some farmers had experienced depletion of the soil with the use of mineral fertilizers, especially when rain did not come as expected, but the influence of the GR was much less in this state than in Punjab. Uttarakhand has a rich biodiversity both in wild plants and agricultural crops and there are ancient as well as new seed banks in use around the state. The farmers reported that their local food security is improved through biodiversity conservation and control over their own seed and other inputs. Local farmers cultivate a number of traditional crops that are famous for their taste and quality, which are sold as niche produce in Delhi and Mumbai, but there is a need to improve marketing. Many certified organic producers often receive a market premium only in urban markets, while at local markets a similar price to that of conventional produce is frequently paid.

When the farmers convert to organic, they experience a period of roughly three years of lowered crop yield while they transfer from using mineral fertilizers to using compost and dung, before the soil has regained fertility and moisture related to enhanced organic matter within the soil. This pattern of reduced yields is common, ranging from ten to 30 percent, depending on the crop (Badgley, et al. 2007; Mäder, et al. 2002). While yields are lower initially, the organic farmers obtain similar levels of profit compared to conventional farmers per given unit of land, because of less expenditure on inputs. Some farmers reported that crops grown organically would later give a similar yield to that of conventional methods, while others argued that they got a little more, or a little less yield compared to conventional methods.

My findings are consistent with much research on agricultural systems and sustainability in recent years throughout the world; for example the extensive scientific literature that the IAASTD reports and reports presented by the UN Human Rights Council are based on. In one sentence it could be phrased as: Reinvestment in sustainable agriculture is vital to the realization of the right to food for all, rural economic development with economically independent farmers, healthy environments, adaption to climate change, and biodiversity conservation.

How work was carried out?

Fieldwork was conducted between February 2007 and October 2008, and I divided my time between field sites in the states of Punjab, Uttarakhand, Tamil Nadu, and West Bengal. Living in the villages for about a year, I interviewed 250 farmers and staff from farmers' organizations. In addition I carried out informal conversations with many farmers, community members and farmers' organizations staff on the 77 farms in the 56 villages, and in the three towns and five cities, where I did interviews. Data from interviews and field observations in Punjab and Uttarakhand are included in this paper.

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Productivity and growth in organic value chains in East Africa – potentials and challenges for accessing local high value markets

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Implications

The project "Productivity and Growth in Organic Value Chains (ProGrOV)" is a collaboration between universities in Uganda, Kenya, Tanzania and Denmark addressing the need for sustainable development of smallholder farming systems in East Africa with focus on value chains for local high-value markets as well as export chains. While some research has focused on improving productivity and Natural Resource Management of smallholder farmers in Eastern Africa this has most often not been linked with studies of how to link improved production to market access and quality demands. NGO's have demonstrated the synergy of supporting ecological intensification through improved marketing and innovation capacity of groups of smallholder farmers but only very few research projects have studied this potential synergy (Pali et al., 2007; Hawkins et al., 2009; Høgh-Jensen et al., 2010). ProGrOV contributes to the development of a platform of scientific capacity and evidence on potentials of organic value chains and agroecological approaches to agricultural development.

Background and objectives

Increased market orientation linked with intensification of farming methods is suggested as a vehicle for economic rural development in African countries. Sub-Saharan Africa's agribusiness sector faces the challenges that most crops are produced by small-sized farms with poor market access and limited capacity for quality assurance and grading for high value chains. At the same time the current pressure on natural resources such as soil and water is not sustainable.

Organic agriculture and food systems, based on agro-ecologcial approaches, is an interesting case of smallholder farmers' intensification from the perspective of market access via high value chains, improved food security and livelihood and improved natural resource management (Halberg et al., 2006; Bolwig et al., 2009). However, the degree and type of improvement in natural resource management and in livelihood for smallholder farmers varies between different organic value chains. The actual development outcome depends on the dynamics and processes in the product chains such as the character of power relations, the importance of training, differences in the approach to cash crops versus whole farm development, and the coordination-, financial- and managerial skills/back up of the intermediaries involved (Pali et al., 2007; Sultan et al., 2008; Bolwig et al., 2010). ProGrOV address the need for an integrated research into – on the one hand – how to organise organic high value chains to improve chain management and livelihood benefits for the farmers and – on the other hand – further develop agro-ecological methods for farming systems intensification based on sustainable natural resource management. The overall hypothesis of the project is that improved organic value chains may serve a dual purpose for:

- developing and demonstrating innovating partnership models for chain based economic and social growth; and at the same time
- improving productivity potential and sustainable natural resource management.

Key results and discussion

The project will be completed in 2016, however, some preliminary findings on major challenges facing the development of organic value chains in East Africa can be extracted from the initial phase. Production and to a certain degree also the market is fragmented with a large number of smallholder producers and lack of organized chains. A consequence of this is that farmers have limited access to information on the market and depend on information from traders that act as intermediaries between producers and the market. Furthermore, the farming community are facing challenges in logistics amongst themselves to collectively produce sufficient amounts, as well as the transport from the farming community to the high-value markets in urban centres or tourism hubs in itself is challenged by limited infrastructure and distances. In addition the development of the organic sector is facing suspicion and misinformation on concepts, implementation and potential of organic agriculture among agricultural policy makers and national research and extension actors; but also, for example, within the tourism sector. Misperceptions relate to organic agriculture being associated with low productivity, low technologies, old-fashioned and out-dated, and that agriculture in Africa is "organic by default". These initial findings and experiences of ProGrOV underline the need for scientific documentation of the potential of Organic Agriculture in countries such as Uganda, Kenya and Tanzania.

How work was carried out?

The project is a combined research and capacity building project aiming at strengthening research based knowledge for supporting increased productivity and sustainable growth in organic production and value chains, and building capacity for future development of the OA based value chain in Kenya, Uganda, and Tanzania. Research is implemented via 9 PhD and 6 MSc studies at Makerere University in Uganda, University of Nairobi in Kenya and Sokoine University of Agriculture in Tanzania. Each student has supervisors from their own university and from either Aarhus University or University of Copenhagen. All studies are interlinked either through the chain being addressed or the produce itself (pineapple, vegetables, livestock). The project is developing a "value chains approach" based on information feedback loops on market requirements, retailers requests, etc., that are translated into quality attributes guiding the research questions in the studies related to the organic farming systems. The field work in the individual studies is undertaken in a participatory approach in collaboration with farmers and with support from the organic movements in the three countries (NOGAMU, KOAN, and TOAM). Economic studies are based on data collections through surveys and interview of stakeholders.

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How can organic agriculture contribute to long-term climate goals?

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Implications

The EU countries aim to reduce their emissions of greenhouse gases (GHG) by 80-95% by 2050 (European Commission, 2011). The food sector accounts today for 25% of Swedish greenhouse gas emissions, most of which arise in agricultural production, so there is a need for radical reduction of GHG emissions in this sector. For organic farming in Sweden, this implies that it is time to move beyond the discussion on whether organic products have a lower or higher life-cycle climate impact than conventional products (Cederberg et al 2011). Instead, the interesting question is: What can and should be done to drastically reduce the climate impact of organic agriculture? The science-based response to that question is relevant for Swedish agriculture as a whole.

Development towards lower climate impact from organic agriculture requires further monitoring and technology development to reduce emissions of nitrous oxide, methane and carbon dioxide. But it also involves developing production systems that are more efficient in the use of nutrients, energy and land, as well as shifting focus from producing animal food towards more legume, grain, vegetable and fruit products.

Background and objectives

EPOK's aim is to disseminate knowledge and coordinate and initiate research on organic agriculture in Sweden. As the climate impact of organic agriculture is high on the agenda, a knowledge synthesis was initiated (Röös and Sundberg 2013). The aim was to describe the state of knowledge and identify knowledge gaps regarding greenhouse gas emissions from organic agriculture in Sweden and its potential to contribute to reduced climate impact from the food sector. This required an explanation of the principles of systems analysis needed for comparison of climate impact from different agricultural production systems.

Key results and discussion

Improved nitrogen efficiency: Nitrous oxide emissions from soil are the largest, but also the most uncertain source of greenhouse gas emissions from agriculture. It is important to monitor emissions from current and alternative production systems. It is known that nitrous oxide emissions are linked to availability of surplus nitrogen, so improved nitrogen use efficiency is important for reducing the nitrous oxide emissions from organic agriculture.

Higher yields: Increasing the yields and decreasing losses in organic production is important for decreased climate impact per kg of product. High yields caused by increased nitrogen use efficiency gives double climate benefit, but other measures aiming at higher yields may be in conflict with animal welfare or biodiversity.

Increased soil C stocks: Grass and clover forage, common crops in organic farming, contributes to reduced climate impact through increased soil carbon stocks (Leifeld and Fuhrer 2010). However, very high increases in soil carbon are required if this is to compensate for methane emissions from ruminants. The climate benefit can be large if grass and clover is used for bioenergy production.

Resource efficient systems: Energy use is a minor part of greenhouse gas emissions from agriculture, but the energy used is largely of fossil origin. This can be replaced by renewable fuels, and bioenergy production for on-farm use requires only a small proportion of the agricultural land (Ahlgren, 2009). There is a need for research and development for design of production systems that produce valuable products with reduced requirements on land and other limited resources. Optimal use of local resources such as pasture land, local feed crops, by-products and waste heat is necessary, in order to reduce the pressure on global land and energy resources.

More vegetarian food: Swedish organic farming is dominated by milk production, but animal products have much higher climate impact than crop produce. There is a need for development of organic production of new and old crops for human consumption in a variety of production systems (with or without livestock, and in mixed systems that produce animal and vegetal foods). In these systems, nutrient supply is a key issue. Anaerobic digestion of manure, grass and residues can contribute to nutrient supply as well as reduced climate impact through supply of renewable energy.

How work was carried out

The synthesis was based on a review of scientific literature and interviews with about 30 researchers in scientific and technical subjects. In a report from the project, mechanisms for emissions of nitrous oxide, methane and carbon dioxide are described, as well as climate aspects in a systems perspective, including life cycle assessment, food production, bioenergy production, land use change, and climate aspects of nutrient cycles (Röös and Sundberg 2013). Biogas production and the potential to sequester carbon in soils are addressed specifically.

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Multispecies grasslands for crop productivity and carbon storage

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Implications

Organic grasslands have long been recognized for their provision of ecosystem functions and services and this may be further increased by inclusion of appropriate herb species. Inclusion of herb species in grasslands has in the present experiment shown to increase yield stability. Furthermore, the data presented here has indicated some potential of species known to have deeper and denser rooting systems to increase belowground biomass, an important asset for C sequestration in grasslands.

Background and objectives

In grasslands, most C originates from roots and total allocated C increases with plant species richness (Adair et al., 2009). The larger roots seem to be more important than small roots to enhance the C pools (Rasmussen et al., 2010). However, the storage of C in soils depends on both the inputs and the decomposition rate, which is especially important in farming systems with frequent grassland cultivation. We investigated above and belowground biomass in differently managed multispecies mixtures and CO_2 emission upon grassland cultivation.

Key results and discussion

Aboveground biomass increased considerably with increasing content of herbs (including lucerne) in the mixture and also with fertilizer application in plots with a 4-cut strategy (Table 1). With a 6-cut strategy, aboveground biomass was much depressed compared to the 4-cut strategy; in the previous years this depression was only noticed in the 100% herb mixture (Mortensen *et al.*, 2012). The herb mixture was dominated by lucerne, most pronounced without fertilizer, and caraway, most pronounced with fertilizer application.

Table 1. Aboveground biomass and botanical composition of swards with different herb seeding rates, manure application and cutting frequency in spring cut in the third production year. Biomass values with different letters are statistically different (*P*<0.05). Annual biomass production in Mortensen et al. (2012)

Herbs in mix	Manure applied	Cuts per year	Bio-mass	Rye-grass	White Clover	Lu-cerne	Cara-way	Chi-cory	Salad burnet	Plan-tain	Birds-foot trefoil	Un-sown
			t DM ha^{-1}	Proportion of dry weight (%)[1]								
5%	0 N	4	2.6^{d}	61	32	4	3	0	0	0	0	0
50%	0 N	4	3.6^{c}	34	10	40	14	1	0	0	0	0
100%	0 N	4	4.7^{b}	0	0	77	17	1	2	0	1	2
5%	200 N	4	3.2^{cd}	74	22	0	5	0	0	0	0	0
50%	200 N	4	4.4^{b}	37	7	26	30	0	0	0	0	1
100%	200 N	4	5.9^{a}	0	0	30	67	1	1	0	0	1
5%	0 N	6	1.8^{e}	59	39	0	0	0	0	0	0	2
50%	0 N	6	1.7^{e}	61	33	0	3	0	0	1	0	2
100%	0 N	6	1.6^{e}	0	0	15	39	5	8	6	8	20

[1]Chervil, melilot and fenugreek were not present at all.

Total root biomass (small and large roots at all depths) was not significantly affected by treatments or by species type in the pure stand experiment (Figure 1). However, differences appeared in specific size classes and depths. Thus, in the 100% herb mixture the biomass of small roots (<8 mm) in the top layer were significantly lower (*P*<0.001) than in mixtures with white clover and ryegrass, and similarly, the root biomass in this fraction was lower without fertilizer application ($P<0.01$). The biomass of large roots (>8 mm) in mixtures with herbs showed considerable variation probably as a result of more taproots, and there was a non-significant tendency towards increased biomass in the large root fraction with increasing herb content. This was probably related to the high contents of lucerne and caraway both having significantly larger root biomass in 10-20 and 20-50 cm in the pure stand plots

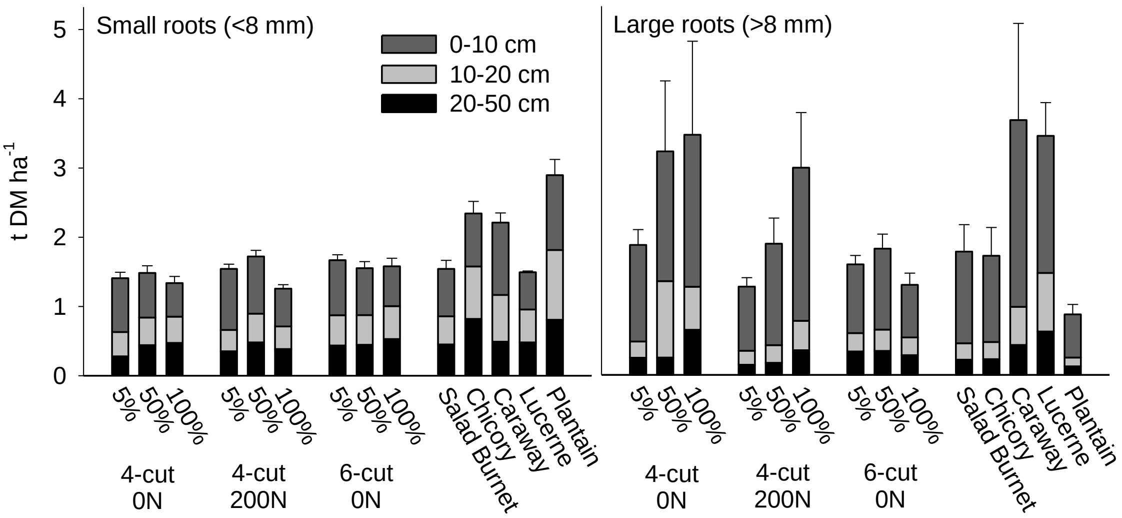

Figure 1. Root biomass at different depth of swards with variable herb seeding rate (5, 50 or 100%), manure application (0 or 200N) and cutting frequency (4- or 6-cut) and of selected species in pure stand in a separate experiment. Error bars: SE

How the work was carried out

A plot experiment was established in two replicates with three mixtures: 1) a herb mixture containing salad burnet, fenugreek, chicory, caraway, birdsfoot trefoil, chervil, plantain, lucerne and melilot, 2) 50% of the herb mixture and 50% of a white clover/perennial ryegrass mixture, and 3) 5% of the herb mixture and 95% of the white clover/ryegrass mixture. Also, some herbs were established in pure stands (Figure 1). All mixtures were managed with 4 or 6 cuts per year with and without fertilizer application (200 kg N ha^{-1} via cattle slurry) for the 4-cut system. The pure stand was managed with 4 cuts and without fertilizer. In the spring of the 3rd production year, aboveground biomass was determined by harvesting plots of 1.5x12 m and belowground biomass were determined by wet sieving of eight soil samples per plot from three depths (0-10, 10-20 and 20-50 cm) sampled with an 8.75 cm inner diameter auger. Furthermore, CO_2 release following simulated cultivation was investigated in an incubation experiment for soils from 0-10 and 10-20 cm depths. Data were analyzed as a split-split-plot experiment using the MIXED procedure of the SAS statistical package with fertilization as main plot, fertilization and cutting regime as split plots.

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Nitrogen mineralization and greenhouse gas emissions after soil incorporation of ensiled and composted grass-clover as green manure

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Implications

Main conclusions and recommendations: This 3-month incubation study showed that ensiled grass-clover was a better nitrogen (N) source than a composted grass-clover and straw mix (grass-clover:straw, 4:1, w:w), owing to the high content of labile compounds compared to the more degraded compost. Our study also indicated that emissions of the strong greenhouse gas nitrous oxide (N_2O) can be reduced by incorporating green manure using harrowing instead of ploughing. The silage-derived N release by the end of the incubation was equivalent to 38-42 kg N ha^{-1}, which corresponded to one third of the N applied in silage, with no difference between ploughing and harrowing. In contrast, no net release of mineral N was detected from the composted grass-clover.

Expected importance and impact: These results are important for organic arable crop producers, who depend on nitrogen input to their farming systems via biological N_2 fixation in leguminous green manure crops. Organic arable farming faces challenges with low crop yields, partly due to inefficient use of green manure-derived N, which also leads to significant environmental N losses with negative implications for aquatic ecosystems and the global climate. Our results suggest a way to improve green manure nutrient management in order to 1) increase yields of cash crops in organic rotations, and 2) reduce the environmental impact of arable organic farming.

How we contribute to solve the problem: In this experiment, we test a new green manure management strategy as part of the ICROFS project HighCrop. Under current farming practices, green manure leys are often cut and mulched during the growing season with the associated risk of N losses to aquifers and atmosphere. With the new strategy evaluated here, green manure leys are instead harvested and preserved until the following spring either as compost mixed with straw or silage of harvested ley biomass. In spring, these two green manure materials can then be used for targeted fertilization of spring sown crops.

Background and objectives

In this study, the objectives were to:

- Compare composted and ensiled grass-clover green manures concerning their abilities to provide nitrogen for a growing crop during a 3-month period. We expected faster N mineralization from silage because of its high content of labile compounds and lower C/N ratio compared to the more degraded grass-clover and straw compost.
- Determine whether N mineralization from the two materials is influenced by soil incorporation method, more specifically harrowing (simulated by mixing the material into the top 5 cm soil layer) and ploughing (the material placed at 15 cm depth). We expected that harrowing would result in the largest N release, because decomposing microorganisms had better access to the plant material when mixed into the top soil rather than being placed in a layer in the simulated ploughing treatment.
- Assess the N loss via soil emissions of the strong greenhouse gas, N_2O. We expected that ploughing would lead to higher N_2O emissions due to the development of oxygen-limited conditions around the decomposing materials, which could stimulate N_2O production via denitrification.

Key results and discussion

Mineralization of green manure-derived N started more than three weeks after incorporation of the materials (Figure 1). As expected, grass-clover silage provided the highest N mineralization with a total N release corresponding to 38-42 kg N ha^{-1} over the 3-month period, irrespective of the incorporation method used. In contrast, no increase in soil mineral N was observed for the composted grass-clover and straw mixture compared to the unfertilized control soil. In fact, soil incorporation of compost by harrowing caused immobilization of soil mineral nitrogen 1-2 months after experimental set-up (Figure 1). Thus, overall we had to reject the hypothesis that harrowing would stimulate N mineralization more than ploughing.

Generally, N_2O emissions were higher from the silage-amended soils than from soils fertilized with compost. Especially, silage incorporated by ploughing gave rise to increased N_2O effluxes, corresponding to 0.4 % of applied total N during the 3-month period. In contrast, compost incorporated by harrowing stimulated a downwards N_2O flux into the soil, presumably an effect of lacking mineral N availability in this treatment. Thus, we were right in the hypothesis that ploughing would stimulate highest N_2O effluxes.

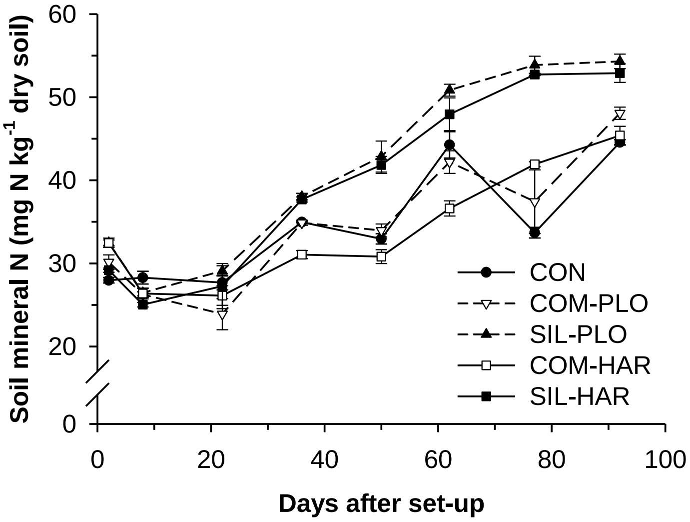

Figure 1 Soil mineral N after incorporation of grass-clover compost (COM) and silage (SIL) by either simulated ploughing (PLO) or harrowing (HAR) compared to an unfertilized control soil (CON) in a 92-day incubation experiment at 15 °C (means ± SE; n = 4)

How work was carried out?

The experimental design included eight sets of 20 soil units, each consisting of a 28 cm long × 10 cm diameter PVC pipe. Each unit was sealed at the bottom by a ventilated plastic cap, and was gradually filled with 25 cm of soil to obtain a consistent bulk density. For the ploughing simulation, a portion of green manure was placed in the unit before the upper 15 cm soil layer was established. For the harrowing simulation, a green manure portion was homogeneously mixed into the upper 5 cm soil layer. The addition of compost and silage corresponded to a fertilization rate of 12 g total N m^{-2}. All 160 soil units were incubated at 15°C in darkness.

On eight occasions, N_2O emissions were measured from a set of soil units using a photoacoustic gas analyzer coupled sequentially to 20 static gas-flux chambers each containing a soil unit (Johansen et al., 2013). Destructive soil sampling occured the day after gas-flux measurement and a representative subsample of the 0-25 cm soil profile was analysed for ammonium and nitrate contents.

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Agronomical and environmental performances of organic farming, France

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Implications

This work suggests that Soil Surface Balance is a robust indicator to compare the performances of organic agriculture with those of conventional agriculture, even strictly following the rules of rational and optimised application of fertilisers. The results of long term nitrogen budget calculation brought us to seriously reconsider the relevance of the need to increase crop yields, and more broadly to reconsider cropping patterns and production systems. In terms of policy levers for mitigating nitrogen contamination of water resources, only the shift to organic farming provides a possible way to reconcile agricultural production and water quality.

Further, this view points out the need for specific measures to encourage more mixed farming approach to organic farming on a territorial basis, thus reversing a 50 years trend to regional specialization into either crop or livestock farming.

Background and objectives

Nowadays, diffuse pollution of agricultural origin is the main cause of severe surface and groundwater contaminations with pesticides and nitrates in the Seine watershed, thus endangering the drinking water resources of Paris.

Organic farming appears as a credible alternative to the conventional input-intensive mode to restore and protect water quality. Positive effect on pesticide contamination is obvious but effects on nitrogen loads remain little known or controversial and deserve peculiar attention (Stopes et al. 2002, Torstensson et al. 2006, Aronsson 2007, Kelm et al. 2008). Since 1996, European Nitrates Directive (91/676/EEC) recommends an optimal nitrogen supply according to the need of the crops but due to insufficient application of the Directive the French Government was forced to establish new regional references (in 2012) to calculate precisely the appropriate rates of nitrogen fertilizers.

In this study, we attempt to assess long term effectiveness of organic farming practices in comparison with those recent mandatory requirements and current conventional practices on the Seine watershed in decreasing N leaching and meeting water quality targets.

Key results and discussion

Spatial organization of organic farming (3% on average of the French Agricultural Land Use in 2010) surprisingly follows the same trends as conventional agriculture, i.e. a strong decoupling of crop and animal farming. The Center of the Parisian Basin is devoted to cereals farming, while livestock farming concentrates in peripheral regions.

Organic farms specialised in crop production rely on complex crop rotations (7 to 14 years) involving legumes crops and forage. Symbiotic nitrogen fixation accounts on average for more than 50% of total nitrogen inputs. Atmospheric deposition contributes for about 10% and remaining part comes from exogenous sources (like distillery residues and animal manure). For mixed and dairy farms symbiotic fixation reach 85% of total N inputs.

Yields of organic cereals show a decrease in the range of 25-40% compared with conventional averages in the same areas. For relevance, organic and conventional farming were compared by integrating the complete rotation of both organic and conventional systems. When investigating N-efficiency by the relationship between total N input and total N export, it appears that the yield of organic farms expressed as N export is equal or higher than that of conventional farms at similar total fertilization rate, although the latter generally receive larger nitrogen inputs. Most organic farms thus show a better N-efficiency and have therefore significantly lower N surplus than conventional farms, whatever the performances of the latter are calculated assessed for current practices or "good fertilization practices".

Farms having mixed livestock and crop farming structure internalizing manure for crop production appear to be the most N-efficient, with N surplus on arable land two times less on average than that of field crops farms. It should be noted that few farms specialized in the production of field crops reach a low level of N surplus (5 to 15 kg N/ha/yr), but with no sustainable nutrient management because largely depending on exogenous fertilizers.

Among the 40 organic farms investigated, more than two third were found to deliver sub-root water meeting the drinking standards of 11mgN/l. In the remaining third, we identify a combination of risk factors such as massive exogenous manure inputs coupled with a huge proportion of legume crops and clover in the rotation, and no harvest/export of high protein legume forage.

How work was carried out?

A survey of 40 contrasting organic commercial farms (face-to-face individual meetings) was carried out over the period 2011-2012 and covers the main types of farms, i.e. field crop, mixed crop and dairy.

We used the Soil Surface Balance, SSB (Oenema et al., 2003, De Vries et al., 2011), extended over a whole crop rotation cycle for a comparative analysis between conventional and organic farming of nitrogen use efficiency and impact on water resources. The N inputs accounted for are synthetic fertilizers, applied manure, grazing excreta, symbiotic dinitrogen fixation (estimated using an empirical model based on exported biomass and taking into account the contribution of residues and roots), atmospheric dry and wet depositions. Outputs are estimated as the N content of harvested crops and forage plus grazing.

Two kind of surplus were evaluated for conventional systems. The first one corresponding to current real practices was established at the administrative "départements" level, using statistics data from the French Ministery of Agriculture. The second evaluation was in compliance to regulatory requirements to achieve equilibrium in nitrogen fertilization.

The SSB was calculated on both permanent grassland and arable land. Knowing the infiltration flux we have straightforward evaluated a theoretical sub-root nitrate concentration considering that most of the cropland nitrogen surplus is leached to the aquifers and the river waters.

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Nitrogen leaching from organic agriculture and conventional crop rotations

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Implications

A great challenge to science is to elucidate how agriculture can feed the increasing world population without damaging the environment, while preserving other resources such as freshwater. In the Seine basin, characterised by intensive agriculture, most of surface and underground water is contaminated by nitrate. Conventional agriculture has regularly increased the use of industrial fertilisers since the WWII, leading to high nitrogen leaching, as shown by lysimeters or suction cup measurements. Such measurements are very scarce for other agricultural systems such as organic farming (Hansen et al. 2000; Haas et al. 2002; Mondelaers et al. 2009). The goal of our study is to investigate nitrogen leaching from organic agriculture, taking into account complete organic rotations (6-9 years). We hypothesize that leaching for organic farming is less than for conventional farming, although factors such as different practices, types of soil and age of conversion need to be taken into consideration. This work should have an impact on nitrogen sufficiency and management of organic practices.

Background and objectives

Due to the massive introduction of reactive nitrogen in the biosphere: aquifers, surface waters and atmosphere (Sutton et al. 2011), many directives for improving water quality by some changes in agricultural practices and have failed (e.g. European Water Framework Directive (2000) requiring "good ecological status" of water masses by December 2015). Long time series of sub-root crop concentrations in conventional agriculture are available for the Seine Basin, and average 25 ± 4 mg $N\text{-}NO_3.L^{-1}$ (standard for drinking water is 11 mg $N\text{-}NO_3.L^{-1}$) in different types of soil, crops and climatic conditions. However, no data still exists for organic agriculture in this area. Therefore, a scientific project supported by the Ile-De-France Region and the Water Agency of the Seine Basin has been launched in 2012. Several farms and experimental sites of arable crops have been equipped with suction cups in all their rotations, for several pedoclimatic situations, in order to determine concentrations and fluxes of nitrogen leached under complete organic rotations.

Key results and discussion

According to our first results (2011-2012), the sub-root concentrations were the highest at the beginning of the drainage period and then decreased progressively. Sub-root nitrogen concentrations in ceramic cups (N=24) have different average concentrations according to crops: 15 mg $N\text{-}NO_3.L^{-1}$ for wheat after two years of alfalfa; 7 mg $N\text{-}NO_3.L^{-1}$ for crops after legumes and 1.5 mg $N\text{-}NO_3.L^{-1}$ for alfalfa (Figure 1).

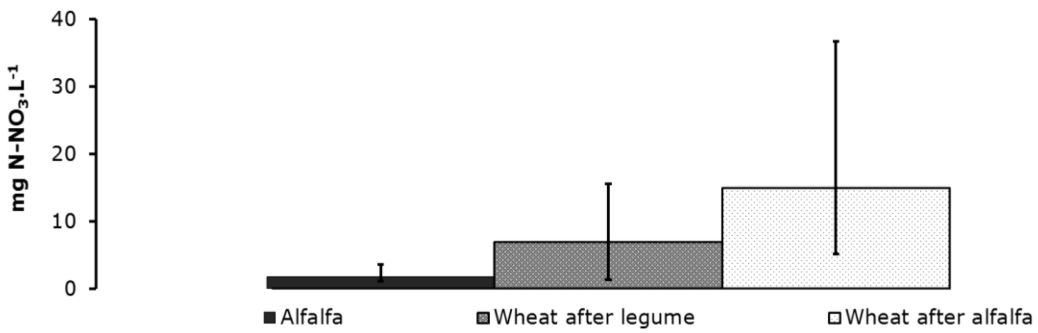

Figure 1 : Averages, minimums and maximums of nitrate concentrations in organic crops during the six months washout period (2011-2012)

Regarding legumes, this figure is in well agreement with the one mentioned for biological nitrogen fixation (Berg et al. 1999). Further results (2012/2013) will integrate all the terms of eleven rotations to determine nitrogen leached from complete rotations in different conditions (organic and conventional practices, climate and soil characteristics).

How the work was carried out?

Several farms within four pedoclimatic poles of the Seine Basin (France) were equipped for each term of their rotations with 6 suction cups set vertically to a depth of 90cm (Table 1). At this stage, 39 parcels have been studied for organic agriculture and 7 for conventional one (i.e. about 275 suction cups). After 48h under vacuum, the sub-root water is collected from the suction cups with a vacuum pump. Samples are taken once a week throughout the period of drainage (Lord et Shepherd 1993; Stopes et al. 2002; Bowman et al. 2002). Additionally, soil samples were analyzed at three soil horizons over the 90 cm, for nitrogen concentrations, granulometry and physicochemical properties. Nitrogen concentrations (ammonium, nitrite and nitrate) were determined with a colorimetric autoanalyzer (Quaatro, Bran & Luebbe, Inc.).

Table 1. Nitrate leaching equipment in the Seine Basin (France)

Period	2011-2012	2012-2013
Number of farms	2	8
Number of parcels	8	46
Number of suction cups	24	234

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Management affects nitrate leaching from organic farms

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Implications

Management decisions significantly affect nitrate-N leaching (N-leaching) from comparable organic fields. The main concern is field management during autumn and the management of grass leys. After ploughing-in fertility building crops, like grass-clover leys, effective catch crops are important during autumn and winter for at least two years on sandy soils. On farms with grazing animals the occurrence of "hot spots" should be avoided. These hot spots develop with uneven concentrations of animal manure combined with limited N-uptake in the ley. Management measures to minimize N-leaching may conflicts with the farmers aim to produce high quality feed and/or to combat yield limiting perennial weeds. It may also conflict with the organic regulations for the grazing period of cows.

Background and objectives

The Danish action plans for the aquatic environment include organic farming as one of several measures to reduce the N-leaching from cropped land. The selection of this specific measure of action is based on studies of farm nitrogen balances and scenario calculations using dynamic models. However, these calculations do not include whether a field is bare or covered by an effective catch crop during autumn and winter. And they do not include the grazing strategy and actual manure application to the leys. Both factors have major influence on the actual N-leaching risk. The aims of organic farming to optimize yield, minimize negative environmental effects and improve animal welfare lead to dilemmas because the management measures may be contradictory.

This paper, partly based on studies of Askegaard et al. (2004, 2011) and Eriksen et al. (2004, 2008, 2011), extract the most important management measures, which can reduce N-leaching further from organic farms. Also it points out the challenges and barriers for a full implementation of these measures.

Key results and discussion

Table 1 lists different managements with potential for reduction of the N-leaching. A main challenge in organic arable farming is control of perennial weeds (managements 1, 2 and 7) especially in crop rotations with a high proportion of catch crops where autumn harrowing is not possible. However, the problem can be reduced if the selection of species in the crop rotation is prioritized towards robustness including competition against weeds (Askegaard 2008). Two other major concerns are the autumn grazing of grass-clover leys on sandy soils (management 3) and the application of slurry to leys used only for grazing (management 4). Investigations have shown that it is possible to maintain autumn grazing without increases in the N-leaching provided a large grazing area (Eriksen et. al 2008). When grass-clover leys are used only for grazing, slurry should not be applied when on sandy soils (Eriksen et al. 2011). In this case slurry has resulted in increasing in N-leaching and only modest yield response.

Table1. Managements for reducing N-leaching from organic arable, dairy and pig farms, and the barriers or dilemmas that follows

	Management	Barriers and/or dilemmas
Arable farms		
1	Effective cover crops/catch crops in autumn and winter on sandy soils	Removes the possibility for mechanical weed control. Costs on seed and sowing
2	Always catch crops undersown in faba bean and lupin	Removes the possibility for mechanical weed control. Costs on seed and sowing
Dairy farms		
3	Reduced grazing period for milking cows in the autumn	Conflicts with the regulations for organic farming
4	Omit application of slurry to grazed grass-clover leys	Potassium must be imported from other sources
5	Increased age of the grass-clover ley	Yield decrease over the years
6	No ploughing-in of grass-clover leys in autumn/winter on sandy soils	No winter cereals at this position in the crop rotation
7	Effective catch crops 1st and 2nd year after grass-clover cultivation	Removes the possibility for mechanical treatment against perennial weeds
8	Avoid maize 1st and 2nd year after grass-clover	Reduces the feed quality. Increase costs on imported feed

How work was carried out?

The N-leaching was measured in two or three factorial long-term organic arable and mixed dairy field trials by means of ceramic suction cups installed at 1 m depth. Management factors like manure application, catch crops and grazing was included. The specific experimental designs are described in details in the mentioned papers.

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Optimizing nitrogen utilization by ecological recycling agriculture (ERA)

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Implications

The main purpose of agriculture is food production. There are always limited resources available for food production, thus the resource efficiency is always the key issue. The modern agriculture is using resources like external nutrients (fertilizers) and non renewable energy in large scale. The high production intensity results in high production per hectare, on the other hand it results also in serious environmental harms.

Organic farming is based on more internal and renewable resources than conventional farming. Very often it results also in lower production intensity and lower production per hectare. There is a common criticism against organic agriculture as inefficient use of land and also inefficient use of nutrients and energy per output unit.

Closer scrutiny indicates far too often, that the system boundaries and definition of production system explain the results rather than the fundamentals of different production systems. Some examples of these types of misleading factors are purchased fodder (e.g. production area and input resources for that are partly or fully ignored) and partial nutrient system, e.g. comparison between artificial nitrogen fertilizers and farm yard manure (FYM), i.e. primary nutrients and secondary nutrients (=FYM) are compared, despite of fact that no secondary nutrients exist without primary nutrients.

In this survey the whole production system is introduced and all the main nutrient flows are presented. Integration between the animal husbandry and crop production is supported by diverse crop rotation and nutrient recycling in form of FYM. High recourse efficiency is reached and environmental harms can be highly reduced by ERA-farming.

Background and objectives

There is a 3-year EU-financed Baltic Sea Region project, BERAS Implementation, where the main focus is to develop ecological recycling agriculture (ERA) aiming at to decrease the eutrophication to fresh waters and to the Baltic Sea. As a part of the project some 30 ERA-farms all around the 9 Partner countries on the Baltic Sea watershed were observed and recorded. Based on the data from Finnish ERA-farms a farm model was built up to illustrate the characteristics and fundamentals of ERA agriculture.

The main two ideas of ERA-concept are

1) the balanced ratio between the number of animals and the area of arable land, i.e. minimum 85% fodder self-sufficiency;
2) running the production system with the intensity based on the local renewable resources and the system itself, i.e. biological N-fixation (BNF), crop rotation and nutrient recycling

Key results and discussion

In the farm model the main production line is milk production, but some beef and calves for beef production are produced as an essential part of milk production. In addition about 20% of total crop yield is sold out. It reflects the average share of direct human consumption of crop yield in Finland and commonly around the Baltic Sea region. (Table 1).

Table 1. Crop rotation, yields (dry matter and nitrogen) and biological nitrogen fixation (BNF) in the farm model

		legume (d.m. kg/ha)	non-legume (d.m. kg/ha)	N-legume (%)	N-nonleg (%)	N-harvested (N kg/ha)	BNF (N kg/ha)
1. ley	red clover+timothy	2000	2000	3,5	1,5	100	100
2. ley	red clover+timothy	1600	2000	3,5	1,5	86	80
3. cash crop	barley/wheat		2200		2	44	20
4. mixture	pea+oats	1000	1100	4	2	62	50
5.undersown	barley+grass seed		2300		2	46	20

The only primary source of nitrogen into the system is based on biological N-fixation of legumes and the amount of N-fixation determines the maximum yield potential of non-legumes. BNF has been calculated with rough equation BNF = A*B*C, where A is average total content of N in legume biomass (A = 3,5%), B is proportion of fixed nitrogen in legume biomass (B =70%) and C is the proportion of harvested biomass to total biomass of legumes (C = 50%). Equation results in 4.9 kg BNF/1 t harvested legume biomass; finally, the rounded value 5,0 kg BNF/1 t harvested legume biomass has been used in the model calculations. However, some BNF is not related to harvested yield, i.e. the undersown ley and post-harvest ley. Both of them has been estimated to be 20 kg/ha BNF. Within the 5-year crop rotation the average total BNF equals 54 kg/ha. Beside BNF 5 kg/ha N as an atmospheric deposition has been added to total external input, i.e. primary nitrogen is totaling 59 kg/ha.

All the other harvested crops are used as a fodder inside the farm except cash crop yield. The amount of nitrogen in manure has been estimated to be 50 % from total content of nitrogen in fodder (25% into animal products, 25 % mainly gaseous N-losses from manure before spreading to the fields). Thus, from total harvested N-yield (68 kg/ha) about 9 kg/ha is sold in the form of cash crop and about 30 kg/ha is left in the farm as farm yard manure (FYM). This amount of manure can be spread for one crop in a 5-year crop rotation, i.e. undersown cereal receives FYM (147 kg/ha total N).

How work was carried out

The work follows the method developed by Seuri (Seuri 2002, 2008; Seuri and Kahiluoto 2005). The model is built up based on data from farms. In this case there are 9 Finnish organic farms all around southern Finland. The farms have been followed for two years (2011-2012).

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Contaminants in manure – a problem for organic farming?

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Implications

This work addresses possible ways in which animal manure might become contaminated by undesirable elements and how such manure might pose a risk to the health of soil organisms, animals, plants and humans. Research has shown that the pathways of organic compounds such as veterinary medicines and pesticides may be unpredictable and that undesirable elements can be transferred to the food chain. The basic principles of organic farming, in this case specially related to the principles of health, ecology and care, imply that special attention should be given to precaution and responsibility. These are key concerns in the management of organic farming. Taking these principles seriously, would mean a more restrictive practice on the use of animal manure from conventional farming. Through identifying which compounds might be present, their environmental properties and their residue levels in manure and environment, the authorities will be able to establish restricted practice based on knowledge.

Background and objectives

The review (Serikstad et al. 2012) came forward as a request from The Norwegian Food Safety Authority (NFSA) and The Advisory Committee for Organic Farming Regulations. The purpose of the project was to gain more knowledge concerning potential contamination of manure by undesirable elements, such as residues of veterinary medicines and pesticides or high levels of heavy metals.

Within certain restrictions, conventional animal manure can be used in organic farming when the farm's own resources do not cover the demand for plant nutrients. A survey (Holten 2012) among Norwegian certified organic farmers showed that different types of conventional manure are used for both fodder and food production. Many farmers wish to continue using manure from conventional farming. It is important for both the environment and the reputation of organic food products that this source of nutrients doesn't contain any toxic contaminants.

Key results and discussion

The sources of heavy metals in manure are mainly the fodder but also drinking water, bedding and the fixtures where the farm animals are kept. Manure from pigs and poultry can contain amounts of copper (Cu) and zinc (Zn) at levels that reduce the quality and affect its usage according to Norwegian regulations for organic fertilisers. This might apply to manure from other animals and other heavy metals as well.

Residues of veterinary medicine can be found in animal manure (Jacobsen and Halling-Sørensen 2006, Martínez-Carballo et al. 2007). These residues can be taken up by plants and localised in different parts depending on the plant species and the type of medicine (Boxall et al. 2006, Eggen et al. 2011). Special attention should be given to veterinary medicine used as prophylactic treatments for the whole herd. The decomposition time of organic compounds in the environment, including potential residues of medicines or pesticides, will be prolonged in the cold, Nordic climate compared to a warmer climate.

Residues of certain herbicides in manure and compost have been found to give crop failure or deformation. Particular consideration should be given to persistent pesticides. Pesticide residues can reduce the quality of commercial manure and compost and cause problems for the companies who sell these products.

Conventional manure is used in organic farming in Norway. The manure can come from parallel production on the farm, conventional farms or as commercial fertilisers. Usage is restricted based on the amount of nitrogen. As yet there are no special restrictions regarding levels of contaminants in animal manure from one's own or imported conventional manure. Commercial fertilisers based on conventional animal manure are regulated through the general governmental regulation for fertilisers. This only specifies levels for heavy metals. For other potential contaminants such as veterinary medicines or pesticides, the regulation only requests precaution so products won't contain such substances at levels that might pose a threat to health or the environment.

Both the literature review and contact with relevant research and advisory institutions in Europe shows that there is a need to investigate the topic further. There is a lack of documentation on residue levels of veterinary medicine and pesticides in animal manure. Furthermore, when the risk compounds are detected, there is a need for knowledge related to these compounds' dissipation rate, and particularly their potential for transfer to plants. Since there are no analytical methods established for many of the relevant compounds in environmental matrixes, establishing this and performing a screening of potential risk compounds in different manures after medicine treatment should be the very first step. Those who make standards for use of manure in conventional and organic farming need more knowledge to make better decisions.

How work was carried out?

The work was carried out through a literature review and through contact with researchers, governmental authorities, organic certifying organizations and organic farmer organizations, mainly in the Nordic countries but also in other European countries.

A Nordic workshop for researchers, control bodies, advisers and government administration was arranged. The aim of the workshop was to exchange knowledge, establish a Nordic network and to discuss the need for future research on a Nordic level.

