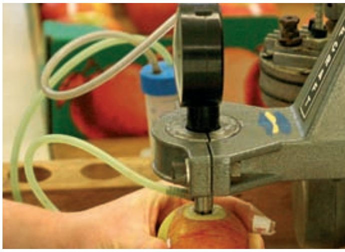
Improving Sustainability in Organic and Low Input Food Production Systems

Proceedings of the 3rd International Congress of the European Integrated Project Quality Low Input Food (QLIF)

March 20 – 23, 2007
University of Hohenheim, Germany





Edited by Urs Niggli, Carlo Leifert, Thomas Alföldi, Lorna Lück & Helga Willer

QualityLowInputFood

The Integrated Project QualityLowInputFood aims to improve quality, ensure safety and reduce cost along the organic and ‚low input' food supply chains through research, dissemination and training activities.

The project focuses on increasing value to both consumers and producers using a fork to farm approach.

The project was initiated on March 1, 2004 and is running for five years. It is funded by the European Union and has a total budget of 18 million Euros.

The research involves more than 30 research institutions, companies and universities throughout Europe and beyond.

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Errors may have occurred when compiling and formatting these proceedings. Should corrections become necessary, these will be published at the congress homepage at www.qlif-congress.org/proceedings.html.

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A printed version may be ordered from the FiBL shop at www.shop.fibl.org, order number 1455.

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Preface

These proceedings document the results of the congress 'Improving Sustainability in Organic and Low Input Food Production Systems' held March 20 – 23, 2007, organized by the Research Institute of Organic Agriculture FiBL in cooperation with the University of Hohenheim. This congress is the 3rd in a series convened as part of the EU-funded Integrated Project 'Quality Low Input Food' QLIF[1].

The 3rd QLIF congress was held in parallel with the 9th Scientific Conference on Organic Agriculture in the German-speaking countries, entitled 'Between Tradition and Globalisation', hosted by the University of Hohenheim near Stuttgart, Germany. We wish to express our gratitude to the organizers of that conference, and in particular to Professor Stefan Dabbert, for making it possible to hold the QLIF congress at the same venue.

Previous congresses took place in the UK in 2005 ('Organic Farming, Food Quality and Human Health') and in Denmark in 2006 ('Joint Organic Congress'). The next will be held in Modena, Italy, in conjunction with the Organic World Congress of the International Federation of Organic Agriculture Movements in June 2008.

Thanks are due to Thomas Alföldi and Helga Willer of FiBL Frick, Switzerland, for organizing the QLIF congress, to Sabine Zikeli of the University of Hohenheim for providing support and advice during the preparation of the event, to Natalie Kleine-Herzbruch of FiBL Germany for her technical support, and to Lorna Lück of the Nafferton Ecological Farming Group, Newcastle, UK, for being a constant source of advice on all matters related to the QLIF project.

We also wish to thank the European Commission and the Swiss State Secretariat for Education and Research for their financial support.

Thanks are further due to the International Society of Organic Agriculture Research ISOFAR for supporting the congress.

Last but not least we wish to thank all those who contributed papers to the congress and these proceedings and helped review the papers.

Urs Niggli and Carlo Leifert

Frick, Switzerland, and Newcastle, UK, March 2007

[1] QUALITYLOWINPUTFOOD, FP6-FOOD-CT-2003- 506358. For detailed information see the project homepage at www.qlif.org.

Plenary Session

Improving the quality and safety of organic and low input foods and maximizing the benefits to consumers and producers

Niggli, U.[1] and Leifert, C. [2]

Key words: Quality, safety, organic food chains, organic systems, low input

Abstract

'Improving quality and safety and reduction of cost in the European organic and 'low input' supply chains' (QLIF) is an Integrated Project under the 6th Framework Programme of the European Commission which started in March 2004 and will end in February 2009. After three years of research by 31 QLIF partners, the scientific data on on the benefits of the system approach used in organic and 'low input' agriculture has expanded considerably. At the same time the project has developed an array of technological innovations that are applicable to a wide range of food production systems and novel approaches for whole food chain management. During the 3rd QLIF Congress held at the University of Hohenheim, Germany, in March 2007, these results were discussed in nine synthesis papers and in 37 in-depth papers.[3]

Introduction

QLIF initially had 31 partners and included a further five partners via open calls after the project had started. The total budget is € 18 million of which the Commission contributes € 12.4 million. The duration of the project is five years.

The QLIF project aims to improve quality, ensure safety and reduce costs along the organic and 'low input' food supply chains through research, dissemination and training activities. It focuses on increasing value to both consumers and producers and on supporting the development of realistic business plans for all components of the food chain, using a farm to fork approach.

The main target is to facilitate measurable improvements in food quality and safety, but some potential impacts on human and animal health are also being explored (see figure 1).

The project has four main objectives:

- To identify consumer expectations, perceptions and actual buying behaviours in relation to organic and low input foods in order to enable such farming systems to be developed 'in tune' with consumer expectations, using a range of consumer survey and test marketing methodologies (7% of project effort).
- To quantify the impact of current organic and 'low input' management practices on the nutritional, sensory, microbiological and toxicological quality/safety of foods, using multi-factorial field trials and food analytical & nutritional experiments/surveys (30% of effort).
- To develop novel strategies/technologies which improve quality, ensure safety and reduce production cost throughout the organic and 'low input' food supply chains. This is achieved by a combination of laboratory and field research, including 'farmer participatory' approaches and facilitated through the

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[3] A full list of all papers of the QLIF project presented at this congress is provided at the end of these proceedings.

involvement of ten industry partners (six small and medium-sized enterprises) representing primary production, processing, marketing, services and quality assurance businesses (55% of effort).

- To identity socio-economic, environmental and sustainability impacts of project innovations, efficiently disseminate project results and provide training opportunities to user and stakeholder groups as well as junior scientists (8% of effort).

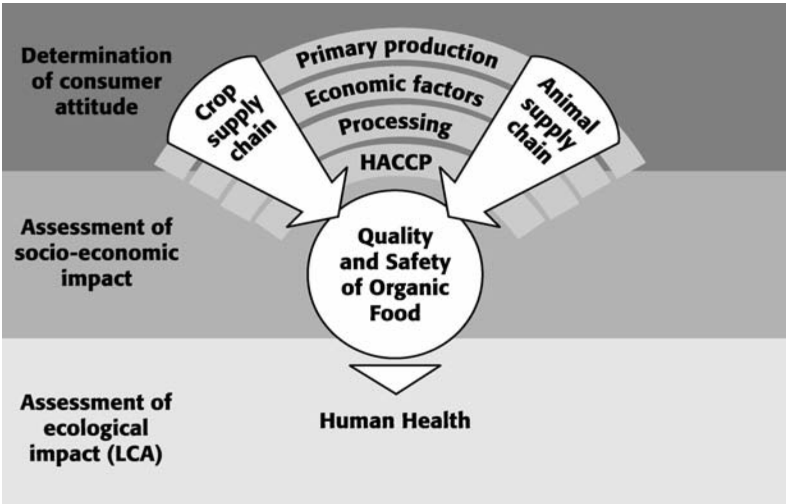

Figure 1: The food chain and the system approach of the QLIF project.

The project pursues a whole food chain approach where findings and in many cases concrete deliverables are taken up from one investigation (= work package) to the other. The project also seeks to involve scientists in interdisciplinary research work and to enable them to understand 'in depth' methodological approaches and results from other disciplines. QLIF focuses on both organic production systems and on 'low input' crop and livestock systems which are characterized by reduced use of fertilizers, crop protectants, veterinary medicine, growth promoters/regulators and food additives and animal welfare focused livestock husbandry systems (e.g. 'free range' systems). While addressing many research questions and technological bottlenecks relevant to organic food, it is recognized that not all requirements of organic farming can be met within the scope of this project.

Consumer perceptions and buying attitudes (subproject 1)

The available local and national consumer studies were critically re-evaluated in order to gain a clearer picture of the expectations of European consumers and their buying attitudes. It was found that organic markets are segmented into a smaller group of regular buyers and a large group of consumers who occasionally buy organic food. Whilst the first group is relatively stable, further growth of consumption is thought to depend on increasing the numbers and 'dedication' of occasional consumers. Focus groups and in-depth interviews showed that for the occasional consumers, organic and 'low input' alternatives ('free range', 'local' and even 'integrated production') are market substitutes. Therefore, more information on factors affecting product loyalty and the drivers behind consumer decision making (e.g. why ‘low input’ or organic products are chosen) are needed and will be provided in years four and five of the QLIF project. Methods used will include ethnographic observation, cross-European household panels and choice experiments.

For a more detailed description of the work carried out under subproject 1 see Zanoli *et al.*, 2007.

Nutritional quality and safety of organic and low input food and effects on livestock and human health (subproject 2)

Intuitively, consumers expect organic food (and also ‘low input’ alternatives/substitutes) to have a higher nutritional value, to be healthier, or simply to be safer or less risky. The effects of organic and ‘low input’ production methods on food quality and safety and finally on livestock and human health are therefore scrutinized in experiments under subproject 2. Wheat, potato, cabbage, onion and lettuce were chosen as model crops, complemented by some work on feed crops and dairy production as the main livestock model. It was shown that high input (conventional) crops have higher levels of protein and vitamin E (wheat), carotenoids (potato, cabbage, lettuce) and alkaloids (potato) whereas organically grown crops tend to have more phytic acid (wheat), volatile metabolites (potato), phenolic compounds (potato, cabbage), glucosinolates and vitamin C (cabbage). Not well designed ‘low input’ methods in wheat production, which omitted either pesticides or mineral fertilizers, resulted in the highest levels of undesirable compounds (e.g. mycotoxin loads). However, work in the first three years also showed that the relative impact of adopting organic and low input production methods on food quality and safety may change over time (e.g. because of long-term effects on soil characteristics and/or changes in plant and animal varieties/breeds used).

An extensive milk quality survey of different dairy production systems in Denmark, Sweden, the United Kingdom and Italy demonstrated that milk from organic and low input, grazing-based dairy systems has significantly higher levels of the nutritionally desirable unsaturated fatty acids (the omega-3 fatty acids, vaccenic acid and conjugated linolenic acid) compared to milk from conventional production methods. Similar results were obtained with fat soluble antioxidants like α-tocopherol, β-carotene, lutein and zeaxanthine where organic and other grazing-based production systems were better than conventional ones.

In order to assess potential risks of organic and outdoor livestock management, the pathogen shedding of pigs was studied. Results indicate that, compared to pigs reared indoors, pigs reared in organic and other outdoor systems are more likely to come into contact with *Salmonella* and to develop immunity, resulting in pathogen shedding being reduced both on the farm and at slaughter.

Still not very conclusive are the results of two work packages which investigate the effects of organic, low input and conventional feeds on animal health status. One study showed no significant effect of chloro-choline chloride (CCC) on pig reproductive health. According to the second study organic wheat and vegetables seem to improve the immunological status of rats, but many interactions between the sex and the age of the animals occurred.

For a more detailed description of work under subproject 2 see Leifert *et al.*, 2007.

How can different crop strategies improve the quality and safety of food? (subproject 3)

The potential of organic and 'low input' methods for high quality, high safety and economically viable crops is far from fully exploited. Consequently, crop strategies are being scrutinized, namely interactions between soil fertility and plant health, nutrient release characteristics and nutrient uptake in organically managed soils, organic manuring and food safety as well as pest and disease control. In organic systems (and to a lesser extent in 'low input' systems), soil fertility management and its effect on plant health and eventually on yield, quality and food-borne pathogens are major issues to be addressed by research. The long-term use of organic matter based fertility inputs was shown to significantly increase the efficiency of organic production (input/output ratio) and also to suppress both seed-borne and foliar diseases.

In order to analyse the wide range of interactions responsible for such effects and to enable farmers to make the best use of them, long-term field experiments are crucial. Several work packages of both subproject 2 and 3 use long-term experiments in various parts of Europe, to facilitate the development of improved nutrient models and precision farming systems. As a main result it can be concluded that the potential of manure and compost based systems for improving crop yields and crop quality is still high. Wheat as a model crop showed the potential of fertility management improvements in order to increase both yields and quality. Field trials in the UK in 2005 demonstrated how improved fertility management increased yields of winter wheat by 6 to 33% (depending on the cultivar) and in summer wheat by (-4) up to 14%. Novel wheat varieties selected especially for 'low input' conditions produced protein contents between 11 and 12%, while the reference cultivar remained at 9.2%.

On the other hand, soil fertility is only one factor affecting disease suppression, as many interactions with other agronomic factors and soil properties occur. These will be analysed in the second half of QLIF.

The use of manure in organic farming systems – while having significant benefits for soil structural stability, biological activity and overall fertility – has also been criticized because it may increase the risk of transfer of enteric pathogens into the food chain. These aspects were addressed by several field experiments. Enteric pathogens were found in lettuce at extremely low levels and independently of whether organic manure or mineral fertilizers were used. The most efficient way to reduce pathogen loads was shown to be the composting of manure.

Crop protection in organic and 'low input' systems has remained a bottleneck and affects both the cost of these production systems and the quality (and safety) of food products. The integrated use of preventative protection strategies (rotation design, fertility management, environmental diversification) are the basis of weed, pest and disease control in low input crop production. Such strategies minimize the need for crop protection products. In the QLIF project wheat, tomato, onion and apples were chosen as model crops to develop **(a)** a wide range of novel preventative crop protection techniques and approaches and **(b)** integrate preventative techniques with crop protection methods based on more benign forms of intervention (companion plants, biological control agents, elicitors and plant extract based products). Results so far are extremely promising and substantial progress can be expected when transferred into practice.

For a more detailed description of work under subproject 3 see Tamm *et al.*, 2007.

How can different livestock strategies improve the quality and safety of food? (subproject 4)

The livestock work packages of the QLIF project focus on the development of improved strategies for **(a)** the control of endo- and ectoparasites as well as bacterial zoonoses in pigs and poultry, **(b)** maintaining udder health and reducing enteric pathogen shedding in dairy cows and **(c)** improving feeding regimes for poultry and pig production systems and **(d)** health status of pigs. In these trials, both product quality and food safety are addressed.

The experiments with different layouts of hen runs showed that the prevalence of endoparasites (e.g. *Heterakis* and *Ascaridia*) is strongly influenced by the size of the run and the density of hens. Unfortunately, what has been defined so far as an 'ideal' run is not good enough, as only a very low hen density could reduce the average faecal egg counts.

Bioactive compounds in fodder plants, such as inulin (in dried chicory roots) appear to be very effective against nodular worm of pigs but not against roundworms. In contrast, no reduction of endoparasites could be observed in poultry fed with anthelminthic plant products. Positive results were obtained by diatomaceous earth (86% silica, 5% sodium, 3% magnesium and 2% iron) on poultry ectoparasites, an effect which was equal to natural acaricides.

In co-operation with farmer groups, mastitis prevention strategies were developed on dairy farms. As the knowledge of the farmers on preventive management measures and on non-antibiotic therapies is generally low, the co-operation between farmers and veterinarians led to a considerable improvement of udder health status. Some farmers were able to reduce the use of antibiotics to zero and in parallel to improve milk quality, including somatic cell count. In addition, a novel teat sealant was successfully tested and recommendations were made for sealants, homeopathic treatments and targeted antibiosis. A successful case study comparing three calf rearing methods showed that suckling methods did not have a negative effect on milk quality (somatic cell counts). This is important evidence as mother cows and calves are more robust and less disease susceptible if they are allowed a longer and more natural suckling period.

Feeding experiments with pigs showed that supplementation of feed with synthetic amino acids can be replaced by use of home-grown grain legumes. Although the pig performance suffered, the intramuscular fat content (IMF) increased, resulting in a better meat quality and economic performance was therefore not affected negatively. In an on-farm study in Germany and Austria, experimental groups of pigs were fed during the fattening period with high proportions of grain legumes (36 and 40% respectively) in order to verify the on-station results. The grain legumes consisted of lupines, faba beans and peas. Although results are impressive so far, more knowledge on the digestibility of protein, amino acids and energy in organically grown protein crops is urgently needed.

Feed supplementation with probiotic bacteria (Lactic Acids Bacteria, LAB) can significantly decrease the risk of gastrointestinal infections and diarrhoea caused by enteric bacterial pathogens. In the QLIF project, we investigated the synergistic effect of adding oligosaccharides and lactose containing whey. These 'nutribiotics' were tested after weaning and for piglets challenged with Salmonella. Although some effects on growth performance were significant, initial culture based tests indicate that Salmonella populations were not reduced. In a next stage, the probiotics will be tested on growing-finishing pigs and more sensitive molecular tests are being employed to test the impact of treatments on microbial diversity and Salmonella populations in the upper intestine of pigs.

For a more detailed description of the work carried out under subproject 4 see Spoolder *et al.*, 2007.

Improving food quality and safety by 'low input' food processing methods (subproject 5)

The processing of food also affects food quality and safety. In a Delphi study European experts welcome the development of clear principles and criteria for the evaluation of additives and processing methods. 'Careful processing', 'minimal use of additives' and 'authenticity of food' seem best to describe principles for a future regulation of processing. In order to implement such principles, a code of practice is needed. It will provide clear guidance for operators on company level. Nonetheless, reconciling the three main trends (authenticity of food, added value with regard to health and ethical issues, and convenience) in consumer wishes with respect to food will remain a challenge, in particular for the organic food industry. Two main topics of processing are addressed in the project by experimental work: The first is the treatment of ready-to-eat lettuce where the conventional treatment with chlorine is replaced by careful and natural disinfection methods (e.g. ozone). This was shown to be successful but has so far only been done on a laboratory scale. In the last phase of the project, these small scale procedures have to be tested on industry scale. A second experimental study was carried out on fermentation processes of dairy products enhancing CLA content (e.g. butter).

Improving food quality and safety by HACCP and reducing costs of the organic food chain (subproject 6)

HACCP protocols and manuals for six commodities (wheat, field vegetables, apples, milk, eggs, pork meat) are being developed within the QLIF project. These HACCP based quality assurance systems address both **(a)** minimizing food safety and quality hazards and **(b)** ensuring maximum desirable quality characteristics demanded by the market. The focus on ensuring 'added value' quality characteristics (in particular nutritional composition) is a major difference to conventional HACCP systems, but essential for consumer confidence in organic standards. In some cases, organic production and processing standards are quite complex and demanding, and open to error. Such complex situations (e.g. with different conversion periods in animal and crop production and different rules for annual and perennial crops) are best addressed by the establishment of a detailed customized HACCP system (see Knight and Stanley, 2007).

The goal to analyse the economic performance of different food chains on a European scale was ambitious. Case studies have been performed with wheat, tomatoes, apples, milk, pork and eggs. In a first round of semi-structured interviews with enterprise managers (SWOT analysis) economic problems of the food chains were analysed. Weak points of European organic food supply chains were high logistic and transport cost, high input costs and low expenditure on research and product development. As the organic food market is a niche (1% of the total EU market), there is on the individual company level no benefit from economies of scale. A key strategy for companies in order to reduce costs would therefore be improved co-operation (see Stolze *et al.*, 2007).

Assessment of the ecological impact of novel strategies and technologies in organic food systems and outreach of the QLIF project (subproject 7)

Organic farming reduces many of the environmental and ecological problems caused by intensive conventional farming such as pollution, loss of biodiversity, soil erosion etc. However, there are also critical points in the way that organic farming is practised. As a result it is important that new strategies and novel technologies that allow environmental impacts to be reduced further are introduced into organic and low input farming systems, through projects such as QLIF or other national and international research activities. In a first approach, subproject 7 addresses nitrate leaching depending on changes and optimization of crop rotations. Additional simulations will also be done with other factors (e.g. energy use) to provide an overall ecological and environment impact assessment of innovations developed under QLIF. The goal of these investigations is to improve the overall sustainability of organic production strategies on both crop and livestock level (see Thorup-Kristensen, 2007).

Dissemination of results gained through basic and applied research activities is a crucial effort of the QLIF project. In addition to many well known tools for outreach such as peer reviewed papers, publication in farmers' journals and magazines, all QLIF project outputs are made available at the Organic Eprints online archive at http://www.orgprints.org/, the most frequently visited Internet site for organic stakeholders. QLIF results have also recently been published in a '*Handbook of organic food quality and safety'* for producers, processors and scientists (Cooper *et al.* 2007).

Outreach activities include farmer workshops and visits to field trials, and QLIF training programmes for Master and PhD students as well as for junior scientists in cutting-edge organic food and farming research. These international training and exchange courses offer 'state of the art' knowledge on interdisciplinary and trans-disciplinary research approaches used in agricultural, landscape and environmental science and build a bridge for young scientists to poly-factorial and multi-level problems in practical science (see van der Burgt and Wagenaar, 2007).

Closing remark

The first three years of the QLIF project have clearly demonstrated the significant advantages of using a large 'integrated project' approach for the development of an industry (low input and organic farming, processing and retailing) that relies on the integration of both **(a)** a wide range of production system components and **(b)** multidisciplinary teams from across Europe to achieve its food quality, safety and production efficiency targets. QLIF has clearly already contributed significantly to achieving its specific research & development and wider integration objectives. It has also identified a range of issues (most importantly to select and breed crop varieties and animal breeds that are better adapted to organic and low input systems) that need to be addressed in future integrated research & development programmes.

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Determining consumer expectations and attitudes towards organic/low input food quality and safety

Determining consumer expectations, attitudes and buying behaviour towards 'low input' and organic foods

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Key words: consumer expectations; attitudes; organic food; food quality; food safety.

Abstract

This paper reviews the first results and achievements of the QLIF subproject 1 (SP 1) 'Determining consumer expectations and attitudes towards organic/low input food quality and safety'. The paper aims to illustrate the array of methodologies used and to discuss the ongoing research in light of the first results.

Introduction

The QualityLowInputFood (QLIF) integrated project aims to improve quality, ensure safety and reduce cost along the European organic and 'low input' food supply chains through research, dissemination and training activities. It focuses on increasing value to both consumers and producers and on supporting all components of the food chain, using a fork to farm approach. To achieve the overall aim the project has, as first of four objectives:

Objective 1: To improve the match between producer aims and consumer expectations regarding quality and nutritional value of organic and other 'low input' food.

The QLIF Subproject 1 (SP 1) specifically aims to:

- explore and determine consumer perceptions, expectations and attitudes about quality and safety of organic and low input foods (WP 1.1);
- explore and determine actual & potential evolution of consumer buying behaviour (WP 1.2).

The multiplicity of methodological approaches employed in this subproject has the objective of providing an element of 'triangulation' in social science research, in which the outcomes from one approach can be validated by those of another. In addition, each of the approaches focuses on particular elements of consumer behaviour. The methodological debate entailed by the application of these various methods in a cross-cultural context is itself one output of this subproject.

Both qualitative and quantitative approaches are being used. A review and re-analysis (WP 1.1.1) of existing consumer studies/data was undertaken with a view to quantifying and explaining differences and similarities between EU countries with respect to consumers expectations and attitudes concerning the quality and safety of organic foods and their likely conventional alternatives (hereafter referred to -as 'low-input conventional foods' or 'low input foods'). Consumer expectations and perceptions regarding organic and other low-input products' characteristics were

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explored by means of focus groups (WP 1.1.2). Consumer attitude measurement is being achieved by surveying a large sample of consumers in several European countries (WP 1.1.4), by means of a specially designed cross-cultural questionnaire (WP 1.1.3). The reported buying behaviour of organic consumers, and its evolution, relative to knowledge, awareness and changing attitudes, is being explored by in-depth interviews and direct ethnographic observation ('consumer biographies & narratives'), supplemented by a quantitative analysis of household panel data (WP 1.2.2). The understanding of consumer attitudes and reported behaviour will be complemented by consumer choice experiments (WP 1.2.1), in which buying behaviour is observed in the presence of alternative price/attribute packages. Finally, the implications for future demand for organic foods will be sketched by integrating all of these approaches into alternative scenarios, attempting to make sense of the results obtained in this subproject (work package 1.2.3).

Materials and methods

The review and reanalysis of existing consumer studies and data indicated that prior to the EU research project 'OMIaRD', (within which work package 4 dealt specifically with a Pan-European analysis of the organic consumer), most consumer research in the organic sector relied almost exclusively on self-reporting of attitudes and buying behaviour drawn from quantitative surveys. Observation of consumer behaviour at the retail level was almost nonexistent in the literature or, if commissioned by supermarkets or other multiple retailers, results had not been made generally available. In addition, although numerous consumer studies had been undertaken across Europe, there was limited pan-European research in the field, and it was difficult to generalise findings from individual countries. The application of different research methodologies according to different target groups, food products or market segments, together with variations in the national or regional scope of studies, meant that wide-ranging, in-depth coverage of consumer perceptions and motivations, or knowledge of issues concerning the consumption of organic foods across Europe, did not exist. Furthermore, since for the most part emphasis had been on quantitative research methods, there was limited qualitative empirical investigation of organic consumers. On the other hand, the OMIaRD project focused only on in-depth qualitative analyses (focus groups and laddering) of the organic consumer across eight European countries (AT, CH, DE, DK, FI, FR, IT, UK).

Both focus groups and laddering data were specifically reanalysed for the QLIF project, aiming at highlighting quality and safety issues regarding consumer perceptions of organic food. Furthermore, the findings were compared with the results from the Danish DARCOF study based on consumer panel datasets regarding household expenditures (in DK and UK), supplemented by qualitative data provided by consumer panel members. Finally, based on these reanalyses and reviews, issues for discussion and further investigation were raised, highlighting differences in consumer perceptions and attitudes to the quality and safety of organic food.

Based on this comprehensive literature review and reanalysis of recently completed project data, WP 1.1.2 established four focus groups (FG) in each of five countries (France, Germany, Switzerland, Italy and the United Kingdom), concentrating on four products (bread, yoghurt, tomatoes, and eggs; two products selected for each FG). These products were chosen to reflect both processed and non-processed, and animal and vegetable origin. The focus was on occasional, 'uninvolved' consumers of organic products, which are compared with substitutes in the eyes of the consumers (conventional, integrated products, local products, etc.)

The FG results highlighted major differences in attitudes, beliefs and understanding between consumers in the five countries. This had been anticipated and a major objective of the survey (WP.1.1.4) was to identify similarities and differences between consumer perceptions and attitudes towards organic and low input products in the different countries surveyed. What was less expected was the degree to which consumer perceptions and concerns relating to organic agriculture could be so product specific. With so much product-specific information now available from WP 1.1.2, it was therefore decided to select the same four products in the survey, and to design the questionnaire in such a way that each respondent would complete a questionnaire relating to only one of the four products - including a number of product-specific questions. These related mainly to quality and safety characteristics of the products at issue. For example, when asked to say how important each of a list of attributes were as indicators of the quality of the product, following a number of attributes common to all four products, product specific attributes were added:

- For bread: made from wholegrain, no genetically modified ingredients, texture, smell, made with natural yeast;
- For eggs: quality of poultry feed, produced with freedom to move, outdoor production, size of egg, colour of yoke, colour of shell;
- For yoghurt: fat content, packaging, fruit content;
- For tomatoes: in season, not artificially ripened, not produced under glass, pre-packed; country of origin, the variety, not genetically modified.

A similar approach was adopted in the case of questions concerning food safety concerns. Most of the factors which people were asked to assess in relation to possible health risks needed to be product specific. For example, for yoghurt, the list was: Fat content, sugar content, standard of hygiene in milk production, use of hormones in milk production, unnecessary use of veterinary medicines, use of additives, genetically modified ingredients. Questionnaire design was the objective of WP 1.1.3.

The responsibility of administering the survey was given, by an official EU tender, to ORC International (for CH, DE, FR, IT, and the UK), while a separate sub-contract was made with MAICH to administer the survey in Greece, a non-partner country. In addition, and consistent with the stated aim of the QLIF project to seek collaborative research opportunities outside the boundaries of the IP itself, agreement was reached with a Turkish academic institution for the questionnaire to be also administered in Turkey. The questionnaires are administered by CATI; at the time of writing, data collection for the UK and Greece is completed and completion for the remaining counties is expected within the next few weeks. Data analysis will commence soon.

The reported buying behaviour of organic consumers and its dynamics is currently being investigated by combining a comparative analysis of qualitative interview data collected in Denmark, Great Britain and Italy with a quantitative analysis of household panel data regarding actual household purchases on these 3 markets. The objective of the quantitative analysis is to delineate the chronology of typical purchasing patterns in specific household types over a 3-5 year period with respect to product categories and product groups. The qualitative methods employed include interviews and *participant observation*. By immersing him- or herself in the subject being studied, the researcher is presumed to gain understanding, perhaps more deeply than could be obtained, for example, by questionnaire methods. This method relies on first-hand information, and on relatively simple and inexpensive methods, resulting in high face validity of data. The downside of participant observation as a data-gathering technique is increased threat to the objectivity of the researcher, unsystematic gathering of data, reliance on subjective measurement, and possible observer effects (observation may distort the observed behaviour). As a result, a broad range of ethnographic data are currently being collected in each country in the form of detailed case studies of 18 principal subjects with varying degrees of commitment to purchasing organic food products and focusing on *oral narratives*, which feature *biographical accounts and trajectories* detailing important events that have influenced decisions regarding food purchases and food consumption in the household, supplemented by direct observation of a shopping trip and oral interviews with shopkeepers and family members of the principal interviewee.

The methodologies underpinning WP 1.1.3 and WP 1.2.1 are discussed in separate papers at this conference; and that for 1.2.2 explored further later in this paper.

Results

One prominent issue emerging from our review and reanalysis of consumer attitudes towards quality and safety of organic food is the fact that they are complex, unstable, and embedded in a wide range of issues linking food to health, environment, ethics and identity. The meanings of 'natural', 'pure', 'traditional' and 'authentic' for consumers and food specialists need to be examined carefully and reassessed, particularly with regard to technical development and policy innovation. Organic products serve a wide range of functions, and consumer expectations of them are high, although not always in a conventional sense (for example, they may be suspicious of flawless presentation of products, but they do want taste intensity, and reassurance about production, processing and distribution systems).

Another major theme concerns the segmentation of organic consumers into two main types: regular and occasional, or heavy, medium, light and non-users. There is some ambiguity about the implications of this issue, as well. Core organic consumers have commitment to the extent that organic products represent the quality and safety characteristics that they seek. They have also integrated social concern for the environment (and sometimes even broader ethical issues) into their purchasing behaviour, and appear to display, at least to a degree, missionary zeal in wishing to extend organic consumption, and hence organic production, and its presumed environmental benefits. Other (occasional or 'new') organic consumers appear to be more price- and convenience-sensitive, but it is not (yet) known or explored if their attitudes would change if their commitment to organic food were to increase. To some extent, therefore, organic market development may rely on achieving scale economies in distribution and greater levels of processing, and expanding into the large retailers' shelves (Midmore *et al.* 2005).

These insights gave strong anchors (taste, freshness, appearance, healthiness and purity, environmental concerns) for development of protocols for further, more detailed examination of quality and safety issues in the new round of focus groups in WP 1.1.2.

As mentioned earlier, one of the major findings of these focus groups was that many consumer-relevant attributes are very product specific, even for organic products.

For fresh or lightly processed products, organic is seen as a guarantee of the naturalness and 'pureness' of the food. Organic is associated with freshness and a minimal level of processing. Organic is thus linked to short distribution channels, on-farm production, and self-production. Indeed, for some consumers, organic can be a synonymous with any product purchased locally or through short distribution channels (Sylvander and François 2006).

For processed products, organic is associated with some assurance of food safety if compared with conventional products, when 'industrial' food processing is suspected. Consumer product knowledge in general appears quite low, with differences among countries; the level of information is particularly low with respect to farming and processing techniques. Not all (organic) consumers are active information seekers, since many think it is too time-consuming and tiring to keep up-to-date with respect to products they purchase on a regular basis (Sylvander and François 2006). Food products are generally thought of as being low involvement products, which are routinely purchased with little or no information seeking (Peter *et al.* 1999).

Issues highlighted to be further explored in the survey were the 'overuse' of additives, the preference for 'natural', the links between organic and other concepts, such as 'local' ' free range' 'home-grown' 'fair-trade'; organic versus 'industrial' production; the relevance of ethical considerations in production; the fact that organic is not well understood and the need therefore to research the components of organic products separately.

Currently, results from the survey are not yet available, although WP 1.1.3 allowed the development of a common survey instrument for administration in different countries enabling legitimate inter-country comparisons to be made – which has been difficult in the past on the basis of differently designed national studies.

Consumer narratives and biographies are in the phase of being collected by means of participant observation. No empirical results are therefore available yet. However, a significant result is the conceptual framework and the protocol of the qualitative study itself. Our approach to the planning of data collection and analysis is inspired by some theoretical contributions regarding the cognitive processes that underlie changes of mind, the character of substitution strategies in the context of everyday shopping, and the character of product loyalty (Zanoli and Naspetti 2006 a & b; O'Doherty Jensen 2006).

Changes of mind

Taking into consideration individuals' cognitive/reasoning processes, and assuming that cons umption of organic food involves (or possibly has involved at some time in the past) changing one's own mind about food experiences and food habits, we have been inspired by the work of Gardner (2004) on this topic, with particular reference to the following two points.

1) According to Gardner, when someone undergoes a change of mind (or attempts to change the mind of another person) the process of persuasion usually involves concepts, stories, theories, and skills. We will try to identify the concepts, stories and theories mentioned by respondents in their discourses about organic food. Consumer reasoning can be studied with reference to these elements with a view to obtaining a deeper knowledge and understanding of consumer discourses.

1a) The *concept* is the basic unit. Concepts are stored terms easily remembered. Terms, such as 'food' or 'meal' are relatively clear and familiar ideas around which related facts are linked. People usually understand what these concepts mean, but due to the fuzzy limits of such concepts individuals may have different perceptions of the domain to which the term refers, especially in the case of more abstract terms such as 'democracy', 'pride', etc. In all likelihood, the term 'organic' is a fuzzy concept for many consumers.

1 a) Story or narrative describes events that occur during time. There has to be a protagonist. There have to be goals. There have to be obstacles people can identify with. There has to be an ultimate resolution—hopefully a positive one. A story is not the same as a message or a vision or a slogan. It's a more encompassing, realistic, enveloping thing.

1b) Theories are formal explanations of worldwide phenomena. They are capable of predicting future occurrences or observations of the same kind, and capable of being tested by experiment or otherwise falsified through empirical observation, but they can also change over time due to new knowledge. Individuals can observe an apple falling on earth. Adults usually know that apples fall towards the centre of the planet, and the theory that explains why they do so is the current theory of gravitation. Children learn these theories later, although they can sometimes observe the phenomena to which they refer at an earlier stage.

1c) Skills The cognitive aspects of 'skills' are usually attained in practice and tend to remain implicit, rather than being conceptualized, articulated in words or related to explicit processes of reasoning. It is therefore difficult to obtain data on skills by means of posing questions. However, some skills are particularly relevant in the present context. These are skills related to the choice and uses of food products in the household. Cooking skills have special relevance insofar as the choice of relatively less processed products may be heavily dependent upon the resources of skill, as well as those of time and/or money, available in a given household. Organic, as compared to conventional products, have largely been available in relatively unprocessed forms. Particular attention will therefore be given to discourses regarding the level of interest in and involvement with the tasks of food preparation in given households, whether these constitute a reason for or a barrier against the choice of organic foods.