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Ashes for organic farming

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Implications

Nowadays only eight percent of the cultivated field area is used for organic farming. The Ministry of Agriculture and Forestry has published the guidelines for the program of organic farming to diversify the supply and the consumption of organic food. The aim is to increase organically arable land to 20% by the year 2020.

The demand of organic fertilizer products is strongly increasing. Interest in forestry by-products (ash, bark, zero fiber, etc.) for use in organic production has recently been exceptionally high. For example, development of pelleted fertilizers with zero fiber, ash and a nitrogen-containing fertilizer material is in progress.

The ash fertilizer contains many valuable nutrients in fairly optimal ratios: these include phosphorus, potassium, manganese, magnesium, sulfur, zinc, calcium, boron, cobalt, copper and smaller amounts of other trace elements. Ashes contain phosphorus in large amounts, which is useful in organic production. More important nutrients than phosphorus and potassium are apparently trace elements. Neutralizing value of the ash is quite rapid compared to many liming materials allowed in organic farming. The price quality ratio of ash as a liming material is also good.

The use of clean wood ash is permissible in organic production. Peat and straw ash cannot be used in organic production because of the fact that in the EU peat is not considered a renewable resource. Restrictions include only inputs from outside of the organic farm.

Background and objectives

Ash suitable for organic farming is little available In Finland. It constitutes mainly from grate boiler bottom ash. There are many ash products in which harmful metals are below allowed maximum limits, but very often they contain peat. For that reason they are not suitable for organic farming.

In wood ash cadmium rarely falls below the limit value of 2.5 mg/kg of dry material, because bark is mainly used in the combustion. Cadmium accumulates in the bark.

Evira controls ash products from power plants. In 2007 the suitability of ash for use as fertilizers as well as the quality and the reuse applications of ash were investigated. 21 ash samples proved suited for fertilization of fields, 33 ash samples only for fertilization of forests and 12 ash samples were banned from use as fertilizer due to high levels of harmful metals.

Evira's registry "*Fertilizers and soil conditioners suitable in organic production*" contains ash products from only four manufacturers.
Since the year 2007 ash samples qualified to field fertilization included also samples which would have qualified to organic farming. To promote organic farming in Finland we should inform and encourage manufactures to register more products to organic ash fertilizers.

Table 1. Trace metals in organic ashes from the years 2007 -2011

Ashes	Arsenic	Mercury	Cadmium	Chromium	Copper	Nickel	Zinc
Allowed Maximum value	25 mg/kg dm.	1,0 mg/kg dm.	2,5 mg/kg dm.	300 mg/kg dm.	600 mg/kg dm.	100 mg/kg dm.	1500 mg/kg dm.
Product 1	0,5	0,01	1,9	15	50	16	830
Product 2	2		1,6	28	87	26	348
Product 3		0,01	1,4	113	37	28	220
Product 4	1	0,01	2	24	99	22	340
Product 5	17	0,28	0,7	60	68	33	160
Product 6	5,2	0,38	0,6	85	320	64	100
Product 7	14	0,25	1,5	49	44	26	520
Product 8	20		1,3				
Product 9	0,58		2,2	9,4	80	40	950
Product10	17		0,85	33	39	19	440

Key results and discussion

We have analyzed the harmful metals in the ash samples and indeed, heavy metals often limit their use. Also nutrients and neutralizing values are analyzed. Our samples included ashes registered as organic fertilizer products as well as other ash fertilizers used at conventional agriculture. The aim of our work was to ensure the quality of organic ash fertilizers and compare the differences between ash products.

Procedure

ICP-MS and ICP-OES- techniques and microwave dissolution with nitric acid and hydrogen peroxide were used to analyse 13 elements from ash (wood, peat and plants) fertilizers.

Evira method 8129, EPA Method 3050B and 3051A

Neutralizing value was analyzed according to SFS-EN 12945.

The Chemistry and Toxicology laboratory in Evira is accredited according to ISO 17025.

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The impact of conversion to ecological recycling agriculture (ERA) on farm nitrogen budgets and production levels

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Implications

The data used in this study is collected under BERAS Implementation project from ERA-farms in Finland in 2010 to 2012 (three years averages) and from three different production lines on ERA farms: beef, egg and milk. The data indicates the production level, the products sold and feed and other supplements purchased on the farm each year. Accordingly it has been calculated A) how much area B) how much other inputs (e.g. nitrogen and phosphorus) is needed to maintain the production level. Based on these calculations it makes possible to estimate how much of these nutrients are recycled on the farm, how much of the used nitrogen is based on biological nitrogen fixation and how much non-renewable resources have been needed. This makes it possible to calculate the output-input ratio of nitrogen.

Three case examples (*):

1. A beef and lamb production ERA-farm produces yearly 1100 kg N in products, which means 12 kg N /ha, without buying any N outside of the farm. If this same farm was conventionally driven, it would produce 1400 kg N /year in products, but it should have to buy 6500 kg N in fertilizers. This would mean that the nitrogen balance would be 63 kg /ha negative.

2. An ERA farm with 10 000 laying hens and 55 ha own fields. The production level is 140 000 kg eggs annually, which contains 2500 kg of nitrogen. This amount of hens requires 490 tons of cereal-pea mixture, of which 115 tons are produced on the farm. The total production area of 305 ha does not include the area required to produce feed concentrate (70 tons, which contains 3850 kg N), but 110 ha green manure area for the crop rotation. The total production of N is -1350 kg N /year and - 4,5 kg N /ha. Conventional farms get average yields of 3200 kg cereals /ha for which they need 153 ha cereal area as well as 70 tons of concentrate in order to feed 10 000 hens. But on these 153 ha is used average 80 kg of nitrogen/ha, which makes 12 250 kg N /year. Including the concentrate, the farm balance is 98 kg N/ha is negative on egg production.

3. An ERA farm with milk production has 61 ha of own field area and 70 lactating cows and young cattle, altogether 100 animal units. Milk production farm works in co-operation with three organic plant production farms, which have 150 ha fields. This means 211 ha of field area are needed yearly for feed production. The farm produces 22690 kg meat and 636000 kg milk, which contains nitrogen 700 kg in meat and 3500 kg in milk annually. The incoming nitrogen flows in the form of feed additives are 2300 kg yearly. Net N-production is 1900 kg N, which is 9 kg N /ha yearly. If the mentioned farm would be a conventional farm, it would need only 150 ha arable land to get all needed hay and cereal and also pastures. However, conventional milk farms in Finland use approximately 130 kg N /ha and it is 19500 kg N to 150 ha area and besides that same amount concentrate as is used on this ERA-farm. So the nitrogen balance should be negative.

Background and objectives

There is increasing concern about the dependence of agricultural food production on mineral fertilizers (especially N and P) and other agrochemicals, because these inputs are associated with significant negative environmental impacts, reduce the sustainability of crop production systems and negatively affect future food security (Bartlett 1998, Cordell 2009, Tilman 2002). Ecological Recycling Agriculture (ERA) is organic agriculture based on local and renewable resources with an integration of animal and crop production (Granstedt et al 2008). This way a large part of the nutrient uptake in the fodder production is effectively recycled. This in effect means that each farm (or farms in close proximity) strives to be self-sufficient in fodder production (min 80 % own fodder) which in turn limits animal density and ensures a more even distribution of animals to most farms.

As in organic production generally no artificial fertilizers and pesticides are used in ERA model. However, it provides a system in which the recycling of nutrients is more effective, either within one/a farm or as a result of co-operation of a few farms located nearby. Consequently the input-output ratio is better in balance compared to conventional farms (Granstedt et al 2008).

Key results and discussions

The study of the three ERA-farms demonstrates, that the ERA-model enables a better input-output balance in N compared with conventional farming methods. It has however to be considered that implementing the ERA-model the field areas have to be larger than in conventional production, if the meat production and consumption stays at the present level. Another important factor is NUE (nitrogen use efficiency), which demonstrates the synchrony between N supply and crop demand (Cassmann 2002). The farm cases indicate that ERA-farms could have quite high NUE values because the yields are quite high in relation to the low inputs.

ERA-farms are using only recycling organic fertilizers, which are made from manure and crop residues in the farm. They increase the inherent fertility of soils, when used repeatedly over many years. Future food security is likely to depend on reducing the reliance on mineral fertilizer inputs yet maintaining and/or increasing current levels of productivity in crop production, because the production of mineral fertilizers relies on non-renewable resources. The main strategy available to replace mineral fertilizer use is to recycle a larger proportion of nutrients which are removed from soils as crops and livestock products back into agricultural soils. This will have to be based on the efficient recycling of agricultural, food processing and domestic organic waste.

(*) Conventional farm figures are statistical averages from Tike, Information Centre of the Ministry of Agriculture and Forestry In Finland

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In crop rotation green manures as winter cover crops enhance ecosystem services of farming

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Organic farming systems should be characterized by excellent soil fertility management to keep plant nutrient cycles short and as closed as possible.

Therefore, it is extremely important to establish growing systems that have rotations with appropriate crops and intercrops to ensure fertile and biologically active soils, to enhance biodiversity and to provide high quality crop yields. Locally available organic fertilizers include green manures and animal manure. The influence of green manures as intercrops and these combined with composted cattle manure on soil properties, biodiversity indicators and crop yields was studied in a crop rotation experiment in three organic systems at the Estonian University of Life Sciences.

In a five-field crop rotation experiment, winter wheat, peas, potato and barley undersown with red clover and red clover were grown in succession. System Org 0, as control, follows this rotation. In System Org 1, green manures as winter cover crops are used: after winter wheat – ryegrass, after peas – winter oilseed rape and after potato – winter rye. In System Org 2 green manures plus cattle manure at 40 t/ha was applied. Thus, in both Systems Org 1 and 2 all plots had green plant cover in winter.

After the first rotation the following tendencies have been observed.

Under the influence of green manures (Org 1) and when these were combined with cattle manure (Org 2) organic carbon (from 1.26 to 1.43%), potassium (from 13.64 to 14.61 mg/100g) and phosphorus (from 9.88 to 10.25 mg/100 g) contents of the soil and its pH level (from 5.86 to 6.10) increased. Also, microbial hydrolytical activity (from 43.1 to 52.7) increased significantly indicating soil life activation and some physical properties (water holding capacity etc.) improved.

Biodiversity indicators – ground beetles and weeds – were also influenced by organic manures. Ground beetles play an important role in pest control and their abundance was significantly higher (1.4 times) in systems with green manures, which apparently act as refuges offering them places to hibernate. The species diversity of weeds was dependent on the green manure crop – the greatest number of different weeds was in ryegrass and also in the following pea crop. The best suppressor of weeds was winter rye (Org 1 and 2).

Yields of barley and winter wheat increased under the influence of green manure and significantly when it was combined with cattle manure (according yield increase in barley 0.73 t/ha and 1.43 t/ha in winter wheat). In all crops, yield quality was dependent on the organic manures used (Org 1 and 2). Depending on the crop there were differences in metabolomics, microbiological parameters and in contents of single chemical components.

Thus, the first rotation is already showing that the use of green manures as intercrops covering the soil during winter brings multiple benefits for ecosystem services. Green manures offer supporting services, such as nutrient cycling and soil formation. They offer a regulating service with promotion of beneficial insects for pest control. They offer provisioning services such as good quality food products.

Acknowledgment

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Clover fatigue – a reason for precaution in organic farming?

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Implications

Different species of fungi and nematodes cause clover fatigue. The literature review shows that there is a lack of knowledge about the status of clover fatigue in Norway. Samples from fields with clover/grass ley on organic farms in Norway demonstrated the presence of plant parasitic nematodes (Serikstad and De Boer 2013).

High densities of fungi and nematodes can impair the growth of legumes. Intensive use of clover in organic farming systems and a warmer climate are factors that indicate a need for attention to increased occurrence of diseases and pests in clover (Brandsæter et al. 2006). Problems with growing legumes will influence the nitrogen supply and economy in organic farming negatively.

Background and objectives

Before chemical fertilizers were widely used, different clover species were common in leys and clover fatigue was a serious problem. In the Nordic countries, Stem nematode (*Ditylenchus dipsaci)* was a wide-ranging problem. Plant breeding then focused on nematode resistance. Nowadays, there is little awareness about clover fatigue. Lately, no systematic surveys have been done regarding the situation in Norway.

Legumes, such as clover, provide a major source of nitrogen in organic farming systems, and help to maintain soil fertility. Organic farming systems have been intensified in the past ten years. On a number of farms the crop rotation mostly consists of grass/clover leys. Recently some farmers have noticed a decrease in the amount of clover in the ley, and even a reduction of the total harvest.

The intention of the preliminary study was to provide knowledge about the situation of clover fatigue in organic farming in Norway and to collect knowledge on how they cope with the problem in neighboring countries.

Key results and discussion

Both fungi and nematodes can cause clover fatigue. Few cultivars are resistant to these organisms, so knowledge on the occurrence of fungi and nematodes is essential for effective crop rotations.

In soil from 6 farms the following groups and species of plant parasitic nematodes were detected (Table 1): Stunt nematodes (*Tylenchorhynchus dubius*, *T. maximus* and *Merlinius* sp.), spiral nematodes (*Helicotylenchus canadensis*, *H. pseudorobustus* and *Rotylenchus* sp.), root lesion nematodes (*Pratylenchus crenatus* and *P. fallax*), ring nematodes, pin nematodes (*Paratylenchus* sp. and *P. bukowinensis*), needle nematodes (*Longidorus elongatus*), stubby root nematodes (*Paratrichodorus pachydermus*) and cyst nematodes (*Heterodera trifolii*). Root lesion nematodes occurred in all farms (8), followed by ring nematodes (7), stunt nematodes (6), pin and stubby root nematodes (5), clover cyst nematode (4) and ring and needle nematodes (1). Stem nematode (*Ditylenchus dipsaci*), which was common in the past, was not detected. *Heterodera trifolii*, occasionally related to clover fatigue, was present in 50% of the samples. In a first year ley with damage in red clover, *H. canadensis* occurred in the remarkable high density of 1320 ind./250 ml soil. In one farm trichodids (including *Paratrichodorus*) reached 100 ind./250 ml soil. Even in the samples taken from fields where clover thrived, pathogenic nematodes were present. Not all of the nematodes found are known to be pathogenic to clovers, but *L. elongatus, P. bukowinensis* and the trichodorids can multiply on clover and damage following crops like strawberry, carrot and celeriac.

We wish to continue the work with clover fatigue, focusing on mapping of occurrence, organisms involved, economic damage threshold of the pathogens involved and preventive actions to avoid problems. Co-operation with researchers and advisers in Nordic and Baltic countries are most welcome.

Tabel 1. Numbers of different nematode groups in samples of 250 ml soil from six Norwegian organic farms

Farm no.	Stunt nematodes	Spiral nematodes	Root lesion nematode	Ring nematode	Pin nematodes	Needle nematodes	Stubby root nematodes	Cyst nematodes
1	0	1320	0	0	0	0	0	0
1	4	106	6	0	0	0	0	2
2	0	265	144	0	0	0	0	0
2	0	124	213	0	0	0	0	0
3	0	3	29	0	30	0	8	8 cysts
3	0	57	5	1	12	0	2	0
3	0	4	0	1	0	0	0	1 cysts
3	0	35	0	0	0	0	14	1 cysts
4	13	0	130	0	10	10	15	1 cysts
4	93	0	42	0	0	6	0	0
4	35	0	33	0	0	8	0	-
4	97	0	8	0	0	3	0	-
5	12	262	50	0	58	0	1	16 cysts
5	56	5	118	0	6	0	0	0
6	11	420	27	0	73	0	7	0
6	17	9	20	0	0	0	100	0

How work was carried out.

We made a literature review about possible pathogenic organisms and how the situation is regarding clover fatigue in other countries. Researchers and advisers in Sweden, Denmark and Holland were asked how they cope with the problems in their countries. Advisers in organic farming were asked to take samples of soil and clover plants from fields they considered relevant for analyses. The samples were only analyzed for nematodes. Samples were also taken from fields where clover thrived.

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Plant Parasitic nematodes – problems related to clover and organic farming

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Implications

Organic farming puts new and exciting challenges to the science of nematology. The occurrence of plant parasitic nematodes in organic farming systems needs to be investigated further. Good management strategies for nematodes should include monitoring of the composition and density of nematode populations. This would allow for increased yields and better sustainability of organic farming.

Background and objectives

Out of the more than 20 000 nematodes described, some 4000 species are parasites of plants. Plant parasitic nematodes have a mouth spear (stylet) to puncture plant cell walls, and inject secretions, which changes plant physiology and facilitates food up-take by the nematodes. Some species feed only on the outer tissue of the root system, while others penetrate deeper into roots where they may induce permanent feeding sites.

In organic farming the use of clover and other nitrogen fixating legumes is important for securing appropriate nitrogen levels. Clovers are excellent hosts for many plant parasitic nematodes. Observations in Germany indicate that problems with plant parasitic nematodes may arise after a 5 years period of organic farming (Hallmann *et al*. 2004).

The objective of this paper is to draw attention to plant parasitic nematodes as pathogens in organic farming. Their importance in clover and in subsequent crops, and the kind of symptoms they induce will also be presented.

Key results and discussion

Several nematodes thrive on clovers (Table1). Stem nematode (*Ditylenchus dipsaci*) is a well-known example, but also potato rot nematode (*D. destructor*), spiral nematodes (*Helicotylenchus* and *Rotylenchus*), root lesion nematodes (*Pratylenchus* spp.), clover cyst nematode (*Heterodera trifolii*), root-knot nematode (*Meloidogyne hapla*), stubby root nematodes (*Trichodorus* and *Paratrichodorus*) as well as needle nematode (*Longidorus elongatus*) are known to occur and may be frequent. Stem-, spiral-, clover cyst– and root knot nematodes may cause serious damage.

A number of species occurring in clover may cause damage in crops following clovers in rotations (Table 1). Stem nematode may damage strawberry, potato rot nematode may damage potato and carrot, root lesion nematodes may be pathogenic (*Pratylenchus* spp.) on all crops listed in table 1, *Meloidogyne hapla* on carrot, and, stubby root nematodes (*Trichodorus* and *Paratrichodorus*) on potato, sugar beet and carrot, and needle nematode *Longidorus elongatus* on carrot and strawberry are important pathogens.

Some nematodes damage certain crops irrespective of clover being a pre-crop (Table 1). Leaf nematodes (*Aphelenchoides* spp.) in strawberry, pin nematode (*Paratylenchus bukowinensis*) and carrot cyst nematode (*H. carotae*) are devastating in carrot. *M. naasi* damage certain cereals, potato cyst nematodes (*Globodera rostochiensis* and *G. pallida*), and beet cyst nematode (*H. schachtii*) are serious pests in the respective crops. Cereal and rye cyst nematodes (*H. avenae* and *H. filipjevi*) may cause considerable damage in cereals.

Table 1. Plant parasitic nematodes which are likely to cause damage in organic farming in the Nordic area. X = occasional; XX=frequent; XXX = frequent with high damage

NEMATODE	CLOVER	CEREALS	POTATO	SUGAR BEET	CARROT	STRAWBERRY
Stem nematode	XX					X
Potato rot nematode	X		XX		X	
Leaf nematode						XXX
Stunt nematode		X				
Spiral nematodes	XX					
Root lesion nematode	XX	X	XXX	X	XXX	X
Pin nematode					XXX	
Beet cyst nematode				XXX		
Cereal cyst nematode		XXX				
Rye cyst nematode		XXX				
Clover cyst nematode	XX					
Potato cyst nematode			XXX			
Carrot cyst nematode					XXX	
Root knot nematode	XX	X			XXX	
Stubby root nematode	X		X	XX	XXX	
Needle nematode	X				XX	XXX

Nematode damage usually appears as oval patches of poor growth. Symptoms depend on nematode species and host. Stem nematode causes basal swellings in clover, twisted leafs and necrotic bulbs in onion. Leaf nematodes induce deformed leafs and stalks in strawberry. *P. bukowinensis*, *L. elongatus* and *M. hapla* cause forked, fingered and split roots in carrot. *D. destructor* and *P. penetrans* induce rots and cracks in the same plant. Root lesion nematodes often cause oval brown lesions on roots, but also cross-cracks in potato tuber skin (Holgado *et al*. 2009). A typical sign of cyst nematode attack is the bushy root system to which soil tends to adhere. Root-knot nematodes induce root galls of various shape. In strawberry *L. elongatus* causes typical hook-like root tip galls.

Upon detection of these types of symptoms it is recommended to take soil samples for nematode analysis. Carrot is highly vulnerable for nematode attack. The small plants and severe reduction in the marketable yield is now an increasing problem in organic farming.

How work was carried out

Information has been collected from the literature, complemented by general knowledge on nematode occurrence, pathogenicity and recorded field damage in Norway and elsewhere.

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Opportunities and limitations in use of clovers as N-source in organic farming systems in Norway

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Implications

From an economic as well as ecological point of view, transfer of clover N to the subsequent growing season should be maximised and the risk of environmental pollution minimised. It is very important in organic farming. Detailed studies on white clover lifespan indicated that the foliage is a main source of readily plant-available N as the leaves are short lived. However, the leaf N is largely lost from the plant foliage during the cold season. The risk of loss may probably be reduced by using winter-hardy cultivars that tend to reallocate resources to stolons and roots which are more persistent than leaves.

Background and objectives

Clovers and other legumes are crucial for nitrogen (N) supply in organic farming systems. About 80% of clover N is derived from the atmosphere and is incorporated into clover biomass through symbiosis with *Rhizobium* bacteria. In field in Norway, this N fixation might account for 20 to 175 kg N $ha^{-1}year^{-1}$ (Serikstad et al. 2013) that is essential input of clover-derived N to the soil-plant system. Moreover, the accumulated total N in plant material returns to the soil via the turnover of plant parts or via grazing animals. Amount of clover in the field is also decisive for the protein content and general quality of the forage produced. One of the major problems in maintaining a desired content of clover in grassland is the seasonal and annual variation in performance. Unfavourable management regimes in the previous year might result in poor development of storage organs and low nitrogen and carbohydrate reserves. Clover is sensitive to climate with low temperatures and poor growth can lead to winter damages. Studies have shown that white clover leaves can lose between 57 and 74% of their N between autumn and the following spring independently of harvesting regime during the growing season (Sturite et al. 2006). For the first this may reduce N transfer to the subsequent growing season (Korsæth et al., 2002). For the second, this may have a substantial impact on the risk of nitrate leaching and loss of nitrous oxide because net N mineralisation from dead plant material may be significant even at the winter temperatures prevailing in northern soils (Cookson et al. 2002). Considering that clover is widely used in crop rotations, particularly in organic farming, overwintering of green plant parts may be difficult under northern climatic conditions and can result in pollution hazards.

The objective of the present paper is to evaluate clover as N source during the growing season and clover availability to conserve N throughout the winter under northern climate.

Key results and discussion

The short lifespan of leaves (Table 1) indicated their potential importance as a nitrogen source. Stolons and roots were much less dynamic than leaves during the first growing season. By the end of the second growing season, turnover of stolons and roots increased (Table 1). Thus, dead stolons and roots contributed substantially more to N deposition in the soil in the second than in the first growing season. However, N largely might be lost from the plant biomass during the winter. The winter losses varied greatly (from 14% to 80%) due to different climate conditions during the winter. The amount of inorganic N in soil after snowmelt and mineralization of white clover-derived N during the spring was small. This can lead to negative N balance in the farm, particularly for stockless organic crop rotations with clover-grass fellow and/or postharvest green manure. In the experiment on N recovery, an average of 34% of the foliage N losses (for four years) was found in seepage water. This indicates a risk of surface water pollution in particular if snowmelt happens on frozen soil. Moreover, losses of N from the plant material might result in nitrous oxide (NO_2) emission and contribute to global greenhouse gas accumulation and to stratospheric ozone depletion. Measurements of N_2O emissions during the winter indicated that pure clover stands containing both white and red clover had significantly higher gaseous losses in form of N_2O than pure grass stands. These losses recovered, however, only 2% of the foliage losses during the winter. This suggests that N might be immobilised by a cold-adapted microflora. Brooks et al. (1998) demonstrated that microbial immobilisation under snow appeared to be a primary mechanism controlling N flows during snowmelt.

Table 1. N content (g/m^2) in white clover plant parts in autumn and turnover of marked white clover leaves, stolon and root segments during the first and second growing season (% of dead plant parts by late autumn in the first and second growing season)

Plant parts	N content in autumn	Turnover during the first growing season	Turnover during the second growing season
Leaves	6	61	59
Stolons	10.8	0	23
Roots	2.1	9	54

How work was carried out?

Experiments were carried out four consecutive years (2000-2004) at Apelsvoll Research Centre in Southeast Norway. Detailed descriptions of the methods are published by Sturite et al. (2006, 2007a, 2007b). Gaseous emissions were measured at Tjøtta Reseach Centre in northern Norway from October 2011 to May 2012 by manually closed chambers.

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Profitability of organic and conventional dairy production with different dietary proportions of high-quality grass silage

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Implications

Profitability in milk production was calculated using diets with three different proportions of high-quality grass silage. The treatments consisted of the same feeds, but differed in the dietary proportion of forage: low (L), medium (M) and high (H), representing one conventional and two organic diets. The calculations were based on results in feed intake and milk production from a large dairy cow experiment. In the calculations, three different districts with different conditions for farming were used as models, and calculations were performed on two different herd sizes. In addition, current financial supports were both included and excluded in the calculations. The results showed only minor differences in profitability between using in average 60% or 70% of dry matter (DM) of silage in diets used in organic production. In conventional production, it was profitable to increase the average dietary proportion of silage from 50% to 60% of DM when the prices of concentrate and grains were as high as at the present. The results showed clear economic benefits of increasing the proportion of high-quality silage in conventional Scandinavian dairy cow diets up to levels similar to the standards of the organic production system.

Background and objectives

The feed costs constitute a large part of the dairy farmers' total expenses both in organic and conventional production systems, and it is important to find alternative feeds or diets that can be produced at lower costs. The price of grains is currently high, and has been fluctuating over the last few years, making it an erratic cost item for the farmer. Therefore, high-quality forage is likely to have a large economic potential in future milk production systems. The main objective of the present study was to relate the results from a dairy cow experiment with different proportions of grass silage in the diet (Patel 2012), to the profitability in dairy production. To make the economic assessments more applicable to on-farm situations, calculations were performed using three different districts with different conditions for farming: a plains district in the south of Sweden (SP), a forest dominated district in the southern part of Sweden (SF) and a forest dominated district in the north of Sweden (NF). The economic support from the European Union (EU) is high in the forest dominated districts due to fewer opportunities for agriculture and due to the interest in maintaining an open varied agricultural landscape. Calculations were also performed on two different herd sizes in order to investigate the impact of scale. Furthermore, financial supports were both included and excluded in the calculations to show a wide range of alternatives.

Key results and discussion

The most striking result was that it was only the organic production that reached full cost coverage, i.e. revenues ≥ expenses. The differences in profitability between diet M and H were small in organic production. Diet M performed slightly better compared with diet H in all districts and herd sizes except in the NF district with the support, where it was more profitable to use diet H. This result was probably due to higher price on concentrates in the northern part of the country. Cultivation of grains in the north is challenging due to the short vegetation period. In contrast, the conditions for cultivation of leys are favourable in the north. Maximum profitability in organic production with support was shown with 160 cows in the NF district, and without the support with 160 cows in the SP district. The results showed that overall there were large benefits in economies of scale with higher profitability using 160 cows over 80 cows in production. The benefits of larger herds are associated with less labour hours and lower building costs per cow/year and greater milk price because of large volumes of delivered milk. In conventional production, diet M showed maximum profitability and diet L minimum profitability in all districts and herd sizes both with and without support. The main results also reflect the high costs of housing the animals and the high costs of labour in Sweden, as well as the strong dependency of financial support by the farmers.

How work was carried out?

In the animal experiment, 92 cows were used, randomly assigned to one of three diets that differed in forage proportion. During the first 12 weeks of the lactation, the cows were fed grass silage *ad libitum* and the amount of concentrate was adjusted to meet the target proportion of forage of 40% in diet L representing a conventional diet, and 50% in diet M and H representing two different organic diets. From lactation week 13 until drying off, the forage proportions were gradually increased as lactation proceeded to eventually reach 50%, 70% and 90% in diet L, M and H, respectively. The results from the animal experiment showed similar milk yields on diet L and M, but significantly lower yield on diet H. The milk composition was not significantly different among the diets, although the fat content increased with increasing forage proportion (from 4.3% to 4.5%). Higher concentrations of unsaturated fatty acids, which are beneficial to human health and tend to give e.g. more spreadable butter, are often shown in high forage diets. An important prerequisite for the similar results in milk yield on diet L and M was the high nutritional quality of the grass silage when replacing concentrate with forage. The profitability of milk production was expressed as incomes minus expenses per cow and year on each diet and mainly based on regional enterprise budgets from the Swedish University of Agricultural Sciences (Agriwise 2012). Supports from the EU (environmental payment for cultivation of leys, support for less favoured areas and payment for organic production) were both included and excluded in the calculations.

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Forage legume silage and cold-pressed rapeseed cake for dairy bull calves

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Implications

Rearing of organic dairy bull calves can be contradictory, using calves with a high need for quality protein at the same time as a high intake of forage (>60% up to 6 months of age) is required. Forage legumes contain more crude protein than grass, but with high rumen degradability of the protein. When legume forage is fed together with energy-rich cold-pressed rapeseed cake (CRC) the protein in the feeds can be utilized to a higher extent and a satisfactory calf weight gain can be achieved as shown. Using locally produced protein feeds instead of the often used soya bean meal (SBM) is of great interest not only in organic but also in conventional feeding because of environmentally advantages.

Background and objectives

Organic production aims at feeding high levels of forages to ruminants. Calves need high concentrations of protein with high protein quality in their feed ration for proper growth. Forage and grain legumes as well as rapeseed products can be used. Forage legumes have many advantages, not at least environmentally, but feeding forage legumes only may result in low weight gain as the protein in forages have a high proportion of rumen degradable protein. However, feeding forage legume silage has been shown to increase dry matter intake (DMI) and an accompanying higher live weight gain (LWG) in growing cattle compared to grass silage (Dewhurst et al. 2009). Soya bean meal is widely used in the world as a protein feed of good nutritional quality but the ethics around the cultivation of the beans are often questioned and, furthermore, hexane extracted soya beans are not allowed in organic production. The objective of the study was to compare DMI, LWG and feed efficiency (FE) in calves fed two levels of forages with high inclusion of red clover together with rapeseed cake vs. soya bean meal.

Key results and discussion

Feeding clover/grass silage with a small amount of CRC (CGRS) resulted in lower DMI, LWG and FE than feeding a greater amount of CRC (CGRG) or the SBM diet (Table 1). Feeding the calves CGRG gave the same DMI as the SBM diet, but lower LWG and FE. The intakes of metabolisable energy (ME), crude protein (CP) and neutral detergent fibre (NDF) were the same for CGRG and SBM calves but the intake of NDF in percentage of live weight was higher for the CGRG calves, which might have reduced their total intake in comparison to the SBM calves. The diets in the trial were not balanced to be isonitrogenic as we wanted to test the possible weight gain with feeding high levels of forage, and the forage percentage was 54, 66 and 84 for the SBM, CGRG and CGRS calves, respectively. The forage level in CGRG is consistent with organic standards and the daily LWG was just 0.13 kg lower with rapeseed cake and clover/grass silage as the only protein source, than the LWG in SBM calves.

The fact that calves fed CGRG had the same intakes of ME and CP as SBM calves, but lower LWG, is probably due to the high CP degradability in the rumen of the clover/grass silage. Feeding greater amounts of CRC gave a higher LWG than when calves were fed small amounts of CRC and it is possible that the rumen microbes of the CGRG calves produced more microbial protein that could be enzymatically degraded and absorbed in the small intestine. Feeding energy and protein at the same time is a way to optimize the protein utilisation (Børsting et al. 2003). In the present study total mixed ration feeding was used and thus energy and protein were offered simultaneously. Also, if the CP concentration in the clover/grass silage had been higher the LWG probably had been higher. Rumen function, health and profitability of the calves will be analysed. A new set of calves will be studied in 2013 to find the optimal combination of forage legume silage, CRC and field beans.

Table 1. Average daily intake, average daily live weight gain and feed efficiency of bull calves fed diets containing either clover/grass silage with smaller amount of cold-pressed rapeseed cake (CGRS), clover/grass silage with greater amount of cold-pressed rapeseed cake (CGRG), or soya bean meal (SBM), means and standard error of the means (SEM)

	CGRS	CGRG	SBM	SEM	*P*[1]
Intake of dry matter, kg day^{-1}	3.95a	4.94b	4.99b	0.141	***
Intake of dry matter, % of live weight	3.12a	3.02a	2.83b	0.048	**
Intake of NDF, kg day^{-1}	1.45a	1.74b	1.77b	0.048	**
Intake of NDF, % of live weight	1.11a	1.03b	0.97c	0.016	***
Intake of ME, MJ day^{-1}	45.6a	60.8b	63.1b	1.76	***
Intake of crude protein, g day^{-1}	581a	722b	778b	22.5	***
Live weight gain, kg day[1]	0.717a	1.147b	1.279c	0.044	***
Feed efficiency, g gain MJ^{-1} ME	15.7a	18.9b	20.2c	0.29	***

[1]** $P < 0.01$, *** $P < 0.001$, values on the same row that are significantly different ($P < 0.05$) have different superscripts (a, b, c)

How work was carried out?

The experiment was carried out at Götala Beef and Sheep Research Station, Swedish University of Agricultural Sciences (SLU), Skara. Dairy bull calves (79 Swedish Red and Swedish Holstein) were used in a randomized design. The protein feeds studied were red clover (*Trifolium pratense*)/grass silage (50% each) combined with either smaller amounts of CRC (treatment CGRS; 0.20 kg per animal and day) or greater amounts of CRC (treatment CGRG; 0.46 kg per animal and day), which were compared to imported SBM. The DMI and FE were recorded at a pen level (four pens, each with seven calves, per treatment) while LWG was recorded on the individual calves. The calves were weighed regularly and averaged 94 kg in live weight at the start of experiment, and ended simultaneously at 202, 267 and 290 kg for CGRS; CGRG and SBM, respectively. A total mixed ration consisting of grass silage (90% grass, 10% clover), rolled barley and vitaminised minerals, together with either CGRS, CGRG or SBM, was fed to the calves. Feed was offered *ad libitum* once a day. Diets were rebalanced four times according to changed nutrient requirements during time and subsequent increased live weight. Nutrient composition in DM of the grass silage (124 g CP) the clover/grass silage (144 g CP) and concentrates (CRC 330 and SBM 523 g CP, respectively) were analysed by conventional methods. Analyses of DMI and FE were done with PROC GLM and the model included treatment, whereas PROC MIXED was used for analyses of LWG and the model included treatment and calf nested within pen (SAS 2003).

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Feeding value of red clover-grass, Persian clover and common vetch for pigs

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Implications

Red clover-grass, Persian clover, and common fetch that are generally grown for green manuring in organic cropping cycles, are also valuable forages for the feeding of pigs. They could substitute up to 30% of concentrates (on dry matter basis) in the feeding of growing pigs without negative impact on nitrogen (N) retention. This indicates that protein and amino acids of these legumes are well digested and utilised by the pigs. However, inclusion of roughage to pig diets shifts N utilisation so that N excretion to faeces is increased while N excretion to urine is decreased. Persian clover, in particular, is an intriguing roughage for pigs as its protein contains more amino acids that that of red clover-grass or common vetch. In addition, the digestibility of fibre is good in Persian clover, due to lower cellulose and lignin content in the fibre fraction. In practice, the voluntary feed intake of roughages remains lower, from 5% to 20% of pigs' dry matter intake depending on the production phase.

Background and objectives

Grass and legume forages are considered excellent rooting and enrichment material for pigs, but they can also contribute to the energy and amino acid supply of pigs (Carlson et al. 1999, Reverter et al. 1999). In organic cropping rotation, annual legumes such as Persian clover and vetches are grown for green manuring and fodder and pasture for ruminants (Stoddard et al. 2009). They could be suitable feedstuffs for organic pig production too, but there is a lack of information about their feeding value for pigs. Therefore, our aim was to study the nutrient composition and digestibility of red clover/grass, Persian clover or common vetch, and protein utilisation by N balance in growing pigs fed diets with 15% or 30% of these forages on dry matter (DM) basis.

Key results and discussion

Red clover-grass, Persian clover and common vetch contained crude protein (CP) 187, 196 and 196 g/kg DM, respectively. Their protein contained lysine 4.0, 5.1 and 4.8 g, threonine 3.9, 4.0, and 3.7 g, and methionine 1.5, 1.6 and 1.3 g per 100 g CP, respectively. When the basal diet was replaced with roughages, the total intake of essential amino acids did not change much (e.g. lysine intake 15.3 vs. 14.7 – 15.8 g/d, threonine 11.3 vs. 11.1-12.0 g/d, and methionine 4.3 vs. 4.2 – 4.6 g/d). Faecal digestibility of energy was the highest in Persian clover, 63.7%, followed by red clover/grass (49.1%) and common vetch (42.6%). In particular, the digestibility of crude protein and fibre in the whole digestive tract were higher in Persian clover than in red clover/grass and common vetch. The fibre of Persian clover contained less cellulose and lignin compared to red clover-grass and common vetch.

Inclusion of roughage to pig diets shifted N balance so that faecal N excretion was increased while opposite was seen in urinary N excretion (Table 1). However, the proportion of ingested N that was retained by pigs growing on average 790 g/d did not differ between the treatments. Similarly, Tywonczuk et al. (1997a) reported that supplementing a cereal-soybean meal diet for finishing pigs with up to 15% of Persian clover meal decreased the metabolizable energy value of the diet but had no adverse effects on N balance or nutrient digestibility. In order to maintain weight gain and feed conversion efficiency, the maximum recommended level was 10% (Tywonczuk et al. 1997b). According to Kaliszewicz et al. (1992), fresh or ensiled Persian clover can replace part of soybean meal in the diet of growing-finishing pigs, but can reduce growth performance. The optimal cutting stage is between the budding stage and start of flowering, when OM digestibility is the highest.

Table 1. Nitrogen balance of pigs fed diets with red 15% or 30% of clover/grass (RCG), Persian clover (PC) or common vetch (CV) on dry matter basis

	N intake g/d	N in faeces g/d	N in urine g/d	N retained g/d	Retained % of intake
Basal diet	48.8^{bc}	9.9^{a}	14.8^{c}	24.1^{ab}	49.6
RCG 15%	48.4^{ab}	12.5^{bc}	12.4^{ab}	23.5^{ab}	48.8
RCG 30%	47.3^{a}	14.0^{c}	11.0^{a}	22.3^{a}	47.2
PC 15%	49.6^{bc}	12.3^{bc}	12.4^{ab}	24.9^{b}	50.2
PC 30%	50.3^{c}	13.6^{c}	11.6^{ab}	25.2^{b}	50.4
CV 15%	49.2^{bc}	11.6^{ab}	13.0^{bc}	24.6^{b}	50.3
CV 30%	49.5^{bc}	13.6^{c}	12.4^{ab}	23.5^{ab}	47.9
SEM	0.46	0.43	0.42	0.46	0.84

How work was carried out?

Roughages were grown in Jokioinen, Finland and harvested with silage chopper: common vetch (*Vicia sativa* var. Ebena) on August 14^{th}, red clover-grass (second cut, 46% red clover, 46 % grass species and 8% weeds of fresh mass) on August 16th, and Persian clover (*Trifolium resupinatum* var. Accadia) on August 28^{th}. Clovers were in early bloom and vetch in late bloom. The roughages were stored frozen until fed to pigs. The basal diet (CP 178 g/kg DM) consisted of barley, peas, rapeseed cake and mineral-vitamin premix. It was fed as such or replaced with 15% or 30% (dry matter basis) roughages which were mixed with the basal diet in a cutter before being fed to the pigs (85 g dry matter/kg weight$^{0.75}$/d). The study was carried out in a 7 x 5 cyclic change over design. Seven pigs were fed the experimental diets in five 16-day periods (2 d for transition, 10 d for adaptation, and 4 d for total collection of faeces and urine) between 32 and 95 kg body weight. Diets, faeces and urine were analysed by standard methods (AOAC 1990), and digestibility coefficients were calculated by regression method.

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Inclusion of mussel meal in diets to growing/finishing pigs

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Implications

This study showed that inclusion of mussel meal in diets to growing/finishing pigs yielded growth rate similar to those obtained with a conventional diet, whereas feed conversion ratio was higher. This implies that mussel meal is a potential alternative protein source that can replace fish and soybean meal in organic diets. By using mussels it would be possible to compose diets with 100% organic feed ingredients. However, mussel meal is currently expensive to produce and in addition more research regarding optimal inclusion level and possible off-flavor of the meat is needed.

Background and objectives

Lysine and threonine have been shown to be the first and second limiting amino acids in cereal-based diets to pigs and both are essential. If the requirements of these amino acids are not fulfilled, performance, health and animal welfare can be negatively influenced. In order to assure an adequate supply of essential amino acids, pure (synthetic) amino acids are added to conventional diets. However, in organic diets such supplementation is not allowed and from 2015, 100% of the ingredients must be organically produced. Today, there are a limited number of organically produced protein feedstuffs available. Mussel meal can be an interesting alternative protein source for pig since it has high protein content and a balanced amino acid pattern. Thus, it has the potential to replace fish meal and other conventional protein feed ingredients in pig diets. Mussels are also extremely good filterers of water being an effective tool to clean sea waters from nitrogen and phosphorus that has leached into the water.

To the best of our knowledge, no study has yet investigated the effect of using mussel meal as a protein source to growing/finishing pigs. Therefore the objective of this study, which is a part of an EU-project (ICOPP), was to investigate the effect of inclusion of mussel meal in diets for growing/finishing pigs of two different genotypes. The hypothesis was that pigs will perform well with maintained production results when mussel meal replaces conventional protein feed.

Key results and discussion

Daily weight gain was relatively high, on average 950 g, without any significant difference between the two treatments (Table 1). Neither did diet affect dressing percentage nor carcass lean meat content. Consequently, no difference in daily lean meat growth was observed between diets. Genotype (Hampshire or Duroc boar) had no influence on performance ($P>0.05$ for all traits). The results indicate that at least 5% mussel meal can be included in diets to growing/finishing pigs with unaffected growth rate. However, feed conversion ratio was higher for pigs given mussel meal than for control pigs, 26.0 vs. 23.0 MJ NE/kg weight gain. The results indicate that mussel meal is a potential futural protein feedstuff in organic pig diets. However, mussel meal is today expensive and more research regarding optimal inclusion level is needed.

Table 1. Production performance

	5% Mussel meal	Commercial diet	P-value
Daily weight gain, g	944	949	0.899
Feed conversion ratio, MJ NE/kg	26.0	23.0	*<0.001*
Lean meat content, %	58.8	58.2	0.384
Dressing percentage, %	78.2	78.6	0.497
Daily lean meat growth, g	452	451	0.959

How work was carried out?

A total of 64 growing/finishing female and castrate pigs (Swedish Yorkshire dams × Hampshire sires or Duroc sires) from 12 litters were used in this study. The study was performed at the Research Station, Swedish University of Agricultural, Uppsala, in accordance with Swedish regulations for use of pigs. The sires used were randomly selected from sires available for artificial insemination. Pigs within litter were randomly allocated to four treatments, balanced to sex and live weight. Pigs in two treatments were given a commercial diet with conventional protein ingredients, whereas pigs in the two other treatments were fed a diet containing 5% inclusion of dry mussel meal and a nutrient composition equivalent to the commercial diet. This mussel meal was produced from mussel meat only, i.e. no shells were included. Both diets were given to the two genotypes.

The study started at a pig age of 69.6 ± 3.1 days (mean ± s.d.) and a live weight (LW) of 37.3 ± 5.1 kg. In total there were 16 pens, and each pen held four pigs (two females and two castrates). Consequently, there were four replicates (pens) per treatment. All pigs were fed restrictedly twice a day according to the standard feeding regimen in Sweden (Andersson et al., 1997). Pigs were weighed individually at the start of the study then fortnightly until their final weighing, one day before slaughter. Feed consumption was recorded on a daily basis and feed conversion ratio was calculated pen-wise. Slaughter was performed on two or three occasions per pen at an average age of 144.5 ± 9.3 days and an average LW of 107.6 ± 10.1 kg. Before cooling, carcass weight was recorded and lean meat content was evaluated with the Hennessy Grading Probe (Hennessy Grading Systems, Auckland, New Zealand). Two control pigs and one pig in the mussel meal group had to be excluded due to illness not related to the study. Data were analysed with the SAS software using analysis of variance (PROC MIXED). The model included the fixed factors of diet, genotype and sex, and the random factors of pen and litter. Initial weight was included in the model as a covariate for daily weight gain and carcass weight for lean meat content. Pig was the experimental unit for all traits except for feed conversion ratio, where pen was the unit. No significant interactions were found and were therefore excluded from the model.

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Feed intake and weight and body condition changes of 100% organically fed lactating sows

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Implications

Energy and protein density of the 100 % organic lactation diet should be increased as early as from 3rd week of lactation onwards in order to minimize the weight loss of the sow during the at least 40 day lactation period. Feed amino acid balance from 22nd day of lactation should match the amount of live weight lost during the first 21 days of lactation. This should be supported by providing the piglets feed attractive enough to ensure their high dry feed intake during the late lactation period.

Background and objectives

Multi-phase feeding with amino acids optimized for the particular stage of parity of the sow better meets the nutrient requirements of the sow than single feed for the whole lactation period (Kim et al. 2009). Most studies on sow feeding during lactation have had focus on conventional production and maximum 28 days of lactation.

When nutrient intake of the lactating sow is low, milk production is dependent on the ability of the sow to release body reserves for milk production (Etienne et al. 2000). Thus, the milk production and weight loss of the sow seem to be dependent on the feed intake of the sow during lactation (Quesnel et al. 2005). In organic pig production, designing optimal lactation feed for sows may be challenging as some feed ingredients may lower the palatability of the feed.

The objectives of the present study were to investigate the feed intake and changes of live weight and back fat thickness of sows fed 100% organically during at least 40 days lactation period and the weight change of the piglets of these sows. Based on these results and previous research the aim was to suggest the amino acid balance for sows during long lactation and optimal timing of diet change in phase feeding.

Key results and discussion

Feed intake of the 100% organically fed sows was 3534-4120 MJ NE (7.5 kg/d) during the period from 109th day of pregnancy until weaning at average 45 d after farrowing. In shorter, restrictedly fed conventional lactation periods the feed intake is lower (4.0-5.0 kg/d, King et al. 1997). The sows lost weight during the lactation period on average 22.8 kg and back fat thickness 7 mm despite the well increased voluntary feed intake (Figure 1). The piglet average weight gain (ADG) was 107 g/d for days 1-5, 340 g/d for days 5-21 and 362 g/d from d 22 to weaning. The corresponding estimates of milk production of the sows, calculated according to Noblet & Étienne (1989) was 4.3 kg/d, 13.6 kg/d and 17.7 kg/d, respectively. However, the maximum milk production of a sow, reached around 15th day of lactation, is circa 11-12 kg/d (Hansen et al. 2012). The additional feed enabled the good ADG for the piglets, but the sows still mobilized energy and protein from own tissues to fulfill the needs of the milk output probably because of their non-optimal organic diet. With 12-15 kg weight loss during 21 d lactation 20 % of amino acids in milk output have derived from the tissue catabolism of the sow. Based on this Kim et al. (2009) presented the optimal ratio of limiting standardized ileal digestible (SID) amino acis to lysine: Threonine 0.63, Valine 0.78, Leucine 1.18, Isoleucine 0.59, Arginine 0.59 for lactation period from 22 d onwards.

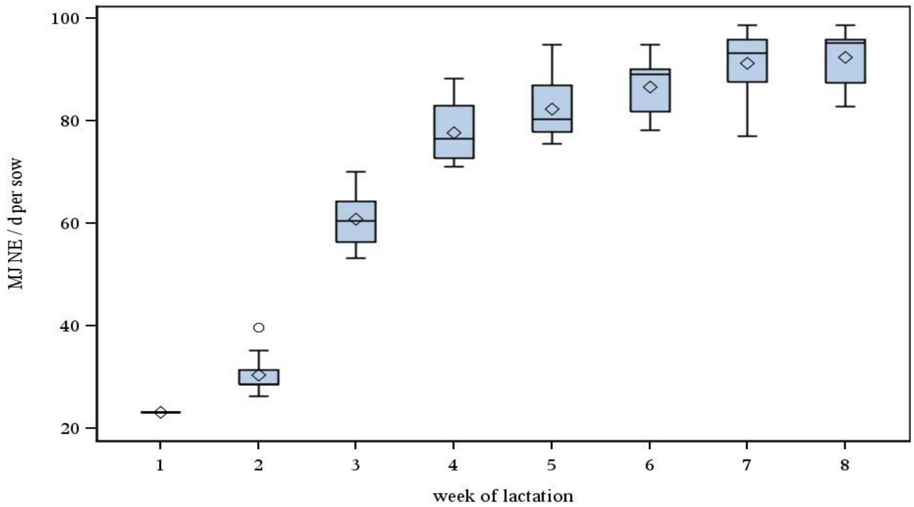

Figure 1. Weekly 100 % organic feed intake in net energy (MJ NE) of the sows from 2-7 days before farrowing to weaning at approx 45 days of lactation. T=maximum, minimum, o=outlier, ▢=50 % of observations, __=median, ◇=mean

How work was carried out?

A total of 12 sows (7 Finnish Landrace and 5 Finnish Landrace x Finnish Yorkshire) from parities 1 to 6 started the trial at 109th day of pregnancy. The sows were fed 100 % organic diet which consisted of oats, wheat, barley, rapeseed cake, peas, faba beans, vegetable oil and vitamins and minerals to meet the Finnish feeding recommendations for lactating sows (MTT 2012). The feed contained, on as fed basis, 9.3 MJ NE/kg, 14.3 % crude protein, 6.5 % crude fat and 0.6 % SID lysine. Roughage was given daily a handful per sow and sows got their feed three times daily from feeders.

Lactation period lasted for 45-49 days and live weight and back fat thickness of the sows was recorded weekly. Piglets were weighed at birth, once a week throughout the suckling period and at weaning. They were given additional dry feed from 13 days of age. Live weight of sows and piglets at d 21 was determined with linear regression from the whole lactation period.

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Control of perennial weeds based on weed biology and environmental considerations

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Implications

Timing, type and duration of tillage operations and cropping practices are of importance for reducing the regeneration of perennial weeds and also for minimizing the environmental impacts of such operations. In the present work and with reference to previous publications we find that, based on the knowledge gained on growth patterns, sensitivity to competition, growth potential of roots and mechanical and management measures it is possible to coordinate control of perennial weeds with considerations of yield and reduced environmental impact.

Background and objectives

In organic farming systems weed control is in general performed mechanically by soil interventions such as mouldboard ploughing (Arshad 1999) and the main factor determining minimum ploughing depth is control of especially perennial weeds (Kouwenhoven et al. 2002). In order to allow early sowing in spring, autumn ploughing is often preferred. However, soil erosion risk and N-leaching losses increase with the number of tillage operations in autumn (Askegård et al. 2011) and the depth of mouldboard ploughing is directly related to CO_2 loss from the soil and increased use of fuel (Reicosky and Archer 2007). Annual ploughing also negatively affects soil quality (Riley et al. 2007) and erosion is larger with deep than with shallow tillage (Lundekvam et al. 2003). In order to optimize the effect of mechanical and cultivation methods on weed regulation, it is important to understand the biology and growth pattern of the various weed species. Variation in growth activity throughout the season exist (Brandsæter et al. 2010), and should be accounted for when timing tillage operations . The depth of the roots or rhizomes varies with species. The root system of *Cirsium arvense* extends to below 200 cm, with the highest root concentration between 20 and 40 cm (Nadeau and Van den Born 1989), while rhizomes of *Elymus repens* and roots of *Sonchus arvensis* grow down to approximately 10 to 15 cm (Korsmo 1954). Following tillage operations, root fragments of *C. arvense* will be present in the upper soil layer and undisturbed roots below the tilled layer. Insights into the regeneration potential from root fragments and undisturbed root systems are therefore important. The challenge is to obtain an acceptable level of weed management and yield in combination with minimizing the environmental impact. This topic will be discussed in the presentation.

Key results and discussion

Deep ploughing compared to shallow ploughing as a single measure is found to give a better control of perennial weeds (eg. Brandsæter et al. 2011). Root fragments of *C. arvense* present in the upper 5-15 cm of the soil, following spring ploughing, may be strongly hampered by a highly competitive green manure cover-crop established in the same spring (Thomsen et al. 2011). However, compared to the established root system, root fragments of *C. arvense* present in the upper 5-30 cm of the soil have limited influence on the total shoot biomass produced, and the established roots possess a high capacity for regeneration in the field (Thomsen et al. 2013). Competition from a green manure cover-crop may hamper the growth of *C. arvense* (Moyer et al. 2000). Selection of competitive species is though important (see Bàrberi 2002) and undersowing of *Trifolium pratense* in oats was not able to compete with established plants of perennial weed species (Brandsæter et al. 2012). In order to reduce the risk of erosion, autumn tillage operations should preferably be avoided. Deep spring ploughing has been found to give a better control of *C. arvense* and *S. arvensis* than autumn ploughing (Brandsæter and Berge 2012) while cereal yield seems unaffected (Tørresen et al. 2003). Bare fallow operations in spring or the inclusion of a green manure cover-crop may eliminate the need for autumn ploughing for the control of perennial weed species. Stubble cultivation in autumn, with a relatively low environmental impact but with a complete cutting of the roots or rhizomes, reduces the total perennial weed biomass (Thomsen et al. 2012). Variation in time and space of tillage intensity in relation to the crop as well as weed infestation could be a more sustainable option (eg. Peigné et al.2007).

How work was carried out?

The material and method for the presented results are all published and may be assessed in the appropriate publications as referred to below.

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Resource effective control of Elymus repens

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Implications

Preliminary results show that there is room for improvement within existing control methods of couch grass (*Elymus repens* (L.) Gould). It may be possible to reduce the number of stubble cultivations during autumn by timing the treatment, and to reduce the cultivation depth by using a goose foot cultivator (5 cm) instead of a disc cultivator (10 cm), without sacrificing couch grass control efficiency. The first year of the experiment, the use of a goose foot cultivator resulted in less nitrogen leaching than cultivation by disc. A reduced number of stubble cultivations potentially reduces nutrient loss, fuel consumption and the workload of the farmer.

Our experiments with cover crops to control couch grass in cereals has yet to prove significant effects on couch grass control, but cover crops combined with goose foot hoeing did reduce nitrogen leaching by more than a third compared to cultivation by disc. Further data is necessary to see if the system can be used to effectively control couch grass without significant yield losses. Regardless, it can reduce nitrogen leaching and potentially provide other ecosystem services, e.g. control weeds other than couch grass.

Background and objectives

Developing new tools to manage weeds and pests is imperative to be able to create a sustainable agriculture. However, it is equally important to improve existing methods for better control and better resource management. This is especially true for the control of perennial weeds that without herbicides often require extensive mechanical control measures.

Couch grass (*Elymus repens*) is a perennial grass weed which causes yield losses in temperate areas. Once established in a field it spreads quickly through underground rhizomes. It is controlled either with glyphosate, or repeated stubble cultivations to fragment and starve the rhizomes.

The mechanical control methods have negative environmental and economic effects, such as increased nitrogen leaching, soil compaction, fuel costs and workload of the farmer. The aim of the project is to develop methods where couch grass is controlled without using herbicides and with insignificant nitrogen leaching.

More specifically we test the hypotheses that perennial ryegrass and red clover cover crops under-sown in spring barley/oat reduce couch grass growth during autumn (1), reduce nitrogen leaching (2) and that mowing in autumn will further reduce couch grass growth (3). Moreover we tested if two stubble cultivations during autumn were significantly better for couch grass control than one time-optimized stubble cultivation (4) and if nitrogen leaching is smaller after cultivation with a goose foot cultivator (5 cm depth) than with a disc cultivator (10 cm depth), with similar effect on couch grass (5).

Key results and discussion

The competitive effect of cover crops in cereals on couch grass has been studied with varying results. Often it significantly reduces couch grass (e.g. Cussans 1972, Melander et al. 2005, Bergkvist et al*.* 2010), but not always (e.g. Brandsaeter et al*.* 2012) and the yield reducing effect differ among studies. The size of the competitive effect of the cover crop depends on weather (Melander 2005) and management, but also on cover crop species. E.g. Red clover (*Trifolium pretense*) is beneficial in some aspects (e.g. it can fix nitrogen to the benefit of the subsequent crop), but it may not be ideal for controlling couch grass, since it is a poor competitor for nitrogen.

In our experiments we have yet to see a significant reduction of couch grass shoots or rhizomes for any of the cover crop treatments compared to the control. However, cover crops combined with goose foot hoeing reduced nitrogen leaching by almost a third compared to traditional disc cultivations after harvest. The lack of significant results for the control of couch grass could be because the competitive pressure was not high enough in the experiments. The first experimental year, 2011, was quite dry and the cover crops did not establish very well. Since 2012 was a better year for cover crop growth, we will get results from better conditions as well. The interaction between cover crops and mowing did result in an interesting, but unsignificant reduction of couch grass shoots when ryegrass was combined with two mowings. Overall mowing twice did result in a small (about 27%) reduction in couch grass shoots in the follow-up year.

There was no significant difference in the amount of rhizome and shoot abundance in the subsequent crop between using one time-optimized stubble cultivation directly after harvest and doing one directly after harvest and repeating it again 20 days afterwards. This contradicts the general recommendation that repeated stubble cultivation is always preferred (e.g Håkansson 1974) when weather conditions allow. The single stubble cultivation did result in couch grass re-growing shoots during autumn. This could be problematic in years when the autumn is long and mild, but could potentially make control more effective in other years if the shoots are killed in winter.

Treatments with goose foot cultivator significantly reduced shoot abundance the subsequent year compared to the control (unlike the disc cultivator in this experiment). One goose foot cultivation resulted in less nitrogen leaching than two goose foot or two disc cultivations. The goose foot cultivator may not be able to replace the disc cultivator in all conditions (e.g. due to soil type restrictions), but further experiments will hopefully illuminate whether it could be a suitable control method of couch grass under some circumstances.

How was work carried out?

Three experiments, each lasting two years, started in 2011 (results presented here) and repeated with start 2012. Exp. 1 and 2 were conducted at three different locations in Sweden and Exp. 3 at one site, all with four replicates in randomized complete blocks. In Exp. 1 the effect of mowing was investigated in main-plots and cover crops in sub-plots. In Exp. 2 stubble cultivation was conducted at different times in relation to harvest of spring barley/oat as the single factor. In Exp. 3, using separately tile-drained plots, the effect of different combinations of tillage and cover crops on N-leaching and couch grass was investigated. Measurements taken were e.g. abundance of couch grass shoots, aboveground biomass (cover crops and couch grass), rhizome biomass, soil mineral nitrogen (Exp. 1 and 3) and N-leaching (Exp. 3).

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Temperature effect on fructan storage and regeneration of Canada thistle (Cirsium arvense (L.) Scop)

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Implications

Organic farming is challenged by perennial weeds such as Canada thistle. The increasing CO_2 concentration levels causing temperature increase may lead to an increased photosynthesis and as a consequence elevated storage in underground perennating organs. In this study, we analyzed fructan, the main storage in Canada thistle, in juvenile and mature plants treated with different temperatures. Low temperatures caused higher concentrations of fructan in four weeks old plants. Proximal root fragments had higher amount of fructan than distal fragments. Regenerative ability from roots with different fructan concentrations was also associated to temperature and age. This implies that the timing of root fragmentation in autumn should occur earliest four weeks before low temperatures for each location. Otherwise, new shoots would accumulate fructan causing sprouting the subsequent spring.

Background and objectives

The effect of soil disturbance and fragmentation of underground organs of herbaceous perennial weeds have been studied (Håkansson 2003). Repeated autumn cultivation reduces spring perennial weed infestation because it breaks paradormancy and depletes the root/rhizome carbohydrate reserves accumulated in late summer and early autumn. However, repeated mechanical control measures conflict with the organic farming principles because of its high energy input (Tzilivakis et al. 2005) and nutrient losses (Honisch *et al.* 2002). Optimal timing of the interventions is highly recommended to avoid waste of energy during the time when underground vegetative propagules are endodormant.

The elevated CO_2 concentration levels cause temperature increase and may lead to an increased photosynthesis and a subsequent storage in underground perennating organs (Patterson 1995). Temperature becomes, therefore, a crucial factor to be integrated into perennial weed management in the autumn. Variations in seasons and latitudes dictate different phenological events in perennials, such as carbohydrate source and sink dynamics. Fructan storage is known in Canada thistle (Hendry 1993) but the time of its storage and the main factors driving its storage are not yet elucidated. To manage the control of Canada thistle, more insights into fructan storage determinants are required.

The objective of this study was to investigate which developmental stage and temperature regime favour fructan storage and subsequent sprouting rate and biomass production in Canada thistle. The first hypothesis was that there is a relationship between the ambient temperatures and the storage of fructan in roots. The second hypothesis was that sprouting rate and shoots biomasses, after regeneration, are related to fructan storage.

Key results and discussion

At low temperature, the three weeks old juvenile plants did not produce horizontal roots. This is in agreement with previous finding on compensation point (Zimdahl 1993) when perenniality is resumed. At low temperatures, photo-assimilates were not enough to exceed the respiration and growth .This indicates that if disturbance is done before the occurrence of low temperatures, compensation point would not be reached. Storage of fructan would be low and the disturbance would reduce infestation in the subsequent spring. Nkurunziza and Streibig (2011) found that carbohydrate translocation to roots starts around 21 to 23 days after emergence

The degree of polymerization (DP) of fructan in plants within the age between 4 and 17 weeks, showed a variation in relation to temperature. The DP of fructan of both juvenile and mature plants decreased with temperature increase. The negative regression slope of DP of fructan on temperature increase was significantly steeper for mature plants with -0.85 (± 0.16) compared to that of the juvenile plants with -0.49 (± 0.08). In case of higher DP of fructan, replanted roots yielded higher shoot biomass 28 days after emergence. In addition, the emergence rates observed in fructan rich roots were higher than of fructan poor. However, there were differences of DP fructan in relation to the position of the fragment taken as already found on *Imperata cylindrica* (L.) Beauv.(Ayeni & Duke 1985).

In conclusion, the stubble cultivation has to be done within three to four weeks before low temperatures arrive. In that way, fructan storage would not be possible. Temperature being location specific, in practice, farmers need to rely on average temperatures over years. Further studies on various sizes of fragments would probably add some value to the knowledge on the fructan storage here reached and the temperature effect.

How work was carried out?

One experiment was conducted twice (2008 and 2009) at the experimental station of the University of Copenhagen, Taastrup, Denmark (55° 40´10N; 12° 18´32E). Each experiment consisted of three main steps: i) initial growth was in the greenhouse to produce plants of different ages, ii) temperature treatment of the plants in growth chambers and iii) vegetative regeneration from roots taken from temperature treated plants in the greenhouse. The determination of carbohydrate concentrations followed the method described by Nkurunziza and Streibig (2011).

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Improved weed management in organic crop production

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Implications

Weed problems can constrain organic crop production resulting in significant losses in yield and quality. Especially perennial weed species such as *Elytrigia repens*, *Cirsium arvense* and *Tussilago farfara* are posing problems as arable cropping systems do not hamper their vegetative proliferation sufficiently. Annual weeds may also reach unacceptable infestation levels leaving the growers with poor yielding crops and severe future weed problems owing to the shedding and spread of weed seeds. Effective weed management is a key component for successful organic crop production and a prerequisite to increase the yielding potential of many organic crop production systems. Weed problems are most severe on stockless arable farms because the supply of nutrients can be limited and may not suffice to produce competitive crop stands. Crop rotations in arable cropping systems often have fewer grass-clovers leys or other perennial crops known to disrupt weed proliferation more effectively than cash crops such as cereals and pulses. The higher nutritional status of soils on dairy farms and the more frequent use of perennial crops for mowing are major causes for less severe weed problems on those farms.

Research has produced many new results on improved tactics and methods to control weed problems in organic crops in recent years. Still the transfer of knowledge to extension services and finally producers has been insufficient and not fully utilized to benefit organic crop production. Consequently, we have synthesized current knowledge of relevance for practical implementation and structured it into three main principles to help extension services and growers plan weed control programs more stringently and still concisely to ensure the commitment of the users. Our principles for weed control in organic farming are: a. competitive crops, b. effective weed control actions, and c. disruption of significant weed problems. The three principles are seen as cornerstones for achieving effective weed management in organic crop production where weed problems should never reach uncontrollable infestation levels. The principles are accompanied by a range of weed control strategies and control interventions that need to be followed to comply with the principles.

Background and objectives

Crop productivity has stagnated in Danish organic farming as yields have apparently not benefited from the recent achievements in research. Low to moderate crop yields limit farmer revenues and hinder the expansion of the organic area. The requirements for organic grain and fodder may not be fulfilled and thus reduce the potential for production of other products in the food chain or necessitates import. The Danish multidisciplinary research project, *HighCrop*, addresses these issues by focusing on new research, development and demonstration. Weed management is one important component in the project with the objective of transforming research results and analyses of existing data into concepts of weed control and finally cropping system planning tools to be used by farmers and advisers to achieve better tactical and strategic weed management.

Key results and discussion

The work on weed management has yielded a set of principles, strategies and tactics to support advisors and growers in their efforts to better manage weeds and improve crop productivity. In addition, the principles, strategies and tactics have been re-formulated into a web-based weed management planning tool for advisers and growers. This tool will be further modified and extended concurrently with the achievements made from analyzing data from long-termed crop rotation experiments.

How work was carried out?

Existing data from previous long-termed crop rotation experiments was extracted, analyzed and synthesized to describe and quantify weed dynamics under the influence of different crop rotations and nutrient management factors (Olesen et al. 2000; Rasmussen et al. 2006). The synthesis is discussed in relation to the literature (e.g. Barberi 2002; Rasmussen 2002; Melander et al. 2005; Rasmussen et al. 2006) and includes information produced in other projects and networks on new control tactics and strategies against perennial and annual weeds (e.g. http://www.icrofs.org/Pages/Research/darcofIII_weeds.html; http://www.ewrs.org/pwc/proceedings.asp). The information amalgamated is used to formulate concepts of weed control tactics and strategies for perennial and annual weed management. These concepts are then modified to suit the three principles: a. competitive crops, b. effective weed control actions, and c. disruption of significant weed problems. For example, the principle of weed disruption requires a cropping strategy based on diversified crop sequences to prevent the buildup of specific weed species. The tactic needed for effective disruption could be crop sequences composed by spring and autumn sown crops including 20% or more of N-fixating green manure crops. The principle of competitive crops can be achieved through a strategy based on fertilizer placement whenever possible as one strategy among other strategies. One tactic for fertilizer placement could be to place slurry between the rows of spring cereals before sowing.

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Organic food prices and the consumer – a review of the evidence

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Implications

There is a lack of research on actual organic price knowledge and on how consumers deal with prices during information search and purchase decision at the point of sale. Further research into this can help market actors to strike the balance between price as a barrier and as a cue to quality perception. Research on consumers and organic food prices should increasingly differentiate between organic consumer segments, product categories, distribution channel and brands. Such research will guide market actors towards more targeted pricing strategies that can support further market growth.

Background and objectives

Many European governments have set themselves ambitious aims of increasing the share of organic farming. A number of barriers are potentially hampering the further development of the sector. For the consumption side, high prices are handled as a major barrier to an increase in demand. In order to shed light on the state of the research with regard to consumer behaviour and organic food prices, we review the literature since the turn of the millennium. The research questions employed regarding organic food are: 1. How important is price as a barrier to choice? 2. What is consumer's state of knowledge and perception of prices and the price premium? 3. How large is consumers' willingness-to-pay? 4. What is known about consumers react to pricing measures?

Key results and discussion

There is a large amount of literature potentially relevant for the topic. However, few address prices and consumer price behaviour as the main subject of research. Several research streams can be identified: First, qualitative and quantitative surveys analysing self-reported motives, barriers, attitudes and behaviour. Second, there is research using e.g. auctions, choice tests or experiments in order to explore willingness-to-pay (WTP) and preferences, often comparing organic to conventional or comparing the relevance of different food attributes such as fair trade or local origin. Third, there are studies using revealed preference data from panel or scanner data sets, exploring e.g. the influence of purchase environments, purchase patterns and category differences.

The literature underlines clearly that consumer report price to be the major barrier to purchase or the greatest barrier alongside with availability. This is shown in quantitative surveys (e.g. Krystallis & Chryssohoidis, 2005) as well as qualitative research (e.g. Padel and Foster 2005). It appears that organic consumers tend to be characterised by higher income (e.g. Ngobo, 2011; Wier et al. 2008). However, findings are partly mixed, and some studies see education as the greater explanatory factor (Dettmann & Dimitri, 2009) or regard both as a combined factor in terms of "social class". Income can be regarded as an indirect sign that prices are a factor of influence. Hughner et al. (2007) are interpreting the contradiction that young consumers hold more positive attitudes while relatively older consumers purchase organic food as a result of the higher disposable income. Yridoe et al. (2005) note that the effect of income on organic purchase might weaken with increasing income levels, a relationship yet to explored further.

Given price is clearly named as a major barrier, it follows that consumers are highly aware of the price premium. Few sources, however, actually further explore or quantify price knowledge. In a study in Germany, Spiller (2001) found an expected premium of 20%, while another German study with 642 respondents surveyed in-store showed that price knowledge of products is rather low, and that consumers purchased organic even when the actual price premium was higher than their willingness-to-pay (WTP) expressed beforehand (Plassmann & Hamm, 2009).

Considerably more work has been carried out about WTP for organic food price premiums (Hamm et al., 2012). WTP varies greatly depending on the category, product, methodologies and country, and can only be interpreted on this background. It appears as if most consumers express a certain WTP for organic (e.g. Bauer et al. 2012), which is consistent with the favourable attitudes generally expressed (Aertsens et al. 2009).

Recently, research has turned to revealed preference data and analysing consumer reactions to pricing measures. Ngobo (2011) suggests organic consumers hardly react to price promotions and that there might even be a negative relation following an inverted U-shaped function. Bezawada and Pauwels (2012), however, conclude it is mainly the "core" or "frequent" organic consumers that are less price-sensitive.

Two emerging issues appeared of future relevance on the background of the so-called "conventionalisation" of the sector: First, which price premium strikes the balance between not being a barrier while preserving its function as a quality signal? Second, which segmentation strategy can allow availability to a mainstream market but still serve credibility and exclusiveness?

How was the work carried out?

The following databases were searched: organic e prints, Science Direct, Business Source Complete and Web of Science (search terms: organic, price, consumer; in both title and abstract, from 2000 onwards). The references cited are only a fraction of the literature.

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How can a private standard accelerate the development of organic production?

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Implications

It is possible to use private standards to increase the speed in development of organic production in a wide range of areas and to do that on a solid scientific basis. KRAV has recently improved the standard performance in reducing climate impact of the production and the methodology from this work will be possible to use in several areas such as reduction of environmental impact, animal welfare and reduction of health risk for consumers

It is obvious, though, that we need to get more knowledge on how consumers value our extra requirements in the standard and their willingness to pay for these since this is of crucial importance to motivate the producers to accept more stringent standards.

Background and objectives

KRAV has been developing standards for organic production since 1985. Around 80 % of all organic products on the Swedish market are certified according to the KRAV standard. Since 2007 audits and certification has been done by contracted, accredited, independent certification bodies. The standard is today based on the EU legislation for organic production but is continuously developed to have stronger sustainability performance especially in relation to:

- reduced climate impact including total energy used, reduction of the use of fossil energy and use of electricity from renewable sources
- social responsibility
- animal welfare including:
  - Sows must be able to farrow in seclusion under protection, for example in a farrow hut
  - The natural behavioural patterns of pigs should be provided for, such as rooting and food searching behaviour e.g. through fallow land, forest or woodland and deep litter beds.
  - During the warm part of the year pigs must have access to mud baths or other way of cooling off in water.
  - During the vegetation period all types of animals must have access to grazing during most of the day. Poultry can be kept inside during the night.
  - Established groups of animals must be kept together during transport, barn boarding and anaesthetisation.
  - Every animal must be anaestheticized before slaughter

KRAV is continuously pushing for improvement of the EU legislation through contacts with Swedish authorities and, in cooperation with the IFOAM EU Group, the European Commission

Key results and discussion

1. We have established a method for performing standard development with emphasis on climate impact on a solid scientific basis **and** with a reasonable acceptance among the certified producers. It is possible to apply the method on any other aspect covered by our standard.
2. We have shown in practice that you can combine in the same standard a high performance in a wide range of aspects, in our case mainly;

a. Reduction of environmental impact evaluated against 12 of the 16 Swedish national environmental goals
b. Animal welfare
c. Reduction of health risk for consumers
d. Social responsibility through the chain of custody for food products

We still need to improve our cooperation around research on how consumers value our extra requirements in the standard and their willingness to pay for these which is crucial for our possibility to convince producers to do extra efforts. We would also enjoy seeing more research on best practice to get acceptance for new extra requirements from the producers. Further we would love to see research on possibilities to be independent of risky practices that we have inherited from conventional production e g use of antibiotics.

How work was carried out?

KRAV develops its standard in close cooperation with scientists, producers, consumers authorities and other stakeholders. When our board has decided that we shall improve the standard in relation to an aspect of sustainability, the following steps are performed:

- The KRAV staff works in cooperation with our Standards committé (with representatives of all the mentioned categories of stake holders) and a reference group with experts from relevant stake holder categories
- The team identifies what relevant scientific data are available as well as all input that has reached us from stake holders since the last standard revision. The team produces a proposal for revised standard based on optimal sustainability performance in a balance between best practice in relation to scientific data, consequences for the economy of certified producers and risk for loss of sustainability performance through loss of certified producers
- The proposed standard is sent for referral to KRAV members, relevant stake holders and producers and. It is also displayed at KRAV website, open for anybody to comment. The consultation period is normally at least six weeks.
- The contributions are compiled and taken into consideration and a revised version of proposed standard is prepared for the KRAV boards decision.

When developing standards for reduction of climate impact we worked in cooperation with a team of scientists from SIK – the Swedish Institute for Food and Biotechnology – specialists in life cycle assessment of food production. The project collected data that we used as a basis for standard development according to our usual procedure. Data and results can be found on http://www.klimatmarkningen.se. Our freedom as private standard owners makes it possible for us to advance fast as compared to the development of the common EU legislation and, thus, set example of how far it is possible to increase the sustainability performance of the standard in practice.

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http://www.klimatmarkningen.se

Transition to organic food in Danish public procurement: can a top-down approach capture the practice?

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Implications

This paper is addressing the attention towards organic transition processes which takes place in a Danish political context at the moment. With departure in the explicit propositions in an organic vision 2020 launched by the Danish government the practice in public kitchens is presented and discussed. The main findings in several recent studies address the lack of relations between key actors in the field and the challenges in embedding the change into a resilient practice. Especially the relation between kitchen staff and the public administrations seems to be lacking. The political aim is translated into an economic support program dedicated only the teaching of kitchen staff, but does not see the relational character of the transition. Concluding remarks underlines the complexity of a transition approach and problematizes the narrow focus on educational activities as the primary initiative to make farmers and public kitchens convert their production to organic.

Background and objectives

Organic transition has got a renewed focus in a Danish political context This is shown by e.g. the newly formulated political initiatives and visions trying to encourage farmers to convert to organic farming through stimulating demand for organic products by subscribing the public kitchens as main drivers for this demand.

In this paper we will explore the political initiatives as they are stated in the organic vision 2020 paper launched earlier this year (Ministry for Food, Agriculture and Fisheries, 2012), and discuss this vision in relation to two empirical studies in Danish public kitchens. The main purpose is to see how political goals are translated into implementation by the daily work practice of the canteen staff. Focus will partly also be discussing the economic instruments used to push a transition further.

In the analysis of the study Clarkes (2005) mapping methodology has been used to keep the analytical focus on actors, objects and discourses and their relations and power structures. The purpose of the paper is thus twofold. The first purpose is to discuss the implementation of a top-down policy instrument and which implications this seems to have on the practice, and the second purpose is to discuss the methodological approach of situational analysis with departure in the case. The first topic is described by the "zooming in-zooming out" metaphor used by Nicolini (2009) in the sense that it operates on different levels of understanding a transitions in public kitchens as the complex phenomenon it is. Three level are addressed; the meta-level as described by analysis of the political goals, the organizational arrangements of these goals and the practice level, which is necessary to understand the actual implementation of the political goals. All three levels are considered important in order to capture the rationale and the challenges of the real-life actions. The focus on the situation and on the equal attention to objects, actors and discourses as put forward by Clarke (2005) enable the analysis to reflect a change project on the different levels.

Key results and discussion

The empirical evidence in this study of the implementation of political goals show that complex processes can be understood and overcome through a systematic and complex approach, by thinking thorough the whole system in a transitional manner. The top-down approach seems to have difficulties addressing the practice level in the sense that the economic support program translating the political goal only focuses on the direct educational activities in the kitchens and thereby miss the relational aspects of the transition process in their networks. One important object to deal with in more systematical depth will be procurement agreements and their consequences in the daily practices in kitchens. Teachers of vocational learning courses confirm a lack of attention to this aspect of the relational character of the actor-network in public food production. The agency of the objects such as the procurement agreements and the political/financial support programs emphasizes the direct impact on the actual practice in the kitchens and thereby the relevance of using a methodology and analysis that takes physical objects, actors and discourses into consideration.

How work was carried out?

The complexity of food systems is illustrated by the many different approaches towards grasping the performed realities of them. Until now not much attention has been given in the Science, Technology and Society (STS) research regarding food. In this paper we argue for the relevance of contributing to the STS area within food studies. by working with Adele Clarke's (2005) Situational Analysis. This methodological/theoretical approach has a substantial explanation force with regards to food enactments. Inspired by many theoretically important contributions from e.g. Strauss' social world theory (2004), Haraway's notion of situated knowledge, and focus on materiality (1988), and also Foucauldian power concepts and symmetry from ANT, Clarke has developed a mapping methodology, which includes actors, objects and discourses and their relations, positions and social worlds/arenas. From a food network approach the understanding presented by Clarke (2005) fits well with the understanding of food as "matter" or objects; food as symbol or discourses and food as constructed and negotiated by actors in networks and social arenas. The focus on the complexity in situations and on the performance of realities rather than seeking the essence of one truth opens for an approach that enables the researcher to discuss the many different influences by actors, objects and discourses in actor-network dynamics of e.g. policy development and implementation versus practice. The different maps have been used in the analysis of the empirical data in order to open for reflections on the complexity. Two main studies is used here as the empirical basis. Both studies are focusing on mainly individual interviews and three focus groups. Observations have been done when possible in relation to the interviews.

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Importance of organic farming research in Sweden for innovations and increased sustainability in agriculture

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Overall implications of organic farming research

Organic farming is known to be a knowledge intensive production system and there is a strong need for new knowledge and innovations to achieve increased sustainability. Furthermore, many of the research goals defined in national and international research strategies for organic agriculture are addressing questions relating to the development of more sustainable food and farming systems in general. Organic systems can thus be seen as a fore-runner and an innovation system to sustainable food and farming (TP Organics, 2009; EPOK, 2013).

Organic research in Sweden during 15 years

Swedish research in organic food and farming has for the last 15 years been mainly financed through specially designated funding. About 30-35 million SEK per year have been put into organic research in a variety of subject areas. Applied research projects dominate and among these, projects within crop and soil science have taken the largest part leaving one quarter of the projects during the first decade of the organic programs (1997-2006) to animal sciences (Formas, 2006). Furthermore, recently prioritized research areas have been biodiversity and provision of ecosystem services in organic systems and systems analyses of environmental impacts.

Organic farming projects addressing new research topics

Research on organic agriculture has early focussed on new topics that are highly relevant today, meeting future challenges of our food systems, e.g. to develop productive farming systems for a growing population and at the same time utilize resources in a sustainable way and maintain ecosystem services in the agricultural landscape. As a result a large amount of knowledge has been produced that has been very important to agriculture as a whole. We will here describe some examples of organic research in Sweden financed by the targeted research programmes on organic agriculture. The research has implied new innovations and knowledge, contributing to the development of organic farming and also for agriculture in general.

Non-chemical crop protection methods

A bottle-neck for stable crop production levels in organic farming are different crop protection problems. A number of research projects have focussed on basic knowledge on weed ecology together with resource efficient weed control technology (Lundkvist, 2009). Furthermore, knowledge about the complex interactions between natural enemies and pest organisms have been developed within the organic research programmes resulting in preventive measures aimed to strengthen the biological control by natural enemies (Nilsson et al., 2012). Innovative research has also been conducted on chemical interactions between cereal varieties as a preventive measure against aphid attacks (Ninkovic et al., 2011).

Locally produced feed and new protein feed sources

In the development of sustainable animal production systems, the feed protein supply is a key issue. Mussel meal has proven to have great potential as protein source for poultry (Jönsson, 2009) and pigs, and thereby also recycling nutrients from the sea or from lakes back to the agro-ecosystem. Research on organic farming has also been a fore-runner in the search for effective use of locally produced feed and the use of high proportions of roughages in dairy production (Johansson and Nadeau, 2006).

Outdoor animal production systems
A number of projects on animal production systems have been innovative by having a multidisciplinary approach for developing systems solutions with the aim to identify synergy effects and handle possible goal conflicts between animal welfare, environmental impact, working environment, and profitability. One example is research on developing outdoor organic pig systems (Salomon et al., 2012).

Agricultural systems producing renewable energy
Before efforts to move towards a fossil-free agriculture was on the general agriculture research agenda's, this was a prioritized topic within organic agriculture and several research projects have been conducted to analysed possibilities for e.g. on-farm production of bioenergy (Kimming et al., 2011).

A new Swedish research agenda for organic agriculture

EPOK has developed a research agenda in an open process together with interested parties in the food chain to provide a well-supported document which will enable research funding bodies to prioritize future research ventures on organic agriculture (EPOK, 2013). According to an evaluation of organic research in Sweden (Formas, 2006) a continued public support to research in this area is recommended, which could be justified by the public goods that organic farming provide; increased biodiversity, decreased use of chemical plant protection products and benefits for animal welfare (Jordbruksverket, 2012). Five prioritized focal areas are pointed out in the research agenda: 1) High productivity with maintained sustainability, 2) Innovative production systems with many functions, 3) Closed-loop cycles and renewable resources, 4) Sustainable businesses and developments of markets and 5) Healthy food with added valued.

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The new tendencies in the scientific research of the organic food system in Finland

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Overall implications of organic research in Finland

The European Union as well as the Finnish authorities are guiding us towards a more sustainable world and the organic food system has an important role in it (Commission of European Communities 2004, MMM 2012). It is obvious that to develop the system more sustainable, we need food chain stakeholder-based research to give us better solutions as well as new innovations. The scientific research of organic food-related subjects in Finland has, for couple of decades already, been targeted mostly to the agricultural sector for the farm level operations. For being a complicated system, the research of the organic system needs more multidisciplinary, even holistic approach in the future. Also a better commitment from both, the Government as well as from the food system stake holders is needed.

Background for the situation in the Organic Food System

The Finnish organic food system is developing, but still slower than in many other European countries. In 2012 the share of organic cultivated land was 9% (Heinonen 2012) and the share of markets was 1,6% equal to 200 million Euros (23% increase from 2011) (Pro Luomu 2013). The organic food has been among the Finnish Government official programs since 1999 (VN 1999). The Finnish Government has set a goal of 20% for the share of organic agricultural land for the year 2020 and made a Government program to support that decision.

There have been two research programs for organic food and farming, financed by the government and ran by MTT in 1992-2002 and in 2003-2006, but nothing official ever since, mainly because of the lack of funds. The scientific research on that field has been mainly targeted to the farm level operations such as soil management and environment and also for the economy of the organic food system. The multidisciplinary scientific research is developing now and other faculties such as behavioral, social, political and medical are getting interested on this global "phenomenon", the Organic Food.

The Finnish Organic Research Institute

The high level delegation set for creating the country brand in Finland gave one of its tasks for the Agrifood Research Finland MTT and the University of Helsinki to found a specific organic research institute for coordinating food chain operators and the research scientists to do the research needed for developing the national organic food system from the scientific point of view. (Foreign Ministry 2008). The Finnish Organic Research Institute started in January 2013. The Institute is building a network among the Finnish research scientists as well as getting "signals" from the food chain stakeholders for the most needed research subjects. The Institute is not doing the research itself, but coordinating research scientists from the founding parts, food system stakeholders and the financing instruments.

The biggest challenge is to motivate the scientists to join the network and to get the finances for the Institute. The Finnish government and the parliament show no interest for financing the Institute, but only separate research projects. Public and private money are though needed for the implementation of a national organic food research program and to secure the continuity of the new institute. A national organic research agenda will give guidelines for prioritized agricultural, environmental, food related and communal research for years 2013-2017. Connections have been made already to FiBl, ICROFS and

Bioforsk. Especially the co-operation between the Nordic Institutes would be fruitful, because of the closeness of the cultures and agriculture on same geographical level.

Dissemination of the knowledge

The dissemination of the results from the scientific research will be done for different target groups. The Institute organizes seminars for the scientists and will use the network built also for dissemination. The food chain stakeholders will get targeted information for theirs special field as well as possibilities to attend for scientific seminars. Consumers will get more popularized information through the media as well as from the Internet pages (www.luomu.fi). There is a lot of false information in media about the possible benefits of organic food. It is out most important to have a trusted source for information based on scientific research and that is one of the reasons to have the Finnish Organic Research Institute.

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Organic production and consumption in Norway – new knowledge through research and dissemination

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Implications

The Norwegian government has since 2006 had a goal of 15 % organic food production and consumption, initially by 2015 and later adjusted to 2020. The goal has primarily been justified by consumer demands, and to some extent by environmental benefits. Organic farming is said to be a "spear point" in the development of a more environmental friendly and sustainable agriculture in Norway, but the government's policy lacks thorough political support and the goal is far from achieved.

In 2012, certified land and land area under conversion to organic farming comprised 5.6% of the agricultural area (Debio 2013). The turnover of organic products was more than 1.1 billion NOK in 2012; an increase of 11% from 2011 (NAA 2012). In 2009, organic food represented 1.3% of total food turnover in Norway (Willer and Kilcher 2011). The share of grassland in organic managed land comprised 77 % in 2012 (Debio 2013). Strong efforts are needed to reach the official goal in 2020 and to diversify the organic production. The Action Plan for Organic Farming (MAF 2009) points out actions to reach the governmental goal, including research and dissemination of knowledge.

Background and objectives

Research and knowledge dissemination on organic farming in Norway started in the eighties. The Research Council of Norway has funded a large part of this research at a national level. In 1992-1996 there was a specific research program for organic farming (Løes and Schjøth 2006), but since 1996 funding of research on organic food and farming has been included in the general agricultural research programs. No specific body coordinates research priorities or evaluates proposals relevant for organic agriculture. Bioforsk, with its Organic Food and Farming Division, has been particularly active within organic food and farming research in Norway, but other actors have also conducted research on organic production and consumption.

Future research

An evaluation of the research and development on organic agriculture in Norway for the period 1999-2009 (RCN 2010) recommends that research on organic production should include both primary production as well as the rest of the production chain. To develop organic food and farming systems and to fulfill the main goals of organic farming, including the 15% goal, further research is needed and many topics are relevant. Many of the research areas important for the development of organic agriculture are also applicable for conventional agriculture. Hence, increased research on sustainability, reduced negative environmental impact and better animal welfare, which are the current strategic research areas for Bioforsk Organic Food and Farming Division, would be beneficial for both organic and conventional agriculture.