2) Gardner identifies 'seven levers' that may influence a mind change: research (relevant data), resonance (the affective component), re-descriptions (mutually reinforcing images of what will result from the change), resources and rewards (perceived cost-benefit relationship), real world events (wars, hurricanes, terrorist attacks, depressions, etc.), and resistances (motivation stimulated by opposition). He also asserts that over time, people become more resistant to change. Set in their ways, determined to protect their 'comfort' and 'custom'.

Product substitution

The following consumer strategies have been identified as responses to a situation in which a given sought after product proves to be unavailable while shopping. The examples given here refer to a situation in which a particular organic product proves to be unavailable.

- Close Substitution: the decision taken is to substitute the missing organic product with a different organic product in the same shop.
- Treason: the decision taken is to substitute the missing organic product with a similar but conventional (or integrated, low-calories, etc.) product.
- Re-try: the decision taken is to come back to same shop in the near future to search for the product.
- Re-locate: the decision taken is to look for the missing organic product in a different shop.
- Surrender: the decision taken is to simply abandon the attempt to find this product without deciding to look for it in the near future.
- These strategies will inform our data collection and analysis of substitution as a factor underlying the character of relatively stable or fluctuating demand for organic products.

Loyalty

According to Dick and Basu (1994), product loyalty on the part of consumers is characterised by repeated patronage with regard to a particular product/brand/label and by the relative attitude towards that product, antecedents of a given attitude comprising cognitive, affective and conative elements.

- Three consequences of customer loyalty have been identified. These are:
- How likely it is that a given customer will search for alternatives

- How resistant the customer is to counter-persuasion (presented by competing, substitute products)
- How likely the customer is to tell others about the preferred product (word-of-mouth recommendation).

These perspectives will likewise inform our data collection and analysis of loyalty as a factor underlying the character of relatively stable or fluctuating demand for organic products. In particular, we will seek to understand the ways in which relative levels of loyalty are constituted over time for different consumers and to identify the factors that influence this process.

Discussion

So far, the only available results which suggest issues of wider significance for the QLIF project as a whole are those derived from WP 1.1.1 and WP 1.1.2.

Firstly, for arable and livestock experimental work, it is important to take improved experiential qualities into account, whilst at the same time recognising that uniformity and high levels of processing and packaging are regarded by consumers of organic products with a significant degree of suspicion (Midmore *et al.*, 2005). At the same time, as the FG results have highlighted, ‘consumers’ knowledge of agriculture, food technology and processing seems to be weak, with differences between countries’ (Sylvander and François, 2006)

There is also merit in trying to orient technical developments so that they can be disseminated to small producers supplying local niche markets, for the impact on rural development that might ensue, but also in terms of gaining consumer trust, shortening distribution chains, and providing generalised environmental benefits in terms of decreased pollution. Issues raised here can be tested in the consumer experiments, which will be conducted later on in the QLIF project.

As far as food safety issues are concerned, standards and certification seem to fall short in terms of consumer reassurance, at least for the uncommitted group. Clearly, there is a need to develop certain aspects of the food chain to meet general food safety regulations and best practice within an organic standards framework. The life sciences components of QLIF will need to interact with the standards bodies so as to inform the development of their certifying frameworks, and also to work in ways that make communication of assurance about the imbued standards to anxious and mistrustful consumers easier, and more effective. There is even merit in the further exploration of these issues in future research, e.g. FP7.

Conclusions

Although the subproject core tasks are still in the data collection phase, we can attempt to draw some conclusions in the context of the overall QLIF aims.

Firstly, in terms of benefits and values sought by the consumer, organic food can be considered a category and be positioned consistently on the (European) market; country differences exist, but the common elements prevail at the benefit and value level (Zanoli 2004) and – to a certain extent – these remain across products too.

Country differences are more marked at the level of product characteristics, which – as was evidenced by the focus groups – are very product specific even at the abstract attributes level. Expectations regarding bread are obviously different between different cultures and countries, and of course what you expect and perceive to be relevant when purchasing bread is not the same that you expect and perceive to be relevant when you buy yoghurt or eggs or tomatoes. But these product-specific differences are even more marked when speaking of organic products; for example, while the issue of GMO is mentioned as an unsought product characteristic for bread and tomatoes and, indirectly, for eggs (since consumers care about the poultry feed), they seem to be of no concern for the consumption of organic yoghurt.

The attribute level is the most relevant for product policy, and needs to be carefully explored when designing 'new' products – both raw and processed – and new services – e.g. inspection and certification – regarding organic supply-chains. The results of the survey and of the consumer choice experiment could bring new insight on the ranking of quality attributes in relation to their degree of importance in influencing purchase decisions.

Finally, since organic and 'low input' alternatives are *de facto* market substitutes, the insight into *product loyalty* and the dynamics of *changes of mind* which will be gathered by the consumer narratives & biographies will further enhance our comprehension of what *really matters* when consumers choose to purchase and consume organic or alternative food. This means, in line with the overall QLIF aims, that we will be able to better identify the 'triggers' enabling organic and 'low input' farming systems to be developed 'in tune' with consumer expectations.

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Organic consumption in three European countries

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Key words: organic, consumption, panel data, socio-demographic

Abstract

The present paper describes the consumption of organic foods in Denmark, Italy, and the United Kingdom. The study is based on an extensive set of household purchase panel data for each country. The data indicate that the consumption level in Denmark is substantially higher than in both Italy and in the United Kingdom. Furthermore differences between various socio-demographic groups are investigated. Some of these differences can be identified in all three countries.

Introduction

With respect to consumption of organic foods, Denmark (DK), Italy (IT), and the United Kingdom (UK) represent three markets at very different stages. In DK, the organic market is mature and well functioning. Part of this success can be explained by the existence of a widely recognised, official organic label and by the fact that many organic food products are sold in supermarkets at relatively low price premiums. In IT, the level of organic production is high, but the majority of these products are exported and the level of domestic consumption is rather low. The structure of the Italian organic market distinguishes itself from the Danish by the fact that the main part of the market transactions takes place at local markets, where trust in the farmer functions as a guarantee rather than a state-controlled labelling scheme. In the UK, the demand for organics is increasing very rapidly. The distribution structure in the UK is similar to the Danish in that products are mainly sold through supermarkets. However, the organic market in the UK has not yet reached the level of maturity that characterises the Danish market (*cf.* Torjusen *et al.* 2004). The analyses are based on purchase data recorded by a panel of households in each country. Differences in the volume of organic consumption that are not registered in the data are not accounted for.

Following a brief presentation of the data, consumers are divided into four user groups according to the share of the budget they spend on organics. Hereafter differences and similarities of purchasing patterns are related to socio-demographic characteristics of the user groups. Finally, the conclusion and discussion summarizes the main results and presents some ideas for future analyses.

Materials and methods

The description of organic consumption is based on purchase data for eggs, fruits, milk, vegetables, and yoghurt from DK, IT, and the UK. The panel in DK comprises 1,325 active (reporting at least once a year) households and spans the period 2001-2004. The Italian panel has 5,172 active members from mid-2003 - mid-2006, while the UK panel has 8,096 active households from mid-2001- mid-2003 and 2005 – 2006 (data for mid-2003 – 2005 are not available). Table 1 summarizes the data.

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Tab. 1: Description of data

Country	Food types	Years	Number of households
Denmark	Eggs, Fruits, Milk, Vegetables, Yoghurt	2001-2004	1,325
Italy		Mid-2003-2006	5,172
United Kingdom		Mid-2001-2003 and 2005-2006	8,096

Results

The food budget in the following is defined as the amount of money used to purchase organic varieties within the five available product categories. Figure 1 illustrates the average budget share in the three countries. Danish consumers spend on average 10% of their food budget on organic varieties. The exact share seems to be dependent on seasonal variations, but no consistent pattern of development over time can be observed. The share of the budget that Italian consumers use to purchase (certified) organic items, is approximately 2%, and is also rather stable during the period observed. The budget share for consumers in the UK has on the other hand increased from 2.5% in 2001 to 4% in 2006.

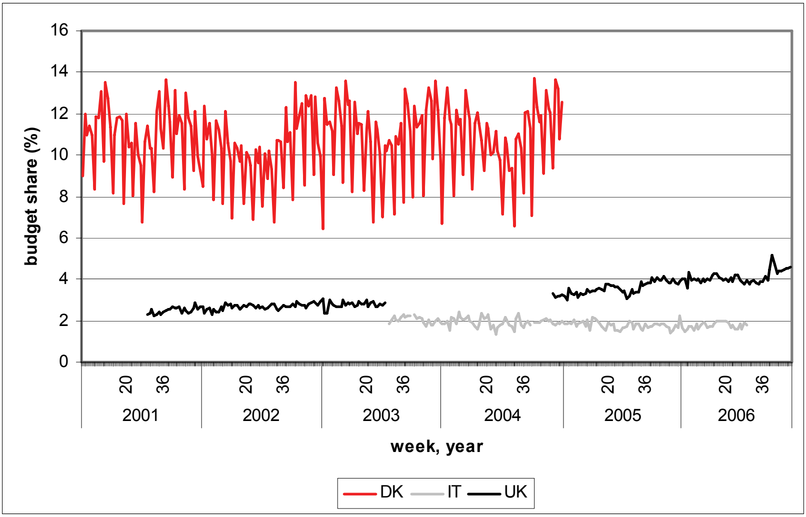

Figure 1: Organic budget share in DK (top line: 2001-2004), IT (grey line: mid 2003 - 2006), and the UK (black lines: mid 2001 - 2003 and 2005-2006)

In order to clarify differences in levels of organic consumption, the households are placed in one of four user groups based on their organic budget share (see e.g. Midmore *et al.* 2005). Households spending more than 10% of the budget on organic varieties are characterised as *heavy* users, households with a budget share between 2.5 - 10% are *medium* users, households using less than 2.5% are *light* users, and finally *non*-users do not purchase any organic foods at all. The average size of each user group in all three countries can be seen in Figure 2.

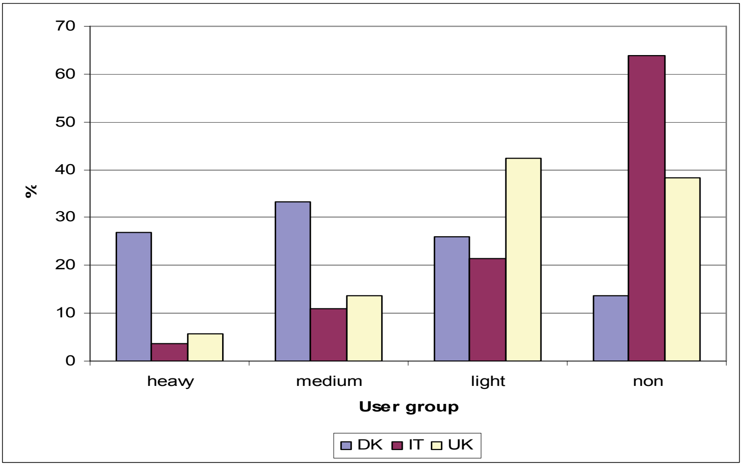

Figure 2: Relative size of user groups in DK, IT, and the UK

Approximately 25% of Danish consumers, 4% of Italian, and 6% of UK consumers, can be categorized as *heavy* users. With respect to *medium* users, a little less than 35% of Danes, 10% of Italians, and 13% of the UK consumers belong to this group. Approximately 25% of the Danish consumers are *light* users together with 20% of the Italian, and 42% of UK consumers. 15% of Danish consumers do not purchase any organics at all. This number for IT and the UK is 65% and 40%, respectively.

The data allow distinctions to be made between consumers with different socio-demographic characteristics, and certain differences can be observed between these groups. Three characteristics are included, namely geographic location/urbanization, social class and family structure. Due to differences in the data sets, the definitions of these characteristics are not quite identical.

The Danish data include information about degree of urbanization[1], whereas both the Italian and the UK data categorize according to regions. A division of the Italian regions into three areas representing respectively the north, the central, and the south[2] of the country has been made. It was not meaningful to use a similar grouping of the UK regions[3]. In both Copenhagen and London, *heavy* users are over-represented. *Heavy* users are under-represented in the rural parts of DK. Similarly, *light* and *non*-users are over-represented in some UK regions: the North East, Yorkshire, Lancashire, and in Scotland. In IT, users with the highest budget shares are mainly found in the northern part of the country, while many *non-users* and *light* users live in the south.

In DK and the UK, the panel is divided into five and six social classes, respectively, and defined as a combination of income and education. In IT, no social classes have been defined, but income and educational level can be employed as indicators of class. The results indicate that a higher social class or income leads to a higher

[1] Copenhagen, urban (more than 10,000 households), and rural (less than 10,000 households).

[2] North (Piedmont, Aosta Valley, Lombardy, Trentino Alto Adige, Veneto, Friuli-Venezia Giulia, Linguria, Emilia-Romagna, Tuscany), central (Umbria, Ancona, Rome, L'Aquila), South (Campobasso, Naples, Bari, Potenza, Catanzaro, Palermo, Cagliari).

[3] London, Midlands, North East, Yorkshire, Lancashire, South, Scotland, East England, Wales and West, South West.

demand for organic food products, while the effect of educational level in IT is less unambiguous.

In the data from DK and the UK it is possible to identify the number of both adults and children in the household. In DK it is furthermore possible to identify the gender of the adults. In the Italian data only the number of people (adults and children combined) in the household is known. In both DK and the UK relatively many heavy users live in single households. The Danish data show that single women tend to have a high budget share, while many single men are *non*-users or *light* users. In IT, relatively many with higher budget shares live in single-person or two-person households, while more than three people seem to decrease the budget share. With respect to the presence of children, consumption in neither DK or in the UK seems to be much affected. One should note that no distinction between young children and teenagers is made.

Conclusion and discussion

We have shown some preliminary results regarding differences in organic consumption levels in DK, IT, and the UK. In DK, the average share of the budget spent on organics has fluctuated around 10%. The corresponding level for IT and the UK is 2% and 3% respectively. In DK and IT the budget shares have been stable over time, while in the UK it has increased. The grouping of consumers according to budget shares supports this result and shows that relatively many Danish consumers are *heavy* users while relatively many Italian are *non*-users. Relatively high consumption levels are seen in Copenhagen, London, the northern part of IT, among singles households (especially women) and among consumers in the relatively higher social classes. However, these extensive data sets offer the possibility of substantial statistical analysis. Ongoing activities include a description of the dynamics of consumption patterns, a deeper look into the effects of socio-demographic factors in each country using e.g. the flexible mixed logit model, the impacts of price premiums and, last but not least, linking these data on observed behaviour with qualitative data regarding stated behaviour in all three countries.

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Assessing consumer acceptance of organic sausage products without curing agents

Hamm, U.[1], Wild, S.[2]

Keywords: market research, food retail, product launch, sales promotion

Abstract:

This paper presents and comments the results of sales experiments on newly developed organic meat products. The main goal of a research study was to examine the issue of consumer acceptance of organic sausage products with no curing agents. The sales experiment lasted over 12 weeks and was run in six supermarkets offering several variants of organic sausages of which three were produced without curing agents and therefore looked different to the variants produced with nitrite. The results allow an analysis of the consumer acceptance for organic meat products produced with and without curing agents as well as a description of the influence of the introduction of organic sausage variants without nitrite on the share of total sales of organic and conventional sausages. Results show a significant increase in sales of organic sausages and even of total sales of sausages and therefore contradict often heard judgements of German market actors that an additional offer of sausages without curing agents would confuse consumers and would lead to a decrease of organic sales.

Introduction and Objectives

There have been ongoing discussions about the use of curing agents in organic meat production in several European countries for many years. One of the main arguments against an abandonment of nitrite additives in organic sausages is that consumers would not accept the different appearance of the sausages (looking pale and sometimes grey) and therefore would not buy them. However, there have not been any publications on the German organic food market up to now backing this argument with hard data. The main aim of the research project ‘Curing Agents in Organic Meat Products’ financed by the Germany Ministry of Consumer Protection was to provide new insights on the theme (Beck *et al.* 2006). The project consisted of different parts. Besides the analysis of the applicability of substitute technologies for avoiding or reducing the use of nitrite and the legal situation in different countries of the European Union, a survey of organic sausage producers in Germany was carried out to get an overview over the range of organic meat products produced with and without curing additives such as nitrite. A central part of the whole study was the sales experiments of organic sausages of which the main results are reported in this contribution.

The aim of the study part was to test consumer acceptance of sausages produced without curing agents under controlled conditions of a store test in regular shops, where all variants of the same sausages, conventional, organic with nitrite additives, and organic without these additives could be sold. A further aim was to analyse whether the kind of the offer, in self service or in service over the counter, has an influence on the sales of the different variants as well as to investigate whether the sales were different between shops in rural and urban areas. Finally, price tests

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should show the influence of different price settings on the sales of the sausage variants.

Methods

To achieve the aim of the empirical study, the analysis took place simultaneously in six conventional supermarkets over a period of 12 weeks to measure short-term and middle-term sales impacts and from there, draw conclusions on the consumer acceptance of the non-use of nitrite in organic sausages. Within the bound of this store test, three newly developed organic sausage products without nitrite were launched parallel to the same organic sausages produced with nitrite and the conventional sausages. Both organic varieties were offered side by side in self-service as well as with service over the counter. To draw consumers' attention to the three new kinds of organic sausage, tasting activities with the assignment of promotion personnel had been carried out in each shop for one week. Besides the tasting activities, sales promotion activities with communication material such as displays, flyers and posters and short time price reductions took place. The six test stores operated by one particular supermarket chain (tegut) were located in rural and urban regions, so that a comparison of the consumer acceptance in different areas was also possible.

Results and Discussion

In the following, the sales developments of the three test products without curing agents were summarised. That was possible because the compared arithmetic means of the three products are nearly identical. The test results show a positive sales development during the first 12 weeks after the product launch of the three nitrite-free versions of the organic sausages. The short-term incremental sales volume that was generated in the product launch weeks exceeded all expectations. The averaged volume of nitrite-free organic sausage variants sold during the week of introduction was 26 kg. The sales of the conventional as well as the organic variants with nitrite sank from averaged 70 kg to 65 kg per week and from 45 kg to 40 kg per week respectively. These results indicate that the launch of the organic nitrite-free sausage variants caused a total sales increase of around 15 kg and substitution effects of around 5 kg each for conventional and organic sausages with the use of nitrite.

Table 1 displays the summary of the market shares as a percentage of the total turnover of the sausages before, during and after the product launch of the new variants. The total turnover of the 9 sausages in conventional and organic quality with and without curing agents increased up to 9 percent during the promotion compared to the weeks before the nitrite-free organic products were launched. The sales of all observed sausages were even during the next weeks 7 percent higher than before. The market share of the organic variants with and without nitrite generated a total market share of 53 percent during the promotional period and 49 percent in the following weeks which is 12 and 9 percentage points respectively more than in the period before the new products launch. Another interesting and unexpected result was that the new pale looking sausages reached a market share of around one third within the organic range from the first week on.

Table 2 gives an overview on the market shares which were reached in different regions (urban and rural) and with different forms of service (self-service and service over the counter). Whereas in the three urban test stores, the market share of the six sorts of organic sausages amounts to 56 percent of total sausage sales, the corresponding market share in rural areas was 43 percent only. Thus, consumers in urban regions have a significant higher appreciation of organic sausages than in rural regions. However, organic sausages produced without nitrite reached a slightly higher market share (34 percent) on all organic sausages in rural areas than in urban areas (31 percent).

Table 1: Averaged market share of the organic sausages as a percentage of the total turnover of sausages

	pre product launch period	product launch promotion period	post product launch period
Index total turnover of sausages	100.0	108.5	106.7
Market share of the organic sausages on the total turnover of sausages in percent	40.9	52.5	49.4
Market share of the organic sausages produced without nitrite additive on the total turnover of the organic sausages in percent	-	35.6	32.1

Table 2: Averaged market share as a percentage of turnover in the weeks[1] after the product launch, differentiated in regions and form of offer

	urban region	rural region
Market share of the organic sausages on the total turnover of sausages in percent	56.2	43.3
Market share of the organic sausages produced without nitrite additive on the total turnover of the organic sausages in percent	31.3	33.5
	self service	**serve over the counter**
Market share of the organic sausages on the total turnover of sausages in percent	65.6	41.8
Market share of the organic sausages produced without nitrite additive on the total turnover of the organic sausages in percent	27.6	35.9

[1] Basis of calculation: 10 weeks only because of late introduction of the new product in one shop

Table 2 also shows a comparison of the market shares for organic sausages in self service and service over the counter. The market share of pre-packed organic sausages in self service (66 percent) was much higher than that served over the counter (42 percent). The market share of the organic sausages produced without the nitrite additive on total organic sausages, however, was significantly higher for the sausages served over the counter (36 percent) than the market share for the same products sold in self service (28 percent). Obviously, consumers need an explanation for the different appearance of the sausages produced without curing agents. Besides that, the empirical findings also show higher substitute effects on the organic variants with nitrite, offered as service over the counter products and stronger impacts of the product launch on the conventional sausage products offered in self service. In addition, the results indicate that the consumer preferences for the form of service differ between regions. In rural areas consumers preferred the service over the counter.

The sales analyses for organic sausages also showed interesting and unexpected results in the field of pricing. Several weeks before the test period, two price promotions for conventional sausages were conducted with significant price reductions of around 30 percent and 40 percent. The result was a strong increase in the sales amount of around 80 and 120 percent for the conventional sausages in the promotion week. The sales amount of organic sausages was surprisingly not effected at the same time. A price promotion for organic sausages also took place in one week of the period before the introduction of the new organic sausages. The sales effect, however, was comparably low (plus 20 percent), even the price reduction was the same as for the conventional product (minus 30 percent). The sales of the conventional sausages were also not effected by the price promotion for the organic sorts.

Conclusions

The realised market share for the newly launched organic sausage variants produced without nitrite exceeded all expectations. Even the new sausages looked pale and the minimum durability was lower, the organic variants without nitrite achieved high sales over the full period of the test. The product launch had a significant impact on products sales for all organic sausage products. An increased market share of all organic sausages of 10 percentage points indicates that many new consumers had been attracted by the new variants. This leads to the conclusion that if the organic variants offer additional benefits over the pure organic production to consumers, as in this experiment sausages being produced without nitrite, then the market shares of organic products could be increased significantly. The appearance of the new variants of the organic sausages which were paler and turned grey obviously needed explanation. The new organic sausage sales were much higher in the service counters than in self service where no salespersons were present to explain why sausages look different. However, it must be mentioned that even in self service organic sausages produced without nitrite additives reached an unexpected high market share above 25 percent of all sales of organic sausages.

Price tests for conventional and for organic sausages have also shown unexpected results leading to the conclusion that retailers should rethink their price policy for organic products. While price elasticity of demand was high for conventional sausages, it was much lower for the organic variants. Interestingly, the cross price elasticity has also been very low between organic and conventional sausages. Thus, new customers for organic sausages obviously cannot only be attracted by a lower price difference between organic and conventional products.

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Applicability of analysis techniques to determine consumer behaviour

Stolz, H.[1], Hamm, U.[2], Stolze, M.[3]

Key words: Market research, consumer behaviour, choice experiment, organic food, EU-QLIF

Abstract

To explain consumers' actual buying behaviour, a choice experiment and a standardised interview shall be combined in a twofold methodological approach. While the choice experiment provides information about consumers' buying behaviour, the interview shall examine backgrounds and reasons for the choice decision by investigating the internal factors consisting of consumer attitudes, motivations and emotions, as well as the external factors, which are socio-demographic characteristics. The data provided by this twofold methodological approach need to be linked in the analysis procedure. Thus, the aim of this paper is to discuss the applicability of single multivariate analysis techniques and their ability to explain consumer behaviour. To identify causalities between the observed behaviour and factors influencing the buying behaviour, two successive techniques are favoured. To reduce the large set of variables collected in the interview, a factor analysis is suggested. To link the variables of experiment and interview, both multiple regression analysis and ANOVA are applicable to explain causalities. Multiple regression analysis is suggested as it is more flexible towards the measurement level of the independent variable if only a small number of non-metric variables have to be transformed into dummy variables.

Introduction

One important task of the organic farming sector is to improve quality, ensure safety and reduce production costs. Thus, an objective of the EU-funded project 'Improving quality and safety and reduction of costs in the European organic and 'low input' food supply chains (QLIF)' is to improve the congruence between producers' interests and consumers' expectations towards quality and safety of organic and other 'low input' food. It is foreseen that consumer research includes a multi-methodological approach. One subproject investigates the following key questions: Which product stimuli are preferred or rather declined? How are socio-demographic criteria of the test persons, their attitudes, motivations and emotions related to their buying decision? Thus, the consumers' actual buying behaviour towards quality and safety of organic and 'low input' food will be observed by a choice experiment. This will be combined with a standardised interview. The interview is aimed at giving insights into backgrounds and reasons for the choice decision observed in the experiment. The data provided by this twofold methodological approach needs to be linked in the analysis procedure. The aim of this paper is to discuss the applicability of various multivariate analysis techniques and their ability to complement each other so that synergy effects can be used to understand consumer behaviour.

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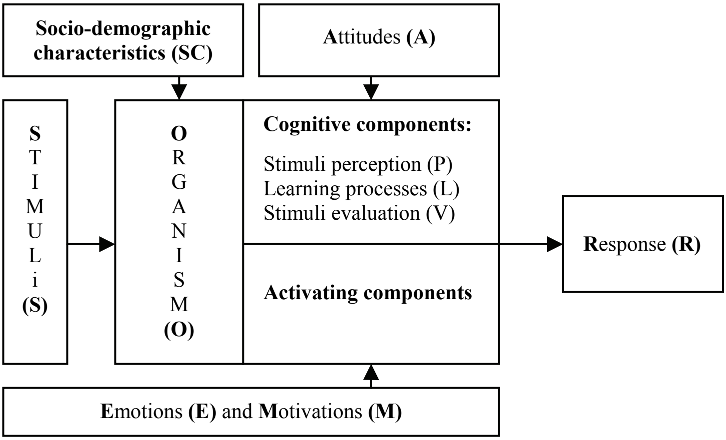
Methodological approach

Neobehavioristic theory explains consumer behaviour by Stimulus-Organism-Response (S-O-R)-models (Kroeber-Riel and Weinberg 2003). According to S-O-R-models, observable stimuli (S) and processes within the organism (O), consisting of cognitive and activating components are causing reaction (R), as for example a buying decision. Hereby, the cognitive component includes stimuli perception, evaluation and learning processes. It is influenced by attitudes, while the activating component is influenced by emotions and motivations. Besides these internal factors, external factors such as socio-demographic characteristics (SC) influence the organism (Figure 1).

Figure 1: The S-O-R-model



Source: Own illustration

Obviously, a single-sided investigation of consumer behaviour without analysing factors influencing cognitive and activating components in the organism falls short. Same applies to the investigation of O without stating the consequent behaviour. How can a research design lead to a more comprehensive understanding of the complexity of consumer behaviour? We suggest interviewing and carrying out an experiment in a complementary twofold methodological approach, whereby R is examined by a choice experiment. This frequently used method is chosen because it closely mirrors actual consumer buying behaviour and especially if nonhypothetical payment is applied (Lust and Schroeder, 2004). Besides, it is a very flexible method with possible integration of several attributes. The experiment will be conducted in a test studio in a close to realistic buying situation and not in a store test, due to three reasons: Not all product stimuli are available on the market. Thus, products have to be manipulated. Furthermore, the lineage of experiment and interview underlies a single source approach. Thus, same consumers have to do both interview and choice test. This would be not practicable using a store test. Furthermore, a store test would be too expensive.

Before the choice test, the test persons get standardised information about the products offered. After the choice experiments, factors influencing O are investigated in a personal standardised interview following the choice experiments. Hereby, the focus lies on consumers' attitudes, emotions and motivations towards food quality, production and processing methods and lifestyle as well as on socio-demographic characteristics. The study will take place in Germany, France and Switzerland in October 2007 with a sample of approx. 50-100 test persons per country. The recruitment will follow typical consumer household profiles. During the choice experiment, test persons may choose one or no product out of a series of product stimuli (S) using a reduced design. The stimuli vary in the production system; products of two production levels ‘conventional’ and ‘organic’ will be offered. Furthermore, the stimuli are offered at different price levels.

Applicability of analysis techniques to explain consumer behaviour

Data collected in the interview shall explain consumer behaviour which was observed in the choice experiment. Thus, variables from both methods have to be linked in the analysis procedure. To identify causalities between the observed behaviour ‘product choice’ and attitudes, motivations, emotions as well as socio-demographic characteristics, dependence analyses provide a higher applicability than interdependence analyses. Nevertheless, to reduce the large set of 20 to 30 variables necessary to describe consumer attitudes, motivations and emotions, a factor analysis is suggested: By grouping metric independent variables with high correlation or covariance between metric variables in order to reduce information, factor analysis delivers latent variables (factors), whereby each latent variable represents a corresponding group of attitudes (Jacq 2006). Therefore, factor analysis is a useful preparation for a succeeding dependence analysis if only a small number of non-metric variables have to be transformed into dummy variables.

Causalities between attitudes, motivations and emotions (reduced and provided as factors) as well as socio-demographic characteristics and the dependent variable ‘stimuli choice’ shall be investigated in a second step applying dependence techniques. To choose the most appropriate technique from a wide range of techniques available, the following exclusion steps are undertaken: Generally, such techniques considering more than one dependent variable are not applicable regarding the survey design. Techniques restricted on the investigation of only two variables are excluded as well, as several independent variables are considered to be relevant. Furthermore, causal analyses, considering dependent non-metric variables (e.g. discriminant analysis) are also excluded, because the dependent variable is measured at ratio level. After these exclusion steps, remaining techniques are the multiple regression analysis (MRA) and the analysis of variances (ANOVA). Both techniques are based on linear models and investigate the causalities between several independent and a dependent variable.

MRA is a technique often applied to investigate the relation of several independent variables and one dependent variable with the aim to build a regression model or a prediction equation (Aaker *et al.* 2004). It is used to describe the variable of interest (Hair *et al.* 2006). If the independent variables are non-metric, they have to be transformed into dummy variables. MRA models have to be linear and need to include the relevant causal variables (Hair *et al.* 2006). Regarding the sample size, the number of cases has to be at least twice as much as the parameters included in the model. In the study, the foreseen sample size fulfils this precondition. To conclude, MRA can be applied to investigate which independent variables cause a high intention to choose the organic or non organic product stimulus.

The alternative technique ANOVA investigates how the variability of dependent variables could be explained by several independent variables. By application of an ANOVA, interactions between independent variables may be considered. Thus, an ANOVA is especially useful if interactions between the independent variables are expected. In this study, interactions for example between consumers’ perception of a product stimulus and their evaluation of the stimulus or between educational level and income are expected. A prerequisite for a successful ANOVA application is again the sample size allowing conclusion from the investigated sample to the whole population. Another important consideration is the measurement level. If in an ANOVA design at least one independent variable is measured at interval level, this is called 'covariate' and the applied technique is the ANCOVA (Tacq 1997). To build up a model including covariates, a complex number of covariate theorems is set up with corresponding F-tests (Tacq 1997), while MRA, in contrast, provides a less cumbersome way of including both metric and non-metric variables by transforming the non-metric variables into dummy variables.

Conclusions

To identify causalities between observed buying behaviour (R) and factors influencing the organism (O) in a buying situation, a choice experiment is linked with a standardised questionnaire, collecting information about consumers' motivation attitudes and emotions towards food, and socio-demographic characteristics. To link the data in the analysis procedure, two techniques are suggested. In order to reduce the large set of variables related to attitudes, emotions and motivations, a factor analysis will be undertaken. To link the variables of experiment and interview, both multiple regression analysis and ANOVA both are applicable when considering the amount and level of measurement of the provided variables as well as the utility of technique to explain causalities. However, as multiple regression analysis is more flexible regarding the measurement level of the independent variable, this technique is more applicable. The results of the study will be available in the mid of 2008.

Acknowledgments

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Organic hospital food is desired by patients and engages the kitchen

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Key words: organic food, Norway, hospital, survey, public procurement

Abstract

In December 2005 a questionnaire survey was conducted at the University Hospital in Trondheim, Norway. Patients and personnel expressed that food is important for their health and well-being. Good taste, appearance and right nutrition were mentioned as being important factors for food quality. About 80 % of the respondents were positive to the use of organic food at the hospital, even though only about half of them agreed that it is worth the price. The absence of pesticides, artificial fertilizers and preservatives in food was ranked to be more important than organic production of food. All respondents seemed to be critical to the use of pesticides and preservatives in food production and processing.

Introduction

In 2003 a project focusing on the introduction of organic and local food was initiated at the University Hospital in Trondheim. The work was coordinated by the Norwegian Institute for Organic Farming (now Bioforsk Organic Food and Farming Division). The aim of serving 30 % organic food by the end of 2006 has been reached on average for the kitchen. The kitchen produces about 1200 meals every day for 60 divisions at the hospital. The objective of this study is to gain empirical insight into the patients', nurses' and kitchen staff's perception of the food served at the hospital, their views concerning food production methods, as well as differences between the three groups regarding the two aforementioned issues. The results are based on a survey, conducted in 2005, which was part of the organic hospital food project.

Materials and methods

The data were collected in a questionnaire survey on quality, processing and attitudes about food served at the university hospital of Trondheim in Norway. In December 2005 the questionnaire was handed out to 200 patients, 370 staff members and all 60 kitchen employees. After several reminders 355 persons (56.3 %) answered. We asked about hospital food, particularly requesting statements on organic and conventional food and on food in general. Most of the questions were closed questions, where statements had to be rated on a Lickert type scale. The results from the three groups were examined by descriptive analyses. Mean values obtained in the groups were compared by *t*-tests for independent samples.

Results

Nearly half of the questionnaires handed out to patients were returned. Nearly 60 % of the nurses and kitchen staff replied, as Table 1 shows. More than four-fifths of the respondents working at the hospital were women, but the male-female ratio among patients was more balanced. The group of patients was older than the respondents

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working at the hospital. More than 40 % of patients had eaten less than seven days at the hospital in 2005, another 45 % less than a month. Seventy-five percent of the nurses had hospital meals on more than 30 days a year.

Tab. 1: Characteristics of the respondents

	Patients	Nurses	Kitchen staff
Number of respondents Response rate in group	98 49 %	222 60 %	35 58 %
Women / men (% in group)	57 / 43	84 / 16	80 / 20

On a Lickert scale, patients and nurses were to rate their satisfaction with the food served at the hospital on a scale from ‘really satisfied’ (1) to ‘really dissatisfied’ (5). On average about half of both groups were ‘satisfied’ with the menu in general, lunch and different ingredients as vegetables and potatoes. The two groups differed significantly (*P*-value < 0.05), in that more patients (about 30 %) were ‘really satisfied’ with the menu in general, lunch and different ingredients than nurses (about 10 %). About 15 to 30 % of both groups were neither satisfied nor dissatisfied (3) regarding these issues.

All three groups were asked to rate statements on Norwegian agriculture on a Lickert scale from ‘totally agree’ (1) to ‘totally disagree’ (5). About 90 % of the patients and nurses agreed somehow or were not sure if the branding of ‘Norwegian farmed food’ (Godt Norsk) indicates pure products, which it actually doesn’t. 24 % of the kitchen staff ‘disagreed’ or ‘totally disagreed’ on the same statement, about three times more (*P*-value = 0.043, based on a chi-square test) than the two other groups. More than 70 % in each group stated that organic farming does not use artificial pesticides. 20 % or less in each group agreed that Norwegian agriculture does not pollute the environment. 56 % of the patients and kitchen staff agreed that organic food is worth the price, compared to 33 % of the nurses. On the other hand, 16 % or less in each group did not agree that organic food is worth the price. The rest was not sure.