Nutrient management is a key to sustainable farming systems, and has been thoroughly studied in several Norwegian projects. Efficient utilization of available nutrients is essential for the plant nutrient supply, to minimize pollution and reduce emissions of greenhouse gases from agriculture. It is also important for an ecological intensification of the farming systems. Reduction of climate impact and mitigation of changing climate effects have received considerable attention in recent years. Anaerobic digestion of organic matter is a "hot topic", with much on-going research activity. Carbon sequestration in the soil is an important ecosystem service, and should be an integrated part of a sustainable farming system. More research is required here. Effects of various nutrient sources, including food safety issues, also needs further study.

Cultivated grasslands and forest and mountain pastures represent a significant and local feed resource, and knowledge is required on the management of such areas. Research projects have covered topics like milk, meat and forage quality related to grassland management, and vitamin and micronutrient supply to ruminants. Changing climatic conditions demand further knowledge on healthy and robust animals that can thrive and produce in various environments. Vector borne diseases, i.e. tick-borne diseases, represent an increasing challenge in grazing systems in tick infested areas and have been given considerable attention in recent years particularly in sheep production. Furthermore, research to improve feed and feed protein self-sufficiency in organic livestock farming is urgent.

Animal welfare is an important ethical attribute for organic food. The potential of the organic standards to promote good welfare is high due to the focus on natural behavior and environmental enrichment. There are, however, still animal welfare problems that are common in organic production that must be acknowledged in research. Using animals that fit the production system is of great importance for animal welfare as well as production economy. This makes gene-environment interactions for welfare traits a key topic for future research.

Projects with a system approach, like on-farm case studies and long-term field experiments designed to develop organic cropping systems are highly useful and have been much utilized in Norwegian organic research. Knowledge extracted from developmental projects within public procurement and small scale gardening is valuable especially to increase organic consumption.

International collaboration is necessary for a small country like Norway. From the Norwegian Research Council it is a clear strategy to support the CORE Organic partnership, in order to strengthen the research capacity and quality of organic research in Norway (RCN 2012).

Dissemination of knowledge

Norwegian Agricultural Extension Service (NLR) have organic divisions inside their regional extension bodies. The dairy, meat and poultry industry have their own extensionists, some of them educated and trained in organic animal husbandry. Bioforsk Organic Food and Farming cooperates closely with these advisers, providing printed and web-based materials (www.agropub.no), conferences and training. Knowledge dissemination is also a crucial part of all developmental projects, e.g. within solar- and bioenergy, organic gardening and public procurement, which are areas where Bioforsk Organic Food and Farming Division has its most comprehensive activities.

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Acquisition and transfer of knowledge within the organic sector in Iceland

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Implications

Organic agriculture is developing at a slower rate in Iceland than in the other Nordic countries, partly due to lack of research and development work. While the supply of organics does not meet demand, and the market is growing, this sector within Icelandic agriculture is largely driven by consumers, ideologists and enthusiasts. They are, for example, trying to solve problems and promote progress by accumulating and disseminating knowledge from various sources. Much more support is needed from the scientific community and politicians should pay closer attention to the contribution organic farming can make to sustainable development and the wellbeing of society at large. Transfer of knowledge from other Nordic countries could, for example, be linked to research on organic fertilizers and methods of teaching and extension.

Background and objectives

Although recognized organic growing in Iceland dates back to 1930 only a few pioneers were involved until 20 years ago (Dýrmundsson 1999a; 2000). Since 1993 the number of organic holdings has increased from 6 to 40 accounting for approximately 1% of the total agricultural production in the country. Conversion support has been much less than in other Nordic countries (Davíðsdóttir 2013; Dýrmundsson et al. 2010). The objective of this presentation is to review briefly the development and status of research and the acquisition and transfer of knowledge within the organic sector.

Key results and discussion

While agricultural research has flourished for several decades in Iceland there is a dearth of such fundamental activity specifically aimed at the organic sector. In 1998 the Council for Science and Technology in Organic Agriculture, having studied the research needs in detail, proposed a list of priorities (Dýrmundsson 1999b, 2000). Hvanneyri Agricultural University and Reykir Horticultural College paid some attention to these priorities, especially the first one dealing with organic fertilizers (Brynjólfsson 2008). However, after the merger in 2005 of all the agricultural-, research- and teaching bodies into the Agricultural University of Iceland (LbhÍ), minimal attention has been paid to the needs of organic farming with the exception of recent positive trends in its horticultural department at Reykir (Stadler, personal communication) where organic fertilizers are included in trials. It should be kept in mind, however, that several past and present studies, e.g. on legume growing, within conventional farming systems, have relevance to the organic sector (Dýrmundsson 1999b, 2000). Given this background we still have to depend heavily on small case studies, observations based on limited statistical data and, last but not least, knowledge accumulated by farmers' experience. Let me give a few examples:

1) In addition to farmyard manure the supply of organic fertilizers may be boosted substantially by by-products and effluents from the fishing industry.
2) The supply of hay and silage for winterfeeding, especially on some organic sheep farms, can be increased a great deal by utilizing natural meadows where sedges dominate (Carex species) and in coastal areas seaweed foraging may supplement organic fodder in winter.
3) All ruminants and horses may be fed on organic grassland products (hay/silage) without grain supplementation throughout the winter. Even dairy cows may produce fairly good milk yields without concentrate feeding.

4) There are indications that both cow health and human-cow relationships are better on organic than on conventional farms, possibly due to less production – and handling stress.

5) Marketing studies have indicated that organic food is favoured by consumers who care for their health and amongst the target groups are women, especially mothers, well educated people and people older than 40 years of age. Of food items baby food ranks highest.

How was the work carried out?

I reviewed all BSc, BEd and MSc theses relating to organic agriculture in Iceland, submitted from 1995-2013, of which 2 out of 10 were from Hvanneyri Agricultural University and none from the Agricultural University of Iceland. Six of them were quoted by Dýrmundsson (2000) while the 4 most recent ones are by Maravic (2008), Magnúsdóttir (2008), Seebach (2013) and Davíðsdóttir (2013), from the Leopold-Franzens-University Innsbruck, Austria, Reykjavík University, Iceland, Kassel University, Witzenhausen, Germany and the University of Iceland, respectively. Moreover, these sources of information were supplemented by knowledge acquired by farmers´ experience disseminated through personal discussions and from meetings where organic farmers have given talks.

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Organic farming research in Estonia

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Implications

The growth of organic farming in Estonia has been rapid in recent decades. To support this development various research projects have been conducted but still a lot of new knowledge is needed to improve the performance of organic sector. Organic agriculture is based on nutrient recycling and it uses a variety of practices that are valuable also for conventional farming in the future because resources of non-renewable synthetic fertilizers are limited and food should be produced more sustainably. Holistic perspective including ecological, economic and social aspects is needed for organic farming studies and future projects should target these issues more thoroughly.

Position of organic farming research

Funding of organic farming research has been very scarce, therefore the number of studies is small, research projects mainly focus on specific topics and holistic multidisciplinary approach is often lacking. Most research so far has focused on organic plant production and soil fertility. It takes time to see the actual changes in organic cropping systems but finding the finances for long-term experiments has always been complicated. Studies addressing biodiversity issues are becoming more common in recent years. Some research topics are still severely understudied, such as feeding strategies in organic pig and broiler production, organic food processing technologies and their impact on food quality.

On-going research projects

Organic farming systems should be characterized by excellent soil fertility management to keep plant nutrients cycles short and as closed as possible. Impacts of green manures and cattle manure on soil properties and biota are currently studied in a long-term field trial (De Cima et al. 2012; Talgre et al. 2013). Different management, yields, weeds and product quality are targeted also by other studies for field crops (Sepp et al. 2009) and vegetables (Põldma et al. 2012).

Finding suitable varieties for organic production in local conditions is relevant for all crops: there are on-going studies for field crops, fruits (Kahu et al. 2009) and vegetables (Bender 2012) as well as grapes in Nordic climate (Karp 2012).

How to manage pests and diseases without synthetic pesticides is one of the key aspects in organic farming. Increased biodiversity in agricultural field may have a positive effect on biocontrol agents through diversifying the species composition of naturally occurring parasitoids and enhancing their abundance in the fields. Therefore finding suitable companion plants for white cabbage (Kaasik et al. 2012) and developing rapeseed production systems with trap-crop plant strips (Veromann et al. 2012, Kovacs et al. 2013) are relevant topics. In addition, the manipulation with amounts of nitrogen fertilizer can play a crucial role in sustainable pest management in oilseed rape (Veromann et al. 2013). Targeted precision biocontrol by using bumble bees and honeybees as carriers to spread biofungicides is found to be a promising measure to reduce grey mould and at the same time increase yields due to the of more active pollination in strawberry plantations (Muljar et al. 2012).

Finding local feeding strategies for organic sheep (Piirsalu et al. 2012) and milking cows (Leming 2012) to stable the yields and to improve the quality of production is essential.

Future research needs

There is a strong need for new and more innovative research projects in order to develop the organic sector. To develop organic pig and poultry production, a suitable feed rotations based on local feeds are needed. In addition, there is urgent need to study technologies of vegetable production, food processing etc. also to carry out long-term multidisciplinary studies. More active international cooperation is needed to share the knowledge, however most of the issues are significantly depending on local conditions and cannot be transferred directly (e.g. feed). Some other topics (e.g. processing technologies) are not so context dependent and results could be used in different countries. More efficient results could be obtained by collaborative research.

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15 years of research in organic food systems in Denmark – effects on the sector and society

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Implications

An analysis of the effect of 15 years of research in organic food systems in Denmark showed that it has had a high impact on the development of the sector. There are three main reasons: First of all, the content of research programs and the funded projects have been closely aligned with the needs of the industry as expressed by farmers, advisors and organizations. Second, many of the projects have had close contact to advisors and farmers securing continuous dissemination resulting in rapid application of results. Third, due to the close contact between researchers and users the research design has been adapted to ensure that treatments to be tested are as relevant and practical as possible, without compromising the scientific standards. Besides the practical applications the number of scientific products has been above average. Our results underpin and exemplify the general recommendations in recent international discussions on the need to improve the relationships between research, extension and agricultural production from a linear to a more complex knowledge interaction.

Background and objectives

The Danish government has funded research in organic agriculture and food systematically since the establishment in 1996 of the Danish Research Centre for Organic Farming (DARCOF, now ICROFS: www.icrofs.org). A recent analysis of the effects of the first 3 organic research programs (DARCOF I-III, 1996-2000) (Halberg et al. 2012) was carried out with the objective to determine not only the impact of the research on the sector from farmers and advisors to industry and retail but also on society from government and regulation to ngo's.

It is generally thought to be quite difficult to evaluate a research program's effect on a sector of society, especially distinguishing the contribution from research from those of other development forces. There are obviously many important factors behind the positive development of the organic sector in Denmark, including public support for market and product development, the regulatory framework from public and private sectors and the establishment of strong institutions in organic farming. A large group of very clever entrepreneurs and pioneers in the organic farming, processing and retailing sectors have also shouldered a good deal of the burden. The results of research obviously need to be channeled through these agents to be used for innovations. Farmers need new knowledge about nutrient balancing, weed control and animal husbandry to ensure an effective and economically viable production which is also robust and resistant to pests and diseases and adheres to the organic principles and regulations but they are indifferent to whether new methods are or the result of research or not, and many learn new methods from colleagues or consultants. The generally good connection in Denmark between research and development, the advisory service and farmers means that the people delivering the new knowledge to farmers tend to be the consultants, often as a result of discussions with scientists, who in turn are affected and inspired in their design of solutions to problems via this process. Results of research and development do not always have farming as the primary target. Other users of the research results are businesses, organisations and the political system where knowledge of the effects of organic farming on, for example, animal welfare, climate and biodiversity form part of decision-making and political processes.

Key results and discussion

The analysis documents and highlights three important reasons for a high impact on the development of the sector: First of all, the thematic focus of research programs and the funded projects have been closely aligned with the needs of the industry as expressed by farmers, advisors and organisations through various stakeholder committees and action plans. Second, many of the projects have had close contact to advisors and farmers securing continuous dissemination resulting in rapid application of results. Third, due to the close contact between researchers and users the research design has been adapted to ensure that treatments to be tested are as relevant and practical as possible, without compromising the scientific standards. Thus, the dialogues between the scientists and the users within projects improve the understanding of how research and the results can be adapted to the specific practical situations. This is a two-way process, and not just a question of improving dissemination of scientific results. There is a more complex interaction between research, development and the application of knowledge in agriculture than the traditional linear communication of scientific results via consultants to producers (EU SCAR, 2012). The report gives detailed documentation of the above qualities and with specific examples of how the research and development has helped improving e.g. milk, poultry, pork and crop production with specific knowledge and methods.

There are clear indications that the project structure and organisation in DARCOF has supported this complexity in knowledge generation and exchange which is a prerequisite for high impact on research in terms of overcoming the farmers' main barriers. This underpins the general recommendations in recent international discussions on the need to improve the relationships between research, extension and agricultural production. In the "International Assessment of Agricultural Knowledge, Science and Technology for Development", (http://www.unep.org/dewa/Assessments/Ecosystems/IAASTD/tabid/105853/Default.aspx/) the conclusions stress that it is necessary with a clean break with the linear relationship of research – extension – uptake. There is a need for the farmers' situation to have a stronger voice when prioritizing and designing research projects and to integrate their local knowledge and experience. This is also reflected in the recent report by the EU supported working group AKIS (Agricultural Knowledge and Innovation Systems), which highlighted the gap between the provision of research results and the application of innovative approaches to farming practice (http://ec.europa.eu/research/bioeconomy/pdf/ki3211999enc_002.pdf)

An evaluation of the research results based on the general point scoring method used to evaluate other research programs was also carried out. Measured on the number of research publications, the output of the earlier programs was deemed to be satisfactory. The experience was nevertheless that this method does not give a satisfactory picture of the effect of the research in terms of the practical application of project results. This is because the point scoring method principally analyses research results (output) and only to a lesser degree research application (outcome).

How work was carried out?

The analysis was carried out as a triangulation of three viewpoints: the research projects themselves and their themes and results, interviews with end-users about how they perceive the role of research in relation to the development of the sector, and an identification of the results that have been conveyed from research to users and the channels used. Please see the more thorough description in the analysis.

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Opportunities of organic agriculture in Albania

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Implications

The perspectives of contribution to organic agriculture, aside from the market aspects, have to be seen in their broader sense. It should be argued that the creation of the organic agriculture might contribute to the conservation of the traditional customs and practices. The possibility of using a higher premium than labour might encourage the population to deal in agriculture for much longer.

The organic agriculture has proven that it is able to provide efficient possibilities on diversification and penetration into the market, this when reference is being made to both marginal and less developed areas. These possibilities do guarantee a satisfactory return for farmers and retains a satisfactory use of the natural resources. We recommend a series of interventions in the integrated organic system to occur over an efficient action plan at the national level that is primarily intended:

- to satisfy and make the normative framework on the sector much easier to be implemented;
- to promote organic agriculture at all levels;
- to organize with other links of supply chain at the start and at the end of the production cycle, that is by improving the availability of inputs, by promoting processing and the positioning of products in the market;
- to support the formation, research and extension
- to develop the organic product markets through a consolidation of the exports, as well

as affair share of attention to the typology of the potential customers in the food market (urban populations with high incomes, tourists that appreciate the rural wealth and the nature of the country). The presence of such policies constitutes one of the development of a connection between policies of territory conservation and agriculture in the strategic activities of the development program of agriculture, programs where the environmental policies, tourism and organic agriculture constitutes the entirety of a sustainable solution and an evaluation of food products, in the rural development and the protection of territory.

Background and objectives

The aim of the present research work is to present a descriptive analysis of the structural and productive indicators of the organic and, at large, the whole agriculture sector in Albania. The first part of the paper analyses the economical and social framework of today's Albanian farming, which is still far from the European Union standards. Although organic farming in Albania is not as regulated as it is in the EU, we tried to outline to what extent organic farming can reach a productive and economical perspectives for local development. In the second part of the paper we analysed the situation of the potential of organic farms by means of a SWOT analysis. The strength and weakness points for the farms, together with the possibilities and threats of the organic market pointed out by environmental analysis, are selected with the intention of addressing the main issues and attempting to delineate some peculiar policies and market intervention for overcoming the actual nodal points.

Key results and discussion

It is reasonable to argue that in Albania, as in other countries, there exist the proper conditions for the distribution and commercialization of organic products. This potential should be exploited to the advantage of the future perspective of development of organic

agriculture (Leksinaj 2007). By acting in such a manner we would most likely observe an increase in the export of agricultural products towards the EU countries, taking into account the current problems and the costly certification.
In table 1 the situation of the organic potential farms was included by applying the a SWOT analysis. According to the methodology of qualitative analysis the role of the interviews with privileged witnesses is that one which embraces the verification and integration of information that has come from statistical data. Such an analysis, which join both a structural and dynamic-forecasting feature, is concerned with the economic, social and demographic aspects, not to mention the natural implications arising from the local developments, this seen from the urban and territorial perspectives.
The main requirement for identification of "witnesses" or "experts" has been their ability to recognize the territory and the local reality; they might also be mouthpieces of specific interests (which in fact several of them are), even though they appear to be experts representing much more general interests. The information obtained via the interviews has been formulated in a general fashion. Experts have brought in specific evaluations, which are related to the sector or areas where they have been practicing. Only in the final evaluation stage a coherent and general tableau of results has been set up in the form of the SWOT analysis.

Table 1. SWOT analysis

Strong points	**Weak points**
Full integration possibilities into supply chain	Small-sized farms
Low cost of labor force	Lack of a system of standard quality control
Favorable environmental conditions	Difficulties in identification of clients
Organizational powers	Difficulties in identification of suitable trade networks
Bigger opportunities from European markets	Difficulties in supply segment
Potential leadership in the internal markets	Lack of a price policy
Availability in innovations	Packaging and other non-suitable promotional instruments
Household traditions	Difficulties in keeping accounting data
Threats	**Possibilities**
A poorly defined snapshot of Albania as a producer of organic products	Demand on the rise
Barriers in exports owing to certification	Likely synergies among farmers
Competition among reputed farms	Availability in the market spaces
Technological viability	Benefits in the market
Lack of well-defined and clear internal reference norms	Differentiation in prices
Trade agreements	Availability of a technical assistance service

Source: Our direct processing work

The weak and the strong points for the farms along with the possibilities and threats of the market of "organic" which have come to the fore in the environmental analysis have been selected and presented with the view to having a summary of issues that would help solve the implementation of productive strategies and marketing. The variables under consideration are a fruit of the joint work of authors and experts in the administration of farms. What it seems straightforward to notice is the existence of the general rules in favour of the objective "*the attainment of a premium price from the organic products in the market, particularly in the European one*" (Leksinaj et. al. 2009).

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Organic farming without fossil fuels – life cycle assessment of two Swedish cases

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Implications

Organic agriculture is dependent on fossil fuels, just like conventional agriculture, but this can be reduced by the use of on-farm biomass resources. The energy efficiency and environmental impacts of different alternatives can be assessed by life cycle assessment (LCA), which we have done in this project. Swedish organic milk production can become self-sufficient in energy by using renewable sources available on the farm, with biogas from manure as the main energy source. Thereby greenhouse gas (GHG) emissions from the production system can be reduced, both by substituting fossil fuels and by reducing methane emissions from manure. The arable organic farm studied in the project could be self-sufficient in energy by using the residues available in the crop rotation. Because of soil carbon losses, the greenhouse gas emission savings were lower with the use of straw ethanol, heat and power (9%) than by using ley for biogas production (35%).

In this research project, the system boundaries were set at energy self-sufficiency at farm or farm-cluster level. Heat and fuel were supplied as needed, and electricity production was equal to use on an annual basis. In practice, however, better resource efficiency can be achieved by making full use of available energy infrastructure, and basing production on resource availability and economic constraints, rather than a narrow self-sufficiency approach.

Background and objectives

One principle of organic farming is the use of renewable resources, yet it depends on fossil fuels. However, with new technologies and the increased emphasis on reduction of GHG emissions, this may change soon. Biomass offers opportunities for energy supply, but requires energy and land, and causes emissions. There are various biomass sources, as well as different technical options. Which of these are preferable? Are there enough biomass residues to supply energy to the production system, or is it necessary to take land from food production for fuel supply? This paper summarizes the findings of our research on how to supply organic agriculture with energy produced on its own land, and the environmental consequences of such production. Greenhouse gas emissions and energy balance of crop production (described in detail in Kimming et al. 2011) and milk production (Kimming et al. 2013) in renewable energy supply systems mainly based on bioenergy were compared with systems based on fossil fuels.

Key results and discussion

The annual energy demand for the milk farm with 100 cows was 300 GJ electricity (0.14 MJ/kg milk), 115 GJ for grain drying and 95 GJ for heating of buildings. Annual tractor fuel demand was 460 GJ. In the arable farm, heat was supplied to the residential building (dimensioned capacity 7.4 kW) the hot water system (1.2 kW), the workshop (1.7 kW) and the grain dryer (227 kW). The total annual tractor fuel demand was 414 GJ, electricity demand was 51 GJ and heat demand 290 GJ.

In the milk production system, biogas from manure was the main energy supply in all scenarios. In Scenario M1, biogas produced from manure and cut straw covered the entire energy demand. In Scenario M2**,** the manure on the farm was utilized to produce biogas, assumed to be combusted in a CHP system (gas engine). Rapeseed oil was assumed to be used to produce rapeseed methyl ester (RME) in a small-scale production unit at the farm. The tractors ran on RME with minor modification of the original diesel engines. Grain produced on the farm was assumed to be dried in a furnace fuelled with wheat straw from 4 ha.

In the arable system, one scenario (A1) was based on biogas from ley. Assumptions were largely the same as in the milk system. Scenario A2 was based on straw, which was converted to ethanol via hydrothermal pretreatment, to enzymatic hydrolysis and fermentation in a large-scale ethanol plant. The lignin is separated out during hydrolysis and was assumed to be used in an integrated CHP plant for production of process steam and electricity, as well as surplus electricity to cover the power demand of the farm.

The fossil energy savings were 2.63 MJ of primary energy per kg milk in the milk production system and 755 GJ for the whole 200 ha farm in the arable system. In addition to greenhouse gas savings from reduced fossil fuel use, there were substantial savings on the milk farm from the reduction in methane emissions when manure was passed through an anaerobic digestion process before storage. In the arable farm study, the GHG emission saving was 35% in the self-sufficiency scenario based on ley (A1) and 9% in that based on straw (A2). There was less nitrous oxide from the soil in both self-sufficiency scenarios compared with the reference scenario, but the impact on the carbon content of the soil differed significantly, with a larger reduction in soil carbon content when straw was removed from the fields.

In both the milk and the arable system, the biomass resources available as residues on the farm were sufficient for supply of energy for the production. There was consequently no need to reduce the production of food products, or increase the land area needed for the total production system.

How work was carried out

We investigated a crop-based production system with a seven-year crop rotation, as well as a system for milk production, where all feed was produced on the farm. Since the goal was to investigate the impact of changing to a new energy supply system, consequential LCA was used for these studies. The substitution method was used to avoid allocation.

The functional unit (FU) used was 1 kg energy-corrected milk at the farm-gate for the milk study. For the arable farm, the FU was the total supply of energy (heat, electricity and vehicle fuel) for the 200 ha organic farm for 1 year. Impact categories were energy balance and global warming potential (GWP100). GHG emissions were calculated according to IPCC Guidelines (IPCC 2006). In addition, the soil carbon balances of the cultivation systems studied were simulated with the ICBM (Andrén and Kätterer 2001).

For each system (crop or milk) self-supply scenarios and a fossil reference system were defined. The biomass energy systems included straw for power, heating and ethanol; ley, manure and straw for biogas generating power, heat and fuel; and willow for heat and power. The selected technologies are available today, at least at the pilot or demonstration level. The investigation focused on biomass potential, energy balance and GHG emissions.

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Embedded energy in dairy stables

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Implications

The calculation of the embedded energy[3] (EE) of twenty barns shows that there is a considerable variation of EE per cow, where the lowest values were one fourth of the highest. Use of timber instead of concrete in walls had most effect to reduce the amount of EE. Cold barns can contribute to reduce the amount of EE, while the amount of EE is higher in free-stall than in tie-stall barns.

While for an existing building the amount of EE is nearly fixed, calculating the anticipated amount for a new building can help to reduce energy use in agriculture and thus contribute to a more sustainable production. Incorporating EE in planning new buildings should be of special importance for organic farming, since regulations demand more area per animal than in conventional farming. In addition to building new, renovation, extension as well as recycling of building materials should be considered. Planning new buildings should also include operational energy, as well as working conditions, animal welfare and economic considerations.

Background and objectives

In countries with cold winters, dairy cows are usually kept in stables in the period without plant growth, sometimes all-year long. There is a goal in organic farming to reduce inputs and to use energy efficiently (IFOAM 2006), and buildings should be included when the energy use of a farm is analysed. Energy for buildings in relation to the overall energy use on a dairy farm has been reported to be between 17 % (Dux et al. 2009) and 32% (Rossier and Gaillard 2004). Despite of both importance and uncertainty, farm buildings are seldom included (f. e. Yan et al. 2011) in articles found about energy use in dairy farming.

We describe how we estimated the EE of twenty dairy stables in Norway near the coast around 63° north. Ten farms are managed conventional and ten organic. Only two built a new barn after conversion, thus we do not differ between organic and conventional barns. The objective of this article was to estimate the amount of EE in existing dairy stables using a simple screening method and to compare the effect of a) different building materials, b) insolation, c) stable type (tie-stall or free-stall barn) and d) additional functions (storing place for silage, hey or machinery) per dairy cow.

Key results and discussion

In buildings older than 30 years, slurry is stored in the cellar. The tie-stall in the ground floor is insulated and in the top floor, hey was stored. Often parts of the building are used to place machines. In 20 to 30 years old buildings the silage tower or horizontal silo is inside the building, the top floor for hey is less usual. Most of the buildings were gradually extended to place more animals, to include silage storage or to adapt to claims for separate rooms for milk, workers and veterinarians. Since 2001, seven free-stall barns for cows were built, without silage-storage and garage-function. Only two out of the twenty stables were cold barns (walls in the barn not insulated).

On average, the amount of EE per cow and year were 2150 MJ. This amount is comparable to the findings of Dux et al. (2009). For our farms it varied from 1320 to 4300 MJ. Using of timber instead of concrete in the walls of the barn reduced the amount

[3] "Embedded energy, also known as embodied energy, is defined as the Energy that was used in the work of making a product." http://www.appropedia.org/Embedded_energy. Accessed: 14.05.2013

of EE. On average, the amount of EE in free-stall was higher than in tie-stall barns. Additional functions as silo and machinery in the building had on average no effect on the amount of EE. The two cold barns had less EE than the average of the insulated barns.

When the entire energy use in agriculture is analysed, often buildings and machinery are not mentioned at all or it is argued, that buildings on the included farms were similar for the different farm types (Thomassen et al. 2008) or had "a similar design on the farms studied" (Cederberg and Mattsson 2000). For the barns on the 20 farms in the project the results show, that the amount of EE in barns can vary considerable (Dux, Alig, & Herzog 2009). Therefore, to include this source in energy balances is important.

How work was carried out?

The results presented are from dairy farms in Norway near the coast around 63° north. The stables were built or extended between 1960 and 2011, the oldest parts in use were from 1930. During farm visits, building materials and main characteristics of the buildings (for example age, measures, building materials, and number of animal places) were noted. Where construction plans were not available, the ground plan was taken from a digital map. The buildings were photographed to find detailed measures. A simple construction plan was created and different surfaces were calculated. The precise approach of Dux et al (2009) was simplified. Since the stables differed in their appearance but little in the composition of different modules, we defined different types of such modules and the material used for one square meter floor, wall or roof. For example, walls of concrete, timber or timber with aluminum paneling, for some including insolation, were described. For all these modules we used the ecoinvent database to calculate the EE for a lifetime of 50 years, including production and use phase as well as disposal (Althaus et al. 2005). Finally, for each farm the EE for the stable was summed up. Nevertheless, the results are rather a rough estimate, for example no test drilling where conducted to determine the construction of walls in relation to different layers or the amount of reinforcement. Transportation of material from store to farm where not included being neutral to the location of the different farms.

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Self-sufficiency of fuels for tractive power in small-scale organic agriculture

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Implications

Small-scale organic agriculture, with integrated crop and animal production has the potential of producing significant amounts of food. Self-sufficiency of fuel for farm work has been investigated closer in this study, based on a set of prerequisites that were identified as important for future sustainability. An implication of the study is that low-tech solutions are more likely to be renewable in the production. Fuel production for farm work at the farm also facilitates nutrient recycling. Draught horse power turned out to be comparable with other biofuels, and in a system perspective even more efficient in some cases. For ensuring a sustained food production social solutions for cleaning and recycling human excreta must be developed. Low-input small-scale agriculture may in theory contribute to solving several environmental challenges. The real challenges are social: how to distribute food and how to have enough labour in agriculture to manage cropping systems that gives a diverse production.

Background and objectives

According to Rockström et al. (2009) modern agriculture currently contribute to crossing most of their identified "planetary boundaries". Reasons such as Peak Oil, Climate Change and Food Security has inspired for investigating self-sufficiency in agriculture in terms of fuel. Yet, a seemingly simple task, to use agricultural land to produce biofuels, turns out to be a complex set of tradeoffs as soon as more than one of the global challenges is addressed. Energy crop production for farm self-sufficiency of biofuel may be easy to obtain once there are no cravings that the production should be renewable. However, when including food production capacity, the importance of a sustainable crop sequence, nutrient recycling and biodiversity, the picture becomes more intricate.

This work is an attempt to address several of the global challenges when investigating what solutions for self-sufficiency of fuels is most viable. This lead to certain prerequisites of the study: as far as possible renewable biofuel production in all steps, low-input agriculture, small-scale agriculture that may have larger biodiversity than large scale (Belfrage et al., 2005), leguminous leys in the crop sequence for soil structure and nitrogen supply, animals required for ecosystem services and for producing food from leys and meadows and animals should not eat what humans can eat.

The aim of this study was to develop scenarios and assess and compare them regarding their impact on food production and NPK fluxes on farm level. From a cropping system based on these prerequisites and other practical limitations we ended up with three possible scenarios for biofuel: Draught horse power combined with cold-pressed rape seed oil in a tractor, ethanol from wheat produced in a conventional ethanol plant and farm-made ethanol from potato. Conventional diesel was used as a reference scenario.

Key results and discussion

Using wheat and potato for ethanol lowered the food production significantly, by 23% and 18% respectively compared to the reference scenario of conventional diesel. By changing the crop sequence to contain less ley and still having enough potato to cover the tractor demand of ethanol, the food production could be held up to 90% of the reference scenario, but such a sequence would be difficult to handle. By combining a draught horse and on-farm cold pressed rapeseed oil the least impact on food production was achieved; 94% of the reference scenario. We have 11.5 ha of farmland excluding the pasture, meaning 58 persons should be supplied if all farmland globally was to be operated at similar yields (Johansson et al., 2013). This is managed when using draught horse power combined with rape-seed oil in a tractor, but not when using ethanol from wheat or potato for tractive power.

By producing the fuel on the farm a larger amount of nutrient recycling can be obtained. The draught horse-rape seed scenario had only a small deficit of P, but the K-deficit was significant in all scenarios except when potato was used for ethanol without altering the crop sequence to a large extent. The deficit of K is not a problem in soils formed of sedimentary clay in Sweden. However, for such systems to be viable in other regions some solution for K-recycling will be increasingly important. N is maintained in all scenarios due to the nitrogen fixing leys. P can be maintained at the fields if bones are recycled, however nutrients, especially K, is moved from meadow to field.

How work was carried out?

The work was carried out in collaboration with a research farm in Roslagen, south eastern Sweden (ca 59°52´ N, 17°40´ E). A model that calculates the amount of food available at a farm in terms of meat, milk egg and crops, converts it into energy units and calculates how many people can be supplied from the farm was developed in MS Excel. We have assumed an average energy requirement of 2,500 kcal/day and capita (Johansson et al., 2013).

A basic requirement was that the energy-crop should fit into a well-functioning crop sequence. The crop sequence developed at the farm functions well and is difficult to alter without making it less purposeful. Thus, when investigating how to be self-sufficient of fuels we had to carefully consider changes in the crop sequence. Which changes are possible without making the sequence unsuitable? What impact on the animal herds and food production capacity would the chosen biofuel system have? We also took into account what technologies that are reasonable at present. To have a measure on the difference between the crop sequences and altered production due to biofuels, we chose to focus on the macronutrients N,P and K.

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Strategic management of nitrogen within an organic cropping system using digestate from biogas production of recirculated crop residues

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Implications

This project investigates strategic management of nitrogen by integrating crop residue management with biogas production. The approach offers potential for diversified farmer income, as food crops, feedstock for biogas and digestate for nutrient cycling are produced simultaneously. This type of diversification provides multifunctional solutions in organic farming, especially in production without access to animal manure. Biogas production from crop residues offers the possibility of reducing both emissions and leaching of nutrients to the surrounding ecosystems, as compared to the case where crop residue is incorporated into the soil for decomposition (Baggs *et* al. 2000; Velthof *et* al. 2002). This type of multifunctional cropping system provides solutions that can also help to solve issues on conventional farms, such as N emissions, and can also provide local production of biogas.

Background and objectives

The main objective is to determine the effects of strategic field application of a biogas digestate on crop yield, crop quality, and methane potential, based on anaerobic digestion of crop residues, catch crop and ley from the cropping system. Our hypothesis is that anaerobic digestion of residues and recycling of the digestate will lead to an improved N use efficiency compared to incorporating the residues untreated in to the soil. This strategy addresses four important aspects of food production: sustainable land use, timely and efficient cycling of nutrients, reduction of N losses and self-sufficiency in renewable energy.

There is a need to optimize the sustainable use of agricultural land in consideration of future food supplies, as well as climate change mitigation and adaption due to an increasing level of competition for land used for food or energy production (Harvey & Pilgrim, 2011). By designing multifunctional cropping systems, it is possible to both produce high-quality food crops and biogas in the same cropping season.

There is also a need for economically feasible supplies of plant nutrients in organic systems without animal production to increase both yields and quality. Mineralisation of N has to be synchronized with crop growth and N acquisition, in order to decrease the risk for emissions of nitrous oxide and ammonia, as well as reduce leaching of nitrate to the ground water and streams (Doltra et al. 2011). Biogas digestate has a great potential for solving these issues by supplying the crops with N when they are in an intensive growth phase with large needs.

Key results and discussion

The three crops that gave the highest yield of residual biomass were pea intercropped with barley, lentil intercropped with oat, and barley in pure stand. The dry weight is tightly linked to the energy exchange for methane production. Calculations with theoretical estimates based on the dry weight show that the crop residues, ley and catch crops from the crop rotation can produce approximately 800 m^3 methane/ha. A medium sized organic farm in Sweden of 90 ha with a similar crop rotation, could thus potentially produce 7200 m^3 of methane/year, equivalent to 72 000 kWh, in addition to food products.

Three main results will be presented at the conference:

1) Dry matter production and nitrogen content in each crop residue, ley and catch crop.
2) Nitrogen content of the digestate from the whole cropping system.
3) The actual methane production from the crop rotation.

How work was carried out?

This research project runs from 2012 to 2015. The cropping system was established in 2012 to determine effects of strategic nutrient management, including a treatment involving anaerobic digestion of crop residues and a grass mixture as the feedstock. The crops were chosen to yield food products that are attractive for the Scandinavian market and in addition allow for an additional production of biomass, see table 1. Additionally, all fields were re-sown after harvest of the main crop with an autumn or winter-growing crop, to reduce nitrogen leakage during the winter season (Catt *et* al. 1998). All crops were fertilised with external biogas digestate during the initial year. In the coming years, we will study the effects of three nutrient management systems on the yield, N-uptake, crop quality, energy balance and economy. The management methods are based on:

4) Leaving the biomass resources in situ in the field.
5) Moving the biomass resources to nitrogen-demanding crops.
6) Collecting the biomass resources for anaerobic digestion and using the resulting digestate for the nitrogen demanding crops.

Table 1. Crops in rotation

No in sequence	Main crop	Catch crop/winter crop
1	Ley	Ley
2	White cabbage	Buckwheat and oil radish
3	Lentil (90%) and oat (10%) undersown with ryegrass, white and red clover	Ryegrass, white and red clover
4	Beetroot	Winter rye
5	Winter rye	Buckwheat and lacyfacelia
6	Pea (80%) and malt barley (20%) undersown with ley	Ley

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Biogas nutrient management in organic cropping – not only a nitrogen issue

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Implications

Nutrient imbalance, mainly due to low K and high Ca and/or Mg concentrations, was a plausible explanation for low growth response to digestate fertilisation by beetroot following harvested grass-clover biogas ley. To derive the full benefit of a transition to a biogas nutrient management (BG) system, extra nutrients except for N may need to be added, especially if digestate supply is divided between many crop positions in the rotation. This is probably of extra importance on sandy soils such as that used in this experiment.

Background and objectives

Nitrogen is often mentioned as the most growth-limiting parameter in organic cropping, especially where farm manure is not available and green manure is the main nutritional instrument. However, in a BG system biodigestion of ley and use of the digestate as fertiliser instead of green manuring may reduce the N limitation. The objective of this study was to identify whether, in an organic BG system without supply of farm manure, nutrients other than N may limit beetroot growth in general and following harvested ley in particular.

Key results and discussion

Dry matter production in beetroot with barley as pre-crop responded linearly to plant-available N (PAN) in 2003, both 32 days after sowing (DAS) (Figure 1) and at final harvest. In 2004 the response followed a linear plateau function indicating no further increase in biomass 32 DAS for more than 139 kg PAN ha^{-1} and in biomass at final harvest for more than 145 kg PAN ha^{-1}. Beetroot generally had lower DM biomass at 32 DAS following ley than following barley, even when PAN was the same. The same pattern was seen in 2004 for final harvest of beetroot following ley harvested twice (2H-ley) and three times (3H-ley), but not following green manure ley (GrM). For final harvest in 2003, the response to PAN was equal for barley and ley pre-crops (not shown).

PAN was the most important variable explaining the amount of total biomass at final harvest of beetroot in 2003. However, PAN was of little importance at 32 DAS in both years and at final harvest in 2004. Compositional nutrient diagnosis (CND) imbalance index showed that K deficiency was significantly greater in beetroot following 2H- and 3H-ley than following barley both at 32 DAS and at final harvest (Table 1). The plants had compensated by increased uptake of Mg and/or Ca. At 32 DAS boron level was also lower following 3H-ley than following barley.

How work was carried out

Fertilisation, with digestate from biodigested plant material, of an organic beetroot crop, with barley, GrM, 2H- or 3H-ley as previous crops, was investigated in field experiments on a sandy soil in 2003 and 2004, including treatments without digestate supply. The beetroot crop following barley was fertilised with digestate according to four different N target values based on the sum of mineral N in soil and NH_4-N in digestate. For beetroot following the different leys only one digestate treatment was included, with supply according to a low N target value. The supply of digestate differed with ley pre-crop and barley at the low N-target value, but the sum of mineral N in soil and NH_4-N added with the digestate was equalized between pre-crops. The actual supply of NH_4-N with digestate to beetroot following barley was 43, 105, 156 and 202 kg ha^{-1} (mean of two years). The actual supply to the beetroot crop following ley were 26, 54 and 65 kg NH_4-N ha^{-1} (mean of two years) for GrM, 2H- and 3H-ley, respectively. The beetroot crop without addition of digestate was supplied with 40 kg Na ha^{-1}

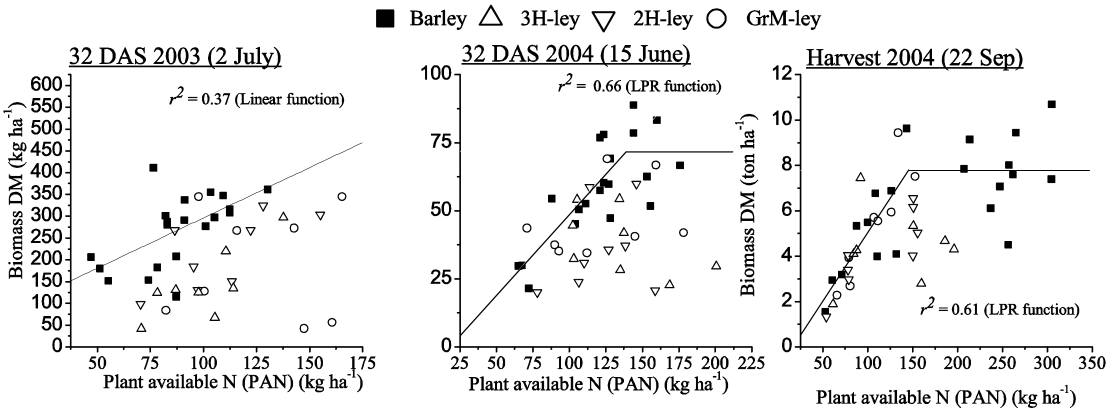

Figure 1. Biomass dry matter in beetroot plants with different pre-crops as a function of plant-available N. The regression lines refer to treatments with barley pre-crop only. DAS = Days after sowing

(Besal, AB Hansson & Möhring) and 150 (after barley), 100 (after GrM) or 200 (after H-ley) kg K ha^{-1} (Kali vinasse). The nutrient concentrations (kg Mg^{-1} fresh weight) in the digestate were: 1.3 NH_4-N, 1.9 N_{org} (i.e. 3.2 total N), 0.4 P, 4.2 K, 1.0 Na, 0.4 Mg, 0.2 S, 0.141 Fe, 0.006 Mn, 0.005 Zn, 0.004 B and 0.001 Cu. The C:N_{org} ratio was 10.

PAN was defined as supply of effluent NH_4-N and apparent contribution of mineral N from soil, including mineralised N from pre-crop residues. Calculations of mineral N from soil was based on the 0-30 cm soil layer at 32 DAS and on the 0-60 cm layer at final harvest.

Partial Least Squares (PLS) (c.f. Magnusson 2002) and CND, calculating nutrient balance index, (Parent and Dafir 1992) were used to interpret nutrient status in plant biomass. In the PLS model, the explanatory variables were PAN and nutrient concentration (log-ratio) of 12 macro- and micronutrients. CND norms were derived from 22 aeroponic experiment treatments with dynamic nutrient supply further described in Gunnarsson (2012, Paper IV).

Table 1. Nutrient imbalance index§ and, within brackets, nutrient concentration (% for K, Ca and Mg; ppm for B) in digestate-fertilised beetroot. All beetroot fertilised to the same N target value. Mean for 2003 and 2004. Different letters show significant difference (5% level, Dunnet) for the nutrient compared with barley pre-crop as a control§§

	32 DAS				Final harvest (total plant)			
Nutrient	Barley	GrM-ley	2H-ley	3H-ley	Barley	GrM-ley	2H-ley	3H-ley
K	-0.8a	-1.8a	-2.9b	-2.9b	-2.9a	-3.0a	-3.9b	-4.7b
	(6.82)	(6.11)	(5.54)	(5.31)	(2.65)	(2.73)	(2.39)	(2.20)
Ca	3.0a	4.1b	4.0b	3.6a	1.14a	2.32a	2.33b	1.0a
	(1.38)	(1.67)	(1.69)	(1.56)	(0.51)	(0.65)	(0.69)	(0.52)
Mg	0.1a	0.7a	1.2b	1.8b	no significant differences			
	(1.18)	(1.29)	(1.41)	(1.52)				
B	-2.7a	-3.3a	-3.5a	-3.8b	no significant differences			
	(29.9)	(27.8)	(27.5)	(26.3)				

§ Imbalance calculated as described by Khiari *et al.* (2001). High negative value indicates deficiency and high positive value surplus compared with the norm. §§Only nutrients for which significant differences were found are included (P, Mn, Cu, N, Zn, Fe, Na and S were also tested)

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Post-harvest sown catch crops – results from two years of organic field trials

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Implications

Post-harvest sown catch crops should be sown as early as possible in order to obtain maximum biomass and nutrient uptake in the harvested crop, as biomass production decreased by 2-3.5 percent per day, when time of sowing was postponed throughout August. Furthermore, the winter hardy species included in these experiments had a tendency to yield less than the non-winter hardy catch crops. These experiments imply that early sown catch crops may become a biomass supplement for organic biogas production, provided sufficient yields are obtained and costs for harvest, transportation and storage are adequately low.

Background and objectives

This study is part of the Danish HighCrop-project (http://agro.au.dk/highcrop/) funded by the Danish Organic RDD-programme and "Promilleafgiftfonden" (a public funding body based on Danish pesticide tax revenues). Growing catch crops in organic plant production is a key element in efficient nutrient management and serve as a tool to preserve the nutrients in the top-soil layers for the succeeding crop and reduces nutrient leaching. Catch crops have traditionally been ploughed under and thus used as green manure. However, as the Danish biogas production in both organic and conventional agriculture is expected to expand, catch crops may become an easily accessible and low cost biomass resource for farm-scale produced biogas, provided sufficient biomass yields may be obtained. The objectives of these experiments are therefore, to investigate the effects on harvested biomass yield (and nutrients) as a function of A) sowing date of post-harvest sown catch crops and B) catch crop species or mixtures.

Key results and discussion

An important result from experiment A (post-harvest catch crop establishment from the end of July to early August) is that early establishment is a prerequisite for obtaining above-ground dry matter yields of 2.5-3.0 ton per hectare in the non-winter hardy catch crops (mixture of yellow mustard and hairy vetch, yellow lupin and yellow mustard). The winter-hardy mixtures (turnip rape/hairy vetch and rye/Persian clover) were not as productive and yielded below 1.5 t per ha when sown early at the end of July. An analysis of variance showed significant effects of both factors: catch-crops and sowing times, but revealed no significant interaction between the two factors. On average biomass dry matter yield decreased by 2-3.5 percent per day that sowing was postponed during the month of August (figure 1).

In experiment B, which compared 15 different catch crops, yield levels varied and the analysis of variance of three field trials conducted in 2011 and 2012 did not show any significant difference between the catch crops. The winter hardy species had a tendency to yield less than the non-winter hardy catch crops. Buckwheat, common mallow, foxtail millet and Structurator, which were only field tested one year, yielded below 1 ton dry matter per hectare. On average 57 kg N, 9 kg P and 36 kg K per hectare were harvested in the non-winter hardy catch crops whereas 47 kg N, 7 kg P and 29 kg K per hectare were harvested in the winter-hardy catch crops.

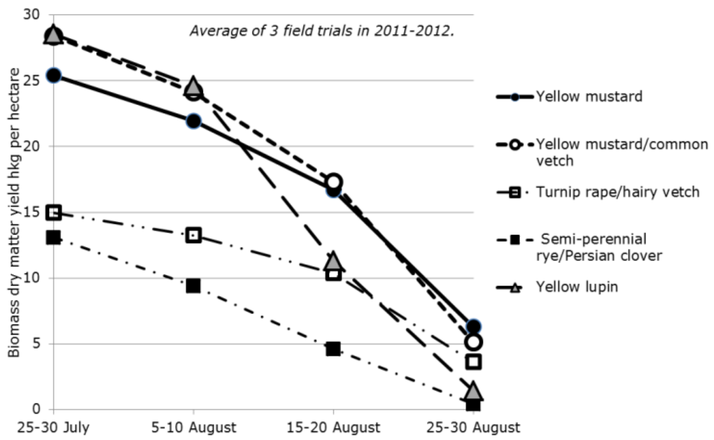

Figure 1. Harvested biomass of five post-harvest grown catch crops in field experiment A (see below) sown at four subsequent sowing dates from late July to late August in 2011 (one site) and 2012 (two sites) (from Pedersen 2012)

How work was carried out?

Two different field experiments were carried out on sandy soils (Pedersen, 2012).

The first field experiment (A) investigated the effect of 4 subsequent sowing dates from late July to late August in five different catch crops: yellow mustard (Sinapis alba), a mixture of yellow mustard (*Sinapis alba*) and common vetch (*Vicia sativa*), yellow lupin (*Lupinus luteus*), a mixture of turnip rape (*Brassica rapa*) and hairy vetch (*Vicia villosa*) and a mixture of semi-perennial rye (*Secale cereale* var. *multicaule*) and Persian clover (*Trifolium resupinatum*). Experiment A was located at 2 sites in 2011 and 3 sites in 2012, with 4 replicates per site. In 2011 one site was excluded from the analysis due to very low yields caused by low soil nitrogen content (previous crop: ryegrass) and a high weed infestation. In 2012 one site was excluded due to extremely wet harvest conditions.

The second field experiment (B) compared 15 different crops and crop mixtures used as catch crops. In 2011 the experiment was established at 2 sites and did not hold replicates, but one site was excluded (same site as in exp. A with ryegrass as previous crop). The 2012 experiment were carried out at two sites each with two replicates. The non-winter hardy catch crops included in both years in experiment B were fodder radish (*Raphanus sativus* var. *oleiformis*), yellow mustard (both fulfill the current Danish requirements for post-harvest sown catch crops), a mixture of yellow mustard and common vetch, yellow lupin and faba bean (*Vicia faba*). Buckwheat (*Fagopyrum esculentum*), common mallow (*Malva sylvestris*), foxtail millet (*Setaria italica*) were field tested only in 2011, whereas phacelia (*Phacelia tanacetifolia*), narrow-leafed lupin (*Lupinus angustifolius*) and Structurator (*Raphanus sativus* L. var. *Longipinnatus*) were field tested in 2012. The following winter hardy catch crops were included in both the 2011 and 2012 experiment: turnip rape, a mixture of turnip rape (*Brassica rapa*) and hairy vetch, a mixture of Italian rye-grass (*Lolium multiflorum*) and Persian clover, a mixture of rye and hairy vetch, a mixture of triticale and hairy vetch, a mixture of semi-perennial rye and Persian clover and finally, a mixture of triticale and yellow lupin.

The experiments were carried out through the Danish National Field Trials and data was analyzed by the SAS 9.2 statistical procedure available in the Nordic Field trial System.

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Management of forb species mixtures for high biomass production

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Implications

Including forb species in grassland mixtures may secure a more biodiversity-friendly production of biomass. This experiment showed interesting future perspectives in terms of production of low-cost biomass for e.g. biogas production, which can be obtained by reducing the number of cuttings without compromising yield levels. No significant differences in dry matter (DM) yields of chicory, birdsfoot trefoil, yarrow and a 13 species mixture were observed between the situations with four compared to one autumn cut per year. Especially the 13 species mixture showed great potential in terms of yield and suppression of unsown species, for which reasons it should be developed further through knowledge on the species in pure stands.

Background and objectives

Production of biomass from species-rich grasslands is interesting in many aspects. The cultivation of multispecies grassland mixtures may increase yield levels (Sanderson et al. 2004), and a nine species herb mixture showed potential to improve yield stability (Mortensen et al. 2012). The objective of this experiment was to investigate yield levels of eleven different forb species, a 13 species- and a standard mixture, when exposed to two different cutting frequencies: four versus one autumn cut per growing season.

Key results and discussion

Annual DM yields of red clover, salad burnet, field scabious, sainfoin, caraway, dandelion, chive, ribwort plantain and the standard mixture were higher with four than one cut per year (Figure 1). Compared to the situation where cutting took place four times per year, regrowth was not stimulated by defoliation, when cutting was performed in autumn only. Moreover, for some forbs, the degree of senescence exceeded the production of new growth, resulting in lower DM yields in the single autumn cut than totally with four cuts. Contrary, there were no significant yield differences between the two cutting situations in case of chicory, birdsfoot trefoil, yarrow and the 13 species mixture (Figure 1). In fact, with one autumn cut, birdsfoot trefoil, chicory and many of the species in the 13 species mixture were able to continue growth throughout the entire growing season.

Dry matter yields of forb species and mixtures were differently influenced by the two cutting frequencies. Compared to the traditional high-yielding standard mixture, annual DM yields of red clover, field scabious, ribwort plantain and the 13 species mixture were not significantly different with four cuts per year (Figure 1). The remaining forb species had DM yield levels, which were almost always significantly lower than those of the high-yielding species. With only an autumn cut, more species were equally productive, but DM yields in plots of salad burnet, sainfoin, caraway, dandelion and chive were relatively low.

The individual forb species and mixtures differed in their ability to suppress unsown species (Figure 1). Consistent with Søegaard et al. (2008), the standard mixture, but also the 13 species mixture, was very suppressive against unsown species, perhaps due to their structural and functional complexity. Moreover, chicory, caraway, red clover and ribwort plantain showed relatively high competitiveness against unsown species. In contrast, species such as sainfoin and chive had very low competitiveness, for which reason they only made up small proportions of the total DM yield in their plots.

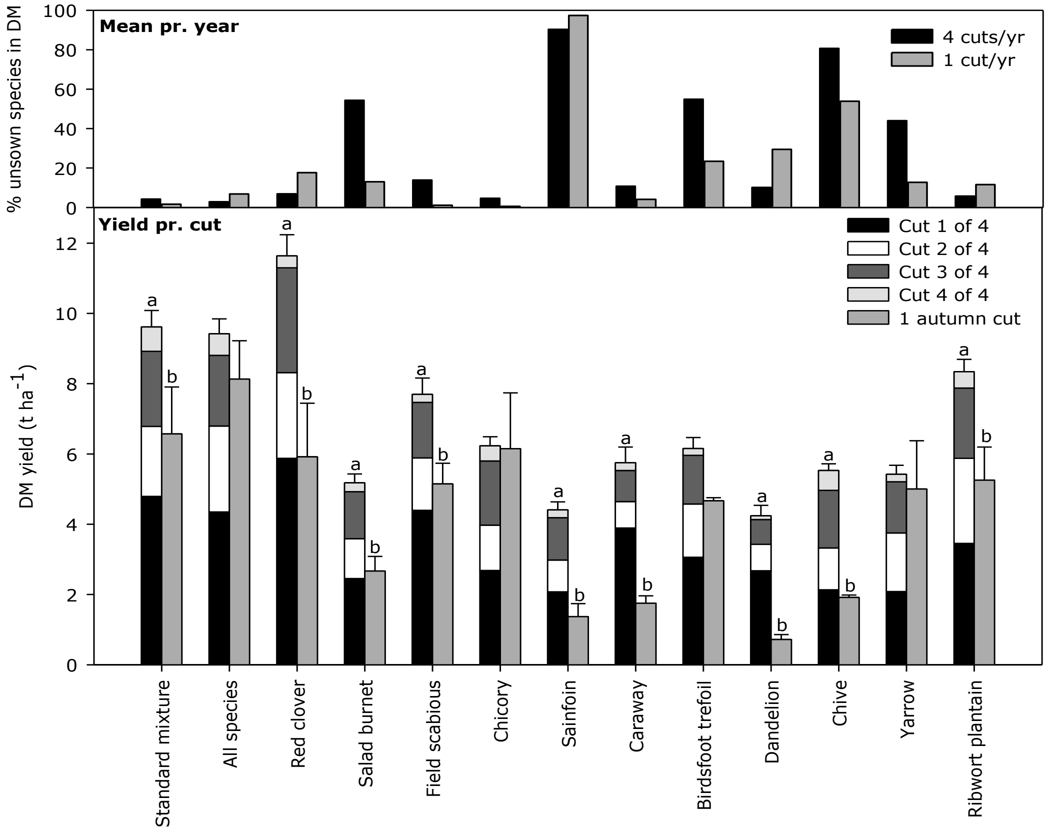

Figure 1. Annual dry matter (DM) yield and percentage (%) of unsown species in the DM of pure stands of forbs, a mixture of 13 species (the 11 pure stand forbs, white clover and perennial ryegrass) and a standard mixture of perennial ryegrass, white- and red clover. Letters *a* and *b* indicate when DM yields of each species or mixture were significantly different between the two cutting frequencies at the P<0.05-level. Error bars: SE

How work was carried out?

A plot experiment was established in an organic dairy crop rotation at Aarhus University, Denmark in 2011 in spring barley. The barley cover crop was harvested at maturity in August, after which there were no defoliations. Pure stands of forbs and mixtures (Figure 1) were sown at 25 kg ha^{-1} in plots of 1.5*10 m, with three replicates each. Plots were managed without application of fertiliser, and cut one- (on 4th October 2012) or four times (29th May, 10th July, 21th August, and 9th October 2012) per year with a Haldrup plot harvester. DM yields were determined per plot by oven-drying of a 150 g herbage subsample at 80°C for 24 hours. The botanical composition at each cut was determined by hand-separating a 100-500 g (depending on the size of the individual plant species) subsample of herbage from each plot. The statistical analysis was carried out using a mixed procedure in the SAS package. In the model, species (or mixture), cutting frequency and their interaction were fixed effects and replicates a random effect.

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Anaerobic digestion of manure – consequences for plant production

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Implications

Organic farming systems are today dependent upon fossil energy. Another challenge are soil nutrient concentrations, which may be depleted with time even in animal husbandry systems (Løes & Øgaard 2001). Anaerobic digestion (AD) of animal manure may produce biogas to replace fossil fuels, and reduce methane (CH_4) emissions during manure storage. Co-digestion of substrates rich in energy increases the economic viability of the biogas plant, and off-farm substrates such as fish silage or household waste may add nutrients to the farming system. AD may also ease manure handling, while reducing the amount of weed seeds and animal pathogens. A reduced proportion of easily degraded C in the AD-manure may however impact the soil fauna/microflora and humus levels. Mineralization of organic N during AD may increase nutrient availability and crop yields. Possibly, the increased levels of root and shoot residues may compensate for the organic C removed via AD.

Background and objectives

A biogas plant was established in 2010 at Tingvoll research farm, NW Norway for AD of the slurry from 25 organically managed dairy cows. A project (SoilEffects, 2010-14) has been established to compare crop yields and soil characteristics after application of untreated versus anaerobically digested slurry. Will AD of animal manure influence crop yields, and impact soil characteristics which are important for soil fertility? Soil physics, chemistry, microbiology and fauna are being studied in a field experiment with slurry application in two cropping systems: 1) arable crops with annual ploughing and no legumes and 2) perennial grass-clover ley established in 2010. The crops in the arable system were oats in 2011 and ryegrass in 2012. Low and high application levels of AD slurry and untreated slurry are compared, with total levels of 85 and 170 kg total N ha^{-1} yr^{-1} applied to arable crops, and 110 and 220 kg to perennial ley.

Key results and discussion

In the perennial ley, the proportion of grass increased with time in both AD treatments (Table 1). The proportion of weeds was lowest in this treatment, especially at the low manure application level.

Table 1. Botanical composition of grass-clover ley over time with different manure application. Values are means (n=4) presented as % DM of Grass, Clover and Weeds. One statistically valid result is highlighted in **bold**

Treatment	**2011, G/C/W**		**2012, G/C/W**	
	1st cut	2nd cut	1st cut	2nd cut
Control, no manure	40/59/1	49/15/36	58/28/14	55/35/10
Untreated slurry low level	50/48/2	57/12/31	59/26/15	56/34/10
Untreated slurry high level	55/44/1	67/8/25	55/31/14	**77**/15/8
AD slurry low level	41/59/0	55/15/30	77/19/4	70/26/4
AD slurry high level	41/58/1	51/11/38	69/14/17	74/18/8

The botanical composition of the control and the low level untreated slurry treatments was quite similar in 2012, in spite of very different yield levels. Only the proportion of grass in the 2nd cut in 2012 differed significantly between treatments, and was then highest by high application of untreated slurry (Table 1).

In the grass system, the yield levels were strongly increased by slurry application (Table 2). AD slurry gave the same yields as untreated slurry. The yields declined over time in the control treatment, whereas they increased in the fertilized treatments. Hence, the relative differences between the fertilized and unfertilized treatments increased over time.

Table 2. Total and relative yields of ley (sum of two cuttings) in 2011 and 2012, tonnes of dry matter (DM) ha^{-1}. Statistically significant differences within year ($P<0.05$) are suffixed as a, b, c

Treatment	2011	2011 rel.	2012	2012 rel.	2012/2011*100
Control	6.61a	100	5.42a	100	82
Trad. Low	8.05ab	122	9.03b	167	112
Trad. high	8.78b	133	10.45bc	193	119
AD low	8.19b	124	8.95b	165	109
AD high	8.44b	128	11.56c	213	137

In the arable system, the yield increases by slurry application were not statistically significant (Table 3). In 2011, this was surprising because differences in growth characteristics such as straw length and plant color were clearly visible between treatment plots during the growing season and straw lengths varied significantly (Table 3). Yield levels in 2012 were generally very small due to bad establishment of fodder rape, which had to be replaced by a late-sown ryegrass crop. Emissions of N_2O were measured in this system in 2012, showing remarkably high values as compared to former measurements in ley at Tingvoll. The average proportion of weeds in 2011 was 10.4 % of the total DM and seemed to increase with fertilization since the control averaged 8 %, whereas fertilized treatments had 10-12% of weeds. In 2012, this pattern was opposite, with more weeds in the control (34% at 1st cut, 11 % at 2nd) than in the fertilized treatments (15-20% at 1st cut, 4-5 % at 2nd).

Table 3. Total and relative yields of arable crops in 2011 and 2012, tonnes of dry matter (DM) ha^{-1}, sum of straw + grain in 2011, sum of two cuts of ryegrass 2012. Suffixed letters as in table 2. 2011 cm = average length of oats straw.

Treatment	2011	Rel.	2011 cm	2012	Rel.	2012/2011*100
Control	5.35a	100	65a	2.23a	100	42
Trad. Low	5.80a	108	69a	2.56a	115	44
Trad. high	5.98a	112	72ab	2.75a	123	46
AD low	5.60a	105	71ab	2.57a	115	46
AD high	6.11a	114	78b	2.64a	118	43

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Long-term changes in soil nutrients and grass/clover yields on Tingvoll farm

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Implications

Long term studies (1989-2012) of soil nutrients and ley yields on a Norwegian organic dairy farm (Tingvoll experimental farm) showed that soil nutrient concentrations decreased over time after conversion. A potential decline in yields due to reduced nutrient concentrations will be difficult to detect, because of large annual variations in yield levels. The sustainability of the nutrient management on the farm should be considered, aiming at keeping soil nutrient concentrations above levels impacting negatively on the yields.

Background and objectives

Organic milk production was established at Tingvoll farm during 1989-1994. The nutrient supply has been manure from the herd, biological nitrogen (N) fixation and some application of lime. The farmers aim at utilizing local resources in a sustainable way. Over the years, milk production has increased due to renting of land and milk quota. A new loose housing barn in 2011 increased the tenant cost. Likewise to most other Norwegian dairy farmers, the tenants at Tingvoll farm have replaced local resources (grazing) by purchased inputs (concentrates) to increase the economic output.

Since1991, yield levels have been recorded annually on most cultivated fields belonging to Tingvoll farm. All cultivated soils (0-20 cm depth) were analyzed for concentrations of phosphorus (P), potassium (K), magnesium (Mg), calcium (Ca) and pH (H_2O) in 1989, 1995, 2002 and 2009. K was analyzed by K-HNO_3 and AL-extraction; other nutrients only by AL-extraction. Former studies of organic dairy farms aiming at self-sufficiency with nutrients (Løes and Øgaard 1997) showed that soil P and K concentrations decreased with time when the import of P was moderate to low (P surplus below 50 kg ha^{-1} yr^{-1}). For K, no correlation was found between K budgets and changes in soil K. In this paper, yield levels are discussed in light of changes in soil nutrient concentrations.

Key results and discussion

The average N, P and K budgets for Tingvoll farm in the period 1994 to 2009 measured in kg nutrient ha^{-1} yr^{-1}, were -0.9 (±5.7) for N, 1.1 (±2.1) for P and 2.1 (±2.7) for K. Nitrogen fixation is not included in these values. On average for all topsoil samples from cultivated soils (n=18), the average P-AL concentrations decreased from 21 to 13 mg 100 g^{-1} dry soil (Figure 1), Mg-AL from 9 to 6, and K-HNO_3 (n=8) from 175 to 135. For K-AL, values varied between 8 and 11 (Figure 1), and for pH between 5.9 and 6.1. This corresponds well to the study referred above. The average nutrient concentrations in 2009 are considered as high for P-AL (optimum value 5-7 mg 100 g^{-1} dry soil), as well as for Mg-AL and K-HNO_3. For K-AL, they are considered as medium high.

The grass yields have fluctuated during the period (Figure 2). Since 2012, all forage has been harvested as round bales. This has reduced the duration of the harvest period significantly, and hence the dry matter (DM) yields have declined. Ley yields are influenced by weather conditions (Figure 2). In 1994 and 2010, yields were low due to low temperature and high precipitation during May and June. In 1992, 2002 and 2011, yields seemed to be restricted by drought, because May + June had high temperature and low precipitation. High levels were achieved in 1997 and 2001, with low precipitation and moderate temperature, as well as in 2004-07 + 2009 with variable climatic conditions. Nutrient mineralization in the soil and biological nitrogen fixation increases by favorable temperature and moisture conditions. The long-term trend of ley yields is slightly negative. Weather does of course not explain all yield variations. It cannot be excluded that reduced soil nutrient concentrations over time may contribute to this trend.

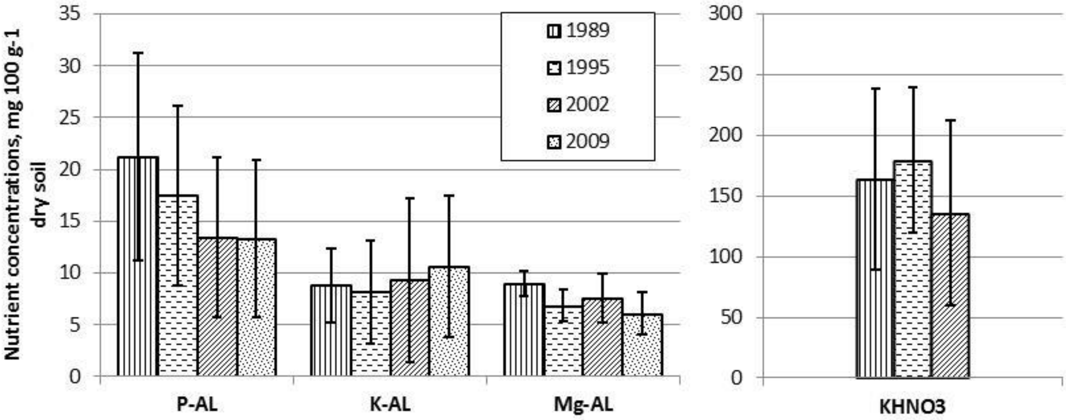

Figure 1. Average nutrient concentrations and standard deviations in the topsoil (0-20 cm) over time

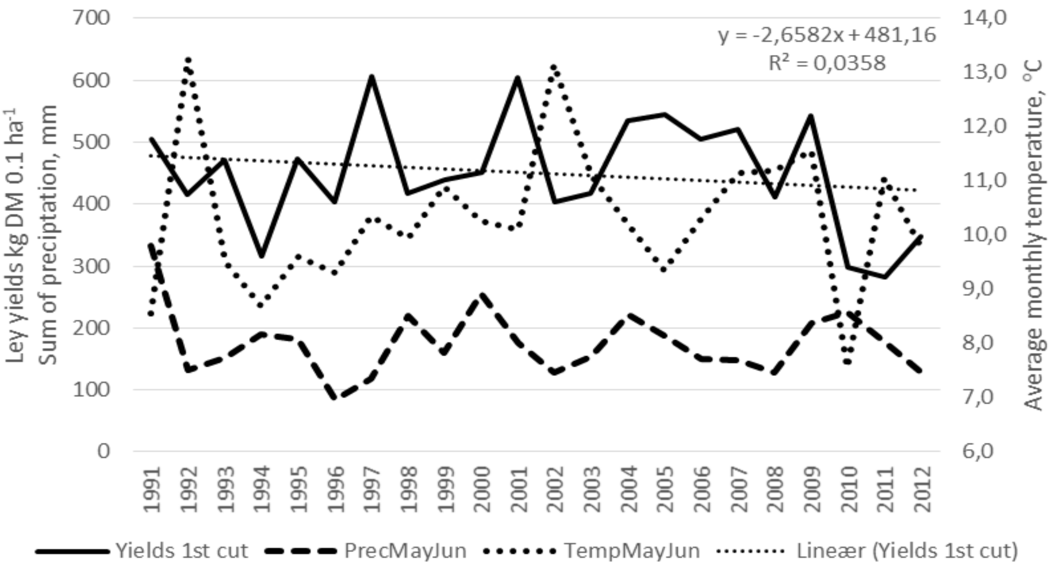

Figure 2. Average ley yields from first cut 1991-2012, x-y fields per year, compared with climatic conditions in May and June measured in Tingvoll

How work was carried out?

Nutrient budgets were calculated based on farm accounts and standard values of N, P and K concentrations (Løes et al. 1996), adjusted for storage of concentrates at the turn of each year except for the period 2004-09. Gross yields where determined by harvesting 5 representative plots of 10 m^2 on each field. Dry matter (DM) content was determined. Soil samples (0-20 cm soil depth) were taken from all cultivated fields, as composites of 10-12 soil cores taken within 5 m distance from a sample point described on a map to ensure that the sample points were the same in each sampling year. Ammonium acetate-lactate extraction (AL) is the routine analysis for measuring soil nutrient concentrations in Norway.

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Estimating nitrogen supply and cereal crop yield in organic crop production

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Implications

Hitherto it has been difficult for farmers to predict the effects of various sources of nitrogen (N) supply in organic farming, since these vary greatly in quality and thus in effect on crop yield. This has limited the planning of organic farming crop rotations and the application of manure and other mobile N sources to the crops, since the effect on crop yield would not easily be estimated. Here we used data from long-term organic crop rotation experiments in Denmark to determine the contribution of various N sources to yield of winter wheat and spring barley. The results showed consistent effects of N in soil organic matter, in organic matter applied to soils, in catch crops, in applied manure and of weed pressure. This opens the possibility for building a simple tool for crop rotation planning that will allow the effects of such crop rotations to be assessed in terms of cereal crop yields, and likely also yield of other non-legume cash crops. Such a tool can be used for strategic planning of crop rotations in organic arable farming taking into account the prehistory of the site as well as the possibilities of N supply through manure or measures to control weeds.

Background

Several studies have demonstrated that crop yield of cereals in organic arable farming is mainly constrained by availability of N and from competition by weeds (Olesen et al. 2007, 2009). Crop N supply for non-legume crops in organic farming depends on several sources, many of which are in organic form. The various forms of N are assumed to contribute differently to crop N uptake and N yield. However, so far it has shown difficult to estimate the contribution from each factor in a way that allows the information to be used for strategic planning of crop rotations and their management. In this study we used data from a long-term organic crop rotation experiment in Denmark to estimate the contribution of various N sources to yields of winter wheat and spring barley.

Results and discussion

The N uptake in grain of winter wheat and spring barley was estimated from data from 2006 to 2009 in crop rotation experiment at three locations (Jyndevad, Foulum and Flakkebjerg) in Denmark. Total N in the soil at onset of the experiment contributed about 0.0036 kg N in grain per kg N in top 25 cm of the soil for both crops. The amount of organic N input in above-ground residues and manure prior to the cereal crop contributed about 0.20 kg N per kg N in annual organic N inputs. Since the average period of inputs was about 10 years, this means a grain yield of about 0.02 kg N per kg N in accumulated inputs since the start of the experiment. The N in the above-ground of an incorporated catch crop prior to spring barley contributed 0.37 kg N per kg N in catch crop. The effect of manure application varied between locations and crops. For winter wheat the effect of ammoniacal N in the manure on grain N yield was 0.17, 0.55 and 0.39 kg N per kg NH_4-N for Jyndevad, Foulum and Flakkebjerg, respectively. For spring barley the effect of ammoniacal N in the manure on grain N yield was 0.58, 0.47 and 0.42 kg N per kg NH_4-N for Jyndevad, Foulum and Flakkebjerg, respectively. Weeds were found to reduce crop N update by 0.52 kg N per % dry matter in weeds at anthesis in winter wheat and by 1.06 kg N per % dry matter in weeds at anthesis in spring barley. The regression equations explained 69 and 73 % of the variation in grain N of winter wheat and spring barley, respectively. The results of grain N yield translated very well into grain dry matter yield with coefficients of determination of 0.99 for both crops.

The results show the relative contributions of various sources of N to crop yield. The smallest contribution (compared with the stock size) comes from native soil N. However, this stock of N is large and may vary considerably between fields, and should thus be taken into account. The amount of organic matter applied over the past 10 years contributes about 5 times as much in proportion of the amount of N present than native soil N, which indicates a faster mineralization of this of pool of soil organic N compared with native soil N. The contribution of N from freshly incorporated N in catch crops is much higher, which probably reflects the low C/N ratio of this material, which therefore releases a high amount of mineral N. The most variable contributions were from N in manure, in particular for winter wheat. Since the manure was applied in slurry and mostly injected to the spring cereals prior to sowing, this resulted in little ammonia volatilization for the spring cereals, and therefore consistent effects on crop yield. The low N use efficiencies of manure for winter wheat at Jyndevad and Flakkebjerg may be attributed to ammonia volatilization following surface application of slurry using trail hoses. The effect of weeds varied between cereals with the largest reduction for spring barley, which may partly be an effect of the generally smaller yields in spring barley compared to wheat, but may also reflect a smaller competitiveness of barley compared with wheat.

Materials and methods

An experiment on organic arable crop rotations was conducted at three sites in Denmark from 1997 to 2009 (Olesen et al. 2000; Askegaard et al. 2011). The experiment included three factors in two replicates: 1) Grass-clover green manure crop (with and without), 2) catch crop (with and without), and 3) animal manure (with and without). Four year crop rotations were used, and all crops in the rotations were represented every year. The experiment was placed at three sites with different soil and climatic conditions: Jyndevad (sand), Foulum (loamy sand) and Flakkebjerg (sandy loam). Where manure was applied this corresponded to about 40-60% of the recommended rates in conventional farming. Grain yields were determined for each plot by combine harvester. Samples of above-ground biomass dry matter were taken in each plot at ear emergence in the cereals, and the samples were separated into cereal, catch crop and weeds for assessing weed pressure. Samples of above-ground dry matter was also taken before cutting of the grass-clover at maturity of the main crops and in early November in catch crops and weeds to determine the amount of N being returned to the soil in residues. The harvested grain N yield in winter wheat and spring barley was related to a number of variables using multiple linear regression: 1) total N in the top 25 cm of the soil at onset of the experiment, 2) annual organic N inputs in crop residues and manure to the soil since onset of the experiment, 3) total N incorporated in spring in grass-clover or catch crops, 4) ammoniacal N in the manure applied, and 5) percentage of weeds in the crop at anthesis. Dry matter grain yield is then subsequently calculated from the grain N yield using a quadratic function.

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Development of phosphatase and dehydrogenase activities in soils of annual cropland and permanent grassland in an organic farm

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Implications

The essential nature of Phosphorus (P) in plant growth and the finite amount of P resources have result in the question: what kind of management in farming systems can lead to P sufficiency in organic farming? The release of acid and alkaline phosphatases of plant and microbes promote the plant availability of soil P. The presented results show a significant higher enzyme activity at permanent grassland (PG) than at arable land with annual crops at an organic farm in Northern Germany. Therefore livestock systems with PG for grazing ruminants seem to have high potential to improve on-farm P-cycles via feed and manure flows even to annual cropland. These systems can profit from the nutrient transfer from PG to arable land through the use of manures. Enhance the soil-plant P cycle by better use of P sources with low availability from PG could be component of sufficiency P management in organic and also conventional production.

Background and objectives

P is a non-renewable resource and essential element required for cellular function. Deficiency, as a consequence of poor availability of P in soil, has a significant negative impact on plant growth and fecundity and represents a major constraint to crop production globally (Runge-Metzger 1995). In contrast to conventional production easy soluble mineral P fertilizers are not allowed in organic farming. Therefore it is necessary to find suitable solutions for an adequate nutrient supply to the plants. A promising option for organic farming is the optimized use of soil-borne P. P is present in many different forms in soil but only a small fraction of total soil P is directly available for plant or microbial uptake. P mobilization from insoluble soil reserves takes place by soil acidification or exudation of enzymes, like acid and alkaline phosphatases by plants and microbes. The activity of dehydrogenase generally reflects the intensity of microbial turnover rates. For that reason the presented results focus on activity of phosphatase and dehydrogenase as an indicator for microbial activity. The P-mobilizing activity at an on-farm perspective is measured under different cultivations at two times: on farmland in the first year after conversion to organic farming and on organic farmland 11 years later.

Key results and discussion

The activity of alkaline and acid phosphatases and dehydrogenase was measured in soil samples taken at different time after conversion to organic farming and in different cultivations (Table 1). The phosphatase activity is significant higher in PG in relation to arable land. This result fits to higher microbial P concentrations in PG than arable land (Oberson and Joner 2005). The dehydrogenase activity is significant higher at PG than at the adjacent conventional acre and show the lowest activity in the organic crop systems. The PG has low pH values and a high level of enzyme activity. This may improve P mobilization from low solubility fractions. Therefore grassland might be an important source for P and important for sustainable nutrient management. Feedstuff from PG which includes microbial activated P enters the on-farm P-cycle as an element of farmyard manures which will be spread out on the arable land. More than 11 years after converting from conventional to organic farming soil of PG shows a significant decline in the measured enzyme activities (Tab. 1), possibly as a result of less nutrient supply and decreasing yields. Soils of different organic crop rotations on the same site do not show an obvious trend between the years. To quantify effects of different crops and their rotations on the soil enzyme activity and P-mobilization more analysis are necessary.

Table 1. Values of phosphatases (phos) and dehydrogenase (DH) in soils 2001 and 2012 in different businesses* (organic=organic system, PG=permanent grassland, conv= conventional system)

		mean values and sign. differences (p<0.001)						standard deviation			n
		alkaline phos# µg p-Nitrophenol /1 g soil		acid phos# µg p-Nitrophenol /1 g soil		DH µg TPF /1g soil					
Business	Year							alkaline phos	acid phos	DH	
organic	2001	136	A	139,1[a]	**A**	49,1	A	10,1	4	14,7[a]	8
Crops	2012	143,6	A	127,7	**B**	42,1	A	12,6	10,6	8,2	8
organic	2001	150,9	A	138,3	A	42,9[a]	A	3,3	14,5	31[a]	8
Rum1	2012	143,5[a]	A	140,2[a]	A	61,3[b]	A	12,6[a]	13,2[a]	22,6[b]	8
organic	2001	140,0	**B**	144,2	A	44,8	A	2,1	3,6	15,9	4
Rum2	2012	154,8	**A**	149,9	A	47,3	A	8,8	7,5	12,5	4
organic	2001	142,1	A	138,0	A	43,4	A	7,5	7,7	13,3	4
Pig	2012	142,2	A	136,7	A	29,9	A	9,3	4,2	11,5	4
mean	2001	142,7	A	139,5[a]	A	45,5[a]	A	9,1	9,3	19,9	24
organic**	2012	145,3[a]	A	136,9[a]	A	46,1[b]	A	11,7	12,6	17,5	24
PG	2001	173,1	**A**	175,6	**A**	133	**A**	5	9,4	25,5	8
	2012	155,2	**B**	161,1	**B**	101,1[a]	**B**	8,8	5,6	34,7[a]	8
conv**	2012	150,1		147,5		87,5	*	8,3	2,6	23,9	4

*abbreviations explained below **= "conv" is significantly different to "mean organic"

[a] = (n-1); [b] = (n-2)

How work was carried out?

The research farm Trenthorst converted from conventional to organic farming in 2001. It is located in Northern Germany (53°46' E, 10°30' N; 10-43 m asl) with a mean annual precipitation of 706 mm and a mean annual temperature of 8.8°C (1978-2007). The soil is characterized as Cambisols and Luvisols with 46% sand, 34% silt and 18% clay from 0- 30 cm and 1.2% C_{org} at the acres and 38% sand, 41% silt and 16% clay and 3.2% C_{org} at PG, on average. In 2012 the chemical soil properties differ between organic annual cropland (pH 6.4-6.75; P-CAL 5.3-8.4 mg/100g), PG (pH 5.4; P-CAL 15.7 mg/100g) and conventional (pH 6.6; P-CAL 4.15 mg/100g). The farm is geographically divided into 4 crop rotations: Ruminants (Rum) 1: grass-clover (gc)-gc- maize+gc- wheat- faba bean-triticale+gc; Rum2: gc-maize+gc- wheat- pea- wheat+clover- triticale+ gc; pig: gc- gc+ pigs- barley- faba bean-wheat- pea+ false flax- triticale+ gc and Crop: red clover- wheat- spring barley- pea- rape-triticale+ red clover. Soil samples were collected at 4 GPS-located points per plot (0-30 cm) and deep-freezed by -20°C. The phosphatase activity is measured by the method of Tabatabai and Bremner (1969) and for the activity of dehydrogenase Thalmann (1968) is used. Statistics are calculated with JMP 9.0.2 software from SAS and an alpha level of 0.001.

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Effects of applying anaerobically digested slurry on soil available organic C and microbiota

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Implications

Anaerobic digestion of animal slurries and plant residues is a valuable technology to produce bioenergy and fertilizers in organic farming systems, while at the same time reducing propagules of weeds and parasites in the input material. However, the digestion changes the quality of the slurry by reducing its content of organic matter and increasing mineral nitrogen (N) levels. This may have profound impact on soil fauna and microorganisms as well as the biogeochemical processes they drive. Organic farmers fear that application of digested materials may have negative implications for soil fertility by reducing the input of organic matter to the soil, compared to fertilizing with traditional animal slurries or green manures. Hence, it is important to gain knowledge about the short- and long-term effects on microflora and carbon (C) balance in soils fertilized with digested slurry.

Background and objectives

The Norwegian project SoilEffects (2010-14) is a field study where the soil is applied with untreated cattle slurry or anaerobically digested slurry in two cropping systems: arable crops with annual ploughing and without legumes, and a grass system with perennial grass-clover ley. The objective of this study was to assess how application of the two types of manure influenced the soil content of readily available organic matter (supposed to govern the community dynamics of the soil microbial community (Johansen et al., 2013), as well as the microbial community structure and activity in the two cropping systems. Data from 2011-2012 are presented.

Key results and discussion

In 2011, the intrinsic soil content of CWEC was about 30% lower in the arable system than in the grass system (Figure 1a and 1b). This was to be expected, since the topsoil content of total C was on average 3.5% and 6.4% in the arable and grass system, respectively. Application of slurries did not change the level of CWEC in the grass system, while in the arable system it increased slightly, by 10-20% at high manure levels (UH and DH). In 2012, the general level of CWEC was 30-50% lower than in 2011 (Figure 1); most pronounced in the arable system. The general decrease in CWEC in the arable system may be explained by soil tillage in 2011 and 2012, causing enhanced decomposition of soil organic matter. In the grass system, the general decrease in CWEC levels may have been caused by the colder and drier spring in 2012 than in 2011, decreasing the turnover rate of the organic matter. It is interesting to see that in 2012, the CWEC levels reflected the applied amounts of manure quite well in both cropping systems. Incubating soil sampled five days after slurry application (2011) in a respirometer showed that microbial turnover (respiration) of the respective materials was positively related to the amount of fertilizer applied to the soil (data not presented).

Phospholipid fatty acid (PLFA) analysis performed on the 2011 samples showed that the microbial biomass was not influenced by the slurry applications (data not shown). However, treating the PLFA data in a principal component analysis indicated that the soil microbial community composition in the two cropping systems was different (Figure 2) as their respective data points separated totally along the PC1 (66% of meaningful variation) axis. This may be due to the differences in the soil content of available organic C. PC2 explained only 10% of the variation, but seemed to reveal that the soil microbial community composition was also affected by the type of slurry applied, since the samples with digested or undigested slurry were grouping up in the bottom or top of the plot, respectively. Hence, the type of cropping system had more impact on the microbial community composition than the type of fertilizer; maybe in combination with the enhanced level of organic matter in the grass system. The present results reveal short-term effects, and observations from more seasons are obviously needed to reveal long-term effects of applying different types of slurry.

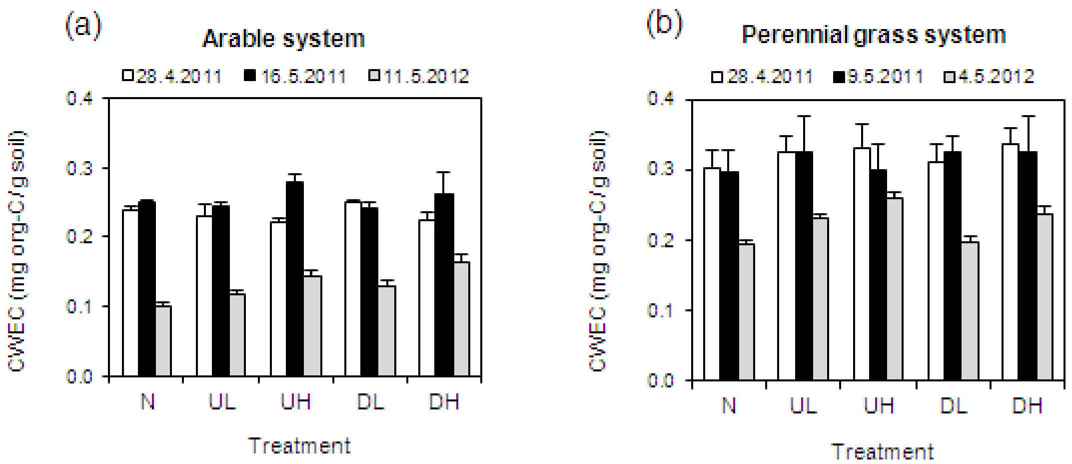

Figure 1. Cold-water extractable organic carbon (CWEC) in soil amended with: Nothing (N), Undigested slurry at Low/High level (UL/UH), Digested slurry at Low/High level (DL/DH). The slurries were applied to the arable (a) or perennial grass-clover ley (b) cropping system 5 days before the sampling dates (shown above the plots), except for the sampling at 28.4.2011 where soils were not amended. Bars represent SEM (n=4)

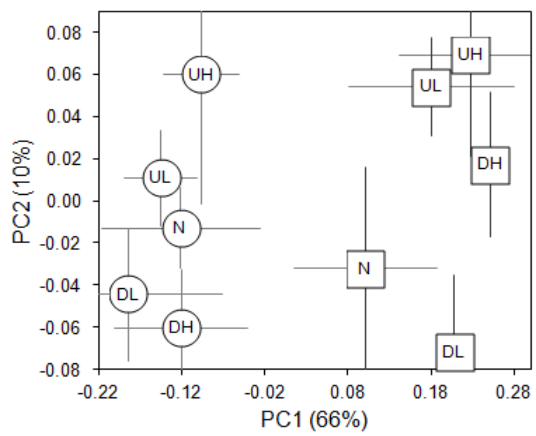

Figure 2. Score plot from a principal component analysis of PLFAs from soil sampled in the arable (squares) and grass (circles) cropping system; five days after application of slurries in 2011. Abbreviations of manure treatments (N, DL, DH, UL, UH) are explained in Figure 1. Bars represent SEM (n=4).

How the work was carried out

Topsoil (0-20 cm) from the experimental plots within the two cropping systems was sampled in spring 2011 (just before slurry application and five days later) and 2012 (two days after slurry application) and analysed for contents of readily available organic carbon (cold-water extractable C; CWEC). PLFA profiling was employed to measuring the structure and growth dynamics of the soil microbiological communities (Johansen et al. 2013).