Asked about food routines at home, about 75 % of patients and kitchen staff and 27 % of nurses (*P*-value < 0.000) answered that they prefer cooking meals based on raw materials rather than using convenience food. There were no significant differences between the groups regarding the use of organic ingredients and seasonal food. More than 60 % in each group used organic products ‘often’ or ‘sometimes’ at home, while less than 10 % used freshly harvested seasonal products ‘seldom’ or ‘never’.

For most of the questions about hospital food and the methods of food production, there were no significant differences between patients and nurses. The expectation that meals should taste and look good was ranked highest. For the respondents it is important that (in decreasing order of importance) food contains the right nutrients, is mostly without preservatives, is produced without pesticides, and finally avoids the use of artificial fertilisers. It was more important for patients than for nurses to get traditional meals and have local food production. All respondents rated the use of organic products as less important compared to traditional meals and local food.

More than 90 % of patients and nurses answered that meals are important for both their health and well being. Asked to rate their opinion about using organic food at the hospital, 37.9 % were ‘really positive’, 44.6 % ‘positive’, 16.9 % ‘neutral’, only 0.6 % were ‘negative’ and none ‘really negative’.

The kitchen staff was asked to rate reasons for introducing organic food at the hospital. The most important reason out of a list of 10 was to have ‘less chemical preservatives’, followed by ‘increased awareness on food, health and the environment', a 'more healthy diet' and better 'animal welfare'. As barriers to the introduction of organic hospital food they mentioned a 'higher price for organic products' and 'less supply' as most important. On the other hand, they disagreed that organic food has a purer taste.

Discussion

On average, all respondents were satisfied with the food served at the hospital. However, it was striking that nurses, eating the same meals, were less satisfied with the food than the patients. There may be several reasons for this difference. Most of the nurses often eat at the hospital. A repetition of the menu every fourth week can be perceived as being monotonous. Furthermore, they may be more critical because they have to pay for the meals, and stress at work may also result in the expression of more critical views in their replies.

While most of the respondents were convinced that branding for 'Norwegian farmed food' indicates pure products, a larger share of the kitchen staff was critical to this implication. As long as conventional agriculture in Norway is strongly associated with 'pure' production it seems to be difficult to convince consumers to pay an extra price for organic products.

Without the positive reputation of conventional farming in Norway, the ideal image of food production and processing without pesticides, artificial fertilisers and preservatives would probably have resulted in more respondents preferring organic products. On the other hand, considering how strongly people like to avoid pesticides, artificial fertilisers and preservatives, it is not surprising that more than 80 % of the patients were positive to the use of organic hospital food. Patients possibly reconsider their outlook on life when facing health problems, especially when these are a result of, or favoured by, food consumption and pollutants (Schuster A *et al.*2006). The results from personnel may indicate that not just one's own disease, but also working with diseases can lead to a more critical attitude towards the use of pesticides and preservatives.

A study by the Norwegian organic inspection body (Debio 2003) pointed out that less than 30 % of Norwegian consumers mentioned to be very or fairly interested in buying organic products. One reason for the different interest in organic products between patients and Norwegian consumers may be an increased interest for organic products over time; another could be the place the questionnaires were conducted: The wish to get more organic hospital food is free of charge. However, if you are interested in buying more organic food yourself you have to pay for it. While more than 80 % of the respondents in this study were positive to the use of organic food, only 56 % of all patients and kitchen employees and 33 % of all nurses agreed that organic food is worth the extra price. This demonstrates the discrepancy between the wish for organic food and the willingness to pay for it. The statement that organic food is more expensive was ranked as the most important barrier for buying more organic food in another Norwegian study about organic food consumption (Askew 2005).

While kitchen staff ranked arguments related to health and animal welfare to be important for introducing organic food at the hospital, they pointed out the higher price for organic products and insufficient supply as important barriers. Indeed, the price premium is important as long as the hospital kitchen has a fixed budget for each meal served. This makes it difficult to use a large share of organic products. However, a growth in organic sales will probably lead to a better supply of organic products and reduced prices. In addition, it is still difficult to obtain certain organic ingredients in Norway. Some products are still not available on the market at all. Other problems are related to quality, time of delivery, quantity and sometimes high price differences.

Conclusions

Organic food is highly welcomed by patients and personnel at the hospital. The kitchen workers are also positive to using organic ingredients. Using organic food and informing about it may lead to a higher contentment among patients and personnel and a higher reputation of the hospital.

All respondents at the hospital seemed to be more interested in getting organic food than the population in Norway as a whole. Important reasons are probably a critical view on the use of chemical pesticides and preservatives and the expected effect of meals on health and well being. Research is needed to find out if the differences between respondents at the hospital and the Norwegian population are significant, and to determine their causes.

The combination of quality and price is highly relevant to the consumers. If consumers shall buy more organic products, consumers need more information about organic production, they need to learn arguments for buying organic food and why the price for such products usually is higher. The kitchen staff, having been provided a course on organic food, was more positive to using organic products than the other groups. This shows that communication and information can be a key to success.

Acknowledgments

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Development of a Methodology for Modelling Consumers' Low Input Food Purchases

Ness, M.[1]

Key words: Low input products, Customer loyalty, structural equation model

Abstract

This paper explains the development of a methodology to model consumers' purchases of low input and organic foods. The focus of the research design is the need to create value and satisfaction that exceeds consumers' expectations and induces loyalty. The adopted analytical framework adopts a structural equation model (SEM) in the context of consumer loyalty research to explore the determinants of consumer loyalty in terms of constructs of perceived quality, perceived risk, sacrifice, perceived value and satisfaction. A General Model is proposed that permits the specification of nested models and hence, tests for the suitability of preferred models. The primary research instrument is a questionnaire applied to four products in five countries. The questionnaire collects data to inform the SEM and in addition, includes measures of attitudes to foods in general, and attitudes to, and beliefs about organic food.

Introduction

This paper explains the development of the methodology to model consumers' purchases of low input and organic foods which underlies workpackages 1.1.3 and 1.1.4. The workpackages involve the design of a questionnaire to measure consumers' perceptions of, and attitudes to, low input foods with respect to intrinsic, extrinsic and credence quality cues, and subsequently, to analyse the data within a model framework.

The structure of the paper is as follows. The next section discusses the development of the analytical framework that establishes the foundation for the questionnaire design. This is followed by a section concerning the methodology adopted. The final section outlines the statistical analysis that will be conducted to satisfy the research objectives of the associated workpackages.

Methodology

The theoretical framework concerns the determinants of customer loyalty. Marketing emphasises building long-term relationships with customers that encourages loyalty and repeat purchase. Loyalty is determined by delivery of quality, value, and satisfaction and confers the benefit of competitive advantage (Kotler *et al*., 2001). Furthermore loyalty enhances profitability and hence, the long-term profitability through, *inter alia*, an increase in the scale and scope of activity, lower customer recruitment costs, and reduced customer price sensitivity (Hallowell, 1996).

Within this general framework, consumers adopt the objective of maximising value, the difference between the benefits conferred relative to costs of acquisition in terms of time, money and the effort invested in product acquisition.

From the perspective of producers and supply chain agents the delivery of value is related to the value chain, which emphasises that value is not just delivered by

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products but also through primary activities and support activities (Porter, 2004). This carries implications for the delivery of value within the supply chain for low input products

The proposed approach is to identify how organic and low input food products deliver perceived quality (percqual), perceived value (percval) and satisfaction (sat), and consequently, how these determine behavioural intentions (behint).In addition to these main constructs the model also integrates constructs of sacrifice (sac) and perceived risk (prisk).

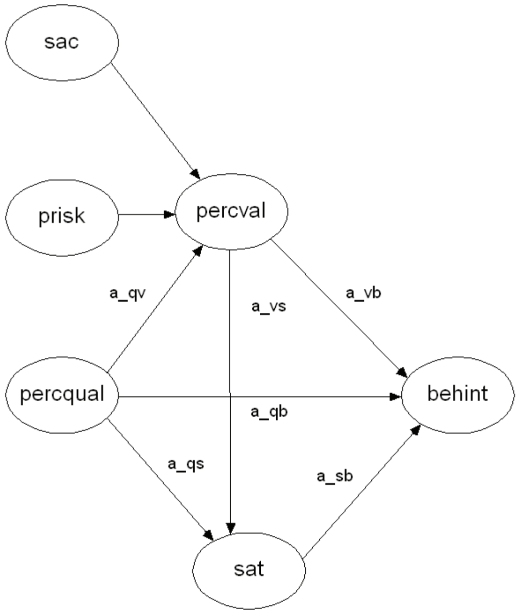
Sacrifice is defined as the as what is given up in the process of acquiring a product or service (Zeithaml, 1988). Within the study it is considered in terms of monetary cost, shopping effort and where appropriate, preparation. Perceived risk is defined as the subjective evaluation of a loss (Stone and Gronhaug, 1993). The approach used in this study is to consider perceived risk in the context of concern about certain product features associated with intensive farming and food production methods. Several studies have found that higher perceived product quality leads to more positive repurchase intentions (Kaplan and Norton, 1996; Bou-Llusar et al, 2001; Rust and Oliver, 1994; Keillor et al, 2004). The measures used for this construct are the importance of indicators of intrinsic, extrinsic and credence quality cues associated with the specific food product. Satisfaction of consumers' needs is defined as an overall evaluation of the purchase and consumption experience (Johnson and Gustafsson, 2000), the degree of fulfilment of some need, desire, goal, or other pleasurable end (Olsen, 2002). Value is regarded as a key determinant of loyalty (Sweeney and Soutar, 2001). Zeithaml (1988) conceives value from four perspectives: value as price; value as want fulfilment; value as a price-quality trade-off; and, value as the culmination of what is obtained and what is given up. Given the relative low involvement in the purchase decision for the specific products, value is based on the concept of want fulfilment. Behavioural intention is a measure of loyalty. This is the most commonly used in marketing literature (Bloemer and Kasper, 1995; Bloemer and de Ruyter, 1998) because it is easy and possible to ask customers whether they have intentions to repurchase a product or service.

In particular the approach is to model the influence of these constructs on behavioural intentions using a structural equation model (SEM), which means that it is necessary to research the nature of the interactive links between the constructs. The value of this approach is that supply chain agents can better understand how to enhance loyalty to low input products, including organic products. The model structure is adapted from Cronin *et al.* (2000). Role of perceived risk in all models follows Sweeney *et al.* (1999). A General Model is adapted from three models within the Quality-Value-Satisfaction literature that incorporates three models: Indirect, Satisfaction and Research models respectively. A further model, the Value Model is also adapted from Cronin *et al.* (2000)

In General Model (Figure 1) the respective constructs of sacrifice (sac) and perceived risk (prisk) affect perceived quality. Perceived quality (percqual) has a direct effect on behavioural intentions (behint). It also has direct effects on perceived value (percval) and satisfaction (sat). Construct percval has a direct effect on sat and behint. Construct sat influences behint directly. The model also demonstrates indirect effects. For example perqual effects behint indirectly via its respective direct influences on percval and sat (percqual→percval→behint, percqual→percval→sat→behint, and percqual→sat→behint). In addition, percval has an indirect influence on behint through the mediating effect of sat (percval→sat→behint).

Imposing constraints on specific path coefficients in the General Model permits the specification of alternative models: The Satisfaction Model (a_qb=0 and a_vb=0); The Indirect Model (a_qs = 0 and a_qb = 0); and, The Research Model (a_vs = 0).

Figure 1. The General Model



The Value Model is treated as a separate model because of the difference in the in the direction of the sequential links between percval and sat. According to the Value Model perceived quality (percqual) and satisfaction (sat) have direct effects on perceived value (percval) and in turn percval has a direct effect on behint. Hence the respective impacts of percqual and sat on behint is through the mediating influence of percval (percqual→percval→behint, and satl→percval→behint).

The primary research instrument is a questionnaire administered in France, Germany, Italy, Switzerland and the United Kingdom for bread, eggs, tomatoes and yoghurt. The questionnaire was developed in the University of Newcastle and further improved in consultation with the partners in subproject 1.

The questionnaire is organised in four thematic sections. The first section concerns consumer behaviour with respect to the specific food product that is usually eaten in the household. It contains a nominal multiple response measure of the outlet where the product is obtained, and measures for the constructs of satisfaction, likelihood of re-purchase, perceived value, sacrifice, importance of quality cues, and perceived risk. The second section concerns food in general. It consists of a single construct with eleven measures of the importance of food attributes that are related to the wider implications of food choice that may be defined as issues concerning the consumer as a citizen. The third section deals with organic food. It consist of measures relating to the frequency of organic food purchase for eight product categories, future purchase intentions for the same product categories, and a comparative measure of organic and non-organic foods with respect to attributes that were also the subject of the measures of quality employed in the section on the specific food product. Finally, the fourth section concerns socio-demographic characteristics of respondents. It contains nominal measures of the presence of children in specific age categories in the household, education level, area of residence, and annual household income.

The initial questionnaire was designed as a generic instrument to apply to all four products. Following discussion with SP 1 partners, it was decided to include product specific measures for the constructs concerned with satisfaction and quality within the specific product section. Furthermore a construct concerned with perceived risk was added for each product. The English version of the questionnaire was pre-tested using a sample of 30 respondents for each of the four products.

The survey was undertaken by a single market research agency employing a computer-assisted telephone survey from a single location. The use of a single agency conferred other benefits that included a facility to translate the questionnaire into several languages, to generate representative samples using in-house software related to the telephone survey method, and to impose required quotas. The respondents were recruited according to the criteria that they were adult shoppers who regularly purchased one of the specified products. A quota of 250 was specified for each for each product type, and additional quotas were specified for age, region, and gender.

Discussion

The survey will generate rich data that provide for a wide variety of analyses including descriptive analysis, and multivariate analysis, in addition to the estimation and testing of the structural equation model. The discussion that follows focuses on the analysis using the structural equation model (SEM).

The procedure for SEM will involve:

- Tests of measures for each construct for reliability using Cronbach's alpha
- Estimation of measurement models for constructs
- Estimation of specific models for country and product
- Evaluation of model fit
- Testing alternative models

The General model forms the basis from which alternative models can be tested. Under the assumption that the General Model is correct, the tests would compare:

- General Model vs Value Model
- General Model vs Satisfaction Model
- General Model vs Indirect Model
- General Model vs Research Model

The results of the tests will provide for a preferred model to be identified in various contexts of application; for product and country models, aggregate product models, and aggregate country models.

Acknowledgments

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Determining consumer expectations and attitudes towards organic/low input food quality and safety - Posters

Consumers' Demands and Preferences for Organic Foods: A Survey Study in Mashhad, Iran

Ghorbani, M.[1], Mahmoudi, H.[2] and Liaghati, H.[2]

Keywords: Organic foods, Consumers, Demand, Awareness, Preference.

Abstract

Agriculture has always been an important sector of the Iranian economy. For this reason, the investigation of consumers' demands and priorities in relation to organic products is our concern since no study has been conducted in this area in Iran. This paper aims to investigate consumers' knowledge concerning organic foodstuffs and the factors influencing consumption of organic product in the families of Mashhad so that some recommendations may finally be presented. In fact, while organic farming has been promoted as an environmentally-friendly approach and has been developed during the last few years in most developed countries, there is little emphasis placed on this in developing countries such as Iran. In order to identify consumer demand for organic foods, 180 respondents were interviewed by means of a questionnaire.

Introduction

The future of organic agriculture will, to a large extent, depend on consumer demand. Thus, a consumer-oriented approach to understanding organic agriculture is important not only in its own right, but also in terms of a response to shifting market dynamics (Bonti-Ankomah and Yiridoe, 2006).

The literature on the demand for organic food is not particularly deep and given the dramatic changes in organic food availability over the past decade, it is not surprising that some of the findings have been somewhat contradictory (Zepeda *et al.,* 2006).

The market for organic food has increased considerably over the last decade due to consumers' increasing awareness of both health and environmental issues (Soler et. al., 2002). This growth in demand is expected to continue in the coming years, even though the situation differs from one country to another in terms of type and quantities of production (Vindigni *et al.*, 2002).

Many farmers in Iran are traditionally applying organic practices. It means their cultural practices are adjusted fully or partially with organic regulations: they never use agrochemicals, apply integrated pest management, and improve soil and agroecosystem fertility by sustainable means. Furthermore, indigenous knowledge of Iranian farmers is consistent with organic farming. Data shows that 113'659 ha of field crops and 125'802 ha of horticultural lands in Iran are cultivated without application of agrochemicals. On the other hand, however, the process of certifying farms as organic is an expensive procedure for which many traditional small-holders who can be classified as organic can not pay for. Therefore, we have not yet organic farms by formally certified organizations like IFOAM, etc.

Within this framework, this study aims to find out more about consumer demand and preference in the Mashhad Province of Iran. To achieve this main objective, the study has been broken down into the following secondary objectives:

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- Determine the level of awareness about organic food
- Determine the tendency for consumption of organic food
- Determine the factors driving the trend towards consumption of organic food

Method

Data from 180 surveys conducted among Iranian consumers in the city of Mashhad, situated in North-eastern Iran, have been used to carry out this study. The study was conducted using the random sampling method.

Results and Discussion

Sample description

The sample consisted of 69 women (38.3%) and 111 (61.7%) men. The average age of the respondents was 36.55 years. More than half of them had finished secondary school (55 percent), 20 percent had a university education and 25 per cent of respondents had only completed primary school.

Consumer awareness

Developments in the demand for organic food have been related to an increased awareness of the importance of organic foods. Increase in demand for organic products depends on consumer awareness. If consumers are not aware of the attributes related to organic products their motivation to demand these foods will decrease.

Consumers were asked ‘Do you know what organic food is?’ Table 1 shows that only 20.6 percent answered ‘Yes’ and the most of respondents cited ‘not aware’. This indicates:

- Without doubt, the organic farming boom has not begun in Iran.
- The Government has not yet invested in organic farming.

Table 1: Consumer awareness about organic foods

Do you know what organic food is?	Frequency	Percentage	X^2
YES (aware)	37	20.6	62.42
NO (unaware)	143	79.4	

The chi square analysis shows a significant difference between the responses. In other words, there is a significant difference between the observed and expected frequencies. Therefore, the results can be generalized for the whole population.

Consumer trend towards consumption of organic foods

The results of Table 1 show that the majority of respondents do not have a good level of knowledge related to these products. Therefore, as a first step, some information has been presented to the respondents, and their resulting tendency has then been assessed as illustrated in Table 2.

Table 2: Consumer trend for consumption of organic foods

Do you have a tendency for consuming organic food?	Frequency	Percentage	X^2
YES	173	96.1	153.1
NO	7	3.9	

Table 2 shows that 173 respondents answered positively and due to the chi square result (X^2=153.1), it is clear that this finding is significant. In other words, enhancing the respondents' knowledge can be considered as an effective method to increase their demands.

Trend drivers

There are several factors driving the trend towards the consumption of organic food. Respondents were asked for 'the reasons for consumers' consumption organic foods'. Answers are given in Table 3.

Table 3: Trend drivers towards consumption of organic foods

Reasons	Percentage
Belief that organic is healthier	45
More tasty (better flavor/smell)	25
Better quality	12
Concern about pesticide residues	8
More environment-friendly	3

As shown, the factors relating to health and taste have a much greater influence in comparison to the rest.

Conclusions

Due to the results, 80% of the respondents have no knowledge related to the organic products. As the chi square analysis was significant, it seems crucial to enhance the respondents' knowledge about organic products through appropriate extension-educational methods so that it leads to increasing the consumption of organic products that consequently could increase the supply of these products.

The public also needs to be made aware of the problems associated with conventional agriculture. Direct and indirect support by the Government will, however, be necessary to achieve this.

Understanding the affective factors influencing organic production makes it clear such factors as superior food healthiness, flavor, and quality have the greatest influence.

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Estonian consumers attitudes to organic food

Pehme, S.[1], Luik, A.[1], Liivaauk, P.[2]

Key words: Estonian consumers, organic food

Abstract

The study of 740 Estonian occasional consumers has shown that 60 % of them are willing to buy organic products mainly because these contain fewer additives than conventional products. Therefore the consumers consider them first of all more natural and healthier. Preferred products are organic vegetables and fruits. Consumers prefer to buy them from supermarkets. Common awareness about organic farming needs improvement – only 11% of consumers felt themselves entirely informed.

Introduction

In Estonia organic farming has developed rapidly. During the last seven years the area and the number of farms increased tenfold – almost seventy thousand ha with more than thousand farms practise organic management. The rapid increase has happened mainly due to intensive promotional work in 1999-2002, as well as to the growing governmental interest in the development of organic farming (including area support for organic farming from 2000 onwards and the support for farmers´ training). In spite of organic area increase the organic market is still poorly developed. To understand the factors limiting the market development, the study of consumer attitudes to organic food was carried out.

Materials and methods

On the request of the Estonian Ministry of Agriculture in January 2005 the survey was carried out to establish what preferences Estonian consumers have in food products buying, how much they know about organic agriculture, whether they recognise the organic label, what kind of organic products and which marketing channel they prefer. A special questionnaire was compiled. Closed and multiple choice questions were posed: 740 occasional consumers were interviewed and their answers analysed.

Results and discussion

In purchasing food products for Estonian consumers the most important values are freshness (95% of respondents), taste (93%) and quality (92%). Also, favorable price and local origin had an impact for 60% of consumers. 11% of respondents had sufficient information about organic farming, 54% consumers answered that they had certain information but they did not know anything about the organic control system, 32% - were not informed and 3% - did not want to know anything about organic farming. Anyway, 60% of consumers are willing to buy organic products because they contain fewer additives than conventional products. Therefore consumers consider organic products first of all more natural and healthier (Figure 1). Research in other countries has shown the similar motivation (Ekelund, 2005; Midmore *et al.*, 2006; Sylvander, Martine, 2006).

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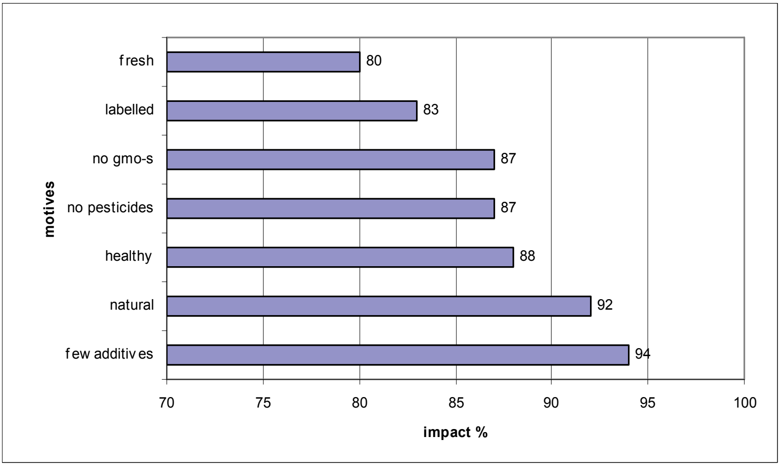

Figure 1: Main motives of the Estonian consumers for buying organic products

First of all consumers want to buy organic vegetables (75% of respondents), fruits (72%), milk products (60%), honey (58%), meat products (57%), bakery products (54%) and herbs (44%).

Most of the consumers (44%) prefer to buy organic food from supermarkets, but 23% are also ready to purchase directly from farms and 18% from markets. Unfortunately, in the current situation in Estonian supermarkets the choice of organic products is very limited because organic processing is poorly developed. Direct marketing from farms is highly dominating. The key issues for the Estonian organic market are the development of organic processing and consumers' awareness.

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Health perception and food attributes

Sijtsema, S.[1]

Key words: Consumers' perception, health, projective techniques, food characteristics

Abstract

Consumers' perception of health related to food products, characteristics, ingredients and attributes is measured in a qualitative and quantitative approach. Cognitive aspects as well as affective aspects are taken in consideration.

In the perspective of health perception consumers talk in terms of unprocessed, nutritious, fresh, and natural attributes, as well as affective aspects like appetizing, happy and enjoy. Different groups of consumers have their own perception of health. Depending the target group and the product the health perception of consumers is correlated to specific attributes and affective aspects.

Introduction

Food is part of everyday life and few things have changed more drastically in the last century than the way food is produced, processed, distributed, marketed and consumed.

The food perception model (Sijtsema *et al.* 2002) represents the four main determinants of food perception, that is, individual consumers (demography, physiology, psychology, attitudes), environment (family, society), product (product characteristics, production system) and consumption moment (time, place). Based on this model the research field is demarcated to get insight in consumers' perception of health in a qualitative and quantitative approach. The aim of this study is to measure consumers' health perception and relate this healthiness to traditional Dutch meal components in terms of attributes, characteristics, ingredients and affective aspects.

Materials and methods

In expressive and associative group discussions with female consumers (4 sessions 6 participants each), health perception and experiences were discussed based on non-verbal expressions, viz. drawings and abstract paintings made by participants themselves to unravel health perception in consumer terms.

By means of a questionnaire (N=344) these insights were related to the perception of eight traditional Dutch meal components in terms of attributes (unprocessed, nutritious, fresh, natural, organic) ingredients (fat, protein etc) and affective (happy, appetizing, enjoy).

Results

The participants of the qualitative research discussed feelings (enjoyment and happiness), associations (e.g. season, water, sun), specific products (e.g. vegetables, fruits) and ingredients (e.g. vitamins, fibres, minerals) and production (organic). (Sijtsema *et al.*, 2007) These insights from the qualitative research were then related

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to characteristics, ingredients, affective and production aspects for eight traditional Dutch meal components (see figure 1).

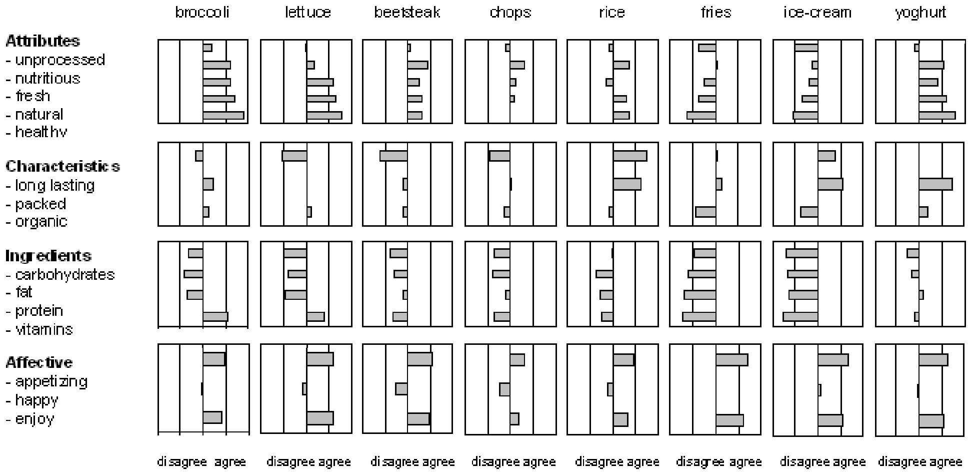

Figure 1: Results of 8 products and 15 terms

Health - The eight meal components were perceived differently with respect to their health-supporting properties. Vegetables were judged as the most healthy component, in contrast to fries and ice cream, which were perceived as unhealthy. The alternative products for the same meal component were judged to be significantly different for human health (e.g. broccoli is considered to be healthier than lettuce). The products perceived as healthy and unhealthy are described in this text as healthy or unhealthy products to indicate that the respondents distinguish them as such. The authors are aware that a product in itself is not healthy or unhealthy, but can be part of a unhealthy or healthy diet.

Attributes – Steptoe *et al.* (1995) found an association between 'healthy' and 'natural'. In this study nearly all of the products received a significantly different score on 'healthy' and 'natural', except for beefsteak, which scored the same on 'natural' and 'healthy'. For products perceived as healthy, the 'natural' score is a little less than that for the 'health' score. The unhealthy perceived products score less negative on naturalness than on healthiness. Nearly all products were perceived as nutritious; fries were regarded as neutral and ice cream as not nutritious by the respondents. Thus, in the perception of consumers, only healthy products can be nutritious.

Characteristics - The products perceived as being good for human health (broccoli, lettuce, yoghurt) were perceived more positive on 'organic' than the other products. However, the proposition about 'organic' may have confused respondents in the sense that some of them do not know what is exactly meant by this characteristic, namely refraining the use of agro-chemicals. So, probably 'organic' is interpreted in different ways. Nevertheless it is not surprising that organic is related to health according to, for example, Schifferstein and Ophuis (1998) and Torjussen *et al.* (2001).

Products sold packed in the shop, score high for 'packed'. Respondents apparently judge according to their internal standard or with the product they are familiar with in mind. It could not be tested whether 'packed' influences health perception. Apparently, the terms used for product characteristics ('packed', 'long-lasting' and 'organic') were not unambiguous enough to get insight in the relation with health perception.

Ingredients - The respondents stated that they do not eat the meal components because of their ingredients (e.g. carbohydrates, fat, protein, vitamins); the three exceptions were broccoli and lettuce (for their vitamins) and yoghurt (for its protein). Consequently, the respondents do not link the composition of the meal components to whether they eat it or not.

Affective aspects - All eight products are enjoyed when eaten and are perceived as appetizing or, in other words, appealing. Fries, ice cream and yoghurt have the highest score on appetizing. The eating of most of the products does not make the respondents happy, except for ice cream and fries, which have a neutral score. It is notable that beefsteak scores most negatively on 'making happy' compared to the other meal components. Respondents do not see a relation between a product and feeling happy; this might be different, though, if the context would be integrated into the research design.

Consumer segments - Cluster analyses based on health opinions of consumers produced four clusters of consumers: (1) healthy and not ill unrelated, (2) no interest in health, (3) feeling healthy, and (4) with health problems, with sample percentages of 21, 10, 50 and 18, respectively. The four clusters do not differ in their perception of health, attributes, characteristics, ingredients and affective aspects for the meal components. Nearly all clusters relate health and attributes; natural, fresh, nutritious and unprocessed for each meal component. But the clusters differ in their perception of health and its link to ingredients and affective aspects. More precise, the cluster 'feeling healthy' relates 'enjoy', 'happy' and 'appetizing' with health for lettuce, beefsteak, pork chops, rice and ice cream.

Conclusion

The expressive and associative group discussions proved to be a promising, fascinating and participant-friendly approach to gain an insight into the affective and the cognitive aspects that consumers relate to health-promoting product characteristics.This approach provides an insight into the aspects of a meal component that are related to health perception: not only ingredients, attributes and characteristics but also affective aspects are related to health in the perception of consumers. Health perceptions of consumers differ for target groups, products and affective aspects. So, when producing a product perceived as healthy, product features on different levels must be taken into consideration to make the product a success in the market.

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Interrelationships between consumers' attitudes, behaviour toward organic food and dietary habits

Tung, S.-J.[1]

Key words: organic food, consumer's attitude, buying behaviour, dietary habits

Abstract

This study examined the relationship between Taiwanese consumer attitudes and purchase behaviour toward organic food. A preliminary effort was made to identify the influence of consumers' socio-demographic backgrounds on the variations in their responses. The dietary habits of organic product consumers are another aspect of this study.

Introduction

With the remarkable rise of global organic agriculture, despite controversies and contradictions over the safety and quality of organic food, organic product providers and policymakers recently have focused increasing attention on consumers' attitudes and buying behavior. Studies of this issue in organic agriculture have increased in the past decade (e.g., Grunert and Juhl 1995; Rimal *et al.* 2001; Lockie *et al.* 2004; Padel and Foster 2005; Rimal *et al.* 2005; Tarkiainen and Sundqvist 2005).

To date, the relationship between consumers' attitudes and behaviour has been a concern in marketing studies with regard to consumers' lifestyle. For instance, dietary choice has a significant impact on environment and increases consumers' purchases of organic product (Lea 2005). In spite of the small body of literature linking lifestyle with consumers' attitudes and buying behaviour with respect to organic food (e.g., Grunert and Juhl 1995), this theory is useful in revealing the potential linkage between consumers' dietary habits and their buying behaviour.

In light of this information, this study makes three points. First, it investigates consumers' attitudes and buying behaviour toward organic food, and their connection as well. Second, this study identified socio-demographic factors contributing to consumers' attitudes and purchases. Finally, a profile of the dietary habits of organic food consumers was created.

Materials and methods

Adults residing in Taiwan became the target population for the sampling procedure. A state-wide telephone survey consisting of 913 randomly-selected household interviewees was implemented as the preliminary study to explore the attitudes and buying behaviour. A follow-up mail survey targeting loyal consumers of organic food was then employed to conclude a profile of their dietary habits. The later sampling frame was constructed using household lists provided by organic food stores, organic farms, and non-profit consumer associations. Four hundred and twenty-one respondents were recruited.

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Results

It is found that 78.1% of the respondents were aware of organic food, while 21.9% were not. The descriptive statistics, shown in Table 1, indicate that the general consumers' pesticide anxiety was predominant - over 90% respondents presented their worries regarding pesticides. Rather than seeking organic products, nearly two-thirds of respondents expressed extremely low faith in organic products. The willingness to pay a premium price to buy organic products, however, was high once the product was proven to be really organic. The overwhelming majority of interviewees agreed with the necessity of organic agriculture and approximately 60% were optimistic about its prospects in Taiwan. Moreover, the finding that around half of the respondents have experienced purchasing organically produced food was surprising, and must also be attributed to the ambiguous definitions of an organic product. Among buyers, merely 2.2% can be deemed as loyal.

Tab. 1: Consumers' attitudes and buying behaviour toward organic food in Taiwan

Attitude dimensions	Extreme	Fair	Rare	Not at all	No opinion
Pesticide anxiety	435 (47.6)	319 (34.9)	74 (8.2)	41 (4.5)	44 (4.8)
Trust in organic food	74 (8.1)	182 (19.9)	356 (39.0)	236 (25.8)	65 (7.2)
Willingness-to-pay	71 (7.8)	353 (38.7)	208 (22.8)	232 (25.4)	49 (5.4)
Perceived necessity of organic agriculture	469 (51.4)	332 (36.4)	19 (2.1)	2 (.2)	91 (10.0)
Perceived prospects of organic agriculture	201 (22.0)	350 (38.3)	168 (18.4)	42 (4.6)	152 (16.6)
Purchase	20 (2.2)	188 (20.6)	236 (25.8)	438 (48.0)	31 (3.4)

n=913; parenthesized are percentages (%)

A comparison of Spearman rank order correlation and pair-wise partial correlation controlling all the other variables wsa implemented to obtain genuine relationships among attitudinal and behavior variables. In terms of bi-variate relationships, most of the attitudinal variables exhibit mutually positive relationships except that between perceived pesticide anxiety and trust toward organic food. It appears that all attitudinal variables are associated with buying behavior.

When the other variables' effects are taken into account, the partial correlations present remarkable differences with regard to perceptions of pesticide anxiety and trust. On the one hand, most of the original in-between relationships with these two variables disappeared and, on the other, the correlation between perceived trust and pesticide anxiety turns out to be negative. It implies that Taiwan consumers' trust in organic food decreases as pesticide anxiety increases. What is noteworthy is that those who were most frightened by pesticide overuse do not believe in the products of alternative farming. Besides, some of the assumed relationships between attitudinal and behavioral variables cease to exist when all the other variables' influence were controlled. Among attitudinal variables, perceived pesticide anxiety and necessity evaluation do not show significant correlation with purchasing. Willingness-to-pay perception, however, is shown to have positive relationships with all the other attitudinal variables. These findings assert that though the consistencies among attitudes and behaviors are largely supported, the inconsistencies still prevail.

Tab. 2: Dietary lifestyle of organic food consumers in Taiwan

Dietary lifestyle indicators	Frequencies
Vegetarianism	1.complete 96 (23.0) 2. part 123 (29.4), 3. no 200 (47.7)
% of food that is organic	1.10% or below 61 (14.8) 2. 10-29% 105 (25.5) 3. 30-49% 104 (25.2) 4. 50-69% 68 (16.5) 5. 70-89% 41 (10.0) 6. 90% or above 33 (8.0)
Taking Chinese herbal medicine	1. always 33 (7.9) 2. at times 310 (74.2) 3. not at all 75 (17.9)
Taking vitamin or mineral supplements	1. always 66 (15.8) 2. at times 216 (51.6) 3. not at all 137 (32.7)
Smoking	1. yes 12 (2.9) 2. no 400 (97.1)
Number of days cooking and eating at home	1. none 6 (1.5) 2. 1 day 10 (2.6) 3, 2 days 22 (5.6) 4. 3 days 24 (6.1) 5. 4 days 32 (8.2) 6. 5 days 87 (22.3) 6. 6 days 77 (19.7) 7. 7 days 133 (34.0)
Percentage of raw food diet	1. 10 % or below 219 (54.3) 2 10-29% 131 (32.5) 3. 30-49% 34 (8.4) 4. 50% or above 19 (4.7)
Tea intake	1. above the average 35 (8.7) 2. on the average 73 (18.2) 3. below average 210 (52.2) 4. none 84 (20.9)
Coffee intake	1. above the average 9 (2.2) 2. on the average 25 (6.1) 3. below the average 180 (44.0) 4. none195 (47.7)
Cooking oil intake	1. above the average 10 (2.5) 2.on the average 120 (29.5) 3. below the average 276 (67.8)
Salt intake	1. above the average 7 (1.7) 2.on the average 119 (29.2) 3. below the average 281 (69.0)
Sugar intake	1. above the average 7 (1.7) 2.on the average 84 (20.5) 3. below the average 319 (77.8)

n=421, parenthesized are percentages

Several logistic regression analyses were conducted to investigate the effects of some socio-demograhic factors, presented by dummy variables, on the attitudinal and behavioral variables. All models were found to have superior model fit and goodness-of-fit. it is revealed that female respondents, higher prestige of the household breadwinner’s occupation, higher educational attainment of respondents and dining home are the most reliable indicators of buying behavior. Perceived trust of organic product and prospects of organic agriculture were proven to be significant predictors of purchasing behavior. People who possess higher faith and feel more optimistic toward organic agriculture are the most likely to purchase. It reaffirms that not all attitudinal variables are good predicators of buying behavior of organic food.

Segmenting consumers by dietary lifestyle is critical to understanding how specific consumer groups approach shopping organic food. As shown in Table 2, the recruited organic consumers are depicted as more likely to be vegetarians, reluctant to dine out, fond of raw-food diet, and likely to take nutritional supplements. Their diet is low in caffeine, salt, sugar, and oil.

Discussion

The finding that the overwhelming majority of Taiwan respondents are anxious for pesticide overuse and in the meantime extremely sceptical of organic products is of special interest for organic food consumption studies and deserves future investigation. Despite this attitudinal ambivalence, half of the respondents have purchased organic food. This phenomenon illustrates a special type of consumption culture that merits further examination and interpretation.

Conclusions

It is found that the hypothesized relationships among consumers’ attitudes and behaviour toward organic food were largely supported, with some exceptions among Taiwan residents. It has also been confirmed that consumers’ dietary habits should be incorporated into their attitudes and in predicting their purchase behaviour.

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Consumers and consumption of organic food in Central and Eastern European new member states of the European Union

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Key words: consumers, organic food, market development

Abstract

Despite the significant growth of organic farms and organically managed land in Central and Eastern European new member states of the European Union (CEE NMS) the consumption of organic food in these countries remains at a very low level. The main barriers to organic food consumption growth are low availability of organic food in the sale channels where contemporary CEE NMS consumers prefer to buy food, high prices for organic products, related, inter alia, to high distribution costs and high gross margins that reflect the undeveloped nature of organic markets in CEE NMS. Further development of the organic sector in CEE NMS will contribute to the growth of organic food consumption by overcoming the supply-related barriers. Nevertheless, to increase the consumption of organic food, many efforts needed to communicate the benefits of organic food and farming to target potential consumers.

Introduction

More than 73 million consumers live in the new European Union member states of Central and Eastern Europe, comprising nearly 15% of the total population of the EU-25 (Europe in figures 2005). Despite the differences in food consumption size and structure CEE NMS have one common characteristic – the low incomes in comparison with Western European countries. National per capita income in CEE NMS ranges between 40-70 % of the average income in the EU 15 countries before 2004. The share of expenses for food in household budgets is just over 20% in Slovenia and the Czech Republic to more than 30% in Latvia and Lithuania (Europe in figures 2005). All this affects the ability to satisfy the food needs of CEE NMS residents as well as their interest in acquiring more expensive food products that also includes organic foods. Despite the unfavourable income situation and limitations in realising consumption, the number of organic food consumers in the CEE NMS continues to increase, while knowledge on the share of organic consumers, their socio-demographic profile, behaviours and attitudes is fragmented in comparison to the EU 15 countries. The main aim of this paper is to present the attributes associated with organic food in the opinion of CEE consumers, their motives to buy organic foods and barriers to consumption of organic products.

Materials and methods

The research was divided into two stages consisting of literature review on consumer behaviour and an organic market expert survey with the use of a semi structured questionnaire. An attempt was made to estimate organic food consumption using the supply balance sheet (SBS) approach (Hamm and Gronefeld 2004). According to SBS methodology, organic food consumption could be calculated in a way where domestic organic consumption = organic sales + organic imports - organic exports. However, the lack of reliable data on primary production, and particularly, international trade, made it impossible to calculate human consumption of organic food in all CEE NMS

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using SBS. Hamm and Gronefeld (2004) obtained most sales and import data needed to estimate consumption from wholesalers and importers. In the case of CEE NMS, obtaining import and export data turned out to be very difficult due to the fact that exports were conducted incidentally and frequently without consideration of organic origin. Wholesale trade in organic foods is still in its infancy in CEE NMS and there was no information to support the identification of organic products sales. As a result, the data on organic consumption was based on estimates by national market experts. They gathered the necessary data via interviews with stakeholders representing various areas of the organic supply chain.

Results

Analysis of the available literature on consumer behaviour across the CEE NMS suggests that the three most important factors driving purchases of organic food are health, environment and taste. Research conducted among Hungarian consumers by Kovács (2003) revealed that the primary motives to buy organic food were health protection (67%), environmental protection (30%) and the desire for healthy nutrition (24%). In research carried out between 2001 and 2004 on a representative sample of Polish consumers, health concerns were mentioned as the primary motive for purchasing organic foods. Sensory values of organic foods, such as taste and smell, were subsequently mentioned in the hierarchy of motives. One of the issues emerging in the 2004 survey involved concern about GMO in food. The absence of GMO in organic food was considered an important attribute of organic food and a factor impacting the decision to buy organic food by 28% of respondents. In a survey of 295 Czech consumers, the most frequently mentioned reason to buy organic food was health (76.2%), quality (53.8%) and low contamination of organic food (49%) (Tvrdon *et al.* 2001). Research conducted in Lithuania shows that there are three main factors that impact the decision to buy organic food by Lithuanian consumers: safety, quality and taste (Rutkovienė *et al.* 2005). The analysis of CEE NMS consumer behaviour shows that among the factors having an impact on the decision to chose organic food, social and cultural aspects are relatively marginal. Consumers are motivated mainly by universal values (‘safety’, ‘health’). Organic farming and organic food have positive connotations when food safety issues come into play, a concern of contemporary consumers. Other concerns such as animal welfare were less pronounced by CEE NMS consumers. Among Polish consumers, just 5% of the 2004 survey respondents perceived organic food as ‘respecting animal welfare’.

The research on CEE NMS consumers show that besides the positive connotations on organic food, various opinions of a negative nature showed up, resulting not so much from the essence of organic food, rather its availability in the preferred sales channels, as well as the conviction it is overpriced and of poor appearance. Limited availability and high prices could be considered a barrier related to the undeveloped nature of organic markets in CEE NMS. As national market experts point out, the latter is an important factor that limits interest in buying organic food in CEE NMS. Another issue that may affect CEE NMS consumers’ interest in the purchase of organic food is the lack of confidence in the reliability of information on organic products (Zakowska-Biemans 2005). Surveys conducted on a representative sample of Polish consumers from 2001 to 2004 show that there is a high share of consumers who were not able to recognize organic food (Zakowska-Biemans 2005). Similar problems were reported by national market experts from other CEE NMS.

Despite the lack of research on preferences among CEE NMS consumers, one can assume that the existing assortment of organic food does not meet consumer expectations and the lack of efforts to promote organic farming and organic foods results, among other things, in low consumption of organic food. Even though most CEE NMS have nation-wide logos for organic food, which is a prerequisite for the organic food market to develop, these logos are not recognized by consumers due to lack of well targeted promotion. These factors, in addition to the unsatisfactory assortment, limited availability and high prices, are deemed as the primary barriers to develop the demand for organic food in CEE NMS.

The results of the market expert survey show that the share of organic consumption in total food consumption in all the CEE NMS is very low and does not exceed 1%. This includes plant and animal products. However, in the case of plant products, the share of organic consumption is higher because of better availability of such products. The highest volume of organic plant products (cereals, potatoes, vegetables, fruit) consumption was recorded in Hungary and Poland. The consumption animal products (milk, beef, pork, poultry, eggs) varies considerably among CEE NMS. The highest consumption of organic milk was observed in Poland and Latvia, but there was no data from the Czech Republic where the level of organic milk consumption could be higher than in mentioned countries since large scale processing is under development. In terms of meat consumption, the data is very inconsistent since a large proportion of pork and eggs is sold via direct sales.

When analyzing consumption data in CEE NMS, it should be also emphasised that semi-subsistence is important. Semi-subsistence is particularly important in the case of Latvia, Lithuania, Poland and Slovenia. As a result, small farms that have low market orientation designate a marginal percentage of products for sale, while most production is designated for personal needs, relatives, friends or tourists.

Discussion

There are still many barriers to overcome, related to both supply as well as demand for organic produce, in order to increase the consumption of organic products in CEE NMS. The national market experts stressed that despite growing production, a small proportion of total organic food production in CEE NMS ends up in organic domestic markets. The export (international trade) orientation still plays a very important role in CEE NMS and particularly in Czech Republic, Hungary and Poland. The low supply of organic products hampers the development of organic processing and sale channels. As a result, the assortment of domestic organic products and the availability of organic food are very poor. Another issue that appears to be a crucial factor towards further development of organic food demand in CEE NMS is the price level. The price premia for organic food in CEE NMS are high due to low supply, high distribution costs and relatively high gross margins. Zanoli *et al.*(2004) think that the barrier is not the absolute price level but rather the perceived ‘opportunity cost’ for consumers, which includes other transaction costs due to limited availability, inappropriate price-performance ratio, lack of pricing transparency, and other psychological factors such as the persistence in memory of prices for organic products. Lowering the prices of organic food in CEE NMS will not enlarge the market if there is no coherent long term strategy to communicate various attributes associated with organic food and organic farming.

Conclusions

The *conditio sine qua non* to stimulate consumption of organic food in CEE NMS is to develop appropriate policy measures that would impact both supply and demand for organic food. There is no research that characterises organic consumers in CEE NMS and there is a need to learn more about CEE NMS organic consumers’ emotions, cognition and behaviour to develop effective marketing strategies. Efforts are needed to differentiate the existing offer of organic foods by strengthening the scope and methods of organic food processing. Development of processing is crucial to stimulate the demand for organic food in CEE NMS. Nevertheless, without investment in innovative processing, it will be difficult to adjust the offer of organic food to the needs of contemporary consumers. It is necessary to communicate various aspects that affect the prices of organic products, particularly those related to organic standards, to show the benefits of organic food consumption. Moreover, to attract consumers, food attributes such as convenience can not be neglected. Further development of the organic sector in CEE NMS will support overcoming the supply-related barriers to organic food consumption growth but communication with consumers remains one of the key issues to ensure further development of organic consumption in CEE NMS.

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Quantifying the effect of organic and 'low input' production methods on food quality and safety and human health

Effects of organic and 'low input' production methods on food quality and safety

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Key words: organic farming, low input farming, ICM, biodiversity, environmental impact, food quality, health

Abstract

The intensification of agricultural production in the last century has resulted in a significant loss of biodiversity, environmental problems and associated societal costs. The use of shorter rotations or monocropping and high levels of mineral fertilisers, pesticides and crop growth regulators may also have had negative impacts on food quality and safety. To reverse the negative environmental and biodiversity impacts of agricultural intensification, a range of different 'low input' farming systems have been developed and are now supported by EU and government support schemes. A range of recent reviews concluded that switching to low input, integrated or organic farming practices results in significant environmental benefits and increased biodiversity in agro-ecosystems. Some recent studies also reported higher levels of nutritionally desirable compounds (e.g. vitamins, antioxidants, mineral nutrients) in foods from organic and 'low input' production systems compared to food from conventional systems. The increasing demand and current price premiums achieved by foods from low input and especially organic production systems were shown to be closely linked to consumer perceptions about nutritional and health benefits of such foods. However, there are other studies reporting no significant differences in composition between low input and conventional foods, or inconsistent results.

*There is currently a lack of **(a)** factorial studies, which allow the effect of individual production system components (e.g. rotation design, fertility management, crop health management, variety choice) on food composition to be assessed and **(b)** dietary intervention or cohort studies which compare the effect of consuming foods from different production systems on animal and/or human health. It is therefore currently not possible to draw overall conclusions about the effect of low input production on food quality and safety. This paper will **(a)** describe the range of organic and other 'low input' standards, certification and support systems currently used, **(b)** summarise the currently available information on effects of organic and other low input crop production systems on the environment, biodiversity and food quality, and **(c)** describe the methodologies and results from subproject 2 of the EU-funded Integrated project QualityLowInputFood. This project focused on improving our knowledge about the effect of organic and low input crop and livestock production systems on food quality and safety parameters.*

Introduction

One important reason for the increasing demand for foods from organic and low input production systems is the environmental, biodiversity and animal welfare benefits associated with these systems. Crop and livestock production in much of Western and Central Europe underwent major changes during the second half of the 20th century as

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a result of the intensification of agriculture (Stoate *et al.*, 2001; Pyšek *et al.*, 2005). In crop production, there was an increase in the use of water soluble, mineral N, P and K fertilisers and chemosynthetic crop protection products (herbicides, pesticides and fungicides and growth regulators). This coincided with the development of new crop varieties with higher yield potential especially under high input conditions (e.g. winter wheat varieties, which produced shorter stems and higher yields, due to the introduction of dwarfing genes) (Borojevic 2005; Verma *et al.* 2005). In addition, the diversity of cropping systems was reduced, with fields merged into larger units, field margin vegetation reduced, and shorter and less diverse rotations or even mono-cropping systems introduced. Also, spring sown arable crops were increasingly replaced by winter crops (Stoate *et al.*, 2001; Pyšek *et al.*, 2005). These changes resulted in significant increases in crop yields and certain quality characteristics (e.g. protein content and baking quality in wheat) (Borojevic 2005; Verma *et al.* 2005).

However, more recently a range of negative environmental impacts and associated societal costs of 'high input' production systems have been identified. These include **(a)** increased surface and ground water pollution from leaching and/or run-off of mineral N and P fertilisers and chemosynthetic crop protection products (Porter *et al.* 1993; Drinkwater *et al.* 1998; Stolze *et al.* 2000; PAN 2002), **(b)** reduced biodiversity of bird, invertebrate and non-crop plant populations in agricultural eco-systems (Eggers 1984; Stoate 2001; Bengtsson 2005; Critchley *et al.* 2004&2006; Pyšek *et al.*, 1991 & 2005; Berry *et al.* 2005; Fuller *et al* .2006) **(c)** a contribution to the depletion of the atmospheric ozone layer by the soil disinfectant methyl-bromide (Butler *et al.* 2002) and **(d)** increased energy use and associated CO_2 carbon emissions (Helsel 1992; Fluck 1992; Dubois *et al.* 1999; Cormack 2000; Pretty *et al.* 2002).

The impacts of agricultural intensification of the environment can also be linked to negative effects on important agronomic parameters. For example, there is increasing evidence that soil biological activity, organic matter content, structural stability/erosion resistance and inherent fertility (level of yield obtained per unit fertiliser input) has decreased in soils used for 'high input' crop production (Matson *et al.* 1997; Reganold *et al.* 1987&2001; Fließbach & Mäder 2000; Mäder *et al.* 2002; Hartmann 2006). Natural ecological/biological processes that increase the availability of mineral nutrients in soil (e.g. nitrogen fixation, and P and micronutrient uptake via symbiotic mycorrhizal fungi) and protect crops against pests and diseases (e.g. natural enemies of pests and antagonists of soil borne diseases) were also shown to be inhibited by specific agrochemical inputs (Mallarino & Wedin 1990; Sattelmacher *et al.* 1991; Ledgard & Steele 1992; Høgh-Jensen & Schjørring 1997; Whalen *et al.* 1998; Esjberg *et al.* 2002; Oehl *et al.* 2003; Hartmann 2006).

In livestock production, there has been an increase in 'indoor' production systems, stocking densities, flock sizes and feeding of energy and protein concentrate feeds. This has been accompanied by an increase in the use of veterinary medicines and growth promoters (e.g. antibiotics, anthelmintics), and pesticides (e.g. organophosphorus sheep dips) throughout the developed world, and animal growth hormones in North America (Vaarst *et al.* 2004; Diaz-Gonzalez 2007; Hirt & Zeltner 2007; Sundrum 2007; Biavati & Santini 2007; Klocke & Walkenhorst 2007; Weller *et al.*2007). The increase in external input use paralleled changes in the type of livestock breeds (e.g. a rapid expansion in the use of Holstein Friesian genotypes at the expense of local/traditional breeds) and breeding strategies (e.g. the introduction of hybrid breeding programmes in pork and chicken production)(Vaarst *et al.* 2004; Hirt & Zeltner 2007)

These changes resulted in significant increases in the productivity of animals (e.g. liters of milk per cow; numbers of eggs per laying hen), and in livestock output per unit land area. The intensification of livestock production was also associated with reduced lifespan for many types of livestock, due to animals reaching slaughter weights, becoming non-productive or showing reductions in fertility earlier (Younie & Wilkinson 2001; Vaarst *et al.*2004).

In addition, the intensification of livestock production systems resulted in significant environmental burdens, such as erosion, overgrazing, nutrient pollution and increased animal health and welfare problems (Vaarst *et al.* 2004; Cooper *et al.*2007)

A range of 'low input' production strategies/standards/schemes have been developed to reverse or minimise the negative environmental, biodiversity and animal welfare impacts of intensification. These can be divided broadly into 3 groups **(a)** organic farming standards (EU 1991 & 1997), **(b)** integrated/low input and/or animal welfare based standards/certification schemes (e.g. Farm assured, LEAF 2006, GAP, Nature's choice, free-range) (EFSIS 2006, LEAF 2006, Eurepgap 2006, TESCO 2006) and **(c)** government agri-environment schemes/standards (e.g. UK countryside stewardship scheme, Swiss Verordnung über die Direktzahlungen an die Landwirtschaft) (DEFRA 2006a&b; Swiss Federal Office for Agriculture 2006). It should be noted that there is some overlap between organic and other 'low input' certification schemes under **(a)** and **(b)** and government agri-environment schemes. Most importantly organic and integrated quality assurance schemes often qualify for support payments under government agri-environment schemes. However, the level of restrictions on the use of 'inputs' (e.g. mineral N and P fertilisers, chemosynthetic pesticides, plant growth regulators) and level of definition/prescription of production practices (e.g. tillage, cropping systems/rotations, field margin/non-crop vegetation management) that need to be introduced to counteract/reverse negative impacts of intensification differ between certification schemes and standards.

Another main reason for the increasing demand for 'low input' foods and the price premiums achieved by organic foods, is the consumer perception that they are 'healthier', 'more nutritious', 'tastier' and 'safer' than foods from intensive conventional production systems (Anonymous 1998, Oughton & Ritson 2007). However, until now scientific investigations have not been of sufficient scale and design to provide a definitive understanding of the extent to which agricultural production systems affect these qualities (Woese *et al.* 1997; Brandt & Mølgaard 2001; Anonymous 2002; Cooper *et al.* 2007). Also, there are currently no organic or 'low input' production standards and/or government support schemes that focus specifically on reversing potential negative impacts of agricultural intensification on the nutritional and sensory quality and safety of foods.

The **main aim** of subproject 2 of the Integrated Project QualityLowInputFood (QLIF, www.qlif.org/) is therefore:

- to quantify the effect of organic and 'low input' prodction methods on food quality and safety and human/animal health impacts associated with the consumption of foods/feeds from low input systems

Subproject 2 was subdivided into 3 main workpackages (WPs) which in turn focused on the following **specific objectives**:

WP 2.1 Effect of crop management practices (organic, 'low input' and conventional) on the nutritional quality of foods

WP 2.2 Effect of livestock management practices (organic, 'low input' and conventional) on the nutritional quality and safety of foods

WP 2.3 Effect of organic food consumption on livestock and human health

The background and current 'state of the art' with respect to these objectives is described in separate sections below.

WP 2.1 Effect of crop management practices (organic, 'low input' and conventional) on the nutritional quality of foods

In European and North American diets, foods derived from crop plants contribute substantially to satisfying the recommended dietary intake of some essential minerals (Ca, Mg, Fe, Se, Cu, Zn, etc.) and vitamins (vitamin C, beta-carotene, folate etc.). It was also shown that supplementation of foods with the same compounds in the form of pills does not provide the same benefits to health as increasing the intake of the plant foods (Pool-Zobel *et al.* 1997). There is also a growing consensus that increased consumption of whole grain cereals and fresh vegetables and fruit will improve human health in many developed countries (e.g. Ness & Powles 1997; Veer *et al.*, 2000; Michels & Wolk 2002; Liu *et al.*, 2003; Hannum 2004; Seal 2006).

However, there is still controversy about which compounds in plants are responsible for the beneficial health impacts associated with increased fruit and vegetable consumption. Crops contain secondary metabolites (e.g. phenolics, glucosinolates, other organic sulphur compounds, sesquiterpene lactones, fructans) which have beneficial physiological/pharmacological properties such as anti-neoplasia, antioxidant and anti-allergic effects, platelet aggregation inhibition, interference with cancer promotion mechanisms and pro-biotic activity (Wattenberg *et al.*, 1980; Frankel *et al.*, 1993; Rice-Evans *et al.*, 1996; Bernart *et al.*, 1996; Waterhouse *et al.*, 1998; Kim *et al.*, 1999; Hecht 1999; Ernst & Feldheim 2000). These compounds are therefore thought to be involved in the well documented beneficial effects of vegetable consumption on health (Pool-Zobel *et al.*, 1997; Ness & Powles 1997; Van Poppel *et al.*, 1999; Veer *et al.*, 2000; Greenvald *et al.*, 2001; Briggs *et al.*, 2001). However, there is little knowledge about the relative nutritional value of individual compounds in plant foods, when they are eaten as part of a typical European or North American diet. Many of these compounds are also important for the sensory quality of fruit and vegetables, in particular the secondary metabolites, which define characteristic flavours, aromas and colours of each product. However, there are only a very small number of sound scientific studies comparing sensory quality between organic and conventional crops (Mäder *et al.*, 1993; Reganold *et al.*, 2001; Brandt & Mølgaard 2001; Wszelaki 2005)

On the other hand, crop plants may contribute significantly to the intake of a range of undesired compounds, which are considered hazardous if consumed in too high quantities. This includes nitrate (> 60% of nitrate is taken up with cereals and vegetables) (McKnight *et al.* 1999; Leifert 2000), heavy metals (e.g. lead and cadmium) (Karavoltsos *et al.*, 2002; Shimbo *et al.*, 2001), pesticide residues (Baker *et al.*, 2002; Benbrook 2002) and mycotoxins (Schollenberger *et al.*, 1999; Obst *et al.*, 1998). Some secondary plant metabolites are also known to have negative impacts on health when they occur in too high concentrations, e.g. glycoalkaloids, glucosinolates and polyacetylenes (Rosa *et al.*, 1998).

Many compounds mentioned above show substantial variations in content in comparable foods, and several hypotheses have been published on how the production system, in particular organic farming as compared with conventional farming, could affect nutritional value and/or other qualities (e.g. Avery 1998; Trewavas 2001 & 2004; Brandt & Mølgaard 2001).

Several studies and reviews have indicated systematic differences in concentrations of minerals, essential amino acids, vitamins, secondary metabolites and mycotoxins in crops produced in different production systems (conventional, 'low input' and/or organic) or specific components (e.g. fertility practices) of such systems (Leclerc *et al.*, 1991; Pither 1990; Woese *et al.*, 1997; Mayer 1997; Schollenberger *et al.*, 1999; Ren *et al.* 2001a; Birzele *et al.*, 2002; Asami 2003; Lombardi-Boccia 2004). Sensory and technical quality has also been shown to vary with production system (Mäder *et al.*, 1993; Weibel *et al.*, 2000; Reganold *et al.*, 2001; Pedersen *et al.*, 2001). However, other studies report no significant differences or inconsistent results (Basker 1992; Jorhem & Slanina 2000; Fjelkner-Modig *et al.*, 2001; Malmauret *et al.*, 2002; Bourn & Prescott 2002; Carbonaro *et al.*, 2002). Also, many of these studies did not use organic and conventional samples matched for potentially confounding factors such as variety, area of origin, soil and climatic conditions during production and/or length of storage, which are also known to affect the chemical composition of crops (Locasio *et al.*, 1984; Vogtmann *et al.*, 1993; de Meeus *et al.*, 2002; Asami 2003). Furthermore, many studies did not take into consideration the considerable variation in agronomic practices within each cultivation system (Brandt & Mølgaard 2001).

On the other hand, concerns were raised by scientists about increased health risks associated with enteric pathogen transfer and contamination with noxious compounds (e.g mycotoxins or heavy metals) in organic and ‘low input’ production systems associated with the use of animal manures and omission of pesticides (e.g. Trewevas 2001, Finamore *et al.*, 2004). There is currently insufficient data to substantiate or dismiss these concerns, and there is therefore a need for controlled experiments to identify and quantify mycotoxin and enteric pathogen contamination risks in different crop production systems.

It is known that deleterious effects of toxicants can be either enhanced or reduced by other compounds, but most possible interactions are unknown, and with today’s knowledge it is impossible to predict the resulting effect on health when the levels of many different compounds change simultaneously (Furst 2002).

From the currently available information, it is therefore not possible to conclude to what extent overall production system and specific production system components affect the content of nutritionally relevant compounds in crops. However, even relatively small systematic differences in food composition can have significant effects on health. For example a 20% increase in the most important health promoting compounds in vegetables was calculated to correspond to an increase in vegetable consumption from 250g/day to 300 g/day, which would lead to 6 months longer life expectancy (Gundgaard *et al.* 2002, using data from Veer *et al.* 2000). It is therefore essential to establish long-term factorial experiments which minimise confounding factors and allow the effect of principal production system components (rotation design, soil management, fertilisation and crop protection methods) to be identified.

In the QLIF-IP such experiments were established as part of WP 2.1 and focused on identifying the effect of, and interactions between, four principal production system components (rotation design, fertilisation regimes, crop protection practices and variety/rootstock choice) on **(a)** crop yield, **(b)** pest, disease and weed pressure (and associated need for crop protection inputs) and **(c)** crop quality parameters (including contents of mycotoxins, pesticide residues, minerals, vitamins, antioxidants and other secondary plant metabolites). Experiments used factorial designs thus allowed interactions between factors to be identified (see e.g. Leifert *et al.* 2007). However, they also allowed comparisons to be made about the effect of growing crops according to organic, low input and conventional standards, on crop yield, health, quality and safety parameters.

Work under WP 2.1 focused on arable (wheat, potato), field vegetable (cabbage, lettuce, onion) and greenhouse crops (tomato). In associated studies that were not part of the QLIF project barley, wheat and carrots were studied. Work on specific commodities under WP 2.1 was closely integrated with workpackages under subproject 3 aimed at improving organic and low input production systems for wheat (WP 3.5.2), lettuce (WP 3.4) and tomato (WP 3.3.2, WP 3.5.3)(see also summary paper and WP-specific papers for subproject 3).

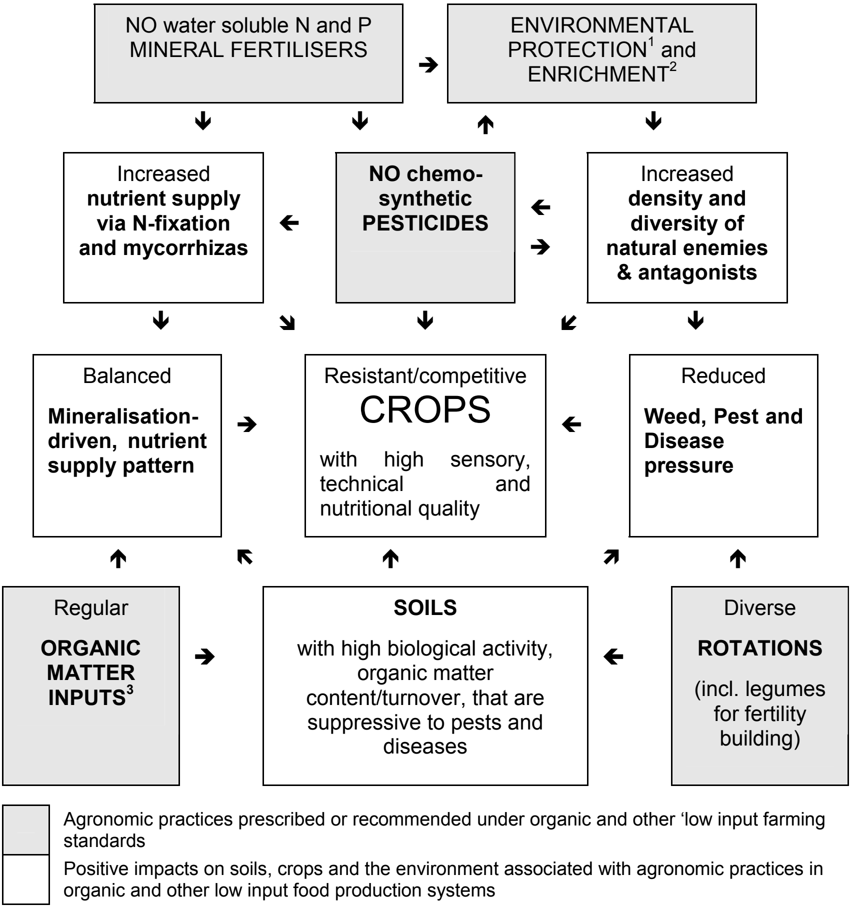
Complete data sets from 2 field seasons are now available for some commodities (e.g. wheat, potato and tomato) and some results have been reported (see Lehesranta *et al.*2007; Cooper *et al.*2006 and these proceedings; Lueck *et al.*2006 and these proceedings; Giotis *et al.*2006; Theodoropoulou these proceedings).

One of the main overarching results was that mineral, mycotoxin, protein and secondary metabolite levels and composition can be significantly affected by one or more of the four main production system components (rotation design, fertilisation regime, crop protection practice and variety/rootstock choice) included in studies. For example, protein profiles in potato were only significantly affected by fertility management, while crop protection practices and rotational position (whether potato were grown after wheat or grass clover) had no significant effect (Lehesranta *et al.* 2007). On the other hand, protein content in wheat was significantly increased by conventional fertility management, but reduced by conventional crop protection practices (C. Leifert unpublished). For a range of compounds plant analyses showed significant interactions between crop protection (use or non use of chemosynthetic pesticides) and fertilisation practices (fertilisation based on organic matter or chemosynthetic mineral NPK fertilisers).

In several cases, such interactions resulted in low input systems (which omitted either mineral fertiliser or pesticide use compared to conventional systems which used both) showing the highest level of undesirable compounds (e.g. mycotoxin loads and pesticide residues in wheat; Lueck *et al.*these proceedings). This indicates that with respect to certain quality parameters, foods produced in 'integrated' or 'low input' crop protection systems are inferior to both organic and conventional systems.

For one processing quality parameter (protein content in wheat, which is closely correlated to bread making quality) studies under WP 2.1 consistently showed lower levels in the organic compared to the conventional production systems. However, studies under WP 3.5.2 showed that the use of long-straw wheat varieties and improved management of grass-clover leys preceding wheat crops can increase both yields and protein levels of bread making wheat (see Wilkinson *et al.* 2006 and Wilkinson *et al.* 2007 in these proceedings).

Also, in some crops (e.g. cereals), the use of mineral fertiliser based fertilisation regimes increased the susceptibility of plants to diseases (e.g. powdery mildew, lodging and *Fusarium* spp.), while the same disease remained at very low levels when organic fertility management practices were used (see Cooper *et al.*2006 and these proceedings for further information). This supports the hypothesis that the use of highly water soluble, and therefore readily plant available, mineral fertilisers (especially N-fertilisers) will increase the need for the use of pesticides and other crop protection products. Crop protection products such as chlorocholine chloride (CCC) have also been shown to result in significant residues in crops (see Lueck *et al.* these proceedings) and have been shown to potentially have negative effects on animal health (Sorensen *et al.*2006; Benbrook 2002 & 2007). This provides further evidence for the hypothesis that increased mineral fertiliser use results in an increased need to use chemosynthetic pesticides and thereby indirectly affects human health.



↓↘↙↑←→↖↗ = positive effects or impacts

1 measures to minimise pollution (e.g. N-leaching and P-run off) and soil erosion events associated with agricultural activities (e.g. non-cropped field margins, fertility catch crops)

2 measures taken to increase biodiversity on farms (introduction of non crop vegetation e.g. woodlands, hedges, non-cropped field margins, beetle-banks)

3 animal and green manures, manure and waste based composts etc.

Figure 1. Logical Framework for Organic (and other ‘low input’) crop production systems (redrawn with permission from Leifert *et al.* 2007)

Although complete data sets are not yet available for many of the crops included in trials under WP 2.1, the data collected so far support the underlying ecological hypotheses and the logical framework (see Figure 1) that forms the basis for organic crop production principles and standards (see e.g. Niggli 2007).

WP 2.1 is closely integrated with other WPs under subproject 2. For example, it provided samples/materials for the investigations into the effect of consumption of foods from organic and conventional farming systems on pig-reproductive health (WP 2.3.1), and immune status in experimental rats (WP 2.3.2). First results from these studies are also included in these proceedings (Baranska *et al.*, Rembialkowska *et al.* and Soerensen & Højsgaard in these proceedings).

WP 2.2 Effect of livestock management practices (organic, 'low input' and conventional) on the nutritional quality and safety of foods

Results from recent surveys in some European countries suggest that livestock products (e.g. milk meat, eggs) from organic and 'low input' livestock production systems result in an **(a)** improved nutritional composition (e.g. Hirt &Zeltner 2007; Weller *et al.*2007)**, (b)** lower levels of veterinary medicine (e.g. antibiotic, anthelmintic) use (e.g. Klocke *et al.*2007; Maurer *et al.*2007) and **(c)** a reduced risk for development of antibiotic-resistant faecal *E.coli* (e.g. Hoyle *et al.*2004) and **(d)** reduced risk of faecal E. coli O157 shedding in the faeces (Diaz-Gonzalez 2007).