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Comparison of organic and conventional dairy farm economic and environmental performances throughout North West Europe

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Implications

From an environmental point of view, organic farming (OF) systems have been identified as beneficial thanks to a system allowing fewer losses of nitrogen (N) per ha and lower green house gases (GHG) emissions per ha and per ton of milk (TM). From an economic point of view, milk coming from these OF systems is sold at a higher prize. However, incomes provided by both systems are similar (for similar amount of milk produced). This may be explained by higher input costs per unit of product for OF systems and by more incomes coming from sold crops for conventional farming (CF) systems.

Therefore, on the one hand CF systems may improve their environmental performances by reducing the amount of inputs brought into the system, for example through a better forage and fertilisation management. On the other hand, the valorisation of milk through a differentiated production or market (price premium due to a label and/or on-farm transformation and/or sale) may bring them higher incomes. OF system may increase their incomes by selling one cash crop destined for human consumption and by finding the good balance between intensivity and extensivity in order to better valorise the inputs brought into the system.

Background and objectives

Dairy farming is an important agricultural economic activity in North West Europe (NWE). As underlined in the Dairyman project – an INTERREG project aiming to enhance the sustainability of dairy sector in NWE (The Netherlands, France, Germany, Luxembourg, Ireland, The United Kingdom and Belgium). Unfortunately, inefficiencies in the use of fertilizers, feeds and energy for dairy production can hamper the delivery of key environmental services such as clean water, clean air and biodiversity. Farmers are also coping with the milk price volatility, high investment costs and narrow profit. Therefore, efforts are needed to improve resource management in order to minimise both production costs and environmental impacts. One way to improve resource management might be developing and improving both OF and CF systems thanks to the identification of practices in these systems that could be efficiently implemented in the other one.

Key results and discussion

In the text below, we only present indicators that appear to be significantly different while comparing organic farms with their conventional homologue (we define homologue as farms with similar structures and constrains to the same geopolitical context). We also present differences observed regarding to the regional effect.

OF systems allow a reduction of N balance (66.5 ± 31.4 N kg/ha vs 148.2 ± 63.7 N kg/ha, $p < 0.001$) and of GHG emissions per ha and per TM (6,930.8 ± 3,468.1 kg of CO_2 equivalent/ha vs 13,118.9 ± 5,979.7 kg of CO_2 eq./ha, $p < 0.001$ and 1,024.3 ± 179.62 kg of CO_2 eq./TM vs 1.267.0 ± 360.1 kg of CO_2 eq./TM, $p < 0.1$). Furthermore, differences were observed for some descriptive indicators: OF systems have, in average, higher proportion of grassland in the agricultural area (90.4 ± 10% vs 73.6 ± 22.3%, $p < 0.001$), smaller proportion of maize and crops (respectively 3.9 ± 5.5% vs 14.3 ± 13.7%, $p < 0.01$ and 5.7 ± 12.3% vs 12.1 ± 13.1%, $p < 0.001$). In addition, OF systems provide, in average, less concentrate per cow and per kg of milk (987.7 ± 705.8 kg/cow/year vs 1,547.4 ± 768.8 kg/cow/year, $p < 0.1$ and 125.9 ± 80.1 g of concentrate/kg of milk vs 191.1 ± 87.6 g of concentrate/kg of milk, $p < 0.1$) but they also get lower cow yield (6,570.6 ± 1260.7 kg of milk/cow/year vs 7796.3 ± 871.6 kg of milk/cow/year $p < 0.01$). OF systems valorize milk produced in a better way (0.37 ± 0.04€/kg of milk vs 0.32 ± 0.02 €/kg of milk, $p < 0.001$). Despite such differences in milk price, incomes per labor unit (LaU) provided by both systems are statistically similar (39,835 ± 13,508 €/LaU for OF systems vs 35,770 ± 14,725 €/LaU for CF systems) while amount of milk produced are also similar.

From a regional point of view (whatever the farming system), two regions are identified as significantly different from the others for some characteristics. The Netherlands (NL) and Flanders (BF) have bigger dairy cow herds per labor unit and produce much more milk ($p < 0.001$, average of 117.1 ± 43.2 dairy cows for NL and BF vs 62.5 ± 7.7 dairy cows for the others region). Furthermore, they have higher input costs ($p < 0.000$, in average 2,356 ± 147€/ha vs 748 ± 322 €/ha). However, they get in average higher incomes per LaU ($p < 0.1$, in average 51,542 ± 7.780 €/LaU for NL and BF vs 33,223 ± 12,333 €/LaU for the others). Although their N balances are in average bigger (152.2 ± 79.4 N kg/ha for NL and BF vs 92.4 ± 54.3 N kg/ha for the others), no significant differences were observed due to high standard deviation minimizing the regional systems effect, neither for the GHG emissions per TM. However, significant differences were noticed regarding to GHG emissions per ha ($p < 0.000$, 12,281.7 ± 5,519.5 kg of CO_2 eq./ha for NL and BF vs 7,939.3 ± 4,128.3 kg of CO_2 eq./ha for the others).

How work was carried out?

Amongst a network of 126 pilot dairy farms across NWE 16 farms have been selected. This sample gathers 8 organic farms and their homologue conventional farm in each region which means 2 farms from Flanders (BF), 4 from Wallonia (BW), 6 from Brittany (FB), 2 from Luxemburg (LU), 2 from the Netherlands (NL). Farm-pairs have been identified to be as similar as possible, using Principal Compound Analysis based on structural data (size of herd, size and occupation of the agricultural area, quotas and familial labour unit) and thanks to discussion with experts following the network.

Environmental performances were assessed through N and P balances per ha, N and P efficiency, GHG emissions allocated to the dairy herd per ha and per TM. GHG emissions were calculated based on the tier 2 method of the IPCC (Intergovernmental panel on climate change) guidelines. Until now, biodiversity and water management haven't been included but such issues should be taken into account in the future analyses. Economical performances (incomes, inputs efficiency, variable cost, etc.) were assessed. Due to the interregional level of the study, incomes have been corrected with the indicator of consumer prices (Eurostat, 2011). Environmental and economic results were compared based on a two ways variance analysis according to the farming systems (fixed factor; 2 levels: organic vs conventional) and the region (random factor; 5 levels). Square means were compared using Student–Newman–Keuls test. Furthermore, using the same statistical methods, groups were characterized and compared through a set of descriptive data (such as age at the first calving, calving interval, amount of concentrate provide, herd size, amount of labor unit, cow productivity, etc.) in order to identify differences in farming strategies.

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Operational strategies for optimizing grazing when using automatic milking systems in organic dairy production

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Implications

Successful grazing when using AMS is possible without having to devote a great deal of time to organize and fetch cows every day. However, a careful strategy and good infrastructure, and observation of cow behaviour and pasture are necessary, and the herd has to adapt to the chosen design and routines. In practice, sectional permanent grazing, part-time grazing and structured rotational grazing have been shown to be successful, in terms of allowing outdoor grazing while still maintaining milking frequency and milk yield. In addition, part-time grazing can be combined with either of the other two systems.

Background and objectives

Automatic milking systems (AMS) are often procured with the aim of saving time on the farm, making the working hours more flexible and relieving physical constraints. The financial investment in an AMS can be considerable and the intended advantages do not directly contribute extra revenue, with economic analyses showing no or negative effects on gross margin (Bijl et al., 2007). This puts pressure on farmers that invest in AMS to increase efficiency, or at least avoid a milk yield decrease through milking frequency falling below two or insufficient feed intake. One of the strategies adopted by many farmers is to reduce grazing and provide more feed in the barn. For not compromising the beneficial effects of grazing on cow health (Burow et al., 2011), they should seek different strategies to ensure that milking frequency is sufficiently high (>2) and not fluctuating too much from day to day. Stable milking frequency per cow is necessary to avoid high somatic cell counts (SCC) and stress in the herd (Svennersten-Sjaunja and Pettersson, 2008). Strategies to secure acceptable milking frequency and stability together with grazing should not result in extra labour requirements or costs. The essential features of three successful strategies for grazing with AMS are described below.

Key results and discussion

Sectional permanent grazing

The grazing land is divided into three or four sections, with the size being dependent on grass growth rate and projected grass intake. After a milking session the cow is guided to a smart gate, which guides her on to a paddock, e.g. paddock A from 3:00 until 9:00 h, then paddock B from 9:00 to 15:00 h, etc. The cows are free to enter the barn, but are only allowed to leave if they are not due to be milked within e.g. 5-6 hours (this is a management choice). When the farmer comes out at e.g. 12:00, the cows from paddock A can be fetched inside, at e.g. 18:00 the cows from B should be fetched, etc. With only daytime grazing only two paddocks need to be used, so as to ensure that cows are not staying out for longer than their optimal milking interval. Without this system, the herdsman would have difficulties in identifying the right cows to fetch (not milked within 12 hours), and all cows would have to be fetched irrespective of the time they had spent outside. Grass intake per cow is generally higher in this system, while still giving a stable milking frequency and little stress. The system stimulates cow traffic.

Part-time grazing
Variations in pasture quality and supply over the season can be a problem, especially for high-yielding cows. A solution to this problem is part-time grazing, where cows have access to the pasture during a fixed part of the 24-h period daily and are restricted to the house and offered indoor feeding during the remaining hours. The system aims to combine the positive effects of grazing with the security of indoor feeding to ensure sufficient nutrient supply to high-yielding cows at all times. It is a flexible system that can be adapted to the pasture conditions of the specific farm and the prevailing weather conditions by varying the hours on pasture and amounts of feed offered in the house. The beneficial effects of pasture and grazing with regard to cow health and milk composition are maintained and the economic benefit of incorporating a low-cost, high-quality feed such as pasture into the diet is achieved. In an recent experiment performed in an AMS barn, a group of cows with access to part-time pasture for 9.5 h, with no indoor roughage during the first 8 h of the pasture period and *ad libitum* silage during the remaining part of the 24-h period, were compared with a group of cows with access to an exercise field 9.5 h and *ad libitum* silage 24 h per day (Andersson, 2012). The silage offered in the house and the pasture ley had a similar content of metabolisable energy (ME), 10.9 and 11.0 MJ ME per kg dry matter, respectively. It was found that the cows with part-time grazing had significantly higher milk yield than the cows in the exercise field (35.6 and 33.3 kg milk, respectively).

Rotational grazing
In rotational grazing, the pasture is divided into many paddocks, each of which can be extended daily using mobile fencing to supply the cows with some hours of new grass, whilst still allowing them to graze on the previous parts of the paddock. This means that the herd is stimulated to come outside and graze, has access to a known amount of fresh grass, but also is stimulated to go back to the house for supplementary feeding. The system can be intensified by splitting the daily access into two paddocks. This intensifies the cow traffic, and can increase the milking frequency if needed. The system needs a well-designed track pattern, which can lead the cows to and from the paddocks, each time passing the milking robot. In some herds a tendency to return to pasture, without passing through the AMS, needs to be counteracted. The advantage of the system is good, uniform grazing of the pasture with a rest period, which guarantees good ley yield. The main drawback of the system is the need for extensive infrastructure and the risk of creating stress in the herd. The system is very attractive for areas that can support grazing without ploughing and reseeding.

How was the work carried out?

During the past 10 years of experience with AMS, different strategies have been tested in research and in practice. Farmer experience groups and farm experiments in Denmark and Sweden are background for the described systems and can be found in the authors' published work.

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Long term farm study of organic milk production — moderate concentrate inputs and high milk yields on Tingvoll farm

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Implications

Long term studies of organic milk production on a Norwegian organic farm (Tingvoll farm) show that it is possible to achieve high milk yields with moderate concentrate inputs in organic milk production with Norwegian Red Cattle. The milk yields at Tingvoll farm were generally higher, and the concentrate input lower than the average of all Norwegian dairy farms. Average annual milk yields, as well as annual concentrate consumption per cow increased during the study period both for organic and conventional dairy production in Norway. The results from Tingvoll farm may inspire conventional dairy farmers to convert, since the differences to organic production are not necessarily too large. Alternatively, they may be inspired to reduce their concentrate inputs.

Background and objectives

Organic milk production was established at Tingvoll experimental farm during 1989-1994. The objectives for the milkproduction where high yield, high roughage intake and low concentrate inputs. Since then, annual records of fodder production, milk yields etc. have been collected. In this paper, we present results for annual average milk yields and concentrate consumption for the period 1991-2012, to discuss the changes in the levels of these characteristics over time.

Key results and discussion

Likewise to the development for most other Norwegian dairy farms, the number of cows, concentrate inputs and milk yield increased considerably at Tingvoll farm during the study period (Table 1 and fig 1). The yields increased rapidly from 2006.

Table 1. Milk yield and feed units concentrate per cow eq at Tingvoll farm, at organic dairy farms in Norway and at all dairy farms in Norway

	2002			2008			2011		
	TF	Org	Coun	TF	Org	Coun	TF	Org	Coun
No. of herds	1	249	17 137	1	281	11 794	1	294	8 935
Cow eq. per herd	13.6	15.8	15.3	19.9	23.1	19.8	20	26.4	22.1
Kg ECM/ cow eq	6410	5024*	6278	7 300	6 448	7 144	8 204	6 771	7 309
Feed units concen- trate/100 kg ECM	16	17*	27	20	22.8	28.3	23	24.7	29.9

TF= Tingvoll farm, Org=average for organic dairy farms in Norway, Coun= National average of dairy farms. ECM=energy corrected milk. Feed units = net energy lactation, and 1 feed unit is equal to 1 kg of barley.
* Not energy corrected milk

The feed rations at Tingvoll farm changed significantly during the study period. Whereas 6 different feedstuffs were used in 1996 (Table 2), only silage, concentrate and hay were used in 2012. The pasture share of the total diet was reduced from 36.8% in 1996 to 13.9% in 2012. Until 2011 the cows grazed day and night. However, after a loose housing barn was built in 2011, the cows grazes only during daytime. The calving season has changed from concentrated spring and early summer calving, in 1991-2006, to an even distribution over the whole year. The changes in management should be seen in light of increase in milk quota over time, which has increased the herd size, reduced the input of forage per cow and increased the farmer's income per man hour. Tingvoll farm has a somewhat higher milk yield and less concentrate input per 100 kg ECM than the average of Norwegians farms.

In Norway, concentrates are usually purchased, even on farms where cereals may be grown. Especially for organic produced concentrates, the ingredients are often imported from abroad, and protein concentrate is hardly produced in Norway at all. The development towards less forage and more concentrates in the diet of organic cows is criticized for not being environmentally sustainable. For the farmers it is clearly economically beneficial.

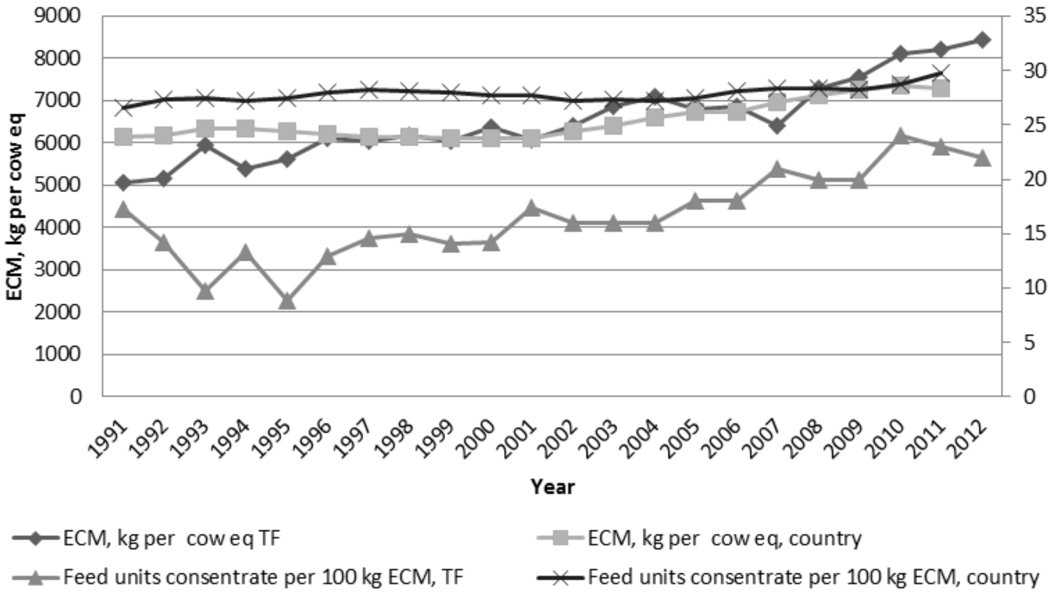

Figure 1. Kg energy corrected milk per cow eq and feed units concentrate per 100 kg ECM

Table 2: Composition of the feed ration for dairy cows at Tingvoll farm in 1996 and 2012, on a feed unit basis

	Year 1996	Year 2012
Total number of feed units	5 118	5 739
% concentrate	15.5	32.9
% pasture	36.8	13.7
% silage	37	53.4
% hay	9.2	
% potatoes	1.5	
% other feedstuffs	0.1	

How work was carried out?

Parameters from Norwegian herd recording from Tingvoll farm, all Norwegian organic dairy farms and all dairy farms in Norway (organic and conventional) were used in this study.

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Feeding toasted field beans to dairy cows

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Implications

Toasting field beans can improve the protein quality of field beans markedly. In the feed demonstrations carried out in Project EcoProtein testing a new method of toasting with a drum dryer, showed, however, only reduced effect on the protein quality due to a lower than optimal temperature. The toasted field beans were fed in two organic dairy herds, replacing a part of the concentrates in the ration in a cross-over design. Preliminary results showed no milk yield difference in herd 1, but a reduced milk yield level in herd 2.

Background and objectives

Organic dairy herds in Denmark have a high average production level of approximately 8600 kg ECM (Energy Corrected Milk) and the feed rations are in most herds medium to high-input of highly concentrated feed. The concentrated feed consists of grain and protein-rich sources such as soy bean and rapeseed cake, which, in the case of soy beans, are imported from south-eastern Europe and China. The price-level of soy beans has in 2012-2013 reached extremely high levels, which has increased the feeding cost markedly. The interest of enhancing the homegrown supply of protein is becoming more and more reasonable in the organic herds. Not only considering the economical aspect, but also regarding a growing concern about sustainability, traceability and feed safety.

During 2012-2015 the Danish project named Project EcoProtein focus on how to grow field beans and lupins, and how to improve the feeding value of the legumes in order to replace imported protein sources in the fed ration of organic husbandry. Preliminary studies show that toasting lupins and field beans can improve the protein quality to ruminants (Jørgensen & Andersen, 2013). According to lab analysis and *in sacco* determinations of the protein digestibility in fistulated dairy cows, toasting the field beans at 120-130°C improved the AAT (Amino Acids available in the inTestine) - value from 110 to 190 gram AAT per kg dry matter (DM)(Jørgensen & Andersen, 2013). The PBV-value (Protein Balance in the Rumen) was oppositely lowered from 142 to 46 gram PBV per kg dry matter. Optimizing feed rations shows that theoretically toasted field beans ought to be able to replace a part of the soy bean and rape seed cake in the feed ration. The objectives of the dairy cow demonstrations of Project EcoProtein are to testfeed toasted field beans in high-yielding dairy herds in order to replace concentrates containing imported protein sources in order to determine whether milk production level and, not least, milk production cost are affected.

Key results and discussion

The demonstrations were carried out from December 2012 to the beginning of April 2013 and the statistical analysis awaits. The method of toasting the field beans in a drum dryer only had reduced effect compared to earlier results due to a lower temperature than expected (110-115°C). AAT levels were increased from121 to 144 gram AAT/kg DM. Results from the first 2 demonstration periods showed no difference in milk yield in herd 1, but a reduced milk yield in herd 2 in the groups feed TMR with toasted field beans. The yield loss in herd 2 could not be counteracted by the reduced ration costs. High yielding dairy cows still need a concentrate supply mainly due to at low fat content in the field beans, but feeding toasted field beans has good potential in order to replace a part of the high-cost protein sources and thereby reduce the feed cost and improve total economy given the milk yield level is maintained. Since the full effect of toasting was not reached in the present demonstrations the full potential of toasting is yet to be demonstrated in practical use.

How work was carried out?

Two organic HF dairy herds participated in a feed demonstration. I both herds, the cows were divided in 2 equal groups and were fed in a cross-over design with one of 2 Total Mixed Rations (TMR). The feed rations consisted of either a concentrate supply with soy bean/rape seed cake or a concentrate supply with toasted field beans. The field beans were toasted by using a drum dryer at maximum temperatures at Danish Agro. This method had not been tried earlier. The planned level of field beans was 4.9 to 5.8 kg per cow per day. The concentrate rations appear in table 1 and 2. Roughage levels were planned to be equal in both rations within herds. The rations were optimized to reach the same levels of energy and protein in both rations within herd.

The demonstration was carried out in winter 2012-13 with 3-4 periods of 4 weeks. In week 4 urine samples were collected from 8 median cows per group. Milk yield, fat and protein content were determined individually and feed control of the 2 TMRs were carried out.

Table 1. The planned concentrate feed ration and cost in herd 1

	Cost dkr (euro)/kg	Soy bean and concentrate (kg/cow/day)	Field bean, concentrate and soy bean (kg/cow/day)
Barley	2.50 (0.34)	6.9	3.5
Soy bean cake, toasted	6.10 (0.82)	2.0	0.4
Field beans, toasted	3.50 (0.47)	0	4.9
Concentrate (25% cr. protein)	3.45 (0.46)	2.3	2.3
Concentrate costs, dkr. (euro)/cow/day		37.39 (5.02)	36.28 (4.87)

Table 2. The planned concentrate feed rations and costs in herd 2

	Cost dkr (euro)/kg	Soy bean and concentrate (kg/cow/day)	Field bean and soy bean (kg/cow/day)
Soy bean cake, toasted	7.2 (0.97)	0	0.4
Field beans, crimped	2.3 (0.30)	2.5	1.2
Field beans, toasted	3.5 (0.47)	0	4.6
Concentrate (33 % crude protein)	5.23 (0.70)	3.7	0.0
Concentrate costs, dkr. (euro)/cow/day		36.90 (4.95)	33.30 (4.47)

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Goal conflicts in long-term cropping system trials – the example of carrots

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Implications

Agricultural research on multiple cropping systems in parallel increases the potential for knowledge transfer between organic and conventional systems. This project aims to develop cropping systems towards greater sustainability through work in long-term trials that have a unique opportunity to contribute to a holistic research perspective. Data on the fourth crop rotation (2007-2012) are now being compiled. This paper presents preliminary results from cultivation of carrots as an example to demonstrate goal conflicts in organic and conventional systems between good nutrient management and good economy on one hand and nematode control and intensive cropping systems (good short-term economy) on the other. Good productivity and sustainable production levels are major overall goals in the project. The conclusion is that more research on nematode susceptibility and propagating at different crops and varieties is very important.

Background and objectives

The issue of different cropping systems has occupied agronomists for many decades and during the 1980s it reached a wider audience. A major research drive was therefore initiated in 1987 and three long-term cropping trials were set up. One of these trials (Önnestad) is still running, but the objectives have changed, with the main aim now being not system comparisons, but system improvement according to the unique conditions. However, there may be goal conflicts between the key figures used to push development forward and evaluate the farming systems: good economy, fossil energy efficiency, nematode control in vegetable crop rotations, integrated pest management (IPM) in conventional systems, improved yields in organic cropping systems, etc.

Key results and discussion

The data presented in this paper are preliminary results for the fourth crop rotation (2007-2012). Taking carrots as an example, the results reveal that goal conflicts are strongly present in cropping system research – just as they are in practice.

Average yield of carrots for the whole rotation (before sorting) was 113 ton/ha in the conventional treatment A. Organic cropping in treatments C and E produced 84 and 78% of the conventional yield (Figure 1). In the previous (third) crop rotation, the crop was sugar beet and the yield in organic C and E was 95 and 85%, respectively, of that in A (Gissén and Larsson 2008). In C, sugarbeet was grown after ley to reduce nitrogen (N) losses (Gissén and Larsson 2008), which are otherwise high after clover-grass ley (Gunnarsson 2001). In the fourth crop rotation, carrots were grown in A, C and E after beetroot, ley and red clover resp. The mineral N content in the topsoil (0-60 cm) in late autumn (=risk of N losses) was high after carrots grown after ley or clover: 44, 143 and 64 kg NO_3+NH_4-N/ha in A, C and E, respectively, compared with the mean for these treatments (46, 53 and 48 kg NO_3+NH_4-N/ha respectively). These high values were surprising, since the carrot growing season is long, carrots are known to have a deep root system, they were assumed to empty the soil of mineral-N and the fertilisation rate was moderate.

To reduce the risk of N losses black fallow has been excluded, which means a potential risk of increasing the nematode *Meloidogyne hapla* in the cropping systems. Analyses in spring 2012 showed that levels of *M. hapla* were high or very high, on average for the crop rotation 270, 100 and 709 nematodes/250 g soil for treatments A, C and E, respectively. The highest levels were found in the plots where carrots were grown (95, 450 and 4000 for A, C and E, respectively). When *M. hapla* infect carrots, they restrict growth and the roots become deformed (Potter and Olthof 1993). On analysing the carrots after harvest, it was clear that *M. hapla* had caused damage to the marketable crop (Figure 2).

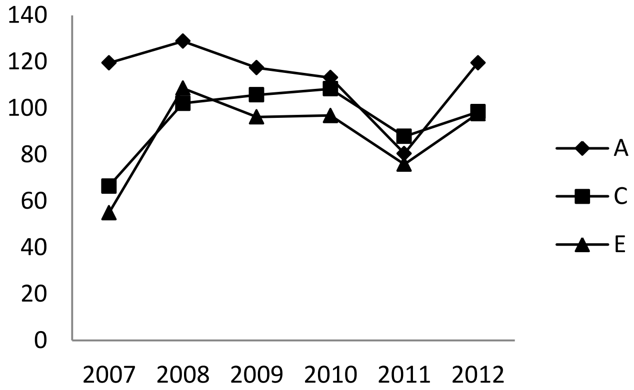

Figure 1. Carrot yield before sorting (ton/ha).

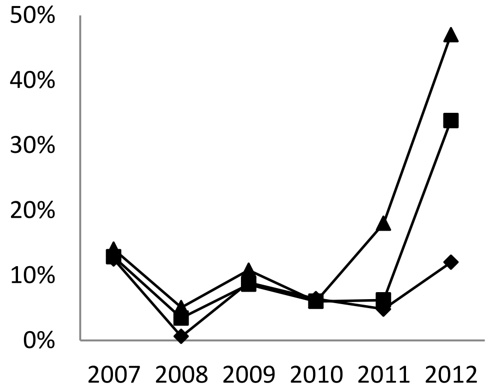

Figure 2. Proportion of deformed carrots.

In 2013 a new crop rotation will start. The challenge will be to deal with the nematode problems without compromising good nutrient management and good crop economy.

How work was carried out

The Önnestad field trial consists of five 6-year cropping systems. Every crop is grown every year, i.e. there are 30 plots, each 12*15 m. The soil has the following particle distribution: 7% clay, 27% silt and 66% sand and the organic matter content is 6%. Despite the light soil texture, water supply is good, presumably through capillary transport from below. Irrigation is used in vegetable crops. The experiment has two conventional and three organic 6-year crop rotations, all with vegetable production (carrots in A, C and E):

A Conventional cropping without animals
B Conventional cropping with ley and manure (with animals)
C Organic cropping with ley for biogas production and digestate
D Organic cropping with ley and manure (with animals)
E Organic cropping without animals

To achieve good productivity levels, the crop rotation is quite intensive:
A Carrot – leek – potato – rye – red clover – beetroot
C Carrot – barley – leek – oats – ley – ley
E Carrot – green manure – leek – barley – rye – red clover.

For detailed methods, see report on the third crop rotation (Gissén and Larsson 2008).

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The results from all study years are available in databases at www.odlingssystem.se

Organic rapeseed production in Finland

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Implications

Most of the 56 organic rapeseed growers interviewed in this research acknowledged modest success in rapeseed yield (often under 500 kg/ha, on average about 800-900 kg/ha), but kept continuing cultivation because of other benefits such as good price and well functioning markets of the product, flexibility in sowing time, possibility to cultivate a temporary fallow to fight the weeds, and need for protein rich fodder for own or neighbor livestock. The main complications in rapeseed cultivation were unfavorable weather conditions, pests and insufficient nutrient levels for optimal yields. The farmers followed carefully the instructions from research and advisory institutions, but were also innovative in developing their own solutions to problems. Because of different conditions with neighboring farms, different soil types and climatic conditions, different sources of fertilizers and availability of pollinators, tailor-made solutions for every farm individually are imperative. Despite problems most farmers were optimistic and were readily investing in the future e.g. by renting and buying more field area for cultivation. Success in organic rapeseed cultivation seems to coincide with optimism, good relationships with family members and neighbors, availability of affordable fertilizers and relatively large cultivation area for efficient crop rotation.

Background and objectives

Rapeseed production in Finland is usually based on spring turnip rape (*Brassica rapa* ssp. *oleifera*), the cultivation area of which varies between 50-80 000 ha in conventional farming and about 2-2500 ha in organic farming. Spring oilseed rape (*Brassica napus* ssp. *oleifera*) can be grown in southern Finland on a limited cultivation area (about 15 000 ha in conventional farming, not mentioned in statistics of organic farming), as the growing season in most areas in Finland is not long enough for oilseed rape to reach suitable quality. The situation is expected to change in near future, though, when climate becomes warmer and growing season longer (Peltonen-Sainio et al. 2009). The yield of spring turnip rape is rather low (1300 kg/ha in conventional farming, 800-850 kg/ha in organic farming), while that of oilseed rape is slightly higher, about 1700 kg/ha. Some attempts are regularly made in both conventional and organic farming to grow autumn-sown turnip rape or oilseed rape, the yields of which are higher in theory, but often lost due to failed overwintering, especially in Southern Finland, where the snow cover may be thin and inconsistent. The cultivation of spring turnip rape has major challenges in Finland, mainly due to dry and cool growing conditions early in season and wet harvesting conditions in the autumn. Dry and cool conditions early in season slow down the growth of rapeseed seedlings, thereby delaying or even preventing recovery of seedlings from the damages inflicted by pests, and providing space for invasions of weeds. The most common pests for rapeseed in Finland are the pollen beetle (*Meligethes aeneus*) and flea beetles (*Phyllotreta* sp.). There are no efficient and affordable protection methods in organic farming against pests, although some biological protection solutions are becoming more easily available (Hokkanen 2008). Weeds, again, while they do represent a problem, can be fought against with cultivations, temporary fallow and autumn ploughing. Due to carefully followed crop rotation practices, pathogens are rarely a problem in organic rapeseed production.

A serious problem in organic rapeseed production is poor nutritional status of the soil. Fertilization is most often given as cow, pig, horse or poultry manure, composts or meat and bone meal. Rapeseed needs a good nutritional status for early growth, and organic nutrient products are not always adequately available. Special fertilizer products (such as meat and bone meal), again, have increased in price during the last years, almost beyond the reach of organic farmers.

The objective of the present research was to interview organic rapeseed growers to find out how they have solved their rapeseed cultivation problems, what the yield levels are and how they have been able to market the yield.

Key results and discussion

Most organic rapeseed growers had started organic farming, and also organic rapeseed production, in 1996, just after Finland joined the EU. The farm size of the interviewed farmers was quite big, from 50 to 150, sometimes over 400 ha, but organic rapeseed area was quite small, around 20 ha. The farmers told that they follow carefully the cultivation instructions of research and advisory institutions. Rapeseed is cultivated with long crop rotation (about 4-5 years between oilseed crops), ploughing in the autumn, several cultivations (temporary fallow) in the spring, extra fertilization to meet the needs of turnip rape, and late and thin sowing (beginning of June, 6-10 kg/ha). Despite the efforts, the yields of spring turnip rape are often very low (under 500 kg/ha), mainly due to early summer drought, pests, and rainy autumn conditions that may hamper harvesting and thereby destroy the yield (shattering of seeds or impossible harvesting because of too wet soil). 1000 kg/ha is mostly considered a successful yield. The market for rapeseed is, however, very good and the price is quite high, which seems to be one of the main reasons why organic rapeseed cultivation continues despite the serious problems. Rapeseed is also not produced just for oil, but for the seed pellet after oil extraction, which is an excellent protein-rich feed for the cattle. Some farmers have an agreement with their neighbors to produce rapeseed pellets for the neighbor cattle, the manure of which they in turn can use as fertilizer.

One reason to cultivate rapeseed is the late sowing time, which allows the farmers to change from a poorly overwintered crop such as rye (*Secale cereale*) to rapeseed and still keep in pace of sowings. Some farmers see the late sowing time as an opportunity to clear a problematic field from weeds with the possibility of conducting several cultivations with a temporary fallow before sowing.

Organic farmers in Finland that keep cultivating spring turnip rape are often rich with self-made innovations and ideas for cultivation. Most farmers have also acquired bee hives near their fields to assist with pollination. The farmers will probably continue producing rapeseed, but real production success may become possible only with the more favorable growing conditions that climate change may bring to Finland. With milder conditions, more productive oilseed rape and higher yielding winter forms of oilseed may be taken into production. However, pest problems may become more serious with milder conditions, calling for profound research and solutions for the future.

How work was carried out?

The results are based on an interview made among the organic spring turnip rape producers in Southern Finland in 2011-2012. The interview was performed with 56 organic rapeseed growers in four agricultural advisory regions.

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Translocation of imidacloprid from coated rape (Brassica napa) seeds to nectar and pollen

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Implications

Bees and other pollinating insects contribute significantly to the world's production of edible crops. Bees and bumblebees are threatened by modern agricultural practices like monocropping, destruction of natural habitats and pesticide use. Organic farming practice avoids the pesticides, but should also actively support the living conditions for pollinating insects, e.g. by maintaining flowering strips and trees. A recent ban on imidacloprid as rapeseed coating in Norway may encourage research in alternative ways of protecting rapeseed against ground flees (*Phyllotreta* spp.). Such studies may be beneficial also for organic rape growers.

Background and objectives

Already in the middle of 1990's, French beekeepers began to report alarming losses of bees, caused by honeybees not returning to their hives (Maxim and van der Sluijs, 2013). Later, significant loss of honeybees, also named Colony Collapse Disorder (CCD), has been reported in many countries and different parts of the world. This serious threat against our valuable pollinators has called for a careful consideration of the reasons for disappearing honeybees. The picture is complex, and there might be several factors involved. One theory is stress related to long distance transportation, especially in regions such as the United States where bees are commonly utilised for pollination more than for honey production. Another important factor is the lack of diversity in modern agriculture, where large areas of monocropping reduce the food offer for a range of insects including bees and bumblebees. Cropping of less protein rich plants result in less glucose oxidase in the nectar (Eishen and Graham, 2008; Aluax et al, 2010), which has a protecting role in the bee community to reduce attacks from virus/fungus/mite as well as the stress linked to exposure to insecticides, out of which several may be toxic to bees. Neonicotinoid pesticides, especially thiamethoxam, clothianidine and imidacloprid, are extremely toxic for bees. Early 2013, The European Food Safety Authority (EFSA) published a report where risks connected to use of imidacloprid, especially for crops that are attractive for bees such as rape, were described (EFSA 2013). Pesticide use is regulated by national law in Norway and of the three neonicotinoid pesticides, only imidacloprid has been authorized by the Norwegian Food Safety Authority (NFSA). NFSA decided in March 2013 to restrict the use of this pesticide to indoor use (greenhouses, decoration plants) and as seed coating on potatoes. From 2014, rapeseed coated with imidacloprid is no longer permitted in Norway.

In 2012, NFSA engaged Bioforsk to study if imidacloprid coated on seeds of rape (*Brassica napa* cv. Mosaikk) used in Norwegian agriculture could be translocated to nectar and pollen. Imidacloprid-coated rape seeds were cultivated on ground in a 50 m^2 plot in greenhouse. Nectar and pollen were sampled during full flowering. Nectar was sampled by capillary tubes and pollen was sampled by careful shaking of the flowers. Nectar and pollen from flowers of non-coated seeds, grown in the same soil as the coated seeds but in another greenhouse, were used as control.

In total, six nectar and four pollen samples from flowers from imidacloprid-coated seeds were analysed. Imidacloprid-D4 was added to the samples as internal standard before sample preparation. Use of internal standard is necessary for the analysis of small samples with low concentrations. The samples were analysed by LC-MS/MS, which has good sensitivity and specificity. The concentrations of imidacloprid were determined by quantification against standards with known concentrations, and adjusted for the internal standard.

The study was designed as an "early warning" study, to reveal if translocation of imidacloprid to nectar and pollen could be found from coated rape seed used in Norwegian agriculture, and thus potentially expose bees and other pollinators.

Key results and discussion

Imidacloprid was detected above limit of detection (LOD=1.5 ng g^{-1}) in five out of six nectar samples and in all pollen samples. The concentrations in nectar and pollen ranged from below LOD to 3.1 ng g^{-1} and 1.8-2.8 ng g^{-1}, respectively. Control samples showed no traces of imidacloprid. Our lowest standard was 0.0002 µg ml-1, which corresponds to 0.8 ng g-1 in a 50 mg sample.

In the EFSA report (EFSA 2013) the data were transformed to *residual unit dose* (RUD). This is an expression which is used in order to compare residual concentrations of pesticides in nectar and pollen between different studies independent of the amount of pesticide applied. The RUD value of imidacloprid for pollen and nectar is referring to an application rate of 1 kg ha^{-1} or 1 mg $seed^{-1}$; meaning that the analyzed residue level will be extrapolated to a pesticide application rate of 1 kg ha^{-1} or 1 mg $seed^{-1}$ if necessary. In our study, the maximal estimated RUD values of imidacloprid were 0.155 mg kg^{-1} in nectar and 0.110 mg kg^{-1} in pollen. These values fall within the range of RUD values reported by the EFSA (2013), which were 0.017-0.159 mg imidacloprid kg^{-1} in nectar, and 0.069-0.156 in pollen.

According to EFSA LD_{50} for acute effects on honey bees after contact and oral exposure is 0.081 and 0.0037 µg bee^{-1}, respectively (EFSA 2008). Chronic lethal effects and behavioral impact including bee hive development of imidacloprid via dietary exposure is given as 24 ng g^{-1} and 20 ng g^{-1} (EFSA 2008). Since field bees only feed on nectar it is relevant to compare these effect values with our measured nectar residue - up to 3.1 ng g^{-1}. Compared with a field situation, rape flowers cultivated in a greenhouse with controlled watering regime are exposed to higher humidity, higher temperatures and no wind exposure. Via their influence on plant transpiration (higher humidity and temperature – higher transpiration, no wind – lower transpiration), these conditions may impact the translocation and concentrations of imidacloprid in various plant organs. However, the results show that imidacloprid might be found in concentrations up to 2-3 ng g^{-1} in nectar and pollen in flowers from coated rape seed used in Norwegian agriculture. A follow-up study will investigate whether important bee-attractive plants commonly found around greenhouses or along potato fields, such as wild raspberries, may contain imidacloprid.

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Organic production systems in Northern highbush blueberries

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Implications

The production of highbush blueberries is increasing worldwide. Organic production of blueberries in Sweden is presently very limited but is expected to have a great potential to expand as the berries are popular and have a good shelf life. The fact that blueberries require acid soils raises several questions concerning suitable substrates in combination with mycorrhizal inoculation and fertilization in organic production systems. Field and pot experiments have been established during 2011 and 2012 with the aim of developing a sustainable production system for high quality organic blueberries. After the second experimental year, total fruit yields were similar for plants grown in a plastic tunnel and in the open field. Yields were not affected by the addition of 10% forest soil to the peat-based substrate. Inoculation with ericoid mycorrhizal fungi had little effect on shoot length in a greenhouse pot experiment. Blueberries may be particularly suitable for organic production as the need for fertilizers is low combined with a relatively low disease pressure on the blueberry crop in the Nordic countries. The Swedish blueberry production might be expected to expand in the near future. The development of a successful and resource-efficient growing system for organic blueberries may encourage new blueberry growers to chose organic production.

Background and objectives

Growing blueberries in high plastic tunnels may prolong the production period. However, since it is likely that cultivation in tunnels will increase the vegetative growth over the season, there is a risk for decreased and/or delayed frost resistance (Kosiba et al 2010). In Sweden, new blueberry cultures are often established on field soils with higher pH levels and lower contents of organic matter compared to the levels normally considered optimal for blueberries. To improve available soils for blueberry production, organic matter like peat, bark or sawdust can be mixed into the planting hole or used as a substrate. In nature, blueberries form mycorrhizal symbiosis with ericoid mycorrhizal fungi. The fungal hyphae contribute to plant nutrient uptake by releasing enzymes hydrolysing organically bound nitrogen and phosphorus. This project focuses on crop management in blueberries in high plastic tunnels and in the open field with emphasis on substrate, mycorrhizal inoculation and nutrient availability.

Key results and discussion

Field experiment

Flowering was delayed for two to three weeks in the field compared to the tunnels. The accumulated fruit yield per plant during July-August 2012 is shown in Figure 1. For all varieties, yield during the first part of the harvest period was higher for the tunnel-grown plants than for the field-grown plants. However, the difference in accumulated yield between field and tunnel was diminished towards the end of the harvest period and there was no significant difference in total fruit yield between plants in tunnel and in the field. Of the two highbush varieties, Duke showed the higher yield. As could be expected, yield was lowest for the halfhigh variety Northblue. No significant difference was observed between the two substrates (data not shown). Blasing (1998) observed that blueberries on agricultural soils grew poorly and were less readily colonized by mycorrhizal fungi than plants on virgin forest soils. However, earlier studies have shown varying effects of the addition of forest soil to soil or substrates for blueberries.

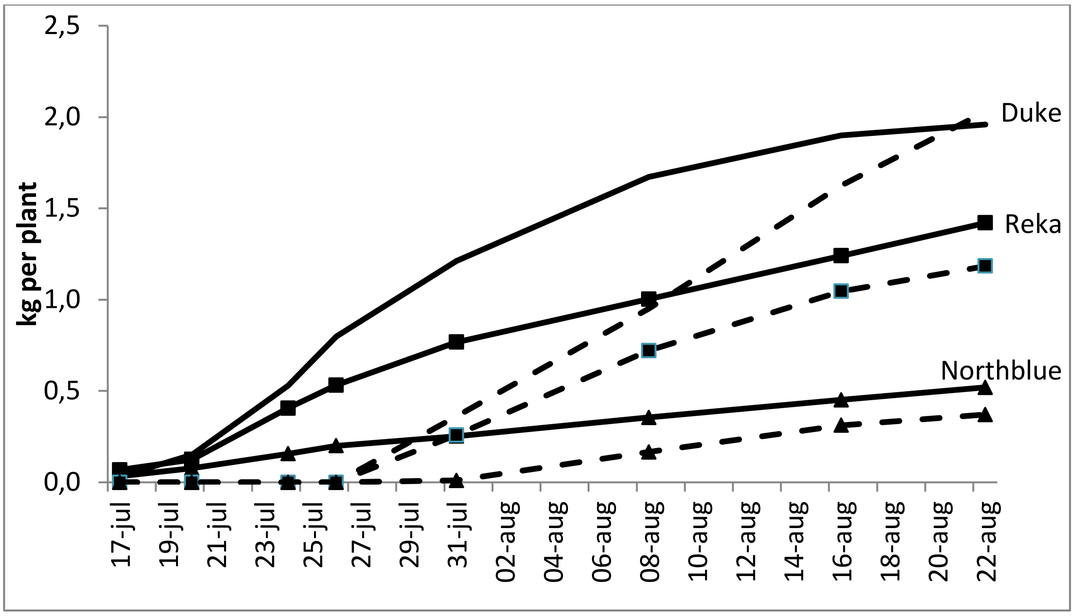

Figure 1. Accumulated yield (kg per plant) during 2012 for the varieties Reka, Duke and Northblue in tunnel (—) and in the field (---)

Pot experiment
There was no significant effect of mycorrhizal inoculation on plant height (data not shown). However, a tendency to increased growth of inoculated plants was observed for Duke and for one of the inoculated treatments for Reka. The influence of mycorrhizal inoculation on plant development and yield will be followed during 2013. Varying results have been observed after inoculation of blueberries with ericoid mycorrhizal fungi, depending on variety, fungal isolate and fertilizer treatment (Eccher et al 2002).