On the other hand, concerns were raised by scientists about increased risks of enteric pathogen transfer associated with extensive outdoor livestock rearing systems and the use of animal manures from such systems (e.g. Trewavas 2001, Finamore *et al.*, 2004). Although no scientifically sound scientific evidence were presented it is important to assess whether or not such concerns are justified.

WP 2.2.1 Effect of dairy management practices (organic, 'low input' and conventional), and nutritional regime on the nutritional quality, health status and shelf life of milk

Surveys into the nutritional quality of livestock products (e.g. milk, meat) have indicated that there may be significant differences in nutritional composition, taste and shelf life between organic, 'low input' and conventional systems (Fedele *et al.*2001; Nielsen *et al.*2002; Butler *et al.* 2006 and these proceedings). In particular, differences in livestock feeding regimes appear to affect the composition of nutritionally relevant components in milk. This includes the fatty acid composition (Dewhurst *et al.*, 2003; Ellis *et al.* 2006) and the content of conjugated linoleic acid (CLA) (Chilliard *et al.*, 2001; Bergamo *et al.* 2003), which has been linked to a reduced risk of obesity in humans (Riserus *et al.*, 2001). Animal products with a high content of polyunsaturated fatty acids, CLA, antioxidants such as carotenoids and vitamin E (compounds which are often increased in milk from fresh grass forage fed animals) are preferable from a nutritional point of view, but the same compounds make the food more susceptible to oxidation, resulting in a greater risk of accumulation of undesirable off-flavours (Hemingway, 1999**,** Nielsen *et al.*,2002; Butler *et al.* 2006; Hirt & Zeltner 2007; Sundrum 2007).

However, there is limited information on the relative importance of specific production system components (breed, feeding and veterinary regimes, husbandry methods) for differences in quality observed between production systems. In particular, previous surveys within one country led to opposing conclusions about differences between organic and conventional milk quality (Lund 1991; Fedele *et al.*2001; Toledo *et al.* 2002). This result reflects regional variations in the degree of similarity of management practices between organic and conventional farmers (Butler *et al.*these proceedings).

QLIF studies under WP 2.2.1 clearly demonstrated that milk from organic and low input, grazing-based dairy production systems have significantly higher levels of the nutritionally desirable unsaturated fatty acids: vaccenic acid, conjugated linoleic acid and α-linolenic acid (the main omega-3 fatty acid found in milk) when compared to milk from conventional production systems (Figure 2, Butler *et al.* 2006; these proceedings and unpublished). On the other hand levels of nutritionally undesirable saturated fatty acids were significantly lower.

Levels of fat soluble antioxidants (α-tocopherol, β-carotene, lutein and zeaxanthine) were also found at significantly higher levels in milk from organic and low input production systems. Apart from being linked to potential positive health impacts in humans, these antioxidants are also known to be important for animal health (e.g. protection against mastitis) and to prevent the development of off-flavours in milk and dairy products (Bergamo *et al.* 2003; Butler *et al.* 2006; these proceedings). It is interesting to note that the proportion of cows treated with antibiotics against mastitis was significantly lower in organic and low input herds compared to the conventional herds included in the study (Butler *et al.* 2006; these proceedings and unpublished).The level of difference between organic and conventional production systems differed between European countries and was greatest in the UK and smallest in Italy (Butler *et al.* unpublished).

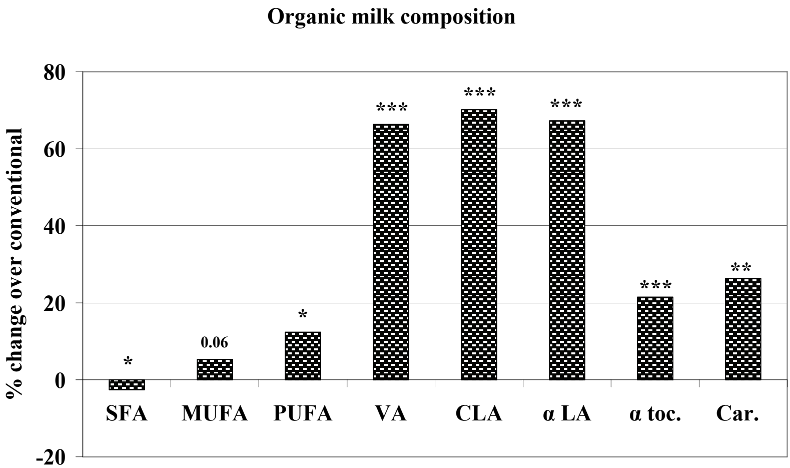


Figure 2. Composition of milk from organic farms, relative to that from conventional farms. SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; VA, vaccenic acid; CLA, conjugated linoleic acid; α LA, alpha linolenic acid; α toc, α-tocopherol; Car, carotenoids. ANOVA p values for the difference between organic and conventional milk: * p<0.05. ** p<0.01. *** p<0.001.

When associations between production system components (dietary regimes, breeds and health parameters) were investigated via multivariate analyses feed composition (the levels of grazing, conserved forage and concentrate feeds used) were found to be most closely related to milk composition, but breed also had an effect (Butler *et al.* 2006; these proceedings and unpublished).

For **dairy production systems** the data collected so far provide further support for the underlying ecological hypotheses and strategies to guarantee animal welfare and product quality (e.g. the focus on maximising outdoor grazing periods and basing ruminant diets on forage, rather than energy of protein concentrate feeds), that form the basis for organic livestock production principles and standards (see e.g. Niggli 2007).

WP 2.2.3 Effect of pig management practices (conventional, 'low input' and organic) and transport on the risk of pathogen shedding at slaughter.

The shedding of enteric pathogens by livestock at slaughter poses a significant risk for the transfer of pathogens into the food chain (Hald *et al.* 1999; Isaacson *et al.* 1999). Recent studies showed that the proportion of pigs from organic production systems testing positive for antibodies against *Salmonella* was not different from pigs reared in indoor production systems, while the proportion of antibody positive pigs tended to be higher in conventional free-range production systems (Hald *et al.* 1999). However, the methodologies (test for *Salmonella* antibodies) used in this and similar studies may not have accurately reflected pathogen transfer risk (Jones *et al.* 2001). For example, when livestock test positive for antibodies against specific enteric pathogens, this may not be associated with high levels of pathogen shedding in the faeces which is a more objective indicator of pathogen transfer risk. The presence of antibodies could on the contrary (i) indicate that the animal has acquired immunity through exposure to the pathogen at an early development stage and (ii) be associated with low levels of pathogen shedding. Certain feeding regimes and stress associated with transport of livestock have also been shown to increase pathogen shedding in pigs (Brunsgaard 1998; Isaacson *et al.* 1999).

In the QLIF IP these deficiencies in knowledge studies are being addressed under WP 2.2.3 which focuses on identifying if and how production systems affect the risk of pathogen shedding associated with the high frequency of exposure to enteric pathogens in free-range production systems.

First results indicate that the antibody tests used to estimate pathogen transfer risk do not give a true reflection of the level of *Salmonella* shedding at slaughter. In fact pigs from organic production systems which show a higher level of positive results in the Salmonella antibody test (indicating exposure to the pathogen on farms) showed lower levels of faecal *Salmonella* contamination at the farm and at slaughter (see Bonde & Soerensen these proceedings).

WP 2.3 Effect of organic food consumption on livestock and human health

Consumer demand for foods produced using organic, and to a lesser extent other 'low input', crop production methods has increased rapidly over the last 20 years (Anonymous 2002b; Weir & Calverly, 2002; Hamm *et al.*, 2002). Characteristics known to be associated by consumers with crop foods from 'low input' production systems (and in particular certified organic systems) include 'healthier', 'tastier', 'GM-free', and/or 'protective of the environment and biodiversity' (Kuznesof & Ritson, 1996; Schifferstein & Opuis, 1998; Goodman & Du Puis, 2002; Lockie *et al.*, 2002; Sanalidou *et al.*, 2002; Zanoli & Naspetti, 2002; Verhoog *et al.*, 2003). Perceived health benefits associated with organic foods are mainly based on the prohibition of the use of chemosynthetic pesticides, plant and animal growth regulators and many food additives (e.g. colourings; hydrogenated fats, processing aids and preservatives) and the prescribed minimum use of veterinary medicines (Hamm *et al.*, 2002; Zanoli & Naspetti, 2002; Verhoog *et al.* 2003). While some physiological effects of foods produced in different production systems can be assessed in *in vitro* experiments or other single factor studies (e.g. Ren *et al.* 2001b; Grinder-Pedersen *et al.*, 2003; Caris-Veyrat *et al.*, 2004; Finamore *et al.*, 2004), the fundamental question remains whether or not the combined effects of the various differences between farming systems can result in significant overall changes in the nutritional composition of food that are relevant for human health. It is therefore thought to be important to investigate the impact of organic, low input and/or conventional food consumption on farms and in experimental animal models that can indicate the potential for human health impacts.

Under WP 3.2 two separate studies were carried out to provide additional information on the potential effects of consumption of organic and low input foods on animal and human health:

WP 2.3.1. Effect of chlorocholine chloride (CCC) residues in feed wheat on pig reproductive health/ performance

WP 2.3.2 Effect of feeding cereals and vegetables produced in organic, low input and conventional production systems on the immunological status of rats

WP 2.3.1. Effect of ChloroCholine Chloride (CCC) treatments of feed wheat on pig reproductive health/ performance

Consumer concerns about residues of chemosynthetic pesticides and plant growth regulators, (PGRs) continue to be a main driver for the increase in demand for foods from organic and other low input systems. However, while it has been shown that crops from organic and low input systems contain no or reduced levels of pesticide/PGRs (e.g. Baker *et al.*, 2002, Lueck *et al.* these proceedings), there is substantial controversy about potential health impacts of residues from the currently permitted crop protection inputs. While certain groups of pesticides that were used widely in the past (e.g. organochlorines, methyl-bromide) have been associated with negative environmental and/or health impacts (Laseter & Rea 1983; Sterling & Arundel 1986; Stephens *et al.*, 1995; Høyer *et al.*, 1998; Thielemans *et al.*, 1999; Garry *et al.*, 1996; Mensink & Katan 1990; Fuglsang *et al.*, 1993; Faustini 1996; Charlier *et al.*, 2003), pesticide regulators and many scientists argue that these problems have been addressed by subsequent prohibition or restrictions on the use of the particular pesticides. However, there is still concern about some substances which are still permitted for use (e.g. organophosphorus carbamate compounds), additive effects of pesticide mixtures and/or mixtures of pesticides and other agrochemicals, and/or recently introduced compounds and their combinations that may have as yet unidentified negative effects on health (Porter *et al.*, 1993; Boyd *et al.*, 1990; Ohlo 1999; Porter *et al.*, 1999; Eskenazi *et al.* 2000; Thiruchelvam *et al.*, 2000; Schreinemachers 2000; Alavanja *et al.*, 2003; Curl *et al.*, 2003). In particular the potential role of pesticides and plant growth regulators in the increasing incidence of allergies, behavioural disorders and reproductive problems is still considered an open question by some scientists (Alm *et al.*, 1999; Porter *et al.*, 1999; Tanaka *et al.*, 2001; Holsapple 2002; Luebke 2002; Wade *et al.*, 2002).

In the QLIF IP this issue was addressed in an animal study under **WP 2.3.1**. Different to other animal models where negative effects of CCC on reproductive health were clearly demonstrated (Sorensen *et al.* 2006), the studies carried out under WP 2.3.1 could so far not detect a significant effect of CCC residues in wheat on pig fertility. This is described in detail in the paper by Sorensen & Højsgaard in these proceedings.

WP 2.3.2 Effect of feeding cereals and vegetables produced in organic, low input and conventional production systems on the immunological status of rats

There have been a small number of studies, which tested the effect of organic and conventional foods on health bio-markers in animal tissues, and dietary intake and bio-availability of specific compounds (e.g. flavonoids, antioxidants) in humans. For example, a study using rat intestinal and splenic lymphocyte proliferation capacity as a bio-marker for toxic compounds in feeds, showed that rats fed conventional wheat had significantly lower lymphocyte proliferation activity than rats fed organically grown wheat, even though the organic wheat sample used had higher levels of mycotoxins (Finamore *et al.*, 2004). A Danish cross-over intervention study showed that human subjects given specific diets composed of organic foods had a 40% higher intake of flavonoids, but findings were inconclusive with respect to bio-availability and physiological health impacts (Grinder-Pedersen *et al.*, 2003). In a French study tomato paste made from organic tomatoes was found to have higher concentrations of vitamin C and lycopene than paste made from conventional tomatoes, but there were no differences in the plasma levels of these compounds in a short-term intervention study in which volunteers were fed tomato paste made from organic and conventional tomatoes (Caris-Veyrat *et al.* 2004).

There are virtually no sound data from medium or longer term dietary intervention studies with animal models or humans, that compare the health effects of food produced in organic, low input and conventional production systems. The main reason for this lack of data is the logistical difficulty in ensuring continuous, standardised food supplies for matching organic, low input and/or conventional groups in diet intervention studies.

Also, virtually all existing cohort studies were designed primarily to quantify the effect of dietary composition on health, and not to identify the impact of foods produced by different production systems. The difficulties of identifying the effect of organic and conventional food consumption on human health in cohort type studies was shown by the recent EU-Parcival study which compared the incidence of allergies in children from families following an anthroposophical lifestyle (which involves a higher level of organic food consumption) and standard lifestyle (which involved a significantly lower level of organic food consumption (Alm *et al.*, 1999). While the incidence of allergies was significantly (around 50%) lower in children from families following an anthroposophical lifestyle, this could not be clearly linked to organic food consumption, due to a wide range of other lifestyle differences between the 2 groups (e.g. lower levels of antibiotic, aspirin/paracetamol and MMR vaccination use, higher incidences of measles, and longer breast feeding in the anthroposophical group) (Alm *et al.*, 1999) In another study the reproductive health of members of an organic farmers' association was found to be better than that of 3 control groups, but it remained unclear to what extent this was due to organic food consumption (Abel *et al.* 1994; Jensen *et al.* 1996).

Clearly, to address the fundamental question of whether consumption of food from organic and/or other 'low input' systems has a positive effect on health will require the establishment of new, well designed animal model or human dietary intervention studies (that test well defined hypotheses with respect to the effect of specific food compounds on specific health parameters) and/or long-term cohort studies.

In the QLIF IP further knowledge in this area was generated by **WP 2.3.2**. Initial results are described in detail in two papers in these proceedings (see papers Baranska *et al.* and Rembialkowska *et al.* in these proceedings). They indicate some differences in immune system activity between rats provided with diets based on organic, low input and conventional crops from the field experiments established under WP 2.1. However, there also appear to be interactions with both animal age and sex with respect to the effect of different feeds on immunological status.

Conclusions

While clear benefits from producing foods under organic and/or low input production standards have been identified for certain commodities (e.g. wheat and dairy products) further investigations are required to confirm these results and trends can currently not be generalised to all crop and livestock commodities.

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Effect of organic, low-input and conventional production systems on pesticide and growth regulator residues in wheat, potato and cabbage

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Key words: organic cropping system, low-input cropping system, factorial systems comparison experiment, Chlormequat, Aldicarb, Chlorothalonil

Abstract

The Nafferton factorial systems comparison (NFSC) experiments facilitate the investigation of effects of, and interaction between, three production system components - a) rotational position, b) fertility and c) crop protection management - in organic, conventional and low-input crop management systems. This paper presents first results on pesticide and growth regulator residues observed over a period of two years. Residues were only detected for three (Chlormequat, Chlorothalonil and Aldicarb) of the 28 pesticides used in the experiments. As expected, residue levels were affected by the crop protection practices, but significant effects of fertility management practices were also detected. This indicates that the human health risks associated with pesticide residues may increase in low input systems which attempt to reduce the environmental impact of conventional farming systems by switching to organic matter based fertilisation regimes.

Introduction

Crops from organic cropping systems have been shown to contain no or lower levels of pesticide residues (e.g. Woese *et al.*, 1997). However, less is known about the pesticide residue levels in other ‘low input’ or integrated cropping systems that focus on reducing (or omitting) mineral N, P and K fertilisers and/or chemosynthetic pesticide inputs. Also it is currently not clear to what extent fertility management and crop protection measures interact in these new low-input systems with respect to levels of pesticide residues.

Chlormequat is the most commonly used growth regulator in conventional agriculture. Recently it has been shown that chlormequat impairs fertility in male and female pigs when fed with chlormequat contaminated grain (Sorensen and Danielsen, 2006). Aldicarb is a carbamate insecticide, which has a high level of acute toxicity to humans through cholinesterase inhibition. It is readily absorbed through the gut and skin, soluble in water and has a half life of one to two weeks (Risher *et al.*, 1987). It is detected as Aldicarb, Alidcarb sulfone and Aldicarb sulfoxide. Chlorothalonil is a broad spectrum fungicide that has been shown to be carcinogenic in rodents and is also suspected to be carcinogenic in humans (Wilkinson and Killeen, 1996).

The aim of the study presented here was to describe the effect of crop protection and fertilisation regimes on residues of chemosynthetic pesticides and growth regulators.

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Materials and methods

The Nafferton factorial systems comparison (NFSC) experiments were established to investigate effects of, and interaction between, three production system components - a) rotational position, b) fertility and c) crop protection management, that differ between organic, low input and conventional production systems. These long-term experiments were established in 2001 on a field with a uniform sandy loam soil at the University of Newcastle's Nafferton Experimental Farm, near Stocksfield, Northumberland, UK. Four separate experiments, each including two principle crop rotations (one typical for organic farming systems and one typical for conventional farming systems in North East England) have been established. In each experiment the rotational sequence starts in a different year to allow results from a variety of crops to be obtained in the same cropping year. The main crops in the NFSC experiments are wheat, barley, potatoes, cabbage, lettuce and onions. The experimental design is a split-split-split plot design with crop rotation as the main factor and crop protection and fertility management as the sub-plot and sub-subplot factors respectively (Leifert *et al.*2007). Conventional crop protection (CON) is applied according to the British Farm Assured (FAB) standards, and organic crop protection (ORG) according to Soil Association organic farming standards. Under conventional fertility management mineral fertiliser inputs (MIN) are applied, and composted manure inputs (MAN) under organic fertility management (Leifert *et al.*2007).

The analysis of pesticide residues in the experiment was performed by the Institute of Chemical Technology, Prague, CZ. For Aldicarb and Chlormequat milled homogenized wheat samples were extracted with methanol. 2 ml of crude extract was filtered through 5 µm PTFE filter into a 2 ml vial and measured by LC-MS/MS operated in positive electrospray ionisation. A Discovery C18 column with mobile phase gradient methanol-0.01 M ammonium acetate mixture was used for separation of Aldicarb and Atlantis HILIC column with mobile phase methanol-0.1 M ammonium acetate mixture (60:40, v/v) was used for separation of Chlormequat. For Chlorothalonil extraction was carried out by ethyl acetate. The crude extract was purified by automated high performance gel permeation chromatography. As a mobile phase a mixture of ethyl acetate-cyclohexane (1:1, v/v) at flow 1 ml/min was used. Identification/quantification of Chlorothalonil was carried out by GC-MS operated in selected ion monitoring mode. For separation a capillary column DB-5MS was used. The level of detection (LOD) was 4, 3 and 8 µg/kg for Chlormequat, Chlorothalonil and Aldicarb sulfoxide respectively.

In both years the significance of fertility management and crop protection, and the interaction between these two terms, was assessed using a linear mixed effects model in R (R Foundation for Statistical Computing, Vienna, Austria 2005), with block treated as a random effect, and crop protection as a fixed effect, nested within block (Pinheiro and Bates, 2000).

Results and discussion

Table 1 shows the pesticides and growth regulators that have been used in the experiment and levels of residues detected in crop samples in two cropping seasons (2004 and 2005). Residues could only be detected for three crop protection products used: the growth regulator Chlormequat, the pesticide Aldicarb and the fungicide Chlorothalonil. All three agrochemicals were detected at levels below their legal thresholds. Here it should be pointed out that the applied FAB standards aims at minimising crop protection residues by ensuring threshold based pesticide use and optimised timing of pesticides.

Table 1: Pesticides and growth regulators applied to crops in the Nafferton Factorial Systems Comparison Experiment (NFSC)

Crops	Below level of detection	Detected 2004	Detected 2005
Wheat	Chlorothalonil, Diflufenican, Epoxiconazole Fenpropidin, Fenpropimorph, Isoproturon, Mecoprop-P, Pendimethalin, Trifloxystrobin	**Chlormequat**	**Chlormequat**
Potatoes	Diquat, Fluazinam, Linuron, Mancozeb, Metalaxyl-M, Aldicarb	**Aldicarb sulfoxide, Aldicarb sulfone**	
Lettuce	Azoxystrobin, Iprodine, Propachlor	-	-
Cabbage	Azoxystrobin, Chlorpyrifos, Cypermethrin, Iprodine, Propachlor	-	**Chloro-thalonil**
Onion	Azoxystrobin, Iprodine	-	-

Table 2 shows how the residues were affected by the management systems. As expected, significant pesticide residues were only detected in crops under conventional crop protection management. Under organic crop protection the chemicals were either not detected or at very low level (10 times lower than the conventional level for Aldicarb). These traces are most likely due to spray drift and are comparable to those found in commercial organic practice (e.g. Baker *et al.*, 2002) and attributed to cross contamination by spray drift and other factors.

Table 2: Effect of fertility management and crop protection on residues found in selected crops and years

Crop		**Wheat 2004**	**Wheat 2005**	**Cabbage 2005**	**Potato 2004**
Residue		**Chlormequat (mg/kg)**	**Chlormequat (mg/kg)**	**Chlorothalonil (mg/kg)**	**Aldicarb sulfoxide (µg/kg)**
		Main effect means			
Fertility management	MAN	0.13	0.23	0.01	0.00[1]
	MIN	0.04	0.06	0.01	4.02
Crop protection	ORG	0.00[1]	0.00[1]	0.00[1]	0.36
	CON	0.17	0.29	0.02	3.66
		ANOVA (p-values)			
Fertility management		****	****	0.81	**
Crop protection		****	**	0.17	0.29
Fertility management x crop protection interaction		****	****	0.81	0.052
Maximum Residue Level (Codex Alimentarius)		3 mg/kg for grain 5 mg/kg for wholemeal		1 mg/kg	500 µg/kg

** significant for P<0.01; **** significant for P<0.0001, [1] values below LOD are reported as zero

Unexpectedly, residue levels of some crop protection products were also shown to be affected by fertility management. While Chlormequat in wheat was detected in higher quantities under organic fertility management, Aldicarb sulfoxide was increased under conventional fertility management. A significant interaction was only detected for the growth regulator Chlormequat. When no growth regulators were applied no or very low residue levels were detected under both fertility managements. However, wheat treated with the growth regulator contained three times higher residue levels when fertilised with manure compost, than wheat grown under mineral fertiliser-based fertility management.

Conclusions

Most of the applied pesticides stayed below the level of detection using state of the art methods. The only detected agents were Chlormequat, chlorothalonil, and Aldicarb. Both Chlormequat and Aldicarb were affected by crop protection measures and fertility measures.

Three times higher levels of Chlormequat residues were found when crops under conventional crop protection were fertilised with manure-compost rather than mineral fertilisers. This indicates that the human health risks associated with pesticide residues may increase in low input systems which attempt to reduce the environmental impact of conventional farming systems by switching to organic matter based fertilisation regimes. Further research is required to understand the impact of fertilisation practices on the levels of pesticide residues.

Acknowledgements

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Effect of production system and geographic location on milk quality parameters

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Key words: milk quality, antioxidants, fatty acid profiles, α-linolenic acid, conjugated linolenic acid, CLA, vaccenic acid, α-tocopherol, carotenoids, omega-3 fatty acids

Abstract

A main reason for the rapid increase in organic food consumption is the perception that organic foods have a superior nutritional composition and/or convey health benefits. However, there is currently limited scientific knowledge about the effect of production systems on food composition. The study reported here compared fatty acid profiles and levels of fat soluble antioxidants in milk from organic and conventional production systems in 5 geographic regions in Europe (Wales, England, Denmark, Sweden and Italy). Levels of nutritionally desirable mono- and poly-unsaturated fatty acids (vaccenic acid, CLA, α-linolenic acid) and/or a range of fat soluble antioxidants were found to be significantly higher in organic milk.

Introduction

Milk fat has historically been regarded as unhealthy, due to its relatively high content of saturated fat. However, more recently, beneficial health impacts such as reduced risk of cancer and cardiovascular disease have been associated with some of the mono and poly unsaturated fatty acids found in milk (e.g. Parodi, 2003). This includes α-linolenic acid (α-LA; the main omega-3 faty acid found in milk), conjugated linoleic acid (CLA) and vaccenic acid (VA). Milk has also been recognised as a source of certain fat soluble antioxidants (vitamin E and carotenoids) (Lindmark-Mansson & Arkesson, 2000). Higher intake of antioxidants is thought to protect against oxidative cell damage and reduced the risk of certain chronic diseases (Willcox *et al.,* 2004).

The fatty acid profile of milk fat can be influenced by dairy management practices, especially dietary composition (Jensen, 2002 and Walker *et al.,* 2004). Grazing and oil seed feed supplements were shown to increase the proportion of nutritionally desirable unsaturated fatty acids in milk (Walker *et al.,* (2004), but this was also shown to make milk fat more prone to oxidation, off-flavours and reduced shelf life (Chen *et al.,* 2004). Less is known about the effect of management practices on the levels of fat soluble antioxidants in milk (Shingfield *et al.,* 2005; Noziere *et al.,* 2006).

Consumer perception that organic foods may have significant health benefits has been a major driver for the rapid increase in demand for organic food. However, there is currently little sound scientific evidence to support or reject these assumptions. Differences in animal husbandry between organic and conventional dairy systems could potentially result in differences in milk composition. For example, organic standards prescribe a minimum forage level (60 % of dry matter) in the diet of ruminants and the use of grass/clover swards instead of the pure rye grass swards commonly used in conventional dairy systems and prohibit routine antibiotic dry cow

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therapy (Dewhurst *et al.,* 2003). However, dairy husbandry systems also differ between geographic regions which may also affect milk composition.

The objective of the study was to quantify differences in milk composition (fatty acid profiles, fat soluble antioxidant levels) between organic and conventional farms in 5 geographic locations in Europe (Wales, England, Denmark, Sweden and Italy).

Materials and methods

Milk samples were collected from the bulk tanks of 50 commercial farms on 4 or 5 dates between June 2004 and May 2005. Farms could be categorised into 2 different systems of production (conventional high input and certified organic), in 5 geographic areas (Wales, England, Denmark, Sweden and Italy). Both systems were represented by 5 individual farms in each location, selected as being typical of each system in that area. Milk was frozen within 10 hours of sampling and kept at -20˚C until dispatched for analysis. In Wales 5 farms using a permanent grazing low input systems were also included in the survey. Only summaries of results from the conventional high input and organic systems in Wales, England, Denmark and Sweden are described here.

Details were recorded on all sampling dates for; cow and heifer numbers, recent calvings, mastitis and other health treatments, current feed and supplement use (including information on whether cows had access to pasture during the day and at night). Estimated grazing intakes were calculated by difference for each herd, with total dry matter intakes (DMI) estimated from average milk yields and assumed live weight (LW) (DMI = 0.025 LW+0.125 milk yield). Milk analysis was carried out at the Danish Institute for Agricultural Science, Folum, Denmark, fatty acids, α tocopherol and carotenoids (ß carotene, lutein and zeaxanthine), were assessed as described by Havemose *et al.,* (2006).

Linear mixed effects models (Crawley, 2002) were used with production system and geographic location as fixed factors, individual farms as a random factor and sampling date as either a linear or quadratic factor. The most appropriate model was used to generate ANOVA results. All proportion data were arcsine transformed prior to statistical analysis, but means presented were calculated from non-transformed data.

Results and discussion

A number of differences were identified between farms due to location and production system. For example, the proportion of grass or grass clover forage was generally higher in the UK (compared to S, DK and I) and higher in organic compared to conventional farms in each country. On the other hand, maize silage and concentrate feeds were major dietary components in Italian, Swedish and Danish herds. Organic cows received lower levels of concentrate feed resulting in a higher proportion of their diets dry matter supplied as forage. Differences in dairy diets between systems were highly significant for all countries ($p<0.001$).

On the whole, fatty acid profiles and antioxidant levels were within the range reported in review articles (Jensen, 2002; Walker *et al.* 2004; Shingfield *et al.,* 2005; Noziere *et al.,* 2006). There were significant differences in milk fatty acid and fat soluble antioxidant profiles between countries and between organic and conventional production (Fig. 1). Milk from organic herds tended to have higher levels of the nutritionally desirable fatty acids (α-LA, VA and CLA) and antioxidants with the largest differences tending to be for UK milk, although α-LA showed considerable elevation in organic milk from all countries. However, Swedish organic milk had lower CLA levels.

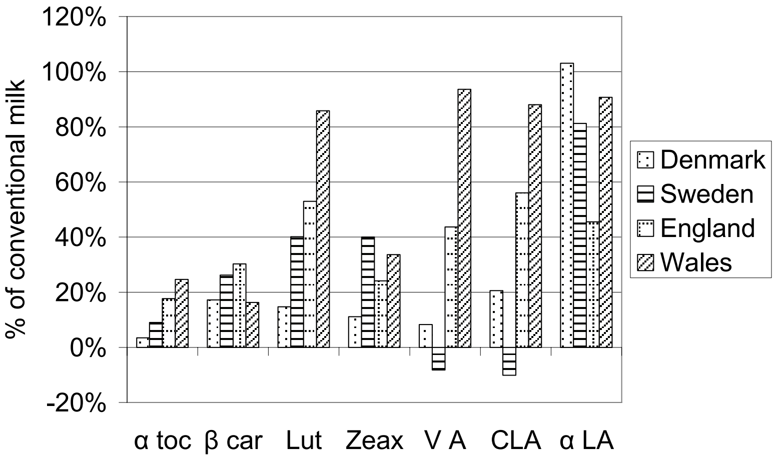

Figure 1: Composition of organic relative to conventional milk: (α toc - α tocopherol, β car-, β carotene, Lut - lutein, Zeax – zeaxanthine)

Higher levels of α-LA and/or CLA in organic milk were also reported in several previous in Germany (Jahreis *et al.,* 1997), Italy (Bergamo *et al.,* 2003) and the UK (Ellis *et al.* 2006). CLA levels are known to increase with the proportion of fresh grass intake, while high proportions of maize silage and cereal based concentrates reduced milk CLA content (Jensen, 2002; Walker *et al.,* 2004; Dhiman *et al.,* 2005). Cutting grass for housed animals (zero-grazing) also reduces milk CLA and αLA content by 50 and 30% respectively compared to grazing (Offer 2002).

Higher levels of nutritionally desirable compounds in both organic and conventional milk from the UK were probably caused by the relatively high level of grass(/clover) in the diet and a longer grazing season in the UK. In contrast, dairy systems in DK, S and Italy used high levels of silage maize and concentrate in the diet, which is thought to reduce levels of nutritionally desirable compounds. The higher levels of fat soluble antioxidants in milk from organic production would be expected to increase the oxidative stability of milk, but whether this can compensate for higher levels of unsaturated fatty acids (especially with respect to sensory quality and shelf life) will have to be determined in future studies.

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Effect of pig production system and transport on the potential pathogen transfer risk into the food chain from Salmonella shed in pig faeces

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Key words: fattening pig, production systems, Salmonella, faecal shedding

Abstract

The prevalence of faecal Salmonella shedding has been compared in organic, conventional outdoor, and indoor finishing pig herds in a Danish survey with participation of 34 herds. Individual faecal and meat juice samples were collected from 30-50 pigs per herd and analysed for presence of Salmonella, and Salmonella antibodies, respectively. The results showed a low level of on-farm Salmonella shedding (<0.2 %) in organic and conventional outdoor herds compared to 2.5 % in indoor pigs (P<0.0001), and also a lower prevalence of Salmonella shedding in outdoor systems at slaughter (<2 %) compared to 4.1 % in indoor systems (P<0.01). The overall seroprevalence was 8.5 % with no significant differences between systems. Seropositivity was a significant predictor of Salmonella shedding at slaughter in individual pigs from conventional systems, but not in organic pigs. The duration of transport did not affect the risk of Salmonella shedding at slaughter.

Introduction

Pork and pork products are recognised as one of the major sources of human salmonellosis (Lo Fo Wong *et al.* 2002, Wegener and Baggesen 1996). Pigs in outdoor production systems benefit from a low animal density, and access to outdoor area, and organic pig production furthermore differs from conventional production in terms of feeding, weaning age, and use of preventive medication (Bonde and Sørensen 2004). It is therefore likely that the risk of Salmonella is different in organic, outdoor, and indoor pig production, respectively. The level of Salmonella shedding at slaughter might differ between the production systems, caused by differences in the level of resistance to the pathogen, which may be due to the immune system based disease resistance and/or components of the husbandry systems affecting disease development and pathogen shedding (see e.g. review by Zheng et al, in press).

Jensen *et al.* (2004) found a higher prevalence of Salmonella antibodies in outdoor than indoor pig production systems. In a survey by Hald *et al.* (1999) the proportion of seropositive pigs tended to be higher in conventional 'free-range' production systems compared to pigs from either organic or indoor production systems. On the other hand Meyer *et al.* (2005) reported that conventional slaughter pigs were more likely to be seropositive than organic pigs. The presence of antibodies indicates that the pig has been exposed to challenge by the enteric pathogen at some stage of its development. Stege *et al.* (2000) reported a herd level association between high seroprevalence and presence of Salmonella in faecal samples from the herd.

A number of stress factors related to the routine management in a pig herd may increase faecal shedding of pathogens. Further, transport of pigs to the abattoir causes significant stress to the animals, which can trigger an increase in shedding (e.g. Lo Fo Wong *et al.* 2002), and duration of transport and lairage may also affect the level of Salmonella shedding at slaughter (Morgan *et al.*, 1987). It is therefore

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essential to compare the faecal shedding before and after transport to the abattoir, when assessing the risk of pathogen transfer into the food chain.

The objective of this survey is to investigate the effect of different pig production systems with indoor or outdoor rearing, and the effect of transport duration, on the potential pathogen transfer risk into the food chain from Salmonella in pig faeces. Further we evaluate seropositivity as a predictor of Salmonella shedding at pig level.

Materials and methods

Eleven organic, 12 conventional outdoor and 11 indoor fattening pig herds were included in the survey. During a one-year period faecal samples were collected in each herd from 3-5 batches of 10 randomly chosen and individually marked pigs 1-7 days before slaughter, and the animals were clinically examined. Further, meat juice samples and samples of caecal content from these pigs were collected at the abattoir. Faecal and caecal samples were analysed qualitatively for density of enteric Salmonella using the modified NMKL method. Meat juice samples from each pig were examined for specific antibodies against *Salmonella enterica* using an indirect enzyme-linked immunosorbent assay (ELISA) (Nielsen *et al.*, 1998). The ELISA combined several *S. enterica* O-antigens, and allowed detection of antibody response after a variety of different *S. enterica* serovar infections. Samples with an OD%>10 were considered seropositive. Data was analysed in SAS in a log-linear model (Proc GENMOD). Information about duration of transport to slaughter was collected from 155 batches of pigs (50 organic, 58 conventional outdoor, and 47 indoor batches), and differences between systems were analysed in SAS by Proc GLM.

Results

The prevalence of Salmonella in the different production systems is illustrated in Fig. 1. The overall prevalence of Salmonella in 1609 faecal samples from pigs on-farm was 0.87 %; the systems were significantly different ($P<0.0001$). The prevalence of Salmonella shedding was 2.2 % in 1556 of these pigs at slaughter, with a significant difference between systems ($P<0.01$). Shedding of Salmonella on-farm was significantly predicting shedding at slaughter ($P<0.0001$). Seropositivity was also a significant predictor of Salmonella shedding at slaughter ($P<0.005$), and tended to predict on-farm shedding ($P<0.10$). Overall 8.5 % of the pigs were seropositive with no significant differences between systems. Neither of the clinical parameters, e.g. diarrhoea, constipation or poor body condition, acted as significant predictors of Salmonella shedding.

The duration of transport is illustrated in Fig. 2. The mean durations of transport to slaughter were 175.3 min (organic pigs), 128.6 min (conventional outdoor pigs) and 96.8 min (indoor pigs) ($P<0.0001$). The differences in transport did not affect the Salmonella shedding at slaughter.

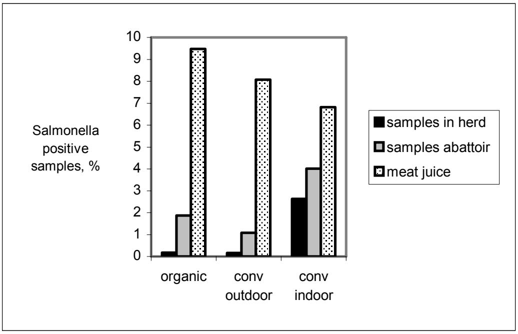

Figure 1. Prevalence of Salmonella shedding on-farm and at slaughter, and prevalence of Salmonella antibodies in meat juice.

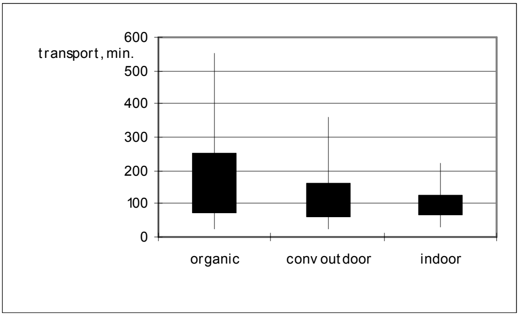

Figure 2: Duration of transport to the abattoir: min, max, 25% and 75% quartiles of the transport duration in minutes for the three pig production systems.

No significant interactions between system and seropositivity were found in relation to Salmonella shedding. Analysis of each production system separately showed that Salmonella shedding at slaughter in conventional outdoor pigs was predicted by seropositivity ($P<0.01$). In indoor pigs it was predicted by on-farm shedding ($P<0.0001$), as well as seropositivity ($P<0.10$). Contrary to this, Salmonella shedding in organic pigs was not predicted by seropositivity.

Discussion and conclusions

We found similar seroprevalences in outdoor and indoor systems, while Hald *et al.* (1999), Jensen *et al.* (2004), and Meyer *et al.* (2005) each found differing results regarding seroprevalence. The prevalence of Salmonella shedding in pigs from outdoor systems was less than in indoor herds. The low levels of Salmonella shedding in organic and outdoor pigs suggest that pigs from low input systems may be more resistant to the pathogen, or may encounter the infection earlier in life so they have cleaned themselves from infection at time of slaughter. The observed differences in transport duration did not affect the risk of Salmonella shedding at slaughter. The lack of association between Salmonella shedding and clinical symptoms is in agreement with Stege *et al.* (2000) reporting predominantly subclinical salmonellosis in Danish finishing pigs. Seropositivity as a means to identify individual pigs that are more likely to shed Salmonella might be better suited to conventional than organic herds.

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The effect of short term feeding with organic and conventional diets on selected immune parameters in rat

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Key words: Organic food, Conventional food, Immunity, Splenocyte proliferation.

Abstract

There is currently no evidence for beneficial health impacts being associated with the consumption of organic rather than conventional foods. This preliminary study was therefore aimed at using haematological parameters, white blood cell (WBC) number and splenocyte proliferation as sensitive assays to evaluate influence of the organic, low input and conventional components in the diet on rats' immune system function. The results of a short term feeding trial with two rat generations indicates a potential effect on immune system function, which has to be confirmed by longer-term exposure studies.

Introduction

Organic farming is an integrated system of agriculture based on ecological principles, promotion of biodiversity, biological cycles and organic matter recycling to maintain soil fertility. The regulations for organic crop cultivation prohibit the use of chemo-synthetic pesticides, mineral fertilizers, growth promoters and genetic engineering or Genetically Modified Organisms (Rosati and Aumaitre 2004). Despite the increasing interest in organic food production, the number of articles describing potential positive and negative effects of consumption of organic and conventional foodstuffs on human and animal health is still very small (Lund and Algers, 2003). The presence of chemical contaminants (e.g. pesticides) in conventional food is likely to have an influence on their concentration in the bodies of consumers, and some *in vitro* experiments indicate that they may cause immunosuppression (Finamore *et al.* 2004). On the other hand, it has been suggested that immune responses in farm animals fed either conventional or organic diets are similar (Millet *et al.* 2005). There is therefore currently no scientifically sound evidence that demonstrates health benefits associated with the consumption of organic rather than conventional foods. However, whether or not the consumption of organic foods has significant health impacts, deserves to be tested in well controlled experimental research. The aim of this study was, therefore, to assess the effect of diets, based on organically, low input and conventionally grown crops on selected immune parameters of rats in a short-term experimental feeding trial.

Materials and methods

Adult male and female Wistar rats were kept under conditions of controlled light (12-h light/12-h dark cycle) and temperature (22–23 °C) with free access to water and experimental feeds. The animals were randomly assigned to one of five experimental dietary groups, according to the protocol shown in Table 1. After three weeks of

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feeding animals were paired and bred. Paternal males were sacrificed one week later, while females were fed the respective diets during the pregnancy and suckling period (total 10 weeks) and sacrificed thereafter along with a part of the off-spring of both sexes. Six young males from each dietary group were left alive to be fed subsequently for 9 weeks and this part of the experiment is still in progress. Animals were anesthetized with Tiopental, blood was collected from heart and spleens isolated aseptically and used immediately for in vitro studies. All animal procedures were in accordance with the Guiding Principles for the Care and Use of Research Animals and had been approved by the First Warsaw Ethics Committee for Experiments on Animals. Experimental diets were prepared using components produced under different agronomy regimes (Leifert *et al.* 2007), and characterized in a paper submitted for presentation at this congress (Rembialkowska *et al.* 2007). The experimental diets used for the different groups are described in Table 1. Control rats were fed a standard feed for rodents (Labofeed, Andrzej Morawski Feed Production Plant, Kcynia near Bydgoszcz, Poland).

Table 1: Experimental protocol (see Leifert et al. 2007 for details)

Exp. groups	Type of diet
ORG-ORG	no synthetic pesticides and no mineral fertilizers (organic farming)
ORG-CV	no synthetic pesticides and with mineral fertilizers (low input 1)
CV-ORG	with synthetic pesticides and no mineral fertilizers (low input 2)
CV-CV	with synthetic pesticides and with mineral fertilizers (conventional farming)
LF (control)	standard rodent's food – Labofeed

Hematological parameters (hematocrit value, RBC number and hemoglobin content) and WBC were assayed using standard laboratory methods. Splenocyte cultures were prepared according to a method used previously for rat lymphocytes (Bik *et al.* 2006). The following mitogens were then applied: Phytohemagglutinin A (PHA), Concanavalin A (ConA) or Lipopolysaccharide (LPS). Control cultures consisted of cells incubated with culture medium alone (spontaneous proliferation). Splenocyte proliferation *in vitro* was assessed by incorporation of ^{3}H-thymidine and expressed in counts per minute (cpm) as mean (± SD) and as stimulation index (SI). For statistical evaluation of differences between groups, ANOVA parametric followed by the Student-Neuman-Keuls test was used. Results were considered statistically significant when $p<0.05$.

Results

There were no significant differences in hematological parameters in rats of both sexes and generations and those fed different diets (data no shown). In adult female rats, the total WBC number were higher than in their 3-week-old off-spring of both sexes. In adult female rats WBC numbers were highest in the ORG-CV and lowest in the CV-ORG group (Fig. 1). In the parental generation only spontaneous proliferation of splenocytes from ORG-ORG and CV-CV diet groups have been examined. Proliferation of splenocytes in rats on the ORG-ORG diet was higher for males but lower for females in comparison with rats in the CV-CV diet group (Fig. 2A). In 3-week-old rats no significant differences could be found between sexes of dietary groups; however, a trend towards lower levels in one of the low input (ORG-CV) and conventional (CV-CV) dietary groups was detected (Fig.2B).

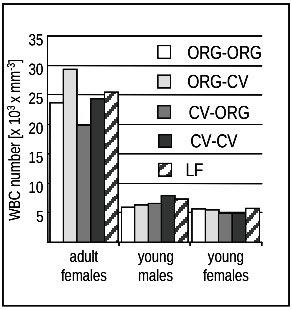

Figure 1: The effect of diet on WBC number

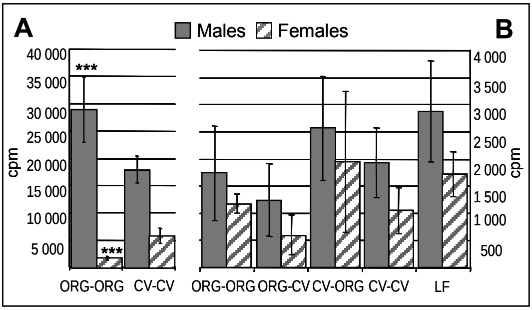

Figure 2: Spontaneous proliferation of splenocytes from different diet groups of adult (A) and young (B) rats, expressed in cpm as mean ±SD for 4 replications of each culture variant. ORG-ORG vs CV-CV ***p<0.001.

Mitogen-stimulated proliferation of splenocytes from young rats was examined over wide concentration range of both T-cell (PHA and ConA) and B-cell (LPS) specific mitogens. The response was dose-dependent and the effect of only one concentration of particular mitogen is shown on Fig. 3. The ability of splenocytes to be stimulated by T-cell specific mitogens was diet-dependent and seemed to be highest in splenocytes obtained from CV-CV and ORG-ORG rats. Moreover, a significantly reduced splenocyte proliferation in ORG-CV dietary groups was observed (Fig. 3A and 3B). Mitogenic response to LPS was much lower, especially in young males, which showed significantly reduced proliferation especially in the ORG-CV group. On the other hand, SI was particularly high in females on the CV-CV diet (Fig. 3C).

As feeding experiments of rats are still ongoing, no statistical test could yet be applied. To evaluate the effect of (and interactions between) (a) fertility management and (b) crop protection practices on the composition of crops and subsequent immune parameters in rats fed diets based on crops from different systems, 2-way ANOVA tests are planned to be carried out as soon as experiments have been completed.

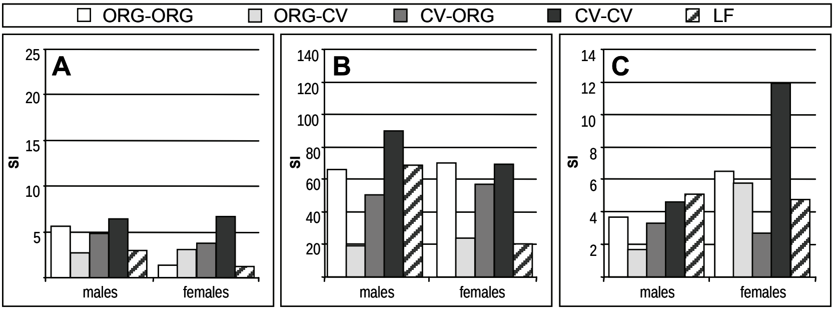

Figure 3: The influence of diet on mitogen-stimulated (PHA 2 µg/well – A; ConA 0.125 µg/well – B; LPS 4 µg/well – C) splenocyte proliferation in young rats of both sexes. Results are expressed as the mean of SI calculated for 4 replications of each culture variant.

Discussion

In this study we used hematological parameters, WBC number and splenocyte proliferation as sensitive measures to detect potential effects of diets based on crops produced by organic, low input and conventional methods, in the immune system of rats. Changes in the parameters examined are difficult to detect after only short term exposure to different diets. We found, however, highly elevated number of WBC and spontaneous splenocyte proliferation in parental females vs young rats, which seems to be related with the immaturity of the off-spring immune system (Spencer *et al.* 2006). Moreover, these results seem to be related to the immunomodulatory effect of prolactin, which was found to be elevated in lactating females and identified as a lymphocyte proliferation regulator (Clevenger *et al.* 1998). These observations suggest a necessity to repeat the experiment over a longer period and with the use of mature young animals. Proliferation of splenocytes from young rats appeared to be suppressed when diets based on crops grown with mineral fertiliser inputs (ORG-CV); also while spontaneous proliferation did not decreased significantly, the response to mitogenic stimulation was significantly less efficient.

Conclusions

The results of the short term feeding of two generations of rats using the diets containing organically, low input and conventionally grown components indicate some changes in their immune system function in comparison to rats fed standard diet. To support the observed tendency of immunomodulatory activity of these diets, a long term feeding and associated *in vitro* studies are necessary.

Acknowledgements

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The content of bioactive compounds in rat experimental diets based on organic, low-input and conventional plant materials

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Key words: rat feed, organic, conventional, low input, polyphenols

Abstract

Rat feed based on raw plant materials was produced according to the nutritional recommendations for rat feeding trials. Rat feeds produced from crops grown under 4 different production systems were used: (a) organic, (b) conventional, (c) low input 1 (organic plant protection was used in combination with mineral fertilizers) and (d) low input 2 (conventional pest management and only organic fertilizers were used). The results showed that rat feeds prepared from the organically produced plants contained more total polyphenols and the nutritionally desirable, bioactive compound lutein. The main objective of analyzing bioactive compounds in the rat feed is to determine whether the differences in composition of feed materials from different production systems could explain any measured differences in impact on the health status of rats.

Introduction

Organic foods are perceived by many consumers as being safer and healthier than conventional ones. Organic farming principles and standards aim to enhance the long-term natural fertility of soils, to minimize water and soil pollution, to avoid the use of mineral fertilizers and chemical pesticides, and this has been hypothesized to lead to positive health effects in livestock and humans consuming organic foods/feeds.

Fruits and vegetables have positive health benefits and contain significant amounts of biologically active components that may be responsible for these effects. Since organic production systems do not use synthetic pesticides, crop plants have to rely upon their own inherent resistance mechanisms/strategies to defend against the diseases and pests. A common strategy is to produce more phytochemicals (plant secondary metabolites) in response to lower levels of soluble plant nutrients. It is therefore thought, that crops grown under organic management may have an increased phytochemical content due to the more constant release of soluble nutrients throughout the growing season (Brandt and Mølgaard 2006).

For example, oxidized juice from organic spinach was found to have 120% higher antioxidant activity than similarly prepared material from conventionally grown spinach (Ren *et al.* 2001). Juices from organic Welsh onion and Chinese cabbage had 20 – 50% higher antioxidant activity than from corresponding conventional leafy vegetables. Green pepper was the only vegetable, for which significant difference in antioxidants content between juices from organic and conventionally grown crops could not be detected (Ren *et al.* 2001).

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For carotenoids there is currently insufficient research data to draw general conclusions Also, results may be variable. For example, Rembialkowska (2003) showed that organic carrots contained less carotenoids in some and higher concentration in other field experiments (Rembialkowska 2003). An experiment performed by Warman and Havard (1997) showed that conventional carrots contained significantly more beta-carotene: (102 mg kg^{-1}) compared to conventional carrots (94.6 mg kg^{-1}).

Overall, there is still insufficient data comparing the levels of potentially health promoting compounds (vitamins, minerals, phytochemicals etc) in plant foods produced by organic, low input and conventional methods and there are virtually no studies evaluating the effect of consumption of organic and low input foods.

Materials and methods

The study was carried out in 2006 in the Division of Organic Foodstuff at Warsaw Agricultural University. Wheat, potatoes, carrots and onions produced under organic, conventional and low input production protocols in the Nafferton Factorial Systems Comparison Experiments (see Leifert *et al.* 2007) were dried to a dry matter content of 89%, irrespective of the initial water content, with a moderate temperature in order to keep their nutritive value. Rat feed based on these materials was produced according to the nutritional recommendations for rat feeding trials (Table 1).

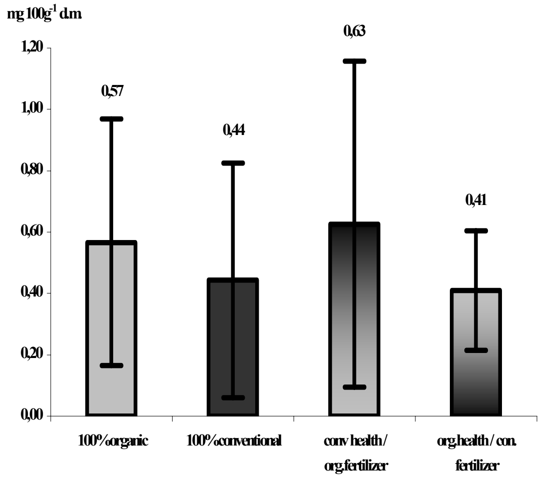
Tab. 1: Composition of rat experimental diet

Component of diet	%	Proteins [g/kg]	Fibre [g/kg]	Lis [g/kg]	Met+Cys [g/kg]	Tre [g/kg]	Try [g/kg]	Ca [g/kg]	P [g/kg]
Lacto-albumin	6.80	3.430		0.487	0.256	0.358	0.103		
Casein	11.03	6.800		0.739	0.272	0.353	0.118		
Wheat	54.50	2.336	0.530	0.061	0.080	0.061	0.022	0.012	0.065
Potato	10.20	0.245	0.200	0.015	0.005	0.003	0.004	0.000	0.008
Carrot	3.92	0.038	0.138	0.002	0.002	0.000	0.000	0.001	0.001
Onion	0.95	0.014	0.014	0.001	0.000	0.000	0.000	0.000	0.000
Rape oil	5.79								
Min+Vit	6.81								
Total	100.00	12.863	0.882	1.305	0.615	0.775	0.248		

Four types of rat feeds based on crops grown under 4 different production systems: **(a)** organic, **(b)** conventional, **(c)** low input 1 (organic plant protection in combination with mineral fertilizers based fertilisation) and **(d)** low input 2 (conventional pesticide based crop protection with organic fertilization protocols) were used (see Leifert *et al.* 2007 for details of the agronomic methods used). The following composition analyses of the rat feeds were carried out: dry matter using the scale method (PN-91/R-87019), total flavonoids according to the Christ–Müller methods described by Strzelecka et. al (1978), total polyphenols by the Folin – Ciocalteau colorimetric methods described by Singleton and Rossi (1965), beta-carotene and lutein by liquid column chromatography as described by Saniawski and Czapski (1983), and total antioxidant activity using the colorimetric method described by Ren *et al.* (1999). The results of these qualitative characteristics of each of the different rat feeds were statistically evaluated using Statgraphics 5.1 program specifically Tukey's test at $\alpha = 0.05$.

Results and discussion

Since the feed was dried before being mixed, all examined rat feeds contained similar contents of dry matter. In previous studies organic vegetables were often found to contain higher levels of dry matter then conventional ones (Rembialkowska 2003, Rembialkowska 2004), but this was not tested in the study reported here. For the total flavonoid content the differences between feeds were not statistically significant (Fig.1).



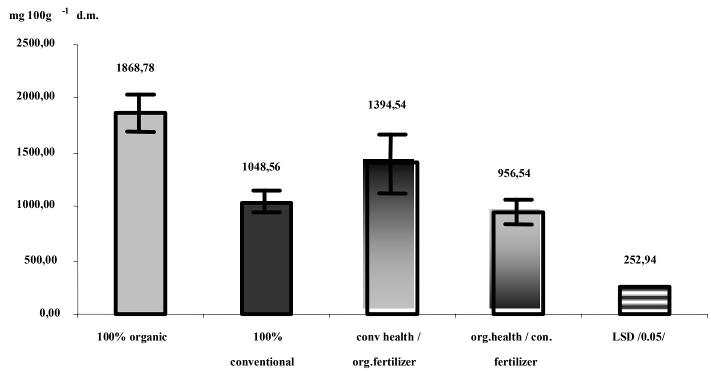


Figure 1: Total flavonoid (top) and total polyphenol content (below) in rat feed with ingredients from organic, conventional and low input production

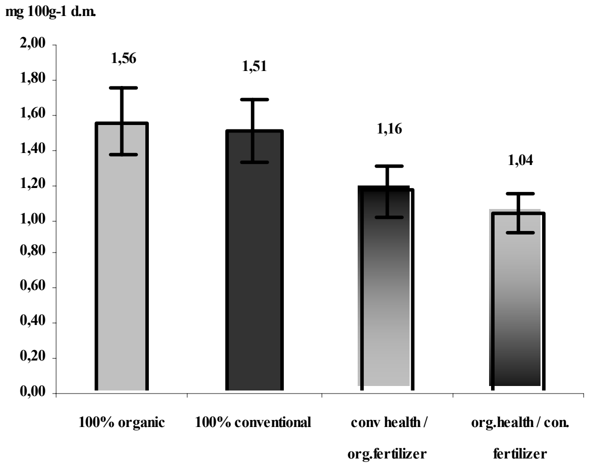


Figure 2: Total beta-carotene-content in rat feed with ingredients from organic, conventional and low input production

There were significant differences in content of total polyphenols between organic, conventional and low input rat feeds (Fig. 1). The highest levels were detected in organic rat feed, and the lowest level of total polyphenols was found in feed produced from crops grown in low input system 2 (oh/cf) (Fig. 1). The content in the materials depends on the cultivar, processing methods, fertilization method, light conditions and plant protection protocols used. It seems that the fertilization methods had a greater effect on polyphenol contents than the plant protection protocols. These results are in line with many other studies comparing different nutrient supply strategies (Brandt and Mølgaard 2006). In contrast, studies comparing different plant protection methods while keeping the nutrient supply similar, such as Young *et al.* (2005) tend to hypothesize, that different levels of pest attack are responsible for the higher content of polyphenols in organically produced leafy vegetables. This can however be dismissed based on the general observation that crops from successful organic farms are not more affected by pests and diseases than corresponding conventional ones (van Bruggen 1995).

The organic and conventional rat feeds contained the highest levels of beta-carotene while levels in feeds based on crops produced under two low-input system conditions were lower, but this difference was only marginally significant. Beta-carotene was found in rat feeds due to the inclusion of carrots as a vegetable component. Previous studies into the β-carotene content of carrots reported contradictory results. For example Rembialkowska (2003) found lower levels of beta-carotene in organic carrots, Evers (1989) reported that the level of nitrogen fertilization had no significant impact on the content of beta-carotene in carrots, and (Leclerc *et al.* (1991) found higher levels of beta-carotene in the organic carrots.

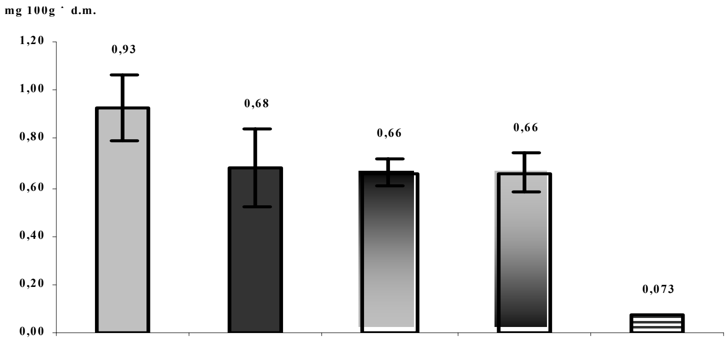


Figure 3: Lutein content in rat feed with ingredients from organic, conventional and low-input production

The highest level of lutein was found in organic rat feed, with all other rat feeds having lower levels (Fig. 3). There are virtually no studies comparing the lutein content in vegetables from organic and conventional production systems. The high lutein content in the organic rat feed may have a potentially health-promoting effect, because lutein, which accumulates in the retina, is regarded as an important natural protector against light-induced damage to the eyes (Alves-Rodrigues and Shao 2004). However, this effect has only been shown in humans and other primates, it is not yet known if it is relevant for nocturnal animals such as rats.

There were no significant differences in the total antioxidant activity of rat feeds made from crops produced in different production systems. In the current study the higher amount of polyphenols in organic feeds was therefore not correlated with a higher antioxidant status. There is not always a positive correlation between polyphenol content and antioxidant activity. For example, Cai *et al.* (2004) showed that some medicinal plants contained high levels of polyphenols but relatively low total antioxidant activity when compared to other plants with lower polyphenol levels. The results obtained showed that the level of some bioactive compounds (total polyphenol compounds, lutein, beta-carotene) was significantly higher in rat feeds prepared from the organic raw materials, but that at the same time the level of total anti-oxidant activity was lower in organic feeds than in low-input feeds. There are two possible explanations of these results:

The anti-oxidant activity of the rat feeds has been only measured for water-soluble bioactive compounds; it wasn't measured for the fat-soluble compounds, such as polyphenols, lutein and beta-carotene. Therefore the measured anti-oxidant activity could have been underestimated.

The chemical structure of polyphenols and the substitution patterns and groups have a big effect on the subsequent antioxidant and free radical scavenging activities of these plant compounds (Plumb *et al.* 1998). The majority of flavonoids, have moderate to high direct antioxidant activity as aglycones. However, aglycones are only formed when plant material is subjected to harsh processing conditions, so in the present study, the natural substitutions to the phenolic hydroxyl groups are probably still intact, resulting in a lower activity (Cano *et al.* 2002, Plumb *et al.* 1998, Williamson *et al.* 1999). Therefore in the future it is planned to **(a)** perform HPLC analyses to profile polyphenols and then determine if the concentrations of specific compounds can be related to the antioxidant activity and **(b)** measure anti-oxidant activity of both water- and fat-soluble compounds.

Conclusions

Rat feeds prepared from the organically fertilized plants contained higher levels of certain bioactive compounds, especially total polyphenols and lutein.

Acknowledgments

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Effects of field crops on animals: Considerations with regard to design using Chlormequat-treated wheat crop as an example

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Key words: Plant growth regulator, Chlormequat, experimental design, reproduction, pig

Abstract

There is concern whether consuming products based on crop from Chlormequat-treated fields can cause reproduction problems in animals and humans. An experiment is presently being conducted to investigate this using the pig as a model. Considerations with regard to experimental design when investigating whether differently treated crop can affect animal/human biology is discussed. Only about half of the data are presently available. A preliminary survey of these data does not show clear differences between Chlormequat-treated and organic non-treated wheat with regard to reproduction performance of pigs.

Introduction

Experiments have suggested that the plant growth regulator Chlormequat is detrimental to animal reproduction (Torner *et al.*, 1999; Sørensen and Danielsen, 2006). In the QLIF project, a new experiment is presently being conducted to further investigate this. The prime question is: Is wheat grain with residues of the growth regulator 'Chlormequat' detrimental to animal reproduction when fed to animals? This question is also relevant for human since there is public concern whether consuming food products based on wheat originating from Chlormequat treated crop can cause reproduction problems.

Considerations with regard to experimental design

Crop or animal experiment?

First of all it is important to clarify what type of experiment is needed to answer the experimental question:

'Is it an animal experiment or a crop experiment?'

In the former case the strength of the conclusions can be increased substantially by increasing the number of animals. In the latter case the animal can be considered as an instrument much the same way as for example a chromatograph, e.g., the animal gives a measure of reproduction performance and the chromatograph gives the concentration of Chlormequat residue. Hence, in the latter type of experiment, the strength of the conclusions is increased by increasing the number of batches of crop, i.e. by increasing the number of fields each contributing with a separate batch of crop. The experiment relevant for investigating the question above is both an animal and a crop experiment – but it is primarily a crop experiment in the sense that it is the variation in crops which is of primary concern.

A naïve design could be to take one Chlormequat-treated field and one organic non-treated field, take the crop from each of these fields and feed to animals (say 10

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animals per treatment). The only random variation in this design is the animal-to-animal variation. However, it is generally accepted that there is field to field variation in crop. These differences may be attributed to e.g. soil composition and precipitation. Hence what might seem as a comparison of the two treatments in the naïve design (e.g. by a t-test) is effectively a comparison of fields (including treatments, precipitation, soil composition etc). Hence one can not from this experiment draw any conclusion with respect to treatment effect.

It is therefore important to create a design that allows test of differences between differently treated crop and not differences between fields. This requires several fields for each of the treatments and the design of experiment literature gives different schemes for choosing these. (One option is to choose the fields 'randomly from the population of fields'. Another option is blocking: Choose a random set of fields and subdivide each of these into two lots and assign the treatments randomly to each of the lots. In the latter case, some of the external effects can be eliminated, e.g. the effect of precipitation.) The crucial point is that when investigating the effect of different crops we need to be able to quantify the field-to-field variation. How many fields are needed depends on the field-to-field variation. Yet, it is important to note that it would not help to use 100 animals instead of 10.

Conclusion: Fields/lots are the relevant experimental units in experiments with crop, and not animals or chromatographs.

Mixed heap of crops or separate crops?

Would it be adequate to use material from a heap of Chlormequat-treated and a heap of organic non-treated crop, respectively, originating from many fields? If so, we avoid going through the logistic troubles of obtaining crops from separate fields and feeding these to animals. The answer is no, as can be seen from the following argument. Suppose the animal-to-animal (or chromatograph-to-chromatograph) variation is small compared to the field-to-field variation. Imagine that the average outcome (in some response) of three Chlormequat treated fields is, 95, 110 and 125 (average=110) while the average outcome of organic fields are 85, 115 and 125 (average=108). The difference in averages 100-108=2 will come out as being significant if the animal-to-animal variation is small. But, by looking at the results from the fields, one can see that there is no clear evidence that the outcome from one treatment tend to higher than the output from another treatment; quite on the contrary. Again the problem is that we throw away the information about field-to-field variation, and again it would not help to use 100 animals instead of 10.

Choice of instrument (i.e., which animal species, gender, experimental period)

With regard to the concern for detrimental effects on human reproduction, it is not possible to verify this in an experiment with human subjects. We have to rely on experiments with animals. Different species are apparently not equally sensitive to Chlormequat. It seems that the rat is relatively insensitive compared to the mouse. There are indications that the pig is more sensitive than the mouse (Sørensen and Danielsen, 2006), which was one of the reasons for choosing the pig. Another reason was that the pig is an important livestock species and that farmers avoid feeding Chlormequat-treated grain to pigs (at least in Denmark) due to concern for their reproduction performance. Generally the male is considered more sensitive to environmental exposure than the female with regard to reproduction. This is in line with results obtained in mice exposed to Chlormequat: Torner *et al.* (1999) found that reproduction was affected in male mice while no effects were observed in the female (Langhammer *et al.*, 1999).

A major part of the development of reproduction organs takes place during foetal life. Thus, it cannot be ruled out that Chlormequat may have serious detrimental effects during this period of life. In order to exclude the risk of not including a period in which Chlormequat potentially have chronic detrimental effects on subsequent reproduction performance, it was decided that the experimental period should be lifelong starting from the foetal stage. Excluding a critical period in life from the experimental period may lead to a false negative result.

Conclusion: It was decided to expose male pigs to Chlormequat (and Control) treatments from the initiation of life, i.e. from the beginning of foetal life.

Choice of measure (i.e., which reproduction trait)

When we want to test an effect on reproduction there are choices to make as to which reproduction trait to focus on. This is not a trivial matter. In the experiment of Torner *et al.* (1999), some reproduction measures were affected by Chlormequat while others were not. Thus a general conclusion with regard to the effect of Chlormequat on reproduction would be in one direction if in vitro fertilization was measured and in another direction if only testicle tissue had been analysed. Thus there is always the risk of a false negative result dependent on the choice response variable. We chose several variables among which was the ability of a male to make a female pregnant.

Conclusion: Fertilization competence of semen was chosen as the prime reproduction trait.

Size of the experiment

Size of an experiment can be determined based on knowledge to relevant variable variances and to the difference in trait that the investigator wants to be able to detect. If the variances are not available one has to rely on guesses/estimates. When this is done there is always, it seems, the trouble of adjusting the whole thing to the available budget. We ended up with a design that included wheat crop from 10 Chlormequat-treated and 10 organic non-treated fields. Three boars were then raised from foetal life (i.e., via three different mothers) to adulthood on wheat from each of these fields. Finally the three boars per field then delivered semen for the experiments.

Conclusion: Size of the experiment was determined based on estimates of relevant variable variation and adapted to the available resources.

The experiment

The experiment is well under way, but due to a long lag time between initiation of the experiment and obtaining data, only about half of the pig reproduction data are presently available. A preliminary survey of these data does not support to the results of Torner *et al.* (1999), i.e., no clear differences in reproduction performance are found between Chlormequat-treated and organic non-treated wheat. The average Chlormequat residue in the treated wheat was 0.333 mg/kg with a max/min of 0.525 and 0.084 mg/kg, respectively.

Closing remarks

If the trend in results for the first half of the data is maintained for the coming second half of the data, the conclusion will be that Chlormequat can not be proven to be detrimental to pig reproduction. In the mouse experiment the conclusion was the opposite (Torner *et al.*, 1999). This leaves us with the question: Is human reproduction mostly comparable to mouse or to pig reproduction? It also leaves us with a need to repeat the ‘Torner-experiment’ in a laboratory where differences could not be found in the pig when using comparable techniques, or that the 'Torner-lab' repeats our pig experiment. Until this is done there will be much uncertainty and confusion in the public as to whether food based on Chlormequat-treated crop can be anticipated to be detrimental to human reproduction or not.

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On-farm influence of production patterns on total polyphenol content in peach

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Key words: organic horticulture, production patterns, peach, polyphenols

Abstract

Peach production in France is constantly confronted with marketing problems due to a decrease in fruit consumption and increasing competition with neighbouring Mediterranean countries. The production of higher quality products using production methods such as organic farming (OF) appears to be a tangible way of differentiating and enhancing peach production. To test this hypothesis, an on-farm study was conducted in one of the major production areas in South-eastern France. Focussing on the peach cultivar, cv. Spring Lady®, paired comparisons were conducted between plots in OF and conventional farming (CF). Farmers' practices were identified and checked against crop measurements and performances (yield, sugar content, size classes) in 2004 (12 plots) and in 2005 (10 plots). Polyphenol contents were assessed as an additional component of fruit quality, using the Folin-Ciocalteu colorimetric method. Organic peaches have a higher polyphenol content at harvest. Contents were 4.8 times higher in 2004, whereas the same phenomenon was not observed in 2005. Levels of nitrogen, yield and tree vigour management appeared to be the key elements responsible for the synthesis of total polyphenols and sugar content This implies new opportunities for improving the nutritional quality of peaches, based on production methods.

Introduction

French peach production is facing an economic crisis due to increased competition with other Mediterranean countries, higher labour costs, emerging pests and diseases and a decrease in fruit consumption. Can organic and low-input farming and food production methods contribute to the improvement of this situation by bettering fruit quality? To answer this question, we focussed our study on one of the major areas of peach production in France. We analysed the relationships between farmers' practices and crop performance. Although organic products have become increasingly popular with consumers, references to the health value of organic fresh fruits are scarce and remain to be clarified. Carbonaro & Mattera (2001) observed a higher level of polyphenols in OF peaches, but did not explain the results in agronomical terms. It is hoped that this study will shed some light on this issue.

After introducing the research protocol and subsequent measurements, we compare technical management and agronomic performances of the two production patterns, organic (OF) and conventional farming (CF), in this paper. In addition to discussing specifications specifications, we analyse relationships between annual nitrogen applications, tree vigour and crop performances assessed on the basis of yield and fruit quality (polyphenols and sugar content). Finally, we discuss these results in relation to low-input food and farming systems.

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Material and methods

A two-year study was conducted (2004 and 2005) in commercial peach orchards located in the middle Rhône Valley (France). Individual fields were selected on the basis of paired comparisons whenever possible: for a given cultivar, an organic plot was located close to a conventional plot with similar soil and climate conditions. Organic orchards conformed to specifications and were third-party certified (EU regulation 2092/91). The study was implemented on 12 plots cultivated with Spring Lady® (an early cultivar of yellow peach) in 2004 (four in OF and eight in CF), and on ten plots in 2005 (five OF and five CF). This protocol was adjusted in 2005 in order to have paired plots (with similar site conditions in OF and CF); as a result, three plots were added (one in OF and two in CF). Fertilisation and irrigation practices were recorded on the basis of data provided by farmers and then complemented with interviews. In each plot, a sample area including six adjacent trees was pre-determined during winter in order to measure fruit load, vegetative growth and yield per tree. The distribution of fruit sizes - namely the percentage of grade A-plus fruit (≥ 67 mm diameter) - and fruit quality components were also assessed for these trees. Fruits were harvested during several operations whose scheduling was determined by the producer. A random sample of 30 fruits from the main fruit-size class was collected for lab analyses from the fruits of these six trees picked by seasonal workers. In addition to classical measurements on fruit quality, polyphenol contents were also evaluated. Total Soluble Solid Content (SSC, °Brix) and firmness were measured on all collected fruits with the automatic lab unit 'Pimprenelle' within two days after harvest. Total polyphenols were determined during the second harvest operation on fruit pulp. This operation best represents peach production patterns and crop development conditions. The method used was that of Folin-Ciocalteu, as proposed by Georgé *et al.* (2005), and results were expressed in mg EGA/100g DM (EAG = Equivalent Gallic Acid and DM = Dry Matter). Between harvest and analysis, fruits were stored at –30°Celsius. Hydric and N status were determined in 2005 by measuring peach leaf hydric potential before harvest and foliar analysis 105 days after full bloom. To compare patterns features the Wilcoxon-Mann-Whitney non-parametric test (with a 5% threshold) was used and we used Principal Component Analysis (PCA) to analyse the relationship between levels of intensification and fruit quality.

Results

Input management was compared among production patterns (Table 1).

Table 1: Average levels of N fertilisation and irrigation. Indicators of nutritional status and number of shoots on Spring Lady® (2004-2005)

Pattern	Farm plot	Irrigation water amount (m3.ha-1)	Leaf hydric potential (2005, Mpa)	N supply (kg.ha-1)	N foliar content (2005, g per100 g DM)	Sucker (number per tree)
OF	9	3189	3.9	58.2	2.8	12.4
CF	13	3380	3.2	80.9	2.8	22.8

Nitrogen fertilisation and water irrigation levels tend to be lower in OF (non-significant differences). The number of suckers in the canopy exhibits a lower vigour in OF orchards, which can be attributed to lower input levels. OF yields are half of those in CF (13.8 T/ha versus 27.7 T/ha) and fruit sizes are also smaller (Table 2). Trees in OF have a limited productive potential, due to a lower initial number of shoots per tree (40.0% less shoots and 41.7% less fruits than in CF).

Table 2: Production and fruit polyphenol contents on Spring Lady® for each production pattern (2004-2005)

Pattern	Shoot beaming (number per tree)		Fruit load (nb per tree)		Yield (T/ha)		% of fruits size >A		SSC (RI in °Brix)		Polyphenol content (mg/100 g EAG)	
OF	77.6	*	252.2	*	13.8	*	27.4	*	8.9	ns	100.7	ns
CF	129.3	*	432.6	*	27.7	*	47.2	*	8.6	ns	68.9	ns

* significant for P<0.05

Taking both a positive correlation between fruit size and their sugar content (Génard, 1992) into account, and a trend for higher sugar content with small fruit sizes, we consider that OF fruits have a higher sugar content than CF-derived fruits. Although harvesting periods differ among farmers, firmness is similar between the two patterns (3.1 kg/cm^2 in OF and 3.2 in CF). Significantly lower yields in OF result from lower tree vigour due to competition with grass cover and lower input levels. The number of shoots bearing fruits and fruit load are therefore reduced. Generally speaking, our results confirm established facts and allow us to partially differentiate the two production patterns.

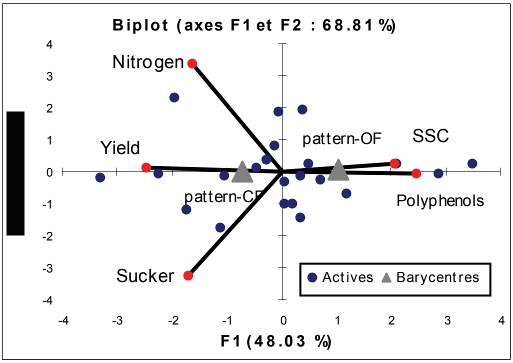

Figure 1: PCA representation on first factorial design with orchard intensification variables (N amount, suckers and yield) and fruit quality variables (SSC and polyphenol content) Biplot (F1 and F2 = 68.81%) F1 (4.8.03%)

Fruit polyphenol contents differ between the two production patterns, based on fresh matter of OF and CF fruits for both cultivars. Organic peaches display higher polyphenol content. The difference is significant for Spring Lady® in 2004 (147 mg EGA/100g DM in OF *vs.* 67.25 mg EAG/100g DM in CF; probability = 1.39%) (Fauriel *et al.*, 2005). There are no significant differences in 2005. Between 2004 and 2005, input levels increased in OF plots, therefore reducing the gap between OF and CF in terms of polyphenol content. The PCA (Figure 1) represents three variables of orchard intensification (N amount, suckers and yield) as opposed to fruit quality (SSC and polyphenol content). The patterns are illustrative variables. Plots in OF are generally cultivated with low inputs and exhibit higher fruit polyphenol content.

Discussion

The influence of the form and amount of fertilisers on polyphenol content has been demonstrated by several authors (Radi *et al.*, 2003), and partly confirmed by our study.

In addition to the positive effects of organic production on nutritional quality and taste (ensuring higher sugar and polyphenol contents, no pesticide residues), the OF production pattern also results in less labour input (for pruning, thinning, harvesting) due to lower tree vigour. Conversely, orchards with low input levels, annual growth and yields are favourable to the synthesis of polyphenols. This may also be the case for low-input production patterns, therefore challenging organic fruit production, since no maximum input level is recommended in OF (except for copper utilisation), in keeping with the conventionalisation thesis (Guthman, 2000). Since the profitability of organic fruit production is at issue, organic producers tend to increase their production objectives and competitiveness, while adopting conventional technical management techniques. This could be detrimental to fruit nutritional quality and increase environmental risks as a result of increased inputs. Only the plots with sustained low-input practices would maintain a high polyphenol content.

Conclusion

As compared with conventional orchards, organic orchards exhibit differences both in harvest performances (yield, fruit size, °Brix, polyphenol content) and input management. Production levels are lower in OF orchards. Even if they generate higher quality fruits, this raises the problem of profitability in OF orchards when quality is not valued on the market. The relationship between production patterns and polyphenol content depends on management practices. An organic low-input production pattern would exceed current EU regulation standards and strike a balance between economic and environmental concerns.

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Quantifying the effect of organic and ‘low input’ production methods on food quality and safety and human health – Posters

Sensory acceptance of organic and conventional food by children in the age of 2 to 7 years

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Key words: young children, preference, acceptance, organic food, breastfeeding

Abstract

This study is initialized to find out which sensory factors might influence the acceptance of organic food by young children. 138 children aged from 2 to 7 years were recruited at the German Research Institute of Child Nutrition in Dortmund. All these children are participating in the DONALD-Study. Detailed nutrition records are available about breastfeeding and feeding of these children from birth to the age of one and further on. In a 2-year testing-period children tasted organic and conventional food in two-sided Paired Comparison Tests. In both years parents were asked a number of questions, mainly about the nutrition behaviour of their children. Sensory tests were analyzed and connected in different ways: with data of sensory profiles, nutrition records and different questionnaires.

Introduction

Nowadays consumers are offered a wide range of organic food. It is of interest to find out which sensory factors might have an influence on the acceptance of organic food by children. This study focused on the age of 2 to 7 years. The objective of the present study is to identify a possible influence of breastfeeding and differences in weaning food (home prepared or industrial) during the first year of life on the acceptance of organic food at the current age. Other factors which might influence sensory acceptance like general liking and use of food, buying habits of parents and mothers` preferences during pregnancy will be discussed. This is the first study that combines eating habits in the first year of life and sensory testing of organic and conventional food with young children.

Materials and methods

A collective of 138 children in the age of 2 to 7 years were recruited at the German Research Institute of Child Nutrition in Dortmund. They all are participating in the Dortmund Nutritional and Anthropometrical Longitudinally Designed Study (DONALD-Study). Detailed data of these children are available about nutrition behaviour (nutrition records), growth, development, metabolism and state of health. Nutrition records at the age of 3, 6, 9 and 12 months show the nutrition behaviour of these children during their first year of life in detail.

In 2005 and 2006 children tasted organic and conventional food in Paired Comparison Tests. This sensory method was chosen to find out preferences for organic or conventional grown food. Both years children were given organic and conventional grown samples of apples, carrots and wheat (as whole-grain rolls). All these food samples were obtained by the University of Kassel, Department of Food Quality,

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where sensory profiles of the samples were prepared. Other food samples, which were tasted, like milk, apple purée and orange-juice, were purchased on the market.

In the first year the children were aged from 2 to 6 years. In the second year the tests were repeated with the same and newly recruited children in the age of 3 to 7 years. In both years parents got questionnaires mainly with questions about the nutrition behaviour of their children, along with some questions about buying habits of parents and about mothers` preferences during pregnancy.

Four steps of evaluation were shown:

1. Preferences testing by two-sided Paired Comparison Tests.

2. a. Selection of Sensory Profiling data of pairs which were used in Discrimination Tests.

b. Analysis of this selected data by paired t-tests.

c. Significant attributes of Sensory Profiling were compared with preferences of Discrimination Tests.

3. Connecting Discrimination and nutrition data by logistic regression / likelihood ratio test, considering:

- 4. Quantity of breast-feeding and consumption of different types of weaning food (home prepared or industrial)
- At age of 3, 6, 9 and 12 months (nutrition records)

4. Analysis of questionnaires with Fisher`s Exact Tests, one-sided:

- Different answers in relating to 'child decision for organic samples'
- Answers from mothers and children under aspect that the child prefers the same kind of food as the mother

All tests were made at significance level 5%, except for 2.a. where adjusted levels were used.

Results

In the preference tests for the fresh food samples only one significant result was found. There was a preference for organic apples from the second harvest year.

Considering the sensory profiling data there were two significant attributes for apples, harvested in 2005. One attribute for sour flavour and the other for firmness of fruit skin. Children tasted fruits without skin, therefore only the significant attribute sour flavour could be responsible for their decision. In the organic grown apples the sour taste was significantly lower than in the conventional one.

The results suggest that organic apples were preferred because they were less sour.

Relating the preferences to relative amount of breast-feeding, at age of 3, 6, 9 and 12 months, there was no significant correlation.

Two significant correlations with home prepared weaning food could be found:

- Correlation between preference of conventional wheat rolls (second harvest year) and high amount of home prepared milk-cereal-meal consumption at the age of 9 months was highly significant.
- Correlation between preference of organic carrots (first harvest year) and high amount of home prepared vegetable-potato-meat-meal consumption at the age of 12 months was significant.

Fisher`s Exact Test did not show significant differences between preferences of the children and the child decision for organic samples. A significant result for carrots, from the first harvest year, was found between buying frequency of organic products and child decision for organic samples. Preference for organic carrots was higher for children whose parents bought more organic food. Comparing only questionnaires there are correlations between preferences of mothers during pregnancy and preferences of children for carrots in both years and for wheat rolls in the first year of testing.

Conclusions

Difference testing of preferences with children at the age of 2 to 7 years should only be applied if differences in samples are big enough. Questionnaires seemed to be a good possibility to get information about product use, general liking and buying habits. Evaluations showed that there are some interrelations between sensory acceptance, feeding in the first year of life, buying frequency and mothers` preferences during pregnancy. Many other connections with DONALD-data and answers of the questionnaire are possible and will be investigated.

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Comparison of the nutritive quality of tomato fruits from organic and conventional production in Poland

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Key words: organic, conventional, tomatoes, flavonoids, vitamin C

Abstract

Organic horticulture is generally accepted as friendly to the environment, good for crop quality and also for the consumer's health. Recent research data has shown that organic crops under organic farming practices contained more bioactive substances such as flavones, vitamin C, carotenoids; they also contain less pesticides residues, nitrates and nitrites. Five tomato cultivars: four large – fruit (Rumba, Juhas, Kmicic, Gigant) and one cherry cultivar (Koralik) were selected for study. The organic tomato fruits contained more dry matter, total and reducing sugars, vitamin C, total flavones and beta-carotene, but less lycopene in comparison to conventionally grown tomatoes.

Introduction

Organic plants products are recognized by some consumers as safer and better in taste than conventional ones. Unfortunately organic cultivation has a markedly negative effect on the yield (Hamouz *et al.* 2005); moreover, organic fruits show more visible defects in comparison to conventional ones. This can make them less attractive for the consumers (Conclin and Tomson 1993).

Considerable research has shown that organic plants contain more bioactive substances such as antioxidants. Toor *et al.* (2006) reported that the mean total phenolic and ascorbic acid content of tomatoes grown organically was higher than the tomatoes grown using mineral fertilization. However knowledge about the nutritive value and antioxidant status of organic crops is still incomplete. There is very limited information about the content of carotenoids (lycopene, alpha- and beta-carotene, lutein) and their interrelationship with vitamins (other than vitamin C) and secondary plants metabolites such as polyphenols (flavonoids, anthocyanins), which are of great health importance. Plants flavonoids, and especially these belonging the flavones group (quercitine, kaempferol and mercitine) have been reported to prevent some kinds of cancer. The consumption of raw fruit and vegetables has a protective effect in humans for some forms of cancer, especially when plants contain flavonoids together with vitamin C, β – carotene and lycopene (Crozier *et al.* 1997). Lycopene is a pigment mainly responsible for a distinctive red color of ripe tomato (Riso *et al.* 1999, Shi 2000). The amount of this carotenoid in raw tomatoes depends on the variety, stage of maturity and the environmental conditions during cultivation (Shi 2000). There is good epidemiological data on the relationship between risk of cancer and dietary intake of tomato fruits and products. Giovanucci *et al.* (1995) found that an intake of lycopene was correlated with a diminished risk of prostate cancer. Nagasawa *et al.* (1995) showed that a prolonged dietary intake of lycopene had a preventative effect of breast tumour growth. The potent singlet oxygen quenching ability of lycopene is twice a high as that β-carotene and 10 times higher than that of α-tocopherol. Among the different tomato cultivars, cherry tomatoes (*Lycopersicon esculentum* var. *cerasiforme*) are well known, for their good taste and flavour, and although the yield of cherry tomato is only half that compared to standard large tomatoes, it is worth cultivating this new variety,

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especially in organic systems, due to their higher nutrient value (Hobson and Kilby 1985, Hallmann, 2003).

Materials and Methods

Five tomato cultivars: four large – fruit (Rumba, Juhas, Kmicic, Gigant) and one cherry cultivar (Koralik) were selected for study. Tomatoes were cultivated in certified organic and conventional farms in the Mazovia region of Poland. At this stage of study, only one of the pairs of the farms (organic – conventional) has been used as it was the Pilot Study. The next stage will involve an increased number of the farms. The organic farm was separated from the conventional farm by a distance of 60 km. The geographical situation of organic farm was 51°42' N and 20°44' E. The tomato plants were cultivated in a light loamy, sandy soil. In the organic system, all recommended standards for fertilization, plant protection and rotation were applied. The fertilizers used were horse manure (applied at 30 t/ha) and compost (applied at 30 t/ha). For plant protection we used the biological insecticide Biobit 3.2 WP, the biofungicide Biosept 33 SL and the pesticide Miedzian 50 WP, which are permitted for use in organic farming. In the crop rotation, legume plants and white mustard were used as compost for fertilization. The geographical situation of conventional farm was 52°09'N and 21°03'E with a heavy clay soil. In the conventional cultivation, the mineral fertilizers used were ammonium phosphate (applied at a rate of 350 kg/ha), ammonium nitrate (applied at a rate of 200 kg/ha), potassium sulphate (applied at a rate of 450 kg/ha), lime (applied at a rate of 1100 kg/ha). The chemical plant protection products we used were fungicides Bravo 500 SC and Amistar 250 S.C. Samples of fully ripe tomatoes were harvested in the same week of fruiting for chemical analysis. Dry matter content was determined by the scale method described in PN-90/A-75101/03, total and reducing sugars content by the Luff – Shoorl's method described in PN-90 A-75101/07, total acidity content as titratable acidity (PN-90 A-75101/04), vitamin C content by Tillman's method (PN-90 A -75101/11), carotenoids (lycopene and beta-carotene) have been determined by liquid column chromatography method. For carotenoid analysis, the whole tomato fruits (peel and flesh) were used according to the method described by Saniawski and Czapski (1983). Flavonoid content was determined by Christ – Müller's method, described by Strzelecka, *et al.* (1978). This experiment did not compare tomato yield, only quality parameters. All analyses were replicated six times and the results were statistically calculated using Statgraphics 5.1 program, specifically Tukey's test at $\alpha = 0.05$.

Results

The results of all the chemical analyses showed a statistically significant difference in the content of dry matter in tomato fruits.

Organic tomatoes contained on average 7.86 $g \cdot 100\ g^{-1}$f.m, and conventional 5.07 $g \cdot 100\ g^{-1}$f.m. of dry matter in fruits. From among the cultivars, cherry tomato contained the highest level of dry matter in comparison to the other varieties tested.

Organic tomato fruits contained twice the amount of total sugars in comparison to the conventional tomatoes. In particular cherry tomatoes from organic cultivation contained more total sugars in comparison to other cultivars examined (table 1). The organic tomatoes also contained higher levels of reducing sugars whereas the conventional tomatoes had higher total acidity in comparison to those cultivated organically, but this difference was very small. The cherry tomatoes had higher total acidity in comparison to other examined cultivars, apart from the used cultivation system (table 1) and contained higher level of vitamin C. It was also found that the cherry cultivar Koralik contained more vitamin C in fruits in comparison to all the tomato cultivars examined under both farming systems.

The analyses also showed that the lycopene content in organic tomatoes was lower in comparison to conventional ones.

The large fruit tomato Gigant had the highest level of lycopene among all the other cultivars. Tomatoes under organic cultivation contained more β- carotene in comparison to those grown under conventional management. These differences were statistically significant. Furthermore organic tomatoes contained more flavonoids than conventional ones.

Overall cherry tomatoes contained twice the amount of flavonoids than the large tomato cultivars, irrespective of the cultivation system.

Discussion

There are only a few research studies comparing the nutritional value of organic and conventional tomatoes. Pither and Hall (1990) found a higher content of vitamin C, vitamin A and potassium in organic tomatoes. In Sweden, Lundegårdh *et al.* (2000) carried out an experiment over three years on the effect of cultivation methods on tomato quality. The results showed that organically produced tomatoes contained a higher level of vitamin C, lycopene and chlorine than conventionally cultivated ones. Furthermore, Toor *et al.* (2006) found higher levels of vitamin C in organically produced tomatoes. In this paper a clearly higher content of flavonoids and β-carotene has been found in organic tomatoes. These results are similar to those previously presented by the author (Rembialkowska *et al.* 2003), and to the results of Toor *et al.* (2006) who found a slightly higher content of the phenols, and a significantly higher total soluble antioxidant activity in organically cultivated tomatoes compared to conventionally grown tomatoes.

As described above, there is evidence that some organic vegetables, in this case tomatoes, contain more antioxidants than conventional ones. Both the research data presented here and the cited results appear to confirm the above theories. But not everything is clear. Heeb (2005) in her Doctoral thesis found different levels of the nutritional compounds she investigated in every year of her studies on tomatoes. Heeb concluded that organic production methods by definition did not guarantee a higher quality product. In order to obtain uniform higher quality standards it is necessary to understand the processes influencing the chemical composition of vegetables - in this case tomatoes. The factors influencing tomato quality are complex and interrelated, and additional studies are necessary to consolidate the knowledge about the real interdependences.

Conclusions

In our study, organic tomatoes contained more dry matter, total and reducing sugars, vitamin C, β-carotene and flavonoids in comparison to the conventional ones. Conventional tomatoes were richer in lycopene and organic acids.

The cherry cultivar Koralik contained significantly more nutrients than the other tomato cultivars. In most respects the results obtained support the GDBH theory as the organic production system, with its lower nitrogen availability in soil, appears to have an impact on the levels of several bioactive compounds in tomato fruit. Organic cherry and standard tomatoes can be recommended as part of a healthy diet including plant products which have been shown to be of value in cancer prevention.

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Organic Vs Conventional Winter Wheat Quality and Organoleptic Bread Test

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Key words: winter wheat, organic, quality, bread

Abstract

In the frame of a long-term experiment carried out in Central Italy, conventional and organic winter wheat cropping systems were compared in 2004 and 2005 to evaluate the effect of system management on wheat grain yield and quality. The organic system showed grain and straw yield about 50% lower than the conventional system. Organic grain samples resulted 20% lower in protein content and exhibited poor bread production qualities. Despite that, organic bread, did not show differences in crust thickness, crumb volume and in crumb alveolus structure in a visual evaluation. Differences were, however, appreciated by panellists who found organic bread harder and more flavourful than conventional.

Introduction

A clear understanding of the relationships between farming systems and crop nutritional quality is very important for designing agricultural management strategies which enhance environmental quality and sustainability while improving consumers health. Agricultural production systems may differ greatly in terms of amount and sources of fertilisers, crop protection strategies and crop rotation. As such, a relationship between food quality and farming systems could be expected. Moreover the concept of quality is not only strictly related to food nutritional composition but it is often associated with the taste and more generally with the sensory properties. The aim of this study within the framework of the MASCOT long-term experiment (Bàrberi and Mazzoncini, 2006) was to evaluate the effects of conventional *vs* organic cultivation on winter wheat grain quality in the years 2004 and 2005 and to give the preliminary results of an informal organoleptic satisfaction test on bread derived from the same wheat variety.

Materials and methods

The MASCOT experiment (Mediterranean Arable Systems COmparison Trial) was established in 2001 at the Interdepartmental Centre for Agro-Environmental Research 'Enrico Avanzi' (CIRAA) of the University of Pisa, Italy. Winter wheat was cultivated in this experiment as a part of a five-year stockless arable crop rotation comparing a conventional and an organic management system. Different nitrogen rates mark the wheat fertilization of two cropping systems: the organic receives an organic fertilizer at the rate of 30 N units per ha, while the conventional is fertilized at a rate of 160 N units per ha using chemical fertilizers. The following quality analyses were performed on grain samples from conventional and organic grown winter wheat (cv *Bolero*) in 2004 and 2005: hectolitre weight, 1000 seed weight, protein content (N x 5.7), SDS (Sodium Dodecilsulphate Sedimentation), gluten index, total phenols and bread production qualities of the flour such as P (resistance to stretching), L (extensibility) and W (strength) were also taken into account. Wheat flour was obtained by stone milling the

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grain in a water driven mill and then sifting it through sieves, separating out only a part of the seed coats and not eliminating the germ. Bread loafs were baked in two commercial bakeries. Tests on bread loafs were performed twice by semi-trained panellists (CIRAA staff -Test N°1: 44 people) and customers of a commercial bakery (Test N°2: 157 people average age 51). Tests included preference and organoleptic analyses related to flavour, fragrance, crust and crumb consistency. Uniform sized samples were pre-coded and presented to the panellists; clean water was provided to the panellists to rinse their mouths between samples tasting. An evaluation form was provided to each panellist to record his or her judgement. The following characteristics were evaluated in Test 1: crust consistency (crisp, intermediate, hard); crumb consistency (soft, firm, hard); flavour (tasty, acceptable, unpleasant); fragrance (pleasant, neutral, unpleasant); overall evaluation (excellent, good, acceptable, poor). In Test 2 panellists were asked to answer to the following questions: 'Which bread do you prefer?' and 'Why do you prefer it?' (flavour, flavour and consistency, consistency, uncertain).

Results and discussion

Organic wheat showed a grain and a straw yield about 50% lower than conventional system wheat, while 1000 seed weight and hectolitre weight were not affected by cropping systems (table 1).

Tab. 1: Conventional and organic wheat yield characteristics

	Grain yield	Straw yield	1000 seed weight	Hectolitre weight
	(t DM/ha)	(t DM/ha)	(g)	(kg)
2004				
Conventional	5.46	6.36	30.9	78.8
Organic	2.38	2.35	34.1	76.4
	*	*	n.s.	n.s.
2005				
Conventional	5.69	6.47	35.1	82.8
Organic	2.57	2.80	33.9	80.7
	*	*	n.s.	n.s.

* significant for $P<0.05$

Protein content was about 20% lower in the organic wheat samples (table 2). As was expected, bread production qualities were strongly affected by cropping systems: organic wheat showed lower values in terms of strength (W) which could lead to less than optimal increase in bread volume. In contrast, the P/L values for conventional wheat flour are lower, which tend to indicate softer dough and bread. There is a strong linear association between protein content on one hand and the SDS (measuring gluten strength) and W indices on the other hand, i.e., an increase of protein leads to an increase of W and SDS as noticed by Ambrogio et Janbzadeh (1987). The gluten index is correlated to the strength and elasticity of gluten and not strictly dependent on protein content. Gluten quality, which is expressed by the gluten index, seemed to indicate a slight superiority in the conventional system in 2004, while in 2005, no differences between the two systems were detected. This result is in accordance with Carcea (2002) whose findings indicated no influence by cropping system on this index.

Tab. 2: Chemical and bread production characteristics of wheat grain

	Protein content	Total Phenols	Ash	Gluten index	SDS	W	P/L
	(% dm)	GE mg/g	(% dm)	(%)	(ml)	(J 10^{-4})	index
2004							
Conventional	14.6	0.50	1.64	99.3	69.3	117	0.29
Organic	11.4	0.44	1.71	97.3	54.0	82	0.84
	*	n.s.	n.s.	**	n.s.	*	*
2005							
Conventional	13.3	0.53	1.78	80.1	51.0	145	0.48
Organic	10.3	0.49	1.84	83.6	30.0	49	0.85
	*	n.s.	ns	n.s.	n.s.	*	*

* significant for $P<0.05$

Table 3 reports the chemical characteristics of the milling products: flour and bran. Nitrogen content was slightly, but significantly, higher in conventional flour and bran samples than in organic ones. Phosphorous content was higher in conventional bran but was lower in conventional flour. As regards phenol content, organic bran showed a 20% higher, but not significant, accumulation in the external parts of the seed represented by bran; differences detected between the two cropping systems were less evident in the flour. This seems in agreement with early findings (Zhou et al, 2004) that reported bran (especially the aleurone fraction) as having the greatest total phenol content. Moreover Carcea (2002) reported higher phenolic acid content in organic wheat grain.

Tab. 3: Qualitative characteristics of bran and flour after grain milling in 2005

	bran			flour		
	N	P	Phenols	N	P	Phenols
	(%)	(%)	(ppm)	(%)	(%)	(ppm)
Conventional	2.9	1.11	1678	1.8	0.12	420
Organic	2.4	1.03	2017	1.3	0.15	444
	*	*	n.s.	*	*	n.s.

* significant for $P<0.05$

Despite organic and conventional grain samples showing the above mentioned differences in protein content and bread production qualities, a visual evaluation of bread did not reveal differences in the crust thickness, crumb volume and in the alveolus structure of the crumb. Bakers noted a lower strength in the organic flour when kneading the bread dough.

Results of Test N°1 - 27% and 73% of the panellists savoured conventional and organic bread respectively. Conventional bread appeared to be characterized by having a crisp crust (54%), a soft crumb (72%), an acceptable flavour (56%) and a pleasant (60%) fragrance. 60% of the panellists gave it an overall evaluation of good and 40%, acceptable (table 4). The crust of organic bread was judged crisp by 41% of the panellists and the crumb as firm by 45%. Most panellists found it tasty (91%) and pleasantly fragrant (74%). Most panellists gave it a good overall evaluation (55%), but all the other overall evaluation values were given too (19% excellent, 16% acceptable, 10% poor). It should be pointed out that 36% of the panellists found that organic bread had a hard crust and 19% a hard crumb, while only few people expressed these opinions about conventional flour bread. About 90% of the panellists preferring organic bread found it tasty, referring to an ‘old- time’, ‘a grassy’ or a ‘more authentic’ flavour.

Tab. 4: Test 1- Panellists overall bread evaluation (%)

	Overall evaluation			
	excellent	good	acceptable	poor
Conventional	-	60	40	-
Organic	19	55	16	10

Results of Test N°2 - Organic bread was preferred both by the women (61%) and the men (57%) who were interviewed; 6% of women and 12% of men did not express any preference. Customers who chose organic bread stated that they preferred it (table 5) for its flavour (40%), flavour and consistency (34%), consistency (16%) and 10% were uncertain.

In both tests, flavour more than other characteristics seemed to have a strong influence in guiding the customer preferences

Tab. 5: Test 2- Panellists answers (%) to the question: *Why do you prefer the bread you chose?*

	Flavour	Flavour and consistency	Consistency	Uncertain
Conventional bread	43	24	25	8
Organic bread	40	34	16	10

Conclusions

The conventional cropping system seems to determine better performance than organic in terms of grain yield, seed protein content and flour bread production qualities. The organic system seems to positively affect flour and bran phenol content. Conventional flour produced 'soft' bread while organic flour produced bread that was judged slightly hard and more flavourful.

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Influence of Processing on Bioactive Substances Content and Antioxidant Properties of Apple Purée from Organic and Conventional Production in Poland

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Key words: apple purée, organic, conventional, polyphenols

Abstract

The organic food market is developing dynamically in many European countries and therefore studies concerning the nutritive value of organically produced foods are becoming increasingly important. It was found appropriate to conduct studies on selected bioactive substances and antioxidant properties of apple preserves prepared from organic vs. conventional apples. Three apple cultivars, Lobo, Boskoop and Cortland, were grown in organic and conventional orchards in the Mazovia region in Poland. Dry matter, total phenols, vitamin C, total flavones and antioxidant activity were determined in fresh and pasteurized apple purée. The apple purée prepared from the organic apples contained significantly more total phenols, vitamin C, total flavones and showed a higher antioxidant capacity than the preserves prepared from conventional apples. Processing had a negative effect on both antioxidant capacity and bioactive substances. After pasteurization, the content of vitamin C, total phenols and flavones and antioxidant properties have decreased in the apple purée from both agricultural systems (organic and conventional).

Introduction

The organic food market in Poland is developing dynamically, but in comparison to other European countries, it is still relatively small. The German organic food market is the good example - it is the second largest in the world after the USA (Meier - Ploeger 2005). Buying organic food is part of an ecological life style and tends to reflect the ideology and value system which encompasses caring about family health and protection of the environment (Wandel and Bugge 1997).

Organic preserves are an important group of products for consumers who want to eat according to the organic rules. The fruit preserves (e.g. purée) can contain larger quantities of bioactive substances in comparison to fresh fruits. For example the antioxidant activity of the blueberry fruit concentrate was considerably higher in comparison to fresh juice (Ścibisz *et al.* 2004). According to epidemiological data the intake of flavonoids is inversely correlated with the risk of coronary heart disease and cancer. Apple purée has recently been described as a good source of polyphenols, procyanidins and quercetin glycosides, which have been found to exert strong antioxidant activity. Considerable evidence is available that processing of fruits causes a decrease in the bioactive substances in the final products such as juice or purée. During the processing of the blueberry fruit, anthocyanins and phenolic compounds are destroyed by oxidation processes. Fresh organic apples were found to contain more flavonoids, anthocyanins and vitamin C in comparison to conventional ones (Rembiałkowska *et al.* 2004). Furthermore organic apple purée and juice had a higher antioxidant capacity and higher levels of bioactive substances in comparison to conventional products (Rembiałkowska *et al.* 2005).

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Materials and Methods

Three apple cultivars, Lobo, Cortland and Boskoop, were produced in two pairs of orchards. The first pair comprised a certified organic and a conventional orchard located in Mazowia region (geographical location 51°42'N and 20°44'E) and were 10 km apart. The second pair comprised two orchards (51°45'N and 19°28'E) and were 7 km apart. In both of pairs of orchards the soil was loamy and sandy. In the organic system all the recommended rules for fertilization, plant protection and rotation were followed. Organic chicken manure was used as a fertilizer, applied at a rate of 6 t/ha at the beginning of the season and only every 4th year. Each year a green manure was used as an additional fertilizer. In the organic orchards the methods and compounds used for plant protection were liquid paraffin, pheromone traps, and mixed copper sulphate with liquid lime. In the conventional orchards chemical fertilizers and plant protection products were used. The liquid fertilizers Wuksal and Florowit containing nitrate and phosphate were applied. For plant protection the pesticides Kaptan 50 WP, Merpan 80 WG, Topsin 500 SC, Syllit 65 WP were used. The apple purée was prepared from 10 kg of apple samples from the two pairs of orchards (organic and conventional). From each overall sample, 5kg of apples were washed, crushed and boiled to a pulp for 20 minutes. The hot apple pulp was then passed through a sieve and put to a glass jar, then cooled to a room temperature. Chemical analysis were done on the fresh prepared apple purée (pulp) and after being pasteurized (20 min at 70°C).

The following parameters were determined in the apple preserves: dry matter by the scale method (PN-90 A 75101/03), vitamin C by Tillman's method (PN-90 A - 75101/11), total flavones by the Christ – Müller's methods (Strzelecka *et al.* 1978), total phenols by a colorimetric method (Singleton and Rossi 1965), antioxidant activity by colorimetric methods, described by Re *et al.* (1999). The results of these qualitative characteristics of fruit were statistically calculated using Statgraphics 5.1 program specifically Tukey's test at $\alpha = 0.05$.

Results

The results of the chemical analysis are presented in Table 1. The organic apple preserves contained more total flavonoids than the conventional preserves. The purée made from organic Boskoop contained the highest level of flavonoids (tab.1). The conventional apple purées contained twice less flavonoids in comparison to the organic ones. In the conventional apple purée the highest level of flavonoids was found in the cultivar Cortland. The pasteurization process decreased the level of total flavonoids in all the samples. In the organic and conventional apple purées the flavonoids level was 25% and 52% lower than before processing.