How work was carried out?

Field experiment
Three-year old plants of the three varieties Duke and Reka (*V. corymbosum*) and Northblue (*V. corymbosum* x V. *angustifolium*) were planted in 25 cm deep beds in a plastic tunnel and in the field at Rånna Experimental Station, Skövde, in late April 2011. Two types of substrates were tested in the beds; Substrate 1 contained peat:bark 9:1 and Substrate 2 contained Substrate 1:forest soil 9:1. Three blocks per treatment, each block consisting of three plants, were established in both the tunnel and in the field. The plants were fertilized with 7.1 g N as Biofer 6-3-12 and Biobact in 2011. In 2012, each plant was given a total of 13.5 g N applied as Biobact from May to August.

Pot experiment
One-year old plants of the varieties Duke and Reka (*V. corymbosum*) were potted in a peatbased substrate and fertilized with a total of 0.4 g N as Biobact. The plants were grown in the greenhouse from March to August. Plant height was measured at the 27th of August before the plants were transplanted to the field on the 29th of August.

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COBRA: a new European research project for organic plant breeding

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Implications

Development of organic plant breeding and seed production will have a valuable impact on organic plant production. Breeding of plant material adapted for organic agriculture is crucial in order to cope with stresses such as climate change, weeds and seed borne diseases. Conventional varieties may not meet the specific needs of organic agriculture. The use of plant material adapted to conditions of organic agriculture will have a positive effect on the productivity and sustainability of organic crop production.

Background and objectives

One of the obstacles to the successful development of organic farming systems is the lack of appropriate plant varieties that are adapted to conditions of organic agriculture (e.g. Wolfe et al. 2008). Plant breeding efforts for organic systems need to be better coordinated to address and resolve these issues. In addition, using plant material with higher genetic diversity has great potential in breeding for these systems. Higher levels of in-field diversity can be used to buffer against the relatively higher environmental variability in organic systems. Continued loss of genetic diversity in the agricultural landscape is of particular importance for organic agriculture, as this germplasm is often more suited for organic systems.

A new European research project called COBRA (Coordinating Organic plant Breeding Activities for Diversity) aims to unleash the potential of plant genetic diversity for organic agriculture by linking up efforts on both pure line breeding and High genetic Diversity (Hi-D) systems in cereals and grain legumes.

In conjunction with the need to breed specifically adapted pure line varieties for organic crop production, a complementary approach is the use of plant material with Hi-D e.g. as in Composite Cross Populations (CCPs) (Döring et al. 2011). Apart from buffering against environmental fluctuations and providing insurance in stressful environments, Hi-D-based approaches allow for evolutionary adaptation to organic farming conditions. However, despite the promising results Hi-D-based systems have shown under organic management, their benefits cannot be used at present due to agronomic, technical and regulatory hurdles. These constraints of Hi-D breeding approaches are shared with and linked to organic plant breeding in general.

Approach

The COBRA project is part of the CORE II program and is led by the Organic Research Centre (UK). It started in March 2013 and brings together 41 partner organizations from 18 countries. COBRA focuses on four major arable crops: wheat, barley, pea and faba bean. It will address five specific areas:

(1) Seed health;

Organic farming systems greatly rely on healthy and vital seed. Furthermore organic production systems only have access to a very limited amount of seed treatments for infected seed. The project will address both germination capacity, vitality of seed and seed borne diseases by improving diagnostic tools, coordinating (by creating a database for seed borne diseases) and improving screening methods for seed borne diseases, improving resistance breeding methods in genetically diverse populations, and by developing methods for direct control of seed borne diseases with the use of essential oils.

(2) Response of crops to multiple stresses;

Organic agriculture is facing the challenges of multiple stresses such as weed control in a time of climate change. Climate change is predicted to cause increased climatic variability and more extreme weather events. One objective of the COBRA project is to study the potential of Composite Cross Populations and specific genotypes to adapt to such climatic fluctuations, to find determinants of early vigour and competitiveness to weeds, and to identify strategies for coping with multiple stressors.

(3) Improvements in breeding efficiency for organic systems;

In organic agriculture there are stronger interactions between genotypes and environment when compared to conventional agriculture. There is a need to exchange germplasm and introduce more material into the genepools available to breeders. In the COBRA network there will be extensive exchange of germplasm. The project also aims to develop and identify methods for improvement of Hi-D material, to improve adaptation of Hi-D material to conditions of organic farming and to further develop breeding methodologies for participatory plant breeding.

(4) Structural issues such as funding for breeding and the regulatory framework;

The European seed regulation is currently under revision, and the project will support the effort by member states and organic organisations to overcome legal hurdles and create legal space for plant material suited for organic cultivation within the seed regulations.

The area of certified organic agricultural land in the EU is increasing and this offers new possibilities for breeders to expand their breeding activities. It is important that breeders become aware of the changing situation. Different organization and financing models for organic plant breeding will be evaluated in order to propose sustainable financing models and possibilities for transnational cooperation.

(5) Networking and coordination.

Activities in organic plant breeding are still fragmented and transnational coordination of these activities is of great importance to ensure successful development. It is valuable to have this trans-European network in order to exchange breeding material, harmonize evaluation tests and not least to exchange experiences and results.

The project will have a public website, and there will be announcements for conferences, workshops, field days and other activities.

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Quantitative population epigenetics a catalyst for sustainable agriculture

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Implications

Ecological intensification of agricultural practices can be a minimum input agriculture with a maximum utilization of the epigenetic potential for a maximum output.

The application of Quantitative Population Epigenetics as a catalyst for sustainable agriculture offers earning opportunities (market segments or business cases) for the existing players in the high-input agriculture in terms of win-win.

For example, agriculture is a major factor in eutrophication of surface waters. By using epigenetically active compounds to switch on yield or stress genes, new crop varieties for low-input agriculture could be developed to improve nitrogen and water use efficiency for cereal production significantly.

Background and objectives

Quantitative Population Genetics (Stauss 1992, Stauss 2012) describes the variability observed in characters due to genetic variation. Quantitative Population Epigenetics describes the variability observed in characters due to factors in the environment -- induced primarily by factors of the farming system.

The "breeder" improves the genotype -- for him environments are "fixed" effects. The farmer strives to intervene in the environment by effecting a specific phenotypic expression, within the norm of reaction inherent in the genotype.

Environments with high-yield potential enable a maximum use of the genetic yield potential -- often resulting in high input agricultural production systems with an overuse of groundwater, natural resources and biodiversity.

The use of Quantitative Epigenetics and the related importance of stress (Steinberg 2011) can be a way out of this impasse. There can be a paradigm shift, away from a maximum input system with a maximum utilization of the genetic potential towards a minimum input system with a maximum utilization of the epigenetic potential, that is, to an optimization of limiting stress factors to achieve maximum results with limited environmental resources. For the agricultural and the food industry there is a need for an ecological intensification of agricultural practices, there is a need for a second green revolution.

Key results and discussion

Ecological intensification of agricultural practices, as defined by Löwenstein (Löwenstein 2012), can be a minimum input agriculture (maximization of $1-h^2$) with a maximum utilization of the epigenetic potential for a maximum output:

- low input with high output and
- utilization of the genetic potential (inherited characteristics) and the environmental potential or environmental inheritance (acquired characteristics).

This approach offers earning opportunities (market segments or business cases) for the existing players in the high-input agriculture in terms of win-win), especially in utilization of genotype-environment interactions, such as

- nutritional deficiencies and for example use of a genotype-low-nitrogen interaction (low input/high output-varieties, breeding companies),

- bioactive "additives" (regulator-active compounds) to switch on yield genes of nitrogen deficiency (chemical industry, fertilizer industry) and
- drought/seed treatment with anti-apoptotic substances (chemical industry, fertilizer industry, breeding companies, agricultural engineering companies).

The cultural sustainability (values, appreciation, ethics, customs, agriCulture, ...) as unifying element for the environmental, economic and social pillar **is** the (positive) stress (maximization of $1\text{-}h^2$) for a paradigm shift in the behavior of stakeholders (Altner G 1992):

- credibility and awareness, life style issues,
- Corporate Social Responsibility,
- low-input with high-output of food and, for example clean water, biodiversity, landscape, agriCulture, ...,
- win-win situation for the actors of today's intensive agriculture and
- see also the INTERREG IV B Baltic Sea Project Baltic COMPASS example (Heinrich C and Rammert U 2011) and agri-environmental measures.

How work was carried out?

In the 80s Stauss has rewritten parts of University Stuttgart-Hohenheim lecture notes of Prof. Geiger, Prof. Fewson and Mr. Utz concerning quantitative genetics and selection indices analogous to the environmental point of view as "selection of biologically active substances (as ingerdiants of the environment) on the basis of quantitative genetics". The "analog invention" was without test results, unfortunately, it could not be patented, but with Stauss 1992 he succeeded with an "application"-publication for the field of agro-industry. The initial reason of his work at that time was a statement of his superiors at Ciba in Basel that the chemical pesticides and plant regulators industry is the competing sector to breeding.

Recently Stauss realized that he basically had developed a script on "Quantitative Population Epigenetics".

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Quantitative population epigenetics in screening and development of regulator-active factors of the farming system

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Implications

Likewise, index selection based on statistical genetic theory in plant and animal breeding the methodology "Quantitative Population Epigenetics" can be appropriated to improve efficiency in screening and development of regulator-active factors of the farming system for potential to enhance quantitative characters such as yield, standability and resistance to unfavorable environmental influences (e.g., water stress, cold temperatures, disease resistance).

For example, as was shown for an effect of monoethanolamine on yield and water use efficiency of spring barley plants (Bergmann et al. 1991).

Background and objectives

Ecological and Evolutionary Epigenetics is a new field of frontier research at the intersection between molecular genetics and evolutionary ecology. The term "Epigenetics" is used only for about ten years. Recently Stauss realized that in the 80s he basically had developed a script on "Quantitative Population Epigenetics" (Stauss 1992, Stauss 2012).

"In a strict sense, the question of whether a characteristic is hereditary or environmental has no meaning. The genes cannot cause a character to develop unless they have the proper environment, and, conversely, no amount of manipulation of the environment will cause a characteristic to develop unless the necessary genes are present" (Allard, 1960).

Optimal screening and development efficiency of regulator-active factors of the farming system obtains with 1) high environmental variability, 2) low heritability (characters for which the genotype sets a wide "norm of reaction" an environmental influences), 3) high correlation between characters under indirect selection and 4) intensity of selection.

Key results and discussion

The main application of quantitative epigenetics could be using the pattern of genetic variances and covariances to predict the response of the mean phenotype to regulator-active factors of the farming system as artificial environmental factors:

- Quantitative epigenetics aims to link phenotypic variation for complex traits to its underlying epigenetic basis in order to understand and predict better epigenetic architecture and changes within natural, agricultural, and human populations -- due to environmental factors.
- Traditionally built upon statistical abstractions of epigenetic effects (environmental, regulator-active factors of the farming system), the field could be used to reveal explicit links between epigenome and complex phenotypes, and could therefore serve as a focal point for bringing together many emerging areas of genetics, epigenetics, genomics, physiology, statistics, bioinformatics, and computational biology.

The application of statistical Quantitative Population Epigenetics to the selection and to the development of biologically active substances (e.g. plant growth regulators) is a fundamentally new approach in planning, evaluation and assessment of experiments.

- In initial screening a "random" subpopulation of genotypes should manifest moderate expression of a target character -- resulting in low heritability.

- In testing for quantitative character enhancement, initial screening should be conducted under stress-environment conditions -- in order to obtain an optimum differentiation of farming factors (low heritability).
- To judge constancy in performance, testing should employ a random sampling of genotypes and non-stress environments -- which afford assessment of the interactions: a) factor-genotype, b) factor-environment and c) factor-genotype-environment.
- It must be possible to identify specific genotype-environment constellations from which issue "amplifier" interactions that intensify differentiation suitability.

Hence the objective is to identify which genotype-environment constellation is the most auspicious to make use of as a "reference combination" to achieve optimum screening efficiency.

Selection indices may be formulated in a manner similar to the optimum index of Smith and Hazel (Smith,1936; Hazel, 1943), that employs heritabilities as index weights (which weights correspond to weights from the optimum index if traits are uncorrelated), or according to the base index proposed by Williams (Williams,1962), which uses economic weights as index weights.

The statistical Quantitative Population Epigenetics theory provides basic rules for experimental designs and data analysis concerning

- experimental design: fix or random effects, size, trial conditions e.g. stress or non-stress, etc.,
- post-experimental evaluation,
- optimization of experimental designs,
- epigenotype analysis and screening of biologically active factors of the farming system with Single Nucleotide Polymorphism (SNP)-Chips and
- quantitative description of single or multiple traits designs e.g. using selection indices.

The impetus to translate this Quantitative Population Epigenetics theory into practice is weighted by a) screening sensitivity, b) time expediency, c) ease of replication, d) reliability, e) heuristic incentive, f) elimination of conjectural risks and g) financial returns.

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Impact of the dynamics of discourses on the development of organic farming in Flanders

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Implications

Discursive dynamics have played an important role in determining the development of the organic farming sector in Flanders (the northern part of Belgium). These dynamics co-shaped political and institutional changes including the implementation of EU regulations and the deployment of supply-and market-driven measures. Moreover, discursive dynamics mediated the effects of these political-institutional changes on the willingness of agricultural stakeholders – including individual farmers – to contribute to a growth of the organic agricultural sector. Our results suggest that a focus on institutional changes or individual farmers' willingness to convert may be useful but only partially explains organic agricultural developments.

Background and objectives

National differences in size of the organic farming sector have been studied extensively. Many studies start from an institutional point of view and explain these differences in light of national institutional conditions and policy (Michelsen et al, 2001; Daugbjerg et al., 2011). Other studies use more actor-oriented analyses to explain individual decisions regarding conversion to organic farming (Burton et al., 1999; Van Huylenbroeck et al., 2005). In our research a third approach inspired by discourse analyses is explored. The aim of the research is to analyse how differences in discourse within different agricultural areas influence practices and the development of organic farming. By studying the interplay of different discourses on organic farming, we attempt to understand the evolution of organic production in Flanders during the past two decades and to use the findings to gain further insights in the development of organic agricultural institutions and practices. After a short period of expansion, the organic sector in Flanders stagnated in 2002. The following years, the organic farmland declined by 17% from 3879 to 3219 ha. From 2004 onwards, the number of organic farms fluctuated around 230 farms. From 2008 the number of organic farmers and farmland started increasing again. But, with a share of 0.6% of its cultivated agricultural land under organic production in 2010, Flanders remains behind the European average of 4.7% (Willer and Kilcher 2011).

Key results and discussion

The results illustrate the presence of different discourses on organic farming and their dynamics in the agricultural areas under consideration– conventional and organic farmers' communities, national/regional agricultural policy and conventional food market. Three analytically distinct discourses were discerned: the agro-ecological, the agro-industrial and the market discourse. We revealed that a competition between two mutually exclusive understandings of organic agriculture–an agro-ecological and an agro-industrial one-has structured debates on the future of organic agriculture in Flanders for much of the last two decades. In the 1990s, organic pioneers framed organic farming methods in opposition to unsustainable, "conventional" farming and food marketing practices. In establishing organic food production and retailing practices, they therefore did not want to affiliate themselves with representatives of conventional food producers and retailers, and developed separate organisations and (short) supply chains. This caused the organic sector to be fragmented and little politically powerful for much of the 1990s. The Belgian implementation of the legislation EC 2092/91 was mainly dominated by politicians and conventional farmers' unions who jointly advocated the agro-industrial

discourse that considered organic farming as a marginal activity that was not worthy of much political support. In this context the implementation of the EC legislation did only cause a slight growth in the number of organic farmers in Flanders.
The number of organic farmers did start to grow when the agro-industrial discourse lost its dominance to the agro-ecological discourse. The dominance of this latter became most prominent in the election of a Green Party Minister of Agriculture, who created a proactive policy in favour of organic farming and released extra resources. However, the novel political-institutional framework could not guarantee a long-term growth of organic production. While in the political domain the agro-ecological discourse had become dominant, most conventional farmers and the farmers' unions still advocated the agro-industrial discourse. Instead of bringing the two discourse coalitions closer to each other, the policy of the Green Party Minister reinforced a polarisation of the organic and the conventional farmers' community. This polarisation limited the success of initiatives taken by policymakers and organic organisations to stimulate organic production.
The lack of a non-competitive relationship between organic and conventional farmers' organisations has been recognised as a barrier to organic sector development by Michelsen et al. (2001). Our study showed that the creation of a cooperative interrelationship between the Flemish organic and conventional agricultural sectors was incited by a policy initiative of the then Minister of Agriculture who demanded that both sectors would help to develop a new strategic plan for organic agriculture, and was co-enabled by changes in key individual actors within the organic and conventional farmers' unions. Most fundamentally, the start of the more cooperative relationship commenced after an – externally mediated – dialogue in which the conflicting discourses of both parties were made a topic of discussion, and in which room was created to find a common discourse: the market discourse. By incorporating the diverse interests within a (suggested) shared understanding of the future of organic and conventional agriculture as competitors within the food market, the common market discourse has facilitated cooperation between policy makers and organic and conventional agricultural stakeholders and the re-establishment of a growth in organic production after years of decline and stagnation. One group of actors that is conspicuously absent in the new coalition of stakeholders that advocate the common market discourse, is supermarkets.

How work was carried out?

We empirically explored the evolution of organic farming in the period of 1998 to 2011. First we conducted semi-structured interviews with key informants in three distinct areas: the farming community (organic and conventional), Flemish agricultural policy and the (conventional) food market. Second, we reviewed policy documents, and official statements and press releases. Our discourse analysis we conducted in two steps. First, we revisited Michelsen et al.'s (2001) and Van Huylenbroeck et al.'s (2005) discussions of the developments of the organic production in Belgium up to 1998. We analysed these documents on the presence of distinct frames of meaning that structured understandings of Flemish organic farming practices and institutions. This resulted in a delineation of three analytically distinct discourses. Additionally, we analysed which actor coalitions advocated these discourses. In a second step, we analysed the data that we collected on developments in these discourses, in the coalitions that were advocating them, and in the relative formal and informal dominance of these discourses.

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Barriers for developing more robust organic arable farming systems in practice

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Implications

There is a gap between the scientific idea of robust and economically viable organic arable farming systems with optimized crop rotations for nutrient and pest management and how these systems look like in practice. In order to explore this gap, we visited and interviewed ten organic arable farms in Denmark. Our main findings are: 1) Organic arable farming operates in a very dynamic and changing environment in terms of prizing and market opportunities, and the main focus of the farm managements was the coping strategy within this changing environment; 2) The farming systems were continuously changing and developing, buying and renting more land, changing manure agreements and other forms of cooperation and arrangements; 3) Short term profit was paid much more attention than more theoretical expectation on long term profit or opportunities in relation to optimizing the production system. This again seems logical in relation to the very dynamic world that the farmers have to operate within; 4) Most of the farmers do not see their farm as a coherent system but as a coordination of a series of separate operations, which means that most decisions are taken with specific reference to the individual field in at the present situation without considering the long-term effects. Management focus is thus much more on solving problems as they are occurring, by adjusting their practice, than it is on developing a robust system preventing problems to occur. This partial focus is also strongly supported by the way in which extension services mostly operate.

The visited farms had very different farming strategies to address this very dynamic situation, but they all had in common a strong focus on how to cope with the changing conditions of the encompassing world. From an economical and managerial point of view this makes perfect sense. In conclusion the main barriers for developing more robust organic arable farming systems are the lack of incentives for focusing on the coherence of the production system prior to the adjustment to the very dynamic economic environment. On the other hand all farmers seem challenged by the principles of robust arable farming systems presented to them and for the involvement of a more systemic and holistic discussion of how to improve their faming systems. In conclusion of our study we suggest three focal points to enhance the farmers' decision making in direction of more robust organic arable farming systems. 1) Enhance the incentive structures of arable framing in the direction a more sustainable and robust farming systems; 2) Provide the farmers with tools and extension concepts that support a more holistic and systemic approach to planning and decision making; 3) Put a stronger focus on the strategic development of the arable farming systems, in terms of cooperation with other farming systems and in relation with other market actors that through mutual benefit can establish long-term framing conditions against which more long-term and robust production systems can benefit.

Background and objectives

This study was conducted as a part of a larger multidisciplinary research project, HighCrop, which as its rationale that the projected expansion of organic farming in Denmark is conditioned on the development of more robust organic arable production systems. This would imply an increased arable crop production, which requires higher and more stable crop yields. This must be achieved while also phasing out the use of imported conventional manure and reducing environmental impacts, such as greenhouse gas (GHG) emissions. HighCrop has two main hypotheses: 1) Higher yields and reduced environmental impact can be achieved by introduction of some basic principles of improved management of nitrogen (N) in catch crops, green manure and crop residues, and better management of weeds; and 2) Low yields in practical arable organic farming are caused by a knowledge gap that requires new strategic management tools to overcome. The main objective of this study was therefore to explore the barriers to implementing these principles in practice.

How work was carried out?

To explore the barriers for the implantation of these principles in practice ten organic arable farms were visit for an interview. Prior to the interviews the project researchers were asked to developed a list of basic principle for robust organic arable framing systems, and for each of these principle a list of potential action were formed (Table1). Picture cards to every of these actions was developed to have better interaction with the farmers.

The visit of each farm was divided into three parts. First a walk and talk around the farm to get a better visual idea of the farming systems. Second, an interview parts one, exploring the farmer's management strategy of his system. Third, an interview parts two, examining the barriers to implement the suggested actions for a more robust arable farming system. In this session the farmer was asked to consider each of the suggested action, and to which extent these were already implemented, realistic to implement or unrealistic or irrelevant to implement on the farm. Each interview was tape-recorded and pictures were taken of the placement of the action card.

Table 1: List of principles and actions for obtaining high yielding and robust arable plant production systems, suggested by the researchers involved in the project

Principles	**Action**
Avoid nutrient losses and enhance N-fixation Distribute N where and when it is needed Long-term supply of P and K should be adequate	• Sow catch crops before August 10 or harvest main crop before August 15 when using under-sown catch crops • Minimum 20% of the crop rotation should be N fixing green manure crops (clover/alfalfa) • Catch crop species adapted to soil and climatic conditions should be used • Nitrogen fixing catch crops should be established between two non-fixing crops • Under-sown clover should be established as "intermediate crop" before sowing winter cereals • Liquid manures should always be injected, and especially surface application of cattle slurry in winter cereals should be avoided • Harvest and distribute green manures to other crops in spring, preferably after biogas digestion • Avoid autumn-sown cereal crops after grass-clover • Avoid unnecessary soil tillage
Crop rotation to break the propagation of weeds Competitive crop rotations Supplement with timely mechanical weed control	• Record weed population on the fields • Mix annual winter and spring crops and biannual crops. • Stop the growth of weeds after harvest by mowing, catch crop or trough cutting soil tillage • Use cross harrowing to make a uniform seed bed • Remove stones before weed harrowing • Keep row crops free of weeds using mechanical weed control

Picture card tool for holistic planning in organic plant production

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Implications

To make it easier to optimize organic plant production a new tool for strategic farm planning and improving farm management has been developed. The tool is based on picture cards with 37 recommendations on how to secure nutrients and control weeds to realize high yields. The recommendation cards are supplemented with other cards to make it possible to use the cards as a "management game".

The new tool is meant as an important help for the advisory service for organic farmers and has its main force in activating the farmer in analyzing the different options on his or her organic farm in relation to actual situation and his/her interests and priorities.

Compared to traditional methods of written or oral advise the picture tool inspire the farmer to give more attention to the recommendations when he/she "plays" the management game where each technical recommendation has to be evaluated on its potential impact and pay off in the actual situation at the farm (including the farmers affinities to follow the recommendations in practice).

If implemented in the organic advisory service the tool will have the ability to raise the yields and the economic performance in organic plant production. The farmer will have a better overview over the many actions that influence crop yields and he will have an efficient tool to decide the most appropriate actions and to maintain and develop his/her plan of actions.

Background and objectives

It is often difficult to maintain sufficiently high yields in organic plant production to secure profitable organic production and much research has been done to find the best ways to optimize nutrient supply and weed control for organic crops. The necessary actions are complicated compared to conventional plant growing by involving crop rotation, manuring strategy, soil tillage and weed control, which call for a necessarily more holistic strategic planning. Therefore the farmers ability to overview the many aspects and possible actions and to select the most appropriate ones to implement at the farm is of greatest importance.

A Danish multidisciplinary research project, HighCrop, has addressed these challenges by introduction of some basic principles of improved management of nitrogen (N) supply in catch crops, green manures, crop residues and livestock manure, and better management of weeds and has developed management tools to overcome the farmer's knowledge gaps on these issues. The picture-based tool is one of these tools; the other is an Excel based program to estimate the development in yields and weed population as a response to different choices regarding crop rotations and manure applications.

Key results and discussion

The picture card tool has been tested as prototype together with organic farmers and advisors. The reactions are generally positive and several suggestions have been made how to use the tool and how it can be further developed. It has thus been suggested that the tool will be very useful and inspiring to use in experience-exchange groups.

The tool should be further tested in real advising situations and with experience-exchange groups to evaluate the potentials of the tool.

The idea with "management games" could also be of interest in the education of young farmers.

How work was carried out?

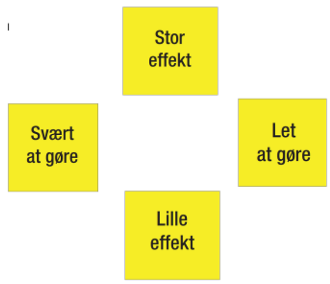
In the HighCrop project the researchers developed a list of basic principles for robust organic arable farming systems, and for each of these principles a list of potential actions was formed (Noe et al. 2013). Each of these suggested actions were translated into picture cards that form the core of a "management game", where the manager places each card in a frame with effect on better yields at the vertical direction and the difficulty to implement the actions on the horizontal direction (fig 1). This process gives the manager a unique set up for considering how he or she will prioritize the possible actions.

Figure 1. Elements in the "management game"

Recommendation cards

Cards describing important conditions

Cards to indicate positions



Cards to build the effect/difficulty frame

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Introducing trees in Dutch dairy and poultry farms

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Implications

The potential of free range areas and grassland on organic farms for performing natural behaviour and offering natural feed is not fully utilized yet. Moreover, there are also chances to be picked up for enhancing biodiversity, carbon fixation and mineral cycling. For example, Dutch organic and free range poultry farms together have 2300 ha range area available. In dairy farms this area is much larger. Challenges on goat and cow farms are a natural enrichment of the ration of the animals and making larger areas of the meadows attractive by providing natural shelter against bad weather. We try to "solve" these problems by introducing forestry in animal production and designing silvopastoral systems. Silvopastoral systems, which are the combination of trees and livestock, are applied traditionally already long times in "low input systems" in Africa (Torres, 1983) and in Mediterranean countries (Olea and San Miguel-Ayanz, 2006). Trees introduced on purpose in more intense livestock production systems in northwestern Europe is rather new (Horsted et al., 2012; Philips, 2002).

Background and objectives

The aims of the poultry farms in network "Trees for Chickens" are providing natural shelter, increase animal welfare, increase the area used by the animals, spread minerals, increase biodiversity and discourage water birds to use the free range area because they are risk species for avian influenza virus. The aims of the goat and cow farms in the network "Fodder Trees" are the nutritional value of several tree species (and willow clones) and how to mechanize the harvest. In both networks also the use of tree products for biomass in wood stoves, litter in stables and /or juice for human consumption are considered. With such applications we try to get the most of the combination of trees and animal husbandry, also in economic sense.

Key results and discussion

In "Trees for Chickens" very recently (early 2013) 3 farms planted fruit trees, 2 farms willow and 3 farms miscanthus, so results are not available yet.

In "Fodder Trees" one goat farm planted willows, another goat farm planted a combination of willows, alder, hazelnut and robinia, one dairy cow farm planted a combination of willows and ash and another cow farmer has a wooded bank which consists of 13 tree species. We have experience now with the performance of several willow clones and with "willow silage", which is being fed to dairy goats in winter.

The willow clones were Sven, Klara, Gudrun and Tora. The total dry matter production of wood and leaves and the percentage leaves for the year of planting (2011) and the year after is shown in Table 1. Of the four willow clones, Sven and Klara were most productive and Gudrun had the biggest leaves.

Table 1: Dry matter production and portion of leaves in willow clones

	2011 (1 season growth)		2012 (1 season growth)		2012 (2 seasons growth)	
Clones	DM-yield	% leaves	DM-yield	% leaves	DM-yield	% leaves
Sven	5.031	26%	4.590	33%	19.133	21%
Klara	4.745	22%	5.818	31%	23.576	16%
Gudrun	1.176	45%	4.142	34%	13.329	23%
Tora	3.337	24%	7.294	25%	15.390	24%

In terms of protein and mineral content all the different trees have potential but the in-vitro digestibility is in general lower than 65%. Possibly the results of the in-vitro digestibility are negatively affected by the content of tannins or other secondary metabolites in the leaves, while in vivo this would be less of a problem since goats can break down certain secondary metabolites. Moreover, dairy goats select the best digestible parts under "free choice conditions", which means a digestibility of the intake till about 75% (Oosting, personal information). For receiving additional information on digestibility, observations on young dairy goats in a nature area have started. Behavioural observations on one of the farms (Meir, 2012) showed that goats preferred willow above roughages, but there was no preference between willow and concentrate. Goats preferred leaves and young parts of twigs, then bark and older twigs.

How work was carried out?

The farmer groups informed themselves by visiting different agroforestry sites in The Netherlands, Flanders, UK and Germany. Together they decided who was going to plant what. Plantations were realized on 4 dairy farms (Apr 2011 - Febr 2013) and 9 poultry farms (Apr-May 2013). DM-production was determined by harvesting a surface of 3 x 1.125 m at a stubble height of 0.30 m. Leaves were separated from woody parts and weighed separately. Form both leaves and woody parts the DM-percentage was determined. In-vitro digestibility was determined according to Tilley and Terry (1963). The observations on the behaviour of 21 dairy goats were done during a choice feeding test inside their stable. Freshly harvested willow branches were offered either with concentrates or roughage (grass and maize silage).

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Utilization of nitrogen in legume-based mobile green manures stored as compost or silage

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Implications

The utilization of nitrogen (N) in green manure leys can be improved by harvesting, storage and spreading of the plant material as manure in other crops. By green manure storage as silage, storage losses of N are lower than by composting. Also, a relatively high fertilizer value of silage N is achievable depending on the C/N ratio of the material. Nitrogen availability in green manure leys is higher after storage as silage compared to composting. Use of mobile green manures is mainly relevant in arable cropping systems without livestock where utilization of the roughage for animal feed or biogas production is impossible, as costs for ley/roughage harvest and transport can be relatively high. Our study showed that surface application of green manure silage to growing crops can damage plants and is therefore not recommended, whereas incorporation of silage before sowing has significant positive effects on crop yields.

Background and objectives

Nitrogen supply is often limiting for crop yields in organic arable cropping systems, especially if animal manures are not available. Under current farming practices, green manure leys are often cut and mulched during the growing season with the associated risk of N losses to the atmosphere, and to leaching during the season, and possibly reduced N fixation in the ley. By harvesting and storage of the green manure until spring it can be used for targeted fertilization of spring-sown crops. The objectives of this field study were: a) to quantify the fertilizing effects of grass-clover and lucerne stored as either silage or compost (mixed with straw) and to relate the N availability to the chemical composition of the manures; b) to compare N utilization after incorporation of silage by ploughing or harrowing, or by surface application in a growing crop; and c) to quantify the losses of N during storage or composting of green manures.

Key results and discussion

During composting of the green manures, N losses of 18-30% were estimated from N/P ratios before and after storage, while N losses from silage storage were estimated to be 6-8%. The N fertilizer value, measured in a spring barley crop, was 32-48% for silage and only 13-22% for the corresponding composts compared to application of mineral N (Table 1). The fertilizer value of injected cattle slurry and digested manure was measured in the same experiment as a reference and found to be 56% and 63%, respectively. There was a significant negative linear relation between C/N ratio of the green manures and the fertilizing value which is in accordance with other studies of N release from green manures/plant residues (Sorensen and Thorup-Kristensen, 2011). There was no difference in fertilizer value whether the grass-clover silage was incorporated by ploughing or harrowing just before sowing the barley crop. The C/N ratio of the green manure has significant influence on the N availability, and leys should be harvested at a young stage to obtain a high N availability. However, the harvest cost also increases with increasing harvest frequency.

In Experiment 2, increasing application rates of red-clover silage applied to oats and winter rye were tested. Yields of oats increased linearly with silage application rate (max 120 kg N ha^{-1}), and the fertilizer value of the silage N based on grain yields was 40% and similar to that of silage measured in Exp. 1. Silage application to winter rye caused plant scorching and had negative effects on yields. This is probably due to temporary poisonous effects of organic fatty acids in the silage combined with acidic conditions.

Table 1. Availability of N in ensiled or composted green manures of grass-clover and lucerne, and in injected slurries, relative to mineral N applied to spring barley, as calculated from N uptake in grain. All treatments received 120 kg N ha^{-1}, and values in parentheses indicate standard errors (n=4)

Manure	C/N	N effect (% of total N)
Grass-clover silage, ploughing	14.9	33 (6.5)
Grass-clover silage, harrowing	14.9	32 (5.2)
Grass-clover-straw compost, ploughing	16.2	13 (3.2)
Lucerne silage, ploughing	12.4	48 (7.2)
Lucerne-straw compost, ploughing	14.9	22 (1.8)
Anaerobically digested mixed manure, injected	5.8	63 (3.0)
Cattle slurry, injected	7.6	56 (2.8)

How work was carried out

Experiment 1: Grass-clover and lucerne crops were harvested in late August about 6 weeks after the previous cut. The crops were either baled and wrapped in plastic as silage, or they were mixed with cut barley straw (4:1, w:w) and composted in porous big bags (0.9m x 0.9m x 1.4m height) insulated on the sides with a 50-mm layer of plastic-coated rockwoll. The insulated bags were thus ventilated via bottom and top. The composting temperature remained above 55°C for several weeks. The composts were covered with loose plastic to avoid leaching losses of nutrients. Losses of N during green manure storage were calculated from N/P ratios before and after storage assuming no P losses. In late April, the manures were applied to field plots on a loamy sand soil at a rate of 120 kg total N ha^{-1}. The manures were incorporated by ploughing, and in a separate treatment grass silage was applied after ploughing and incorporated by harrowing to compare effects of incorporation method. Spring barley was sown in all plots, and N uptake in grain was measured and related to grain N uptake in separate plots receiving increasing amounts of mineral N (Sørensen and Eriksen, 2009). Mineral N was used as a well-defined reference, even though the use of mineral N fertilizers is not allowed in organic farming. Experiment 1 was placed in a conventionally cultivated field; previous studies have shown that land use history has no significant influence on the utilization of N in manures (Bosshard et al, 2009).

Experiment 2: In a second experiment on a coarse sandy soil, ensiled red-clover was applied at increasing rates (40, 80, 120 kg N ha^{-1}) either by incorporation by ploughing before sowing of oats, or by application at the soil surface in an established winter rye crop in spring. Dry matter and N yields were related to yields in separate plots receiving increasing mineral N. The field experiments were organized in a randomized block design with four replicates.

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The impact of nitrogen in red clover and lucerne swards on the subsequent spring wheat

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Implications

The red clover and lucerne swards and their accumulated nitrogen (N) in residues can be useful tool in organic arable systems. Spring wheat grain yield was affected by red clover/ryegrass and lucerne/ryegrass swards and was significantly higher than that after ryegrass sward, except for lucerne/ryegrass sward after cover crop barley for whole crop. Protein content in wheat was sufficient for the grain to be used for food production. These results indicate that red clover and lucerne can contribute to the intensification of spring wheat growing in organic farming, not only by increasing yields, but also by improving quality.

Background and objectives

Nowadays, there are many negative effects on the environment, including pollution by pesticides, emission of greenhouse gases, soil degradation, and loss of biodiversity. The performed meta-analysis of European research concluded that organic farming in Europe has generally lower environmental impacts, but due to lower yields and the requirement to build the fertility of land, not always per product unit (Tuomisto et al., 2012). In practise, organic farmers and producers use national standards or regulations for organic farming; however, to choose the right technologies or their elements adapted to local conditions is not so easy. They need to keep agriculture profitable and make it sustainable for the future. In organic or low input farming systems, legumes are very important as N suppliers for cereals. Legumes also are essential because introduction of ley/arable rotations could be an effective tool for a significant further reduction of use of expensive mineral N-input and improvement of subsequent grain quality (Eriksen et al., 2006; Nemeikšienė et al., 2010) and even soil fertility (Nykänen et al., 2008). The study was aimed to assess the impact of legumes on the subsequent spring wheat in a crop rotation.

Key results and discussion

The total dry matter (DM) yield differed significantly among forage swards (Table). In a wetter year 2005 (based on the multiyear average of rainfall), especially in the first half of the growing season, red clover/ryegrass swards accumulated higher DM yields than those of lucerne. Lucerne sward herbage production depended on the sowing method and cover crop. Significantly higher yields of lucerne were produced without a cover crop. In the drier years, lucerne and ryegrass swards were significantly more productive than those of red clover and ryegrass (Sarunaite et al., 2006).

Several research studies have shown that the choice of forage legume strongly affects the N input to agricultural production (Kayser et al., 2010; Rasmussen et al., 2012). In our experiment there was no significant difference in the amount of N incorporated with red clover/ryegrass and lucerne/ryegrass swards but significantly less N was incorporated with ryegrass sward (Table). Spring wheat did not provide high grain yield and responded to dry growing season in 2006. For any given treatment, spring wheat yields were lower than that in previous experiment (Sarunaite et al., 2006). Grain yield was higher after red clover/ryegrass swards, while in previous experiment after lucerne/ ryegrass swards. This fluctuations of swards effects could have been resulting by different accumulation of N in the soil and also weather conditions. N removal with spring wheat yield almost in all the cases was significantly higher after red clover/ryegrass and lucerne/ryegrass swards than that after ryegrass sward. N removal after red clover/

ryegrass swards slightly varies and soil characteristics might be responsible for this. The spring wheat grain protein was highest when wheat succeeded red clover/ryegrass and lucerne/ryegrass swards.

Table. Dry matter (DM) yield of swards in first year of use, incorporated N amount and spring wheat yield, kg ha^{-1}

Swards+cover crop	DM yield of swards	N in incorpo-rated plant residues	N in spring wheat	Protein in grain, g kg^{-1}	Spring wheat grain yield
	2005			2006	
R. clover/ryegrass	10334	106	63.1	131	2274
R. clover/ryegrass +Bgr	9530	127	84.0	145	2342
R. clover/ryegrass +Bwc	10887	115	69.3	142	2121
R. clover/ryegrass +Pwc	10388	119	74.0	145	2128
Lucerne/ryegrass	9803	133	78.1	146	2183
Lucerne/ryegrass +Bwc	7848	105	72.8	148	1866
Lucerne/ryegrass +Pwc	8810	121	73.9	147	2022
Ryegrass	4207	42	64.9	136	1776
LSD_{05}	771.0	48.1	7.46	-	185.4

N o t e. *Bgr -barley for grain, Bwc -barley for whole crop, Pwc -peas for whole crop.*

How work was carried out?

Field experiments were conducted on a loamy *Endocalcari-Epihypogleyic Cambisol* in Dotnuva, Lithuania (55°24'N, 23°50 E). In 2004, red clover (*Trifolium repens* L.) and lucerne (*Madicago sativa* L.) were sown in mixtures with perennial ryegrass (Lolium perenne L.) without a cover crop or with semi-leafless peas (*Pisum sativum* L.) and spring barley (*Hordeum vulgare* L.) as a cover crop and ryegrass was sown as a monocrop in a randomized trial design with four replicates. In 2005, DM yield of swards was determined and in the autumn the swards were ploughed-in. In the spring of 2006, spring wheat (*Triticum aestivum* L.) was sown for grain. The inorganic N in herbage yields of swards and spring wheat grain was estimated by Kjeldahl and grain protein content was calculated by multiplying N by 5.7. The experimental data were statistically processed using ANOVA.

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Effect of green manure management on barley yields and N-recovery

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Implications

Mulching of GM herbage can increase cereal yields compared to its removal. However, the same GM herbage removed for biogas production will provide biogas residue that can be used as spring fertilizer to cereals. This will improve N-recovery and reduce the risk for N pollution. Cooperation with existing biogas plants will be more efficient, as building small biogas plants are costly and challenging.

Background and objectives

In cereal production on stockless organic farms, green manure (GM) is commonly used to improve soil fertility. Because of the short growing season in Norway, it is usual to keep the GM as a whole year crop. Clover-grass swards are commonly used as GM. They are mown frequently as a means to control perennial weeds in the GM-cereal rotations and to keep the sward in a vegetative state. The mown GM herbage is commonly mulched. The nitrogen accumulated in the GM is a potential pollution problem. Some investigations in fertile soils in temperate climate have concluded that mulching of GM herbage did not increase the yields of successive cereal crops, compared to removal of the mown GM herbage. If the GM herbage is removed, the risk of N-pollution from the field is reduced, and the herbage may be used elsewhere. If GM herbage is anaerobically digested for biogas production, the biogas residue can be used to fertilize cereal fields in the spring. This might lead to higher yields as a common constraint to organic cereal cultivation is lack of easy available nitrogen at the start of the growth period.

The objectives of this study were to investigate the effects of removing, mulching or returning green manure herbage as biogas residue, on barley yields and on nitrogen recovery, potential N-leaching and N_2O emissions.

Key results and discussion

On average, the mulched or harvested GM herbage contained 220 kg N per ha. Removing green manure herbage (0M) reduced substantially the grain yield of the subsequent spring barley crop on the sites with light soils (Site 2 and 3, Table 1). When only the last harvest was mulched, the grain yields where intermediate (1M, Table 1).

Table 1. Barley grain yield (Mg DM per ha ± S.E., n= 4) at four sites in 2010. Treatments: 3M – all three harvest of green manure are mulched, 1M – the last harvest is mulched, 0M – all three harvests are removed, B – Biogas residue applied spring 2010, corresponding to 50% of the herbage removed. Within a site, treatments that share a letter are not significantly different (p<0.05, TukeyHSD).

Sites	3M	1M	0M	0M-B
1. Kvithamar	1.4 (.2)ab	1.2 (.1)ab	0.9 (.1)b	1.6 (.2)a
2. Værnes	3.3 (.2)ab	2.6 (.3)bc	2.2 (.2)c	3.6 (.1)a
3. Apelsvoll	3.2 (.1)ab	2.6 (.2)bc	2.5 (.1)c	3.5 (.2)a
4. Ås	2.5 (.2)b	2.5 (.3)b	2.4 (.1)b	3.1 (.2)ab

In spite of evident N-limitations on barley growth, mulching did not increase grain yield on the heavy soil of the Site 1. A positive effect of mulching on plant growth observed at Site 4 was lost due to unfavorable weather after ripening that damaged the most fertile plots.

The nitrogen recovery calculated as *amount of N harvested in percentage of herbage N added (equation),* was very low. The recovery was particularly low when all three harvests were mulched. Low content of inorganic N in soil indicate that only a small part of N from decomposing herbage is plant available during our nearly 2 year measurement period. Shortly before ploughing spring 2010 the highest total content of inorganic N in the soil 0- 80 cm depth (NH_4-N+NO_3-N), was found at Kvithamar (3M) corresponding to 64 kg N per ha. This was only 17 kg N higher than when green manure herbage was removed. Ploughing and spring fertilization increased the content of inorganic N in soil, but there were no differences between 3M and 0M. Most of the inorganic N was in the upper soil layer. The maximum level of NO_3-N in the deeper soil layers (30-80) cm ranged from 13 kg per ha at Site 1 (before ploughing spring 2010) to 24 kg per ha at Site 3 (Spring 2011).