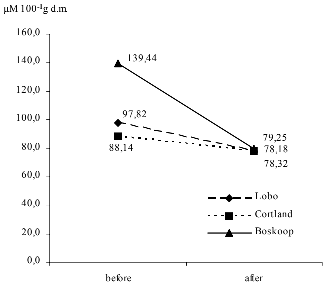
The results showed that organic apple purée contained slightly more polyphenols (4.6%) in comparison to those cultivated in conventional orchards. It should be noticed that the cultivar Boskoop was the richest in phenolic compounds in comparison to all the other cultivars, both organic and conventional (tab.1). Thermal processing, such as pasteurization, had a negative effect on the polyphenols content in the final apple product. After pasteurization the organic and conventional purée contained 23% less polyphenols than before processing (tab.1). The level of vitamin C before pasteurization was significantly higher in the organic apple purée (+ 97%) than in the conventional product; after pasteurization the difference was much smaller but the vitamin C level in the organic purée was still higher (tab. 1). It was found that the organic apple purée prepared from the cultivar Boskoop contained the highest vitamin C content among all the other apple cultivars. Among the conventional apple purées, the cultivar Lobo contain the highest level of bioactive substances. The pasteurization process decreased the level of ascorbic acid in apple purées. It was noticed that organic apple purées showed a higher decrease – 53.21%, while in conventional purées it was only 33.68%. The organic apple purées showed higher antioxidant activity than conventional ones (Fig. 1,2).

Table 1: Content of bioactive substances in organic and conventional apple puree

Tabele. 1. Content of bioactive substances in organic and conventional apple puree (mg·100g^{-1}d.m) before and after pasteurization, respectively

	Before pasteurization				After pasteurization		
	flavonoids	polyphenols	vitamin C		flavonoids	polyphenols	vitamin C
organic				organic			
Lobo	59.49	342.78	83.6	Lobo	7.62	337.29	26.32
Cortland	56.29	490.31	71.09	Cortland	5.04	420.91	51.80
Boskoop	71.44	640.01	119.43	Boskoop	5.56	375.81	50.14
	62.4	**491.03**	**91.37**		**6.08**	**378.01**	**42.75**
convent.				convent.			
Lobo	27.92	313.86	78.28	Lobo	19.88	233.09	23.05
Cortland	39.26	473.45	57.24	Cortland	31.53	525.41	55.37
Boskoop	21.95	617.96	39.84	Boskoop	6.85	361.47	38.85
	29.71	**468.43**	**58.45**		**2.68**	**361.47**	**38.76**
HSD/0.05/ method	8.07	n.s.	11.72				
HSD/0.05/ cultivar	18.06	132.01	n.s.				
HSD/0.05/ meth x cult.	7.28	58.88	10.12				

The results showed that organic apple purée contained slightly higher levels of polyphenols in comparison to those cultivated in conventional orchards. It should be noticed that the cultivar Boskoop was the richest in phenolic compounds in comparison to all other cultivars, both organic and conventional (table 1). After pasteurization, the organic and conventional purées contained 23% less polyphenols than before processing (table 1). The level of vitamin C was before the pasteurization significantly higher in the organic apple purée than in conventional one; after the pasteurization a difference was much smaller but still more vitamin C was found in the organic purée (table 1). It was found that organic apple purée prepared from the cultivar Boskoop contained most vitamin C compared all the other apple cultivars. Among the conventional apple purée, the richest cultivar was Lobo. Pasteurization decreased the level of ascorbic acid in all the apple purées. It was received that the organic apple purées showed a higher relative decrease – 53.21%, while in conventional purées it was only 33.68%. The organic apple purées showed a higher antioxidant activity than the conventional produce, and it was 108.47 μM 100g^{-1}d.m. and 62.1 μM 100g^{-1}d.m. respectively (Fig. 1,2). In general, thermal processing decreased the antioxidant activity of organic apple purée about 27.8% in organic and about 6.7% in conventional pulp.



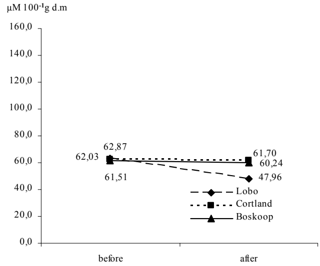


Fig.1. (left) Influence of pasteurization on antioxidant activity of apples purée from organic cultivation

Fig.2. (right) Influence of pasteurization on antioxidant activity of apples purée from conventional cultivation

Disscusion

Polyphenols have been shown to be important components for human health and the antioxidant properties of apple polyphenols have been extensively examined (Ju and Bramlage 1999; Robards *et al.* 1999, Lu and Foo 2000).

In previous studies, our research found that organic fruits contained more bioactive substances as polyphenols, flavones and vitamin C than conventional fruits (Rembialkowska *et al.* 2004, 2005). There has been only one previous experiment, also by Rembialkowska *et al.* (2005), which showed that organic apple preserves contained more polyphenols and had a higher antioxidant activity in comparison to conventional ones. In the present study, organic apple purée contained 50% more flavones and 36% more vitamin C than conventional products. We could demonstrate 47% higher antioxidant activity in organic purées compared to the conventional products (fig. 1,2). Thermal processing of apple pulp decreased the polyphenolic compounds in the final products. Bober (2005) showed that apple juice prepared from the cultivar Idared contained 121.8 mg·100g^{-1}d.m of polyphenols, however Rembiałkowska *et al.* (2005) observed much higher polyphenols, 366·mg·100g^{-1}d.m., in apple juice from organic cultivation. This was possibly due to the fact that fresh organic apples contained more bioactive compounds than conventional ones, so even after thermal processing more polyphenols remained in the final product. Polyphenolic compounds have 10 – 30 times more potent antioxidant status than witamin C (Lu and Foo 2000). This indicates the potential dietary importance of organic of apple preserves in anticancer prevention.

Conclusions

The organic apple purée contained more bioactive substances – total phenols, flavonoids and vitamin C – in comparison to conventional apple preserves. Out of the three organic apple purées the cultivar Boskoop contained the most flavonoids, phenol compounds, and highest vitamin C level. The results showed that among conventional apple purées the Lobo cultivar was the richest in vitamin C, while the Boskoop cultivar contained the highest level of other bioactive substances. Pasteurization had a negative effect on bioactive substance content and also antioxidant activity. Organic apple preserves can be recommended as valuable fruit products, which can contribute to a healthy diet and for meeting the organic consumers' demands for quality processed products.

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Biologically active compounds in tomatoes from various fertilisation systems

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Key words: tomatoes, fertilisation, carotenoids, glycoalkaloids, vitamin C

Abstract

The aim of this study was to investigate the effects of tomato cultivation systems on the content of both health promoting and of toxic components represented by carotenoids (lycopene, β-carotene), vitamin C and glycoalkaloids (α-tomatine, dehydrotomatine). The levels of biologically active compounds were shown to be strongly affected by the degree of maturity of fruit and varied depending on the fertilizsation system. Slurry, an organic fertilizer with high fertilization efficiency, is a good alternative to mineral fertilization. Lower content of toxic glycoalkaloids was found in tomatoes from organic and combined 'low input' farming. To some extent the differences were dependent on the variety.

Introduction

Higher quality standards, better taste and greater satisfaction represent consumers' motives for the purchase of fruit and vegetables from organic or low input farming (Heaton, 2001). Generally, many plant crops are known for their richness in micronutrients and dietary fibre, thus their consumption has been distinctly recognized as being an important factor for good health. It should be noted, however, that the influence of the way of farming on the overall composition of organic crops as compared to conventional products has not been fully assessed until now (Williams, 2002; Worthington, 1998). This highlights how little we know about the impact of food on health, and the need for more and in particular better research (Brandt and Leifert, 2005).

Tomato (*Lycopersicon esculentum*), representing *Solanaceae* family, is one of the most popular vegetable crops. Like many other plant commodities, tomato contains not only health promoting secondary metabolites but also natural toxins. The first group is represented by carotenoids, lycopene (10 -1000 mg/kg fresh weight) and β-carotene (up to 6 mg/kg), lycopene being one of the most important (Burri, 2002). The high intake of lycopene-containing vegetable is inversely associated with the incidence of certain types of cancer (Bramley, 2000). From natural toxins the dominating glycoalkaloid in tomatoes is α-tomatine, dehydrotomatine is only a minor component. At higher doses glycoalkaloids exhibit mainly two toxic actions in exposed mammals: membrane disruption activity affecting the digestive system and anticholinesterase activity on the central nervous system. Amount of glycoalkaloids in tomatoes depends on their size and ripeness. While the glycoalkaloid content in red tomatoes is in maximum 10 mg/kg, in green ones their levels may be as high as 200 mg/kg (Friedman, 2002; ThemaNord599 1999).

The project presented here intends to study to what extent the cultivation conditions may influence the levels of health promoting factors as well as toxic secondary metabolites in selected food plants.

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Materials and methods

Tomatoes were obtained from a green-house study performed at the Czech University of Agriculture Prague in 2005. Two different varieties of tomatoes were used for this experiment – Tornado (T) and Start (S) – hybrid F1. Plants were grown in containers (content 20 L) on peat-bark substrate. The number of plants in each experimental setup was 10. Red ripened tomatoes were used for all experiments. The variety Start from the organic farming system was taken for analysis also 14 and 28 days before harvest (green and light-red tomatoes).

Four different fertilization regimes were employed in this experiment:

- N - control farming (not fertilized with mineral and/or organic fertilizers)
- O - organic farming (slurry in the amount 4 L were added into container, 2 L of slurry were added after 30 days of farming)
- M - mineral farming (15 g of ammonium sulphate and 9 g of potash fertilizer were added into container, 7.5 g of ammonium sulphate were added after 30 days of farming)
- C - combined farming (3 L of slurry, 7.5 g of ammonium sulphate and 4.5 g of potash fertilizer were added into container, 1.5 L of slurry and 3.75 g of ammonium sulphate were added after 30 days of farming)

Levels of carotenoids (β-carotene and lycopene) and vitamin C were analysed by HPLC method with diode array detection (DAD, 470 nm for carotenoids, and 251 nm for vitamin C), separation of sample components was curried out on analytical column LiChroCART, Lichrospher 100 RP-18. The limit of detection (LOD) was 1 mg/kg for lycopene, 0.05 mg/kg for β-carotene and 1 mg/kg for vitamin C.

The main tomato glycoalkaloids (α-tomatine and dehydrotomatine) were determined using LC/MS-MS (SRM mode) method. Analytical column HyPURITY AQUASTAR was used for separation. The limit of detection (LOD) was 0.01 mg/kg for α-tomatine and 0.02 mg/kg for dehydrotomatine.

Results and discussion

Vitamin C content ranged from 180 to 298 mg/kg. The highest content was found in control samples (N), the lowest in organic tomatoes (O) - Figure 1. Levels in ripe tomatoes depended on storage conditions.

Content of tomato glycoalkaloids α-tomatine (major tomato glycoalkaloid) and dehydrotomatine (minor one) ranged from 0.85 to 4.84 mg/kg and from <0.02 mg/kg to 0.24 mg/kg, respectively. The highest levels were found in tomatoes from mineral farming (M), the lowest in organic tomatoes (O). The variety Start tended to contain slightly higher levels of these natural toxins (Figure 1).

Carotenoids content varied depending on the way of farming, variety and other parameters. Levels of β-carotene ranged from 5.4 to 9.8 mg/kg and levels of lycopene from 137 to 286 mg/kg. As shown in Figure 2, slightly higher content of lycopene was found in the variety Tornado. No correlations between these two carotenoid levels were found.

Content of biologically active compounds in tomatoes is strongly influenced by degree of their maturity (see figure 3). Rapid increase of major tomato carotenoids, lycopene and β-carotene, took place during ripening and, simultaneously, a significant decrease of glycoalkaloids, α-tomatine and dehydrotomatine, occurred. Lycopene content in ripen (red) tomatoes was 117 times higher as compared to green fruit, on the other hand α-tomatine levels in this unripe material were 43 time higher than in red fruits. Vitamin C content was highest in ripe tomatoes.

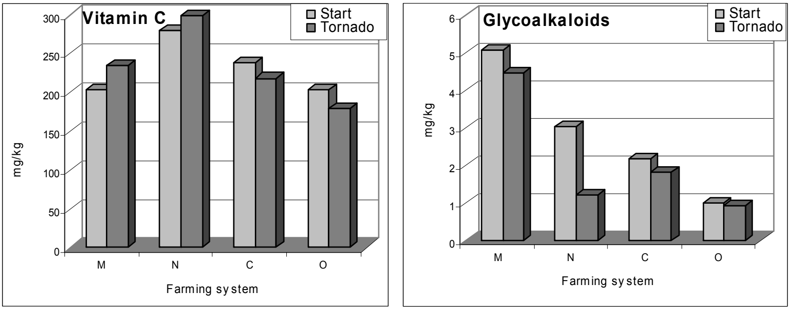

Figure 1: Content of vitamin C and glycoalkaloids (sum of α-tomatine and dehydrotomatine) in experimental tomatoes

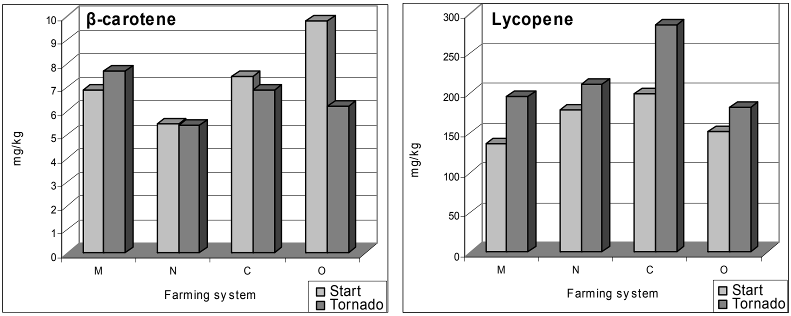

Figure 2: Content of carotenoids (β-carotene and lycopene) in experimental tomatoes

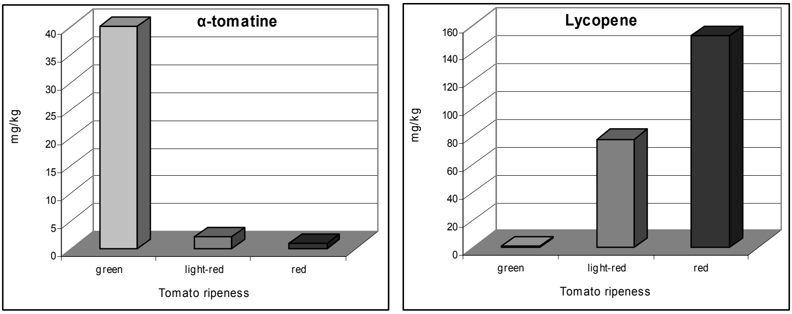

Figure 3: Content of α-tomatine and lycopene in tomatoes in different stages of maturity

Conclusions

Based on experimental data, following conclusions can be drawn:

(i) Organic and 'low input' combined farming resulted in lowest glycoalkaloids levels. Slightly higher levels of these natural toxins were determined in the variety Start.

(ii) No relationship between the levels of biologically active compounds represented by vitamin C and carotenoids and the way of fertilization was observed, differences were found between the varieties. While Tornado was higher in lycopene, Start contained slightly more β-carotene.

(iii) Considering the content of investigated health promoting and toxic biologically active secondary metabolites, slurry - organic fertilizer, was shown as good alternative to mineral fertilization.

(iv) The content of biologically active compounds in tomatoes was strongly influenced by their maturity, decrease of glycoalkaloids and increase of carotenoids occurs.

Further extensive, long-term investigations are necessary to obtain reliable information on the influence of farming systems on the quality of products grown under various conditions. The described experiments were continued in the in the year 2006 and the overall results will be evaluated.

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Development of strategies to improve quality and safety and reduce cost of production in organic and ‘low input’ crop production systems

Development of strategies to improve quality and safety and reduce cost of production in organic and ‘low input‘ crop production systems

Tamm, L.[1], Köpke, U.[2], Cohen, Y.[3] & Leifert, C.[4]

Key words: organic, low input, crop production, soil fertility, food safety

Abstract

The overall aims of organic and low input crop production include the economically viable and environmentally sound production of high quality food and feed. Technological bottlenecks in such systems include insufficient and instable yields and in some instances unsatisfactory processing, sensory and/or nutritional quality of the final product. Recently, concerns have also been raised that the intensive use of manures may lead to increased risk for contamination of food by enteropathogenic micro-organisms. Crop production in low input systems is based on key pillars, i.e. (i) a fertile soil which provides sufficient capacity to allow for plant growth while preventing soil-borne diseases, (ii) high quality, disease-free seeds and plant material, (iii) a crop-specific soil fertility management to provide sufficient nutrients for optimum plant growth, and (iv) adequate crop protection techniques to prevent damage due to noxious organisms. In the QLIF project we develop improved component strategies to overcome technological bottlenecks in annual (wheat, lettuce, tomato) and perennial (apple) crop production systems. In this paper we report the progress achieved so far.

Introduction

One of the principles of organic farming is to attain high quality food production and ecological balance through the design of farming systems, establishment of habitats and maintenance of diversity. Inputs should be reduced in order to maintain and improve environmental quality and conserve resources (Tamm, 2001). However, there are still some ‘technological’ bottlenecks in organic production systems which potentially affect quality and safety in organic foods, the environment, as well as costs of production. These bottlenecks include insufficient and/or untimely availability of nutrients as well as occurrence of pests and diseases. Similar bottlenecks also need to be addressed in other low input and integrated farming systems. The aim of the QLIF project is therefore to (i) improve the understanding of the functionality of inherent soil fertility as a base of crop productivity and health, (ii) to develop improved agronomic strategies to overcome key technological bottlenecks and (iii) to demonstrate the impact of integration of improved management strategies in annual (tomato, lettuce, wheat) and perennial (apple) pilot production systems. By doing so, we aim to evaluate the overall productivity and quality of the novel systems as well as the economic and ecological impact of the component technologies developed as part of the project. In this paper we give an overview of the research under way and the progress that has been achieved so far.

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Soil fertility and inherent disease suppressiveness

Soil management (e.g. crop rotation, soil tillage, organic amendments) has a significant impact on overall soil fertility as well as specific soil properties such as erosion stability, nutrient availability and water holding capacity (Mäder *et al.*, 2002). Microorganisms play a key role in soil quality and fertility as they are involved in nutrient cycling and transformation processes, as well as soil physical parameters (e.g. soil aggregate stability). Soil microbial communities are affected by short-term as well as by long-term management practices. In general, soil microbial biomass, activity, and diversity tends to be higher in organic than in conventional farming systems (Mäder et al, 2002). Fertility inputs to soils are an important means to improve plant production in agricultural systems. While most conventional or integrated farming systems are based on regular mineral N, P and K fertilizer inputs (that are immediately and easily available to the crop from the liquid phase of the soil solution), fertility inputs used in organic farming systems are based on organic matter inputs (e.g. green and animal manures, composts) only become plant available after unlocking of nutrients from the solid phase by weathering or mineralization processes. Mineralization of these organic matter based fertility inputs by soil microorganisms is crucial for nutrient delivery to the crops in organic agriculture. An active and abundant soil flora and fauna is therefore essential for a rapid mineralisation, and activity of the soil biota is itself affected by soil temperature, moisture and by the chemical composition of the fertility input. Fliessbach *et al.* (2007) evaluated the effects of long-term and short-term effects of organic fertility inputs on soil, physical, chemical and biological properties as part of the long-term DOK trial in Therwil (CH) and from short-term fertility input experiments with lettuce in Bonn (DE) and with onions in Yorkshire (UK). The analyses in the DOK trial confirmed that long-term usage of different soil management strategies lead to different steady state situation with respect to soil properties. The trials at Bonn, Tadcaster and Stocksbridge comprised one single fertilizer application per treatment followed by the growing of an one crop. Among the treatments, fresh bovine manure at Bonn and chicken manure at the two UK sites increased soil biological activity, but it could be excluded that the effects observed reflected temporary peaks (rather than a long-term change), due to the differences in amount and quality of the manures applied.

Soil properties are known to affect the occurrence and severity of soil-borne diseases (Tamm *et al.* 2006). The extent of disease is the result of the abundance of disease propagules and the competition between crop plant, causal agent and interaction with antagonists in the soil. Crop rotation is widely used in organic and low input farming systems to reduce the survival of pathogenic propagules. Also the presence of specific antagonists or the addition of organic amendments to soil was linked to a suppression of a range of soil-borne diseases including *Rhizoctonia*, *Pythium*, *Fusarium*, *Gaeumannomyces* or *Phytophthora* spp. There is also evidence that soil properties are affecting the occurrence of diseases on foliar parts of the plant. The systematic use of soil fertility management techniques to reduce diseases is an intriguing concept in theory, but it is not yet widely used in practice, partly due to the lack of understanding of the underlying principles. Despite the claims made by some organic farmers, we still find no evidence that reduced foliar disease susceptibility is a typical feature of plants grown in organic farms (Tamm *et al.*, 2005). Within the framework of the QLIF project, the working groups of FiBL, Kassel University and Newcastle University started a research project in 2004 in order to elucidate the influence of soil properties on soil suppressiveness and to quantify the relative importance of site-specific *vs*. cultivation-mediated soil properties. Preliminary data analysis indicates that differences in suppressiveness may be quantified and related to soil properties and/or organic matter based fertilisation regimes. Furthermore, site-specific factors, which cannot be influenced by agronomic practices, were found to have a greater impact than cultivation-specific effects within the same site. The ongoing research is focussing on verifying hypotheses that aim to identify the underlying correlation between suppressiveness and selected soil properties.

Short-term fertility management and plant nutrition

Nitrogen is a key element in plant nutrition and is in organic production systems often limiting for both, yield and quality. Organic wheat production often suffers from limited nitrogen availability. For example, previous results have revealed that wheat produced in organic and 'low-input' farming systems are characterized by low and irregular grain yield and protein content (David *et al.* 2007). Typically, it is very difficult to synchronise the nutrient release characteristics from organic matter inputs in soil, with the needs of the crop. The aim of QLIF was therefore to improve the understanding of nutrient release characteristics of the organically managed soils and the nutrient uptake of the crop. The use and adaptation of existing models such as *Azodyn* and *Daisy* (Dux & Fink, 2007) to organic and low-input conditions is the aim of this part of QLIF. The use of models may also allow the quantification of additional limiting factors such as weed competition, drought, soil compaction, or pests and diseases which indirectly affect acquisition and uptake of nutrients.

Soil amendments such as plant-probiotic microorganisms (PPMs) may promote plant growth by biological nitrogen fixation, solubilization of phosphorous, synthesis of siderophores, plant hormones, and plant hormone regulators (Bosco et al, 2007). The indirect promotion of plant growth can occur when soil beneficial microorganisms antagonize the action of phytopathogenic organisms. However, there is still a substantial gap in our knowledge about of the principles and the commercial viability of such amendments. The use of PPM is of particular interest in highly demanding vegetable crops such as tomato. Studies to evaluate novel commercial preparations are currently under way.

Soil management strategies and food safety

Since consumption of uncooked ready-to-eat vegetables becomes increasingly popular, public concern about the microbiological safety of vegetable is also steadily increasing (Trewavas 2001). Recently, concerns have been raised that intensive use of manures might lead to increased risk for contamination of food by entero-pathogenic micro-organisms. Food-borne infection outbreaks have been associated with faecal pathogen contaminations of vegetables (Köpke *et al.*2007). Such contamination may potentially take place during cultivation and post-harvest handling. Unprocessed bovine manure may be a source of faecal bacteria that might be transmitted to crops that grow nearby the soil surface. However, composting of manures was shown to be an efficient way to reduce pathogen loads. The aim of these studies (Rattler et al, 2005,) was to assess the effect of different fertiliser types on the transfer risk of enteric bacteria in head lettuce. Different treatments of manure application were investigated and the effect of post-harvest handling (e.g. washing) determined. The effect of different fertiliser types (calcium ammonium nitrate, fresh farmyard manure, composted farmyard manure and nettle extract) on the hygienic quality of fresh and washed lettuce was tested in two trials in summer 2004 and 2005. The hygienic quality was assessed by determination of total aerobic bacterial count and level of coliform bacteria, *Escherichia coli*, *Salmonella enteritidis*, Enterobacteriaceae. No *Salmonella enteritidis* was detected in any of the samples. *E. coli* was isolated independent of the fertiliser type in low concentrations. The total aerobic bacterial count, the levels of Enterobacteriaceae and coliform bacteria tended to be lower after application of mineral fertiliser, but were generally at a very low level. The washing process had no significant influence on the hygienic quality of lettuce. No significant differences in enteric bacterial cfu were detected between lettuces grown in soil treated with farmyard manure that was incorporated into soil or left on soil surface. These studies provide no evidence that the use of organic soil fertility inputs poses any additional safety risk, even if worst-case scenarios were studied. Also field experiments with different strategies of physical weed control did not confirm the hypotheses of a substantial pathogen transfer from soil treated with farmyard manure (Fischer-Arndt et al, 2007). Based on these trials, the application of manures in good farming practice could not be linked to any food safety risk.

Pest and disease control

Although a range of diseases are controlled efficiently by agronomic methods (e.g. crop rotation) certain pests and diseases can cause major problems in organic and low input systems. Several EU- and national funded projects aim to develop novel strategies for pest and disease control. In order not to duplicate research efforts, the QLIF consortium therefore focused on gap-filling research in areas which are not covered elsewhere and the integration of novel crop protection techniques developed elsewhere into organic and low input crop production systems (see below).

The prerequisite for successful crop production is the use of disease-free planting material. Seed treatments are one of the options to remove pathogenic bacteria and fungi. In the QLIF consortium, the studies focussed on the development of strategies to obtain disease-free tomato and wheat seeds. Good control of *Didimella lycopersici* was achieved in seed treatments whereas control of *Fusarium* resulted only in slight reductions of damping-off (Kasselakis et al, QLIF annual report 2006). The bacterial disease *Clavibacter* was well controlled not only by acidified nitrite solutions, but also by a wide variety of compost extracts. Another option which is currently evaluated on wheat is to avoid seed contamination by *Fusarium* during seed production. In the present project it was investigated whether spring wheat cultivars differ in sensitivity to seedling blight and this could be linked to differences in early growth rates of cultivars (Timmermanns et al, 2007). Preliminary results confirm that cultivars differ in sensitivity to seedling blight, and that cultivars with higher early growth rates appeared to be less sensitive to seedling blight. If the repetition of this experiment in 2007 confirms the relation between early growth rate and sensitivity to the disease, this knowledge could be used to select cultivars which are more resistant to seedling blight.

Air-borne foliar diseases such as *Bremia lactucae* in lettuce or *Phytophthora infestans* in tomato may cause substantial losses in organic vegetable production systems. Breeding for varietal resistance is very intensive and novel varieties (especially lettuce) are introduced into the market at high rates. However, the varietal resistance is often overcome within a very short period due to the highly adaptive pathogen population. An alternative procedure to protect plants against disease is to activate their own defence mechanisms by specific biotic or abiotic elicitors. In this study (Cohen, 2007) the efficacy of ß-amino-butyric acid (BABA) in controlling downy mildew in lettuce, especially under field conditions was evaluated. Another objective was to study the mechanism of action of BABA against *Bremia lactucae* in lettuce. A major finding of this study was that BABA was efficient in controlling downy mildew in lettuce under field conditions. Foliar sprays with 201 and 1039 mg/l resulted with 50 and 90% control of the disease, respectively. This result may encourage the introduction of BABA to agriculture as a systemic acquired resistance (SAR) compound against lettuce downy mildew. Due to the fact that BABA occurs naturally in tomato plants (unpublished data) it might also be considered for application in organic farming.

At field level, the need for direct intervention with pesticides can be reduced by promoting build-up of populations of beneficial insects. This approach has been explored in brassica crops in the UK (White et al, QLIF annual report 2006).

Preliminary data analysis indicates that companion plants may decrease the number of cabbage root fly eggs and field margin companion plants may lead to increased predator populations not only in mid-European but also in more humid UK climates.

The integration of preventative crop protection strategies

One of the major aims of QLIF subproject 3 is to integrate novel preventative crop protection techniques into improved crop production systems. Currently, the production system development is under way in apple, wheat, and tomato. Novel crop component strategies evaluated have been developed in other EU and national funded projects but also within QLIF. In the integration of techniques we focus on studying the effect of novel crop protection concepts and treatments on crop quality and safety, the environment, sustainability and production cost & socio-economic impact.

Tomato production systems: Organic tomato production is limited by soil-borne diseases as well as by air-borne diseases. In order to overcome these bottlenecks, strategies to control (Dafermos *et al.*2007) soil-borne root and vascular diseases (corky root rot, *Pyrenocheta lycoperici*, and *Verticillium* spp) are developed. The main objectives were to (i) identify alternative strategies for the control of soil borne diseases and (ii) to evaluate the impact of such novel control methods on fruit yield, size and quality parameters. The use of resistant rootstocks was found to an effective method to control soil-borne disease. Grafting onto resistant rootstocks overall increased root fresh weight and mean fruit weight reduced fruit number, but had no significant effect on fruit composition. However, the type of growth substrate used has a significant effect on fruit nutritional composition and taste (sweetness) of tomato. Compared with tomato crops produced in manured soil (the substrate used in organic production) fruit yields, root fresh weights, fruit number and the mean fruit weights from plants produced in perlite (P) fertilized with mineral nutrient solutions and a soil/gravel/perlite mixed substrate were significantly higher. In contrast, antioxidant levels were higher in soil grown plants.

Another serious disease of greenhouse tomato is powdery mildew. In conventional farming systems the disease is mainly controlled by sulphur and other fungicides while under organic farming standards only sulphur products are permitted. However, sulphur can negatively affect the efficacy of insect predators and be phytotoxic in the greenhouse at high temperatures. Previous studies indicated that soil amendment with chitin in combination with the use of resistant hybrids and the foliar spraying with chitosan or plant extracts, may increase the resistance of crops (e.g. cucumber) to foliar diseases. The use of such treatments was also shown to affect the nutritional composition of crops. However, the integrated use of these strategies against powdery mildew and their combined effect on tomato nutritional composition has not yet been studied. Therefore, the objectives of this study were to: (a) assess the efficacy of integrating compost amendment, hybrid selection and application of alternative foliar spray treatments against the powdery mildew of tomato (*Leveillula taurica*) under greenhouse conditions and (b) carry out selected composition analyses to determine the effect of such treatments on the nutritional composition of tomato. Some of the combinations of the above factors were highly effective in decreasing the percentage of disease severity. Specifically the combination of the hybrid of low susceptibility with the addition of chitin in the substrate and the spray treatment Milsana®+chitosan, was equally effective to sulphur. These results indicate that the combination of the above factors could probably be used as an alternative to sulphur controlling *L. taurica* in the greenhouse. Future experiments will further explore the potential of integrated strategies against soil-borne and air-borne diseases and the impact on quality, sustainability and economic viability.

Wheat production systems: Yield and protein content of wheat produced under organic standards was repeatedly shown to be between 20 and 40% lower than levels achieved in conventional farming systems. This is thought to be at least partially due to lower N-supply to the crop later in the growing season and poor adaptation of the currently used wheat cultivars to organic production conditions. Results obtained so far (Wilkinson et al, 2007) indicate that two of the main problems relating to the sustainability of the current organic wheat production methods (lower yields and protein contents) can be addressed by changes in fertility management practices and cultivars choice. Strategies include (i) the promotion of legumes by Rhizobium inoculation of clover seeds prior to the wheat crop, (ii) and the choice of adapted wheat cultivars. Results showed that cultivar choice had the greatest effect on yields, but that fertility management practices also significantly affected wheat yields and protein quality for some of the cultivars. This clearly indicates that yields in organic wheat production can be significantly increased by improved cultivar choice and fertility management regimes.

Apple production systems. Fruit yield, fruit quality and disease occurrence in organic apple production are controlled by a multitude of interacting agronomic factors, the most important being supply of water and nutrients, especially nitrogen input levels and availability pattern during the growing season. The objectives of this research (Lindhard et al, 2007) were to compare single spring application of standard 'rapid release' organic manures (chicken manure pellets) commonly used in organic production systems and traditional 'organic' approach based on mineralization driven N-supply from inputs such as compost, which contains very low levels of water-soluble forms of nitrogen, with respect to nutritional status, yields, disease incidence and fruit quality characteristics of apple trees. In this study an optimum compromise between net yield and quality had to be identified. A high production combined with trees less infected with fruit tree cancer and with a satisfactory colouring was produced on trees grown in intensive production system of 5555 trees per ha with no nitrogen supply.

The control of scab caused by *Venturia inaequalis* in organic apple production is still mainly focussed on the use of fungicidal compounds applied in spring and summer. Apple scab control is not addressed in QLIF but in the specialized EU project REPCO (Heiijne et al, 2007). The approach of the EU REPCO project is, to integrate several preventive measurements, such as stimulation of earthworms and micro-organisms to degrade overwintering inoculum, and endophytes to reduce numbers of spores in the orchards. The ongoing research produces novel techniques (preventative and direct control) which will further the development of sustainable apple production systems.

Conclusions

Various approaches to provide optimum plant nutrition and to control key pests and diseases are explored in QLIF. The results obtained so far suggest that substantial progress can be made towards more productive organic and low-input production systems. Several of the novel component strategies do improve not only productivity but can also contribute to a better product quality. The use of manure-based fertility inputs is one of the backbones of sustainable agriculture. Our studies show no indication that such practices may lead to increased risk in food safety even under worst case conditions. The integration of novel component strategies into improved crop production techniques is well under way. In this process, we also integrate novel results from other national and EU funded projects.

Acknowledgements

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Soil biological quality in short- and long-term field trials with conventional and organic fertility input types

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Key words: Soil biology, soil microbial biomass, alkaline phosphatase activity, manure, soil type

Abstract

Soils of the DOK trial and three other field trials with manure input were analysed for effects on soil biology. While long-term effects indicate a new steady state at the DOK trial site, differences at the other field trials suggest that fresh manure at the Bonn trial and chicken manure at the UK sites are at least temporarily advantageous, probably due to their relatively fast mineralization.

Introduction

Fertility inputs to soils are an important means to improve plant production in agricultural systems. While conventional or integrated farming systems may utilize mineral fertilizers that are immediately and easily available to the crop, nutrient inputs to organic farming systems may be derived from livestock, from commercial organic fertilizers, and from green manure. Mineralization of these organic inputs by soil microorganisms is crucial for nutrient delivery to the crops. An active and abundant soil flora and fauna is advantageous for a fast mineralisation of organic nutrient sources, which is ruled by soil temperature, moisture and by the chemical composition of the fertility input. The aim of our study was to evaluate long-term and short-term effects of organic fertility inputs. For this we compared chemical, physical and biological properties of soils from the DOK trial in Therwil (CH) and from short-term fertility input experiments with lettuce in Bonn (DE) and with onions in Yorkshire (UK).

Materials and methods

Soil samples were taken from 0-20 cm at each site. At the DOK trial a mixed sample from the four replicate plots and the three crops for each treatment (grassclover 2nd yr, catch crops before maize and soybeans) was taken. At the short-term field trials in Tadcaster, Stocksbridge and Bonn a bulk sample from each replicate field plot was taken before application of the fertility input and at the time of harvesting lettuce and onions. Soils were homogenised and divided into subsamples that were sent to the partners for analysis. We analysed soil physical (water release curves, aggregate stability, particle size classes), chemical (CEC, pH, Corg, Nt, nutrients and trace elements) and biological soil parameters (soil microbial biomass, basal respiration, phosphatase-, protease- and dehydrogenase-activities, fluorescein-diacetate-hydrolysis, and calculated ratios