Table 2. Apparent nitrogen recovery (%) of herbage N in barley 2010 (equation below)

Sites	3M	1M	0M-B
1.Kvithamar	4	7	10
2.Værnes	9	1	16
3.Apelsvoll	10	16	24
4.Ås	2	5	15

The mulching of herbage increased N_2O emission only slightly (Nadeem et al. 2012). In the year with green manure it was 0.37 kg N_2O-N per ha higher throughout the whole growing season than when herbage was removed. Sward management or application of biogas residue did not affect N_2O emissions during barley production in 2010.

So where did the nitrogen in green manure herbage go? Probably most of the N was incorporated in soil organic matter as indicated by the high C/N ratio of the herbage (16). We can however not exclude ammonia volatilization or leaching from decomposing herbage, or denitrification events that we did not capture with our measurements.

How work was carried out?

The effect of various GM treatments on spring barley yields and nitrogen dynamics was investigated at four sites differing in soil and climatic conditions. The locations were Central Norway (Site 1: silty clay loam and Site 2: sandy loam), Eastern Norway (Site 3: loam) and South-Eastern Norway (Site 4: clay loam). In 2008 a grass clover mixture was undersown in barley. In 2009 the clover-grass herbage was either harvested or mulched. In spring 2010 the GM sward was ploughed down and barley was sown. Biogas residue from anaerobically digested GM herbage was applied before barley was sown in spring 2010. It contained 110 kg total N and 60 kg NH_4-N per ha (56 % of the total N in the GM herbage). Soil mineral-N was analyzed at 0-0.8 m depth on several occasions from 2008 until spring 2011, and used to judge the potential for N-leaching. N_2O emissions were measured with the chamber method at Site 4 in 2009 and 2010, when the soil was not covered by snow. Apparent N recovery was calculated according to equation below.

Apparent N recovery (%) = ((N $\text{yield}_{3M,1M \text{ or } 0M\text{-}B}$ – N yield_{0M})/N $\text{applied}_{3M,1M \text{ or } 0M\text{-}B}$)*100

Where *N* $\text{yield}_{3M,1M \text{ or } 0M\text{-}B}$ *is harvested total N (g* m^{-2}*) in barley grain and straw 2010 in the treatments* 3M,1M or 0M-B*,* N yield_{0M} *is corresponding barley total N yield (g* m^{-2}*) in 0M, and* N $\text{applied}_{3M,1M \text{ or } 0M\text{-}B}$ is total N *(g* m^{-2}*)* applied either as mulch in 2009 (3M,1M) *or as biogas residue spring 2010 (0M-B).*

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Effects of organic versus conventional farming on different chemical soil parameters in Estonia

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Implications

A five-year experiment results, have shown that fertilizer amendments are needed for preserving the nutrient balance in the soil. A combination of cattle and green manure, crop rotation and other organic farming practices, with chemical fertilizer amendments could suppose a sustainable solution for maintaining a correct nutrient balance in the soil in long term, better than both farming systems, conventional and organic, by separate.

Background and objectives

The problems associated with conventional management in agriculture such as decline of organic matter, soil erosion, soil and water pollution, etc. united to the new European policy to develop more environmentally sensitive farming practices, have boosted the development and investigation in organic farming as an alternative agricultural management. In the case of Estonia, it has experimented an increasing importance after the re-establishment of the independence in 1991 due to government support, registering in 2012 a total of 134.057 organic farming hectares (14% of all agricultural land in use). There are many studies which compare different soil parameters under conventional and organic farming management, but controversy in results make still difficult for farmers to choose between one or the other. The aim of this study is to compare the evolution of several soil chemical parameters under different farming conditions based on different nutrient amendments, in order to provide a better understanding of organic farming soils, and promote the government support for this kind of agricultural practice.

Key results and discussion

Comparing the evolution after five years of certain chemical parameters in the same soil managed under organic or conventional conditions, some remarkable differences are observed. In terms of soil acidity, no significant year-to-year variations ($P<0,05$) were shown for any of the treatments. Soil organic carbon (SOC) showed a significant increase at the end of the experiment in the ORG. II plots. Several researches like Hoyt and Rice in 1977 or Mathers and Steward in 1984, have reported similar results of organic carbon in soils after following manure application for several years. Meanwhile the unfertilized conventional plots showed marked losses in N_{tot}, the rest of the treatments showed a slightly decrease in this nutrient in the soil, which could suppose a limitation in crop growth if same experiment is run in long-term. According with the results, either green manure or cattle-green manure fertilization are not enough in the organic plots for maintaining a positive balance in terms of P and K. Conventional fertilized plots ($N_{125}P_{25}K_{95}$) showed an increase in phosphorus but as happened with the organic ones, it has significant losses of potassium with time. Berry et al. (2003) among other authors have found that organic managed plots in long term accused deficits of P and K but also N, which directly affects to the crop yield (Rodrigues et al., 2006).

Table 1. Comparison of the different soil parameters analyzed between the beginning of the starting year of the experiment (2008) and the last year (2012). $N_0P_0K_0$ (conventional plots without addition of fertilizers), $N_{125}P_{25}K_{95}$ (conventional fertilized plots), ORG.I (organic plots with green manure), ORG. II (organic plots with green manure and cattle manure. Mean nutrient values of manure: Ctotal: 13.76, Ntotal: 0.97, Ptotal: 0.45, Ktotal: 0.86 and dry matter content: 44.8)

	$N_0P_0K_0$	$N_{125}P_{25}K_{95}$	ORG. I	ORG. II
pH	-0,05	-0,1	0,04	0,14
C_{org} (%)	0,05	-0,03	0,11	0,34*
N_{tot} (%)	-0,017*	-0,002	-0,003	-0,008
P (mg kg^{-1})	-4,5	8,7	-19,9*	-12,9*
K (mg kg^{-1})	-34,2*	-20,9*	-35,6*	-20,2*

+/-: decreasing or increasing tendencies. *: significant differences (*P<0,05*) comparing the average values from 2008 and 2012

How work was carried out?

The field experiment was situated at the experimental station of the Estonian University of Life Sciences in Eerika, Tartu, Estonia (58°22'N, 26°40'E) since 2008 on *Albic Stagnic Luvisol* soil. It consist on 80 plots, 40 of them cultivated under conventional farming system with different concentrations of mineral fertilizers (no addition of chemical fertilizers: $N_0P_0K_0$ and $N_{125}P_{25}K_{95}$), and the remaining 40 plots cultivated under organic farming conditions with the same rotation but having winter oil-rape after pea, winter rye after potato and ryegrass after winter wheat as cover crops. In addition 20 of them (ORG. II) receive yearly 40 t ha^{-1} of manure in those plots were pea is cultivated, except the last year when manure was divided between winter wheat 10 t/ha, barley 10 t/ha and potato 20 t/ha.

Soil samples were collected once a year in April, before any field operation, taking eight replications per plot from 0 to 25 cm depth. Each air-dried soil sample was sieved through a 2 mm sieve and mixed in a KCl solution 1M (1:2,5) for determining the pH, meanwhile the organic carbon concentration was determined by the Tjurin method and total nitrogen was measured after Kjedal digestion. The concentrations of plant available nutrients P and K in the soil were determined by the ammonium lactate (AL) method.

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Robust breeds for organic pig production

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Implications

Robust animals – here piglets – are important for the organic production, since vital and healthy animals are one of the pillars for animal welfare and comfort in the daily management. One of the key issues in the conventional breeding system is a high litter size. The average is 15 – 16 live born, but quite often more than 20 piglets are seen in practice. The organic production system uses the same genetic as the conventional because the production scale is too small to run its own breeding system.

The organic regulation offers a frame for a wide range of high level of animal welfare parameters (free range, prolonged nursing period and access to roughage, just to mention some). However, at the same time it has to face a major problem with high mortality among the piglets. This conflicts with the aim of high animal welfare, and also stresses the staff.

A high litter size is partly responsible for the mortality rate for piglets. The sow normally has 13-14 teats – which makes a litter equalization needed, when there are born more piglets than there are teats. The equalisation management tool works, but the question is what to do, when there are either extra sows or teats available? The conventional production solve the challenge by practising "nursing sows", meaning that, when a sow has brought up her own litter, these are weaned and the sow "adopts" some younger piglets. This kind of management is difficult in the organic production, because the sow has already had 7 weeks lactation and also it can be difficult to make the sow accept new piglets, because it is not allowed to fix organic sows. This has led to a request from some of the organic pig farmers: Can we breed sows where the litter size is balanced to the number of teats? The born piglets should also be both strong and vital.

Background and objectives

In Denmark the organic pig production is characterised by being an outdoor production. Each sow has her own hut in the farrowing pen and the lactation period is 7 weeks, which is one week longer than the EU-organic regulation requires. This set-up has been ordinary practice for more than 20 years. The farmers like the system and are proud of this way to keep pigs. Also the consumers appreciate the opportunity to observe the animals outdoor.

Almost all herds in Denmark use the same genetic material as the conventional indoor production. This is caused by the fact, that the organic production is too small for running a breeding programme itself and because the slaughter quality – measured as meat content – is a high value parameter, concerning the consumer (both home- and export market).But for years the organic farmers have asked: "Is it the right choice to use the same genetic for two systems that differs so extremely"?

A project named "Robuste racer i økologisk sohold" (Robust races in organic sows for piglet production) has been carried out. The aim of this project is to find the answer for the farmers: can the use of other breeds give a sow where 1) the litter size matches the capacity of the sow, 2) the sow produce strong and vital piglets and 3) the slaughter quality is at the same high level as today,

Key results and discussion

Results are measured as: production level, robustness (mortality and treatment) behavior, temperament and slaughter quality. The results are under preparation and will be presented at the seminar. There was not found literature from scientific work carried out with the similar focus.

How was the work carried out?

First some interviews were carried out among colleagues in the organic farming system in Sweden, England, Germany and The Netherlands. We visited farmers, advisers, breeding associations and breeding companies. It is a challenge to compare animals and results while in Sweden, Germany and The Netherlands there in-door farrowing are often practiced. Sweden and to some extend the Netherlands use Landrace x Yorkshire/Large White like in Denmark. England has a total outdoor system and uses breeds, which are very different compared to the traditional Danish (Danish Landrace and Danish Yorkshire). In Denmark Duroc is used as sir (boar) line – in England it is bred as dam (sow) line. Years ago an immigrant settled down in Denmark as an outdoor pig farmer. He brought with him animals from the English Duroc dam line and had very good experience with them concerning behavior and maternal instincts. Based on information from the interviews, visits and production data (in the extend it was available) it was decided to import semen from England (Duroc dam line) and Saddleback (from Ireland). The semen was used for purebred Danish Landrace gilts and offspring form here was the new crossbreed sows. We ended up with 11 Saddleback x Landrace gilts and 7 Duroc x Landrace gilts. For the new crossbreds was used ordinary Yorkshire semen to try to reach the aim for meat content in the slaughter pig. The practical work was located "on farm".

References

The project is funded by Fonden for Økologisk Landbrug, Landdistriktsprogrammet og Udviklingscentret for Husdyr på Friland. The project period is 2011-2013. The work will be finished in July 2013 and the results formulated for the NJF seminar as the first place to be disseminated.

Results from the project will be found (in Danish) at https://www.landbrugsinfo.dk/Oekologi/Svin/Sider/Svinehåndbog.aspx after the end of the project.

Associations between pig leg health and lean meat growth in commercial organic herds

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Implications

Sustainable development of organic pig production needs to include both animal welfare and productivity aspects. Knowledge about associations between animal welfare and productivity could be a key for constructive, long-term development of organic as well as conventional pig production systems. Poor leg health is considered a central animal welfare issue in organic pig production in Sweden. The preliminary results presented in this paper indicate that pigs in organic herds with more severe leg problems have poorer lean meat growth. However, the majority of the lame pigs had milder forms of leg problems, which were not found to be associated with lean meat growth.

Background and objectives

In Sweden, the proportion of pigs from organic herds with leg joint remarks at slaughter has increased from 4 to 8% over the past decade (Heldmer and Lundeheim, 2010). The clinical leg health of live pigs has not yet been thoroughly investigated in organic herds. Poor leg health has been found to be associated with reduced slaughter weight and increased carcass leanness (Lundeheim, 2010), two economically important traits in pig production. The objective of this study was to investigate associations between lameness and swollen joints during the growing/finishing period, leg joint remarks at slaughter and lean meat growth.

Results and discussion

The proportion of lame pigs increased from 5.1% early in the growing/finishing period (approximately 30 kg live weight) to 21.0% at the late assessment performed just before slaughter. The corresponding increase in prevalence of swollen joints was from 0.1% to 8.5%. However, only 2.3% of the carcasses had leg joint remarks during routine recording at slaughter. This was a relatively low value compared with the average prevalence among pigs from organic herds in Sweden (varying from 4 to 8 % over the last 10 years). The purpose of the routine lesion recording at slaughter is to ensure food safety (Livsmedelsverket, 2006), but in addition the recorded data are often used for surveillance or description of animal health and welfare in production systems or specific herds (Heldmer and Lundeheim, 2010, Lundeheim and Holmgren, 2010, Keeling et al., 2012). This recording system provides important and valuable information, but the discrepancies between lameness, swollen joints and leg joint remarks at slaughter observed in this study emphasise the importance of additional, more detailed, observations on live animals.

Among the pigs included in the analyses, carcass weight, age at slaughter, percentage of lean meat in the carcass and lean meat growth rate were on average (mean±standard deviation) 89.5±6.84 kg, 202.1±26.23 days, 56.1±2.52% meat and 252.5±4.14 g lean meat/day, respectively.

Pigs that were lame at the second assessment (at approximately 100 kg live weight) tended to have leaner carcasses than pigs that were not lame (least square mean±standard error: 56.2±0.14 and 55.8±0.21, respectively, $p=0.094$) but no other differences in growth or carcass leanness were observed between pigs with observed lameness and swollen joints and clinically healthy live animals. Pigs with leg joint remarks at slaughter had slower lean meat growth than pigs without leg joint remarks

(230.4±7.24 and 252.1±3.56 g lean meat/day respectively, p<0.001). As the proportion of pigs with leg joint remarks was very low, the reliability of these results could be questioned. It is also important to remember that these are preliminary results based on the first batches of pigs slaughtered in the study (the last pigs will be slaughtered in March 2013). However, unless these results change substantially in the final analysis, the data indicate that some associations between leg problems and lean meat growth do exist. Taking all the results together, it appears as though lameness and swollen joint examination in live animals capture a larger range of leg problems among the pigs, while the leg joint remarks recorded at slaughter capture the more severe cases. It seems reasonable that the association between leg problems and growth is stronger when the leg problems are more severe.

In this study, both sire breeds available to pig producers in Sweden were included (56.1% of the pigs had a Hampshire sire and 43.9% a Duroc sire). However, there were no significant differences between offspring of the two breeds in terms of growth or carcass leanness when reared in organic herds. As expected (and the reason for adjusting for these effects in the statistical model), there were significant differences between herds for both lean meat growth and percentage meat in the carcass, with the latter parameter differing significantly also between the sexes.

On-farm study

Yorkshire x Landrace sows in organically certified commercial herds were inseminated with non-mixed semen from AI boars of Duroc and Hampshire breeds. The two sire breeds were evenly distributed among sows in each herd and production batch. All piglets were individually marked with electronic ear tags. Lameness and swollen joints were individually assessed (normal; yes or no) for all pigs at approximately 30 and 100 kg live weight. The protocol used was based on that formulated for breeding evaluation as described by Eliasson (2013). At slaughter, slaughter weight, carcass leanness (percentage meat in the carcass) and leg joint remarks were recorded for each individual pig. One trained person performed all the lameness and swollen joint assessments and all pigs were slaughtered at the same slaughter plant.

In total, 180 sows and their litters were included in this study and the last pigs born in this study will be slaughtered in March 2013. However, the preliminary results presented in this paper are based on information from 726 pigs from 86 litters, slaughtered from July 2012 to November 2012.

Analysis of variance was performed with procedure MIXED in the SAS package. The statistical model used included the fixed effects of a leg health variable (0/1 classes for lameness at 100 kg, swollen joint at 100 kg or leg joint remark at slaughter), sire breed, herd (3) and sex, and the random effect of litter nested within sire breed (86).

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Low stress and safe handling of outdoor cattle – effective measures to improve work environment and avoid dangerous situations

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Implications

Grazing cattle are needed to preserve 450 000 hectares of semi-natural grasslands of high biodiversity in Sweden. Keeping cattle outdoors promotes their health and possibilities to conduct natural behaviors. Working with cattle on pasture however, can increase accident rates (Health and Safety Authority, 2011). During the last two years, five fatalities and several accidents have occurred during handling of cattle in Sweden. A method, based on knowledge of the animals' natural behavior, referred to as low stress stock handling (LSS-method), has been introduced to Sweden for cattle handling (Atkinson, 2011). A handler who consistently uses this method prevents the use of hits, sticks, harsh voice or negative forceful handling techniques. A consistent predictable approach from the handler creates consistent and predictable animal behavior in return. Cattle become more trusting with their handlers and consequently more cooperative. This positive interaction between human being and animal can lead to both a safer work situation and a better animal welfare. On two of five studied farms so far, the LSS-method was actually intervened during the observations, resulted in a successful reversal of conflict behaviour. On farm1, a highly stressed heifer took over three hours in attempt to load into a transport. It was successfully loaded within an hour after the intervention. On another farm, five escaped cows that the farmer had attempted to capture unsuccessfully for three consecutive weeks were successfully captured through using the LSS-method.

Background

Sweden has one of the highest accident rates related to cattle handling, compared to Norway, Finland and Australia, although those countries have more beef producers. In Australia, regular courses on low stress stock handling are given to farmers by professionals working in this field. Anecdotal evidence suggests farmers who have completed the LSS courses in Australia, handle their cattle more effectively and safely.

Objectives

This project aims to educate a group of Swedish farmers with cattle on pasture to use the LSS-method of handling, in order to improve safety and reduce stress in both human being and animal. A further objective is to test and evaluate the training of the LSS-method to develop a corresponding course adapted to Scandinavian farmers.

Preliminary results and discussion

Table 1 shows information about farms, the tasks studied and working consumption expressed in man hours. On farm1, work consumption was considered particularly high. The farmers mentioned that the task performed on the day was rather difficult due to two heifers being highly stressed when attempting to capture and load them on to a transport from the field. Moving cattle by transport trailers required a high consumption of man hours and number of people. Some of the cattle did several turn backs, escapes, jumps, kicks and falls when cattle were loaded into the trailers in the field. Physical forceful pushes (or hits) towards the cattle with hands, body or by gates by the handlers frequently occurred on all farms where cattle were transported.

Several dangerous risk incidents occurred at the farms, e.g., when standing in front of a heifer using feed to encourage forward movement, a person was hit in the forehead by her horn; a heifer jumped over a man during an escape attempt before transport loading, a heifer ran through the handlers while they were attempting to block her from an escape attempt, and a person tumbled while trying to block a cow from escaping during transport loading.

Table 1. Information about the farms, tasks and working time consumption per person studied

Farm nr	No. of cattle/(bull)	Pasturing period	Tasks studied	Worker (no.)	Time (hour)*
Farm1	30 (1)	Whole year	Transporting 4 highland cattle from forest grazing to farm pasture(2 trips at driving distance of 6 km)	5	11,3
Farm2	181 (1)	May-Oct	Transporting 7 cattle from forest grazing to barn; moving a cattle group, sorting out 2 young bulls	2	2,6
Farm3	306 (6)	May-Oct	Transporting 17 cattle from forest grazing to barn (3 trips at driving distance of 2 km)	3	5,0
Farm4	434 (6)	May-Oct	Sorting & transporting 40 cattle to barn from a pastureland (3 trips at driving distance of 5 km)	3	7,6
Farm5	81 (1)	Whole year	Moving & spraying medicine on 51 cattle on pastureland and moving them to a near pasture	3	6,4

*Calculated as time consumption per person

In general the farmers visited had a positive attitude towards their animals, and were keen to learn tips on alternative handling methods. It is expected that the farmers will be able to move groups or individual cattle to new paddocks, pens or into transports by walking them with less physical force, through training in the LSS-method. Refusal, flee, fright or fight behaviours in the cattle should also be reduced and achieved with less need for handling devices/transports, less conflict, time consumption and fewer handlers.

How work was carried out

Field studies have been conducted on 5 beef farms with at least 20 cattle and one bull. The work tasks investigated were: moving to and from pastures, sorting and transportation of cattle from summer pastures to winter areas. Interaction between human being and animal (stress levels: heart frequency, behavior and working time) were recorded during the animal handling in the field. The field studies comprise three phases as follows:
Phase 1. Observation of animal and farmer behavior during handling of cattle on farm and interviews with the farmers regarding their work environment.
Phase 2. Theoretical and practical training of the LSS-method with the farmers studied;
Phase 3. Evaluation of training effect on the farmer's animal handling.
Note that part of phase 1 has already been carried out and phases 2 and 3 will be performed in the coming year.

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Could a different management routine that strengthens the mother-offspring bond contribute to a more efficient organic piglet production?

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Implications

In current Swedish organic piglet production full reproductive potential of the sows and growth potential of piglets are not achieved. The efficiency is held back by occurrence of lactational oestrus, low litter weight and large weight variation within litter. Therefore it is critical that these obstacles are reduced in a way that is easy to adapt in practice and does not contradict the ideas behind organic animal husbandry.

This project aims to an improvement of the conditions needed to efficiently produce organic piglets in a batch wise manner. The batch wise breeding will reduce production costs and increase disease control.

Our preliminary results indicate that the sow's weaning to oestrus interval can be affected by the time spent in individual farrowing pen during the lactational period.

Background and objectives

In Sweden organic sows are group housed during lactation. Boe (1993) reports that a group housing system compared to farrowing pen does not provide suckling inhibition of ovulation causing the sow to display lactational oestrus. Some factors that affect the occurrence of lactational oestrus are suckling behavior, litter weight gain and sows body score at weaning (Wallenbeck et al. 2009, Hulten et al. 2006). Rydhmer et al. (2005) report that lactational oestrus is considered a problem by organic piglet producers. On average 40-47% of group housed sows ovulate during late lactation. This emphasizes the importance to find a practical solution to the occurrence of lactational oestrus.

One way of circumventing the issue is by inducing lactational oestrus so that sows could be inseminated during lactation in order to achieve a shorter farrowing interval. This approach has been addressed in several studies, (Alonso-Spilsbury et al. 2004, Kongsted and Hermansen 2009). But as Alonso-Spilsbury et al. (2004) state it is not an easy task and it has to be practically applicable.

This project has in contrast chosen to study if lactational oestrus, instead of being induced, can be suppressed by strengthening the mother-offspring bond through different management routines the weeks post farrowing. Thus achieving a suckling behaviour that will inhibit the oestrous cycle throughout the suckling period and thereby enabling a batchwise-breeding.

Key results and discussion

Preliminary results indicate that the weaning to oestrus interval was significantly shorter when the sow and litter spent two ($p<0.05$) or three ($p<0.01$) weeks in the farrowing pen before group housing compared to one week. Although sows ovulating during lactation have a higher body condition score at weaning according to Wallenbeck et al. (2009), no significant differences between the three treatments were observed for back fat and weight changes from farrowing to weaning in this study. Possibly, the piglets that were group housed at one week of age were more dependent on suckling in order to survive and therefore established a stable suckling behavior, which persisted throughout the suckling period. To compare, the piglets that were group housed at two and three weeks of age were not as dependent on their mother for survival and therefore did not exert the same suckling behavior.

How work was carried out?

43 pure bred Yorkshire sows and their piglets participated in this experiment. To alter the mother-offspring bond three different treatments were designed. The sow and litter either spent one, two or three weeks in an individual farrowing pen before proceeding to group housing. All treatments were repeated once with different sows and the piglets were weaned at approximately 42 days of age. The following data were collected; sows weight and back fat depth at farrowing and weaning and signs of oestrus behavior from 21 days postpartum.

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The effect of different compost applications in organic production of lettuce (Lactuca sativa L.)

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Implications

It is well-known that compost and manure applications to all kinds of soils if these organic materials are mature and composted under favorable conditions result in improved soil fertility and crop production in terms of yield and quality, but because manure is expensive in our region and the application of in-farm production compost for organic lands and farms of Turkey is limited, there is a great and urgent need for demonstrate compost using advantages to soil fertility, plant yield-quality and food safety (Kir 2006). Vegetables account for only approximately 2% of total organic production in Turkey, but there is great potential for growth of organic production for both export and domestic consumption of organic products in our country. Lettuce (*Lactuca sativa* L.) is one of the most important species for testing effects of compost applications because of its sensitivity related with phyto-toxic effects of compost (Fuchs et al. 2008) and very important to find out productivity and sustainable production levels in crop production. It is obtained from the results at the end of the first two-year trials, respectively of the three year-planned research under organic management (framework of regulations of EU and Turkey) that (1) the artificial organic materials sourced from farms can be composted and applied to lettuce production to get a great profit in terms of environment and economic aspects of organic lettuce production significantly, (2) promising improvement of industry of compost production can be expected, (3) Organic lettuce can be consumed as microbiologically safe, (4) high quality lettuce production can be attained by using compost.

Background and objectives

This research was designed to study the effects of composted plant residues (C), farmyard manure (FYM), and two different certified commercial organic composts (CCC1, CCC2) on lettuce (*Lactuca sativa* L.) total yield and agro-morphological measurements (head weight, number of outer leaves, number of waste leaves, head length, head width), quality (titratable acidity, pH, dry matter, nitrate), and macro-micro elements and on soil macro-micro elements and on microbiological status of lettuce (*E.coli, E.coliO157:H7, Salmonella sp., Eria monocytogenes*) and soil (*Anaerobic-aerobic bacteria, Enterobacteriaceae, E.coli, Clostridium, Salmonella, S. aureus, B. antrachis, Fecalcoliform, Listeria, Pseudomonas, Enterococ/Streptococ, E.coliO157:H7, Actinomycetes, Azotobacter sp.*) during the autumn season. Taken into account the perspective of organic farming tomato was grown during the summer between the lettuce growing seasons.

Study mainly aimed to promote organic agriculture and to increase the use of compost which is sourced local industry and in-farm produced compost (green waste compost) and demonstrate various organic applications of compost to local and small scale organic growers to obtain high yielding and quality lettuce. It is also aimed to reduce to import of organic fertilizers in Aegean Region where center of the organic production. Approximately 40% organic production of total organic production of Turkey has been produced in Aegean Region, especially in Izmir province in recent years.

Key results and discussion

In both years, the highest yields were significantly affected in the FYM treatment (45-48 t ha^{-1}), and the lowest with the application of CCC2 (42-46 t ha^{-1}). In general lettuce yields range between 20 and 60 t ha^{-1} in open field production as we obtained. The highest net returns were resulted in the C treatment (852-905 \$ ha^{-1}) and the lowest with the application of CCC2 (825-900 \$ ha^{-1}). Nitrate contents in lettuces were ranging from 302.5-322.4 mg/kg to 814,6-854.9 mg/kg in fresh matter (FM) respectively and mean NO_3^- in the FM of organic lettuces were found quite low than the limits of EU regulations. Negative effects of any treatments on lettuce quality were not recorded including microbiological analysis because pathogens were not detected. These findings support the results published by Fischer-Arndt M et al. 2008 and by many other researchers. The effect of treatments on agro-morphological and nutrient measurements of soil and leaves were also significantly different and showed similar ranges with the yields.

How work was carried out?

The trials were carried out at the experimental certified (by ICEA) organic field of AARI in Menemen (Izmir/Turkey) in successive two years (2011, 2012) during autumn season. The local has a Mediterranean climate, with average annual temperatures for the warmest month (July) and for the coldest month (Jan.). Annual average annual rainfall 700 mm and average relative humidity is 60%. Romaine lettuce (Lactuca sativa L., cv. Yedikule-5701-standard variety) which has been produced commonly by local farmers was used. CCC1 and CCC2 were organically certified and provided from commercial companies of our region. Physical and chemical properties of the experimental soil (2 times-sampled (a) before application of treatments and transplant the seedlings and (b) after the last harvests), the applied manure, composts and lettuce leaves (sampled at the harvests) were analyzed according to standard methods. The compost material was obtained by composting green residues from the agricultural production of the organic experimental area and Institute lands. Farmyard manure and green wastes were composted for 8 months. The experiments were conducted in randomized block design in 20 parcels with 5 replications, with 144 plants making up each parcel. Distances between the parcels were 2.1 m. Treatments were C (pH:7.09,N:0.66%,C/N:28) FYM (pH:7.44,N:1.04%,C/N:19)CCC1, and CCC2. Application rate of N not exceeded 170 kg/ha/year. Results were statistically evaluated by ANOVA followed by Tukey's test using SAS (SAS version 9.1, SAS Institute, Cary, NC, USA).

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The effect of companion planting on the abundance of pest complex and its parasitism rate on white cabbage

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Implications

The findings of this paper could help to develop and maintain a sustainable cabbage production by the enhancement of natural pest control with the help of companion planting. Our results indicate that *Lobularia maritima* (*Brassicaceae*) could be used to attract pests of cruciferous plants away from the crop.
Centaurea cyanus (*Asteraceae*) and *Fagopyrum esculentum* (*Polygonaceae*) could be used to suppress pests of cruciferous crops and to increase parasitism rate by fostering parasitoids.

Background and objectives

The expansion of large monocultural fields and an increase of often prophylactically used chemicals have led to widespread decline of farmland biodiversity and ecosystem services, e.g. pollination and natural control of pests. Because of that the need for more sustainable and environmentally safe management systems has arisen.

To rebuild biodiversity and ecosystem services new approaches have been developed (Stoate et al., 2001; Tilman et al., 2002). Companion planting is a system of growing additional plants with the crop to attract beneficial insects, suppress pests, and mask the scent of crop plants or supply the soil with nutrients.

In the temperate climate, several important agricultural and vegetable crops from the family Brassicaceae are grown. In Europe the most grown are cole crops, nearly 69 million tonnes were produced in 2011, of that over 12 million tonnes in Europe (FAOSTAT, 2013). One of the most commonly grown cruciferous vegetable crops in the temperate climate is white cabbage (*Brassica oleracea* var. *capitata*). It is damaged by several insect pests of which the most damaging ones belong to the order Lepidoptera. Commonly occurring and the most widespread are the diamondback moth (*Plutella xylostella* L.: *Plutellidae*), the large white butterfly (*Pieris brassicae* L.: *Pieridae*), the small white butterfly (*Pieris rapa* L.: *Pieridae*) and the cabbage moth (*Mamestra brassicae* L.: *Noctuidae*) which, in the interest of plant protection, are usually treated as pest complex.

All these pests are attacked by natural enemies. Of these, hymenopteran parasitoids form a substantial and diverse portion; more than 50 different parasitoid species are known to parasitize each of these pests (Yu et al., 2012).

The aim of this study was to find out if and how will cabbage companion planting with *Agastache .foeniculum* (Pursh) O.Kuntze (*Lamiaceae*), *Anethum graveolens* L. (*Apiaceae*), *Centaurea cyanus* L. (*Asteraceae*), *Fagopyrum esculentum* Moench (*Polygonaceae*), *Iberis amara* L. (*Brassicaceae*) and *Lobularia maritima* (L.) Desv. (*Brassicaceae*) affect the abundance of lepidopteran pests and their parasitoids.

Key results and discussion

Plant species' significant influence on the abundance of pests of cruciferous plants was statistically proven (Kruskal-Wallis ANOVA $H(6, N=640)=72.84$, $p<0.0001$; Fig. 1).

The most attractive were cabbages planted with other cruciferous plants: I. amara and L. maritime but significantly less pests were found from cabbages planted with C. cyanus and F. esculentum.

Plant species had significant influence also on parasitoids of this pest complex, as parasitism rates were significantly influenced by the plant species (Kruskal-Wallis ANOVA H(6, N=609)=76.78, p<0.0001).

These results suggest that taxonomically different plant species decrease the occurrence of specialised pests and due to extrafloral nectar on C. cyanus and low corollas on F. esculentum these species offer food for parasitoids without fostering lepidopteran pests. Parasitoids benefit more from easily accessible sugar-sources than insects with long probiscus as proven earlier by Winkler et al. (2009).

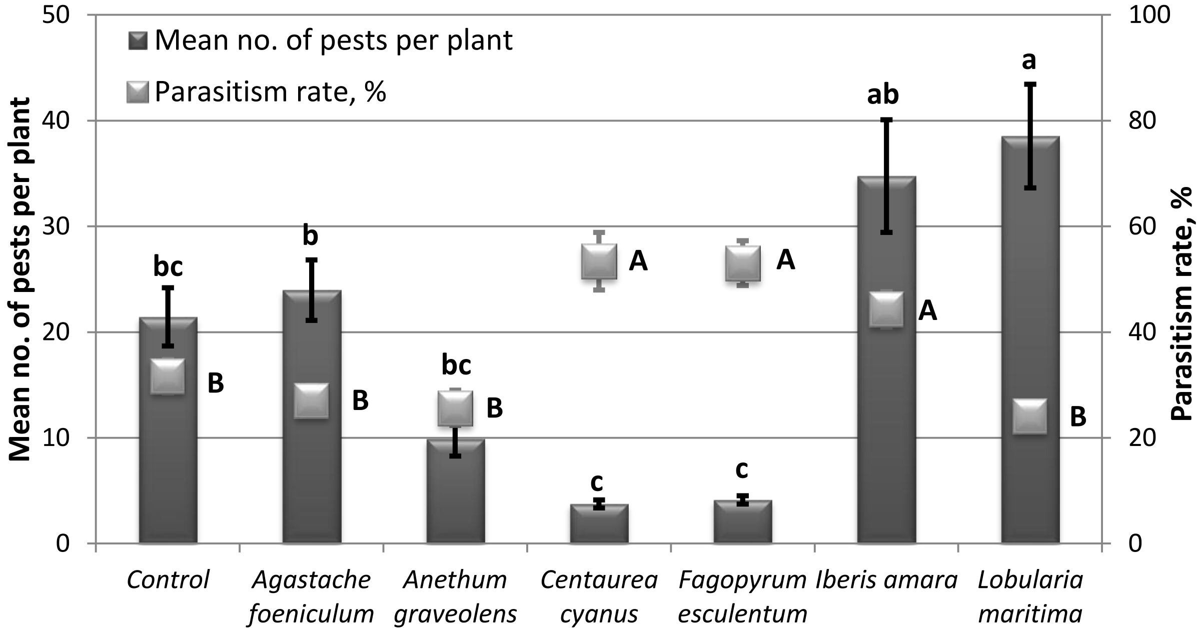

Figure 1. The mean (±SE) number of pests per cabbage plant and their mean (±SE) parasitism rate on cabbages planted with different companion plant species. Different letters indicate significant differences between plant species, lowercase letters – pests per plant, capital letters – parasitism rate (*P* < 0.05, unequal N HSD test)

How work was carried out?

The study was carried out on the experimental field of the Estonian University of Life Sciences, 2009-2012. Six plant species from various families were used as companion plant for white cabbage: *A. foeniculum*, *A. graveolens*, *C. cyanus*, *F. esculentum*, *I. amara* and *L. maritima*. Cabbages were planted with different companion plants using Latin square design. Pests were collected from cabbage plants when they reached last larval instar and incubated in laboratory to rear parasitoids and to calculate the parasitism rate.

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The introduction of the new control method of plant viruses infection for organic farming

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Implications

Pepper mild mosaic virus (PMMoV) and cucumber mosaic virus (CMV) are economically important viruses, which cause enormous losses by infecting various vegetable crops worldwide. Various strategies based on the avoidance of sources of infection, control of vectors have been conventionally employed to minimize the losses caused by these viruses. These strategies, however have not been effective as control tools. We have found that the extracts of gallnuts from *Quercus dentate* and *Rhus javanica* strongly inhibit PMMoV and CMV infection. The gallnuts are plant excretion produced when irritants are released by the larvae of gall insects. They contain high amounts of tannic acid such as gallic acid and ellagic acid. Also the gallnut extracts are widely used in pharmaceuticals, food and feed additives, it is safe natural material which can be used in organic farming. Our results indicate that they are potent plant viruses inhibitors that maybe used to prevent the spread of viruses infections in the cultivating farm.

Background and objectives

This study was undertaken to develop environmental friendly new anti plant-viral agents using natural materials of plant resources, several substances have been reported as plant viral inhibitors such as milk, polysaccarides (Sano 1999). Also many plant resources have been reported to have potent antiviral activity and some of them have already been used to treat animal and human who suffer from viral infection (Hudson 1990), because they virtually constitute a rich source of bioactive. However, little work has been done to control plant viruses by using these natural products in spite of their excellent pharmacologies signification. We found the extracts from gallnuts of *R. javanica* and *Q. dentate* which strongly inhibited the infection of PMMoV and CMV. Here, we introduce several properties of the antiviral activities by the gallnut extracts.

Key results and discussion

The mixed treatment effect of Qbyrus-1 against infections of each virus (PMMoV and CMV) to local infection plant was measured to be 100% to PMMoV and 100% to CMV in 1% conc. As shown in Table 1, the pre-treatment effects against infection of each virus to local host plants were estimated to be 75 to 97.5% for PMMoV and 70.6 to 99.0% for CMV in 0.1 to 1% conc.

Table1: Inhibitory effects of Qbyrus-1 against local infection of PMMoV and CMV

Treatment	Concentration (mg mL^{-1})	Inhibition (%)	
		PMMoV	CMV
Qbyrus-1	10	97.5±1.5	99.0±1.0
	5	93.0±1.2	93.3±0.6
	2	80.2±2.4	84.0±0.5
	1	75.1±0.5	70.6±2.2
Water(control)	-	0.0±0.0	0.0±0.0

To assay the absorption of the antiviral composition of extracts to the inside of the leaf tissue, the extracts (10mg/ml) were applied on the backside of the half leaves of host plants Nicotiana glutinosa or Chenopodium amaranticolor. Virus infection on the upper surface was inhibited by 55.7% for PMMoV and 63.8% for CMV. These results indicated that the inhibitory effect of the extract was induced not only by barrier effect, but also by another unclear antiviral effects.

When the Qbyrus-1 was sprayed before virus inoculation, PMMoV or CMV infection ratio through the leaves of their systemic host was remarkably reduced in greenhouse conditions (Tab.2). This result showed that the inhibitory activity of Qbyrus-1 was superior to the effects of the known viral inhibitors such as skim-milk or Lentemin (Oka 2008). The Qbyrus-1 was apparently harmless to the tobacco seedlings, judging from the fact that there's no change of leaf colours and there's no symptoms of growth inhibition.

Table. 2. Inhibitory effects of Qbyrus-1 against systemic infection of PMMoV or CMV

Treatment	No. plants infected / inoculated			
	PMMoV		CMV	
	Exp. 1	Exp. 2	Exp. 1	Exp. 2
Qbyrus-1	2/20	4/20	8/20	5/20
Skim milk	7/20	12/20	9/20	5/20
Water(control)	20/20	20/20	20/20	20/20

The PMMoV particles were almost segmented by mixing Qbyrus-1, but not affected in the absence of Qbyrus-1. It's thought that one mode of action of Qbyrus-1 is inactivation of the virus due to the destruction of viral particles.

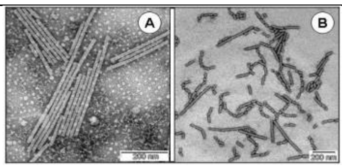

Figure. 1. Electron micrographs of PMMoV particles in the absence (A) or presence of Qbyrus-1 (B), Bar=200 nm

How work was carried out?

The fresh Gallnuts of *Q. Dentata* and *R. javanica* were sampled in Korea. The dried samples were ground using a blender, extracted and filtered. The filtrate was concentrated *in vacuo* at 40℃ and freeze-dried. Furthermore, the inhibitor named "Qbyrus-1" formulated from these gall extracts was tested for its inhibitory effects on PMMoV and CMV infection to each local lesion host plant. *N. glutinosa* was used for local lesion assay of PMMoV infection, while *N. tabacum* cv. samsun was used for systemic assay. *C. amaranticolor* was used for local lesion assay of CMV infection, and *N. tabacum* cv. Samsun NN was used to systemic infection assay of CMV. Antiviral activities in local lesion assay plants were tested using the half-leaf method (Kwon et al. 2010). For the assay of the systemic host, Qbyrus-1 was sprayed onto the leaves of assay plants and the viruses were inoculated onto the leves of each assay plants. The inhibition ratio was confirmed 4 weeks after inoculation by ELISA. 1% Qbyrus-1 was mixed with the purified PMMoV in 10mM phos. buffer (pH7), observed with transmission electron microscopy.

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The influence of organic and conventional production on yield and quality of carrots

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Implications

Although numerous experiments have been carried out to compare nutrient and contaminant contents of organically and conventionally produced vegetables, further research is recommended (Rembialkovska 2007, Hoefkens et al. 2009). This study contributes to the investigations of the levels of various nutrients in organic and conventional carrots. The trial data of 3 years were contradictory for yield and quality. The yields of organic trial were not significantly lower compared to conventional trial. Longer trial period is needed to conclude the role of weather conditions, cultivation regime (used herbicides, insecticides and fungicides) and their interaction.

Background and objectives

Vegetables and fruits are important sources of vitamins, minerals, trace elements etc. Yield and quality of raw products is determined by the availability of plant nutrients. The aim of the present research was to evaluate how the production methods affect marketable yield and content of vitamin C, total sugars and dry matter of carrots. The trials were carried out in 2010, 2011 and 2012 at Jõgeva Plant Breeding Institute.

Key results and discussion

By the results the marketable yield of carrot did not differ between organic and conventional variants in 2010 and 2012 probably due to the lack of damages caused by insects and diseases in these years. The yield data from 2011 are absent as seed sowing and germination period was dry resulting in uneven establishment of carrot plants. Therefore earlier studies (Warman and Havard 1996, Fjelkner–Modig et al. 2000) and also practice have shown that organic yield is usually lower than conventional.

Our results showed that no significant differences of the content of vitamin C in carrots were found between organic and conventional production in 2010 and 2011. Only in 2012 significantly higher vitamin C content were found in the organic treatment. Vitamins content of plants depends usually on a number of factors such as climate, genetic properties, fertilizer and soil (Mozafar 1994). According to Worthington (2001), organic crops (including carrot) contain significantly more vitamin C than conventional crops. However, several scientists (Warman and Havard 1996, Warman and Havard 1997, Fjelkner-Modig et al. 2000) could not verify significant differences in vitamin C content caused by different cultivation methods.

Conventionally and organically grown carrots did not differ in their total sugars content in 2011 and 2012. Only in 2010 significantly higher total sugars content were found in the organic treatment. According to the Polish scientists Rembialkowska and Hallmann (2007), organic carrots contained more total sugars than conventional ones. This contradicts an earlier study carried out at the Jõgeva Plant Breeding Institute that did not indicate any significant differences in content of total sugars between organically and conventionally grown carrots (Bender et al. 2008).

Dry matter content of organic carrots was significantly higher in 2010 and 2012. Our earlier study indicated no significant differences in DM content of carrots (Bender et al. 2008). According to other studies by Leszczynska (1996) and Fjelkner-Modig et al. (2000), organically grown crops (including carrot) had higher DM content compared with conventional ones.

It can be summarized that carrot yield and quality in organic trial was not significantly lower compared to conventional trial.

How work was carried out?

Data for this work were gathered from a 3-year trial. Materials and methods for the trial of carrots were described for carrots in Bender and Ingver (2012). The conventional treatment in this work was treated with 5 chemicals: two herbicides, two insecticides and one fungicide. Mineral fertilizer was applied to conventional plots and horse manure compost to organic plots at N 80 kg ha-1 (both trials).

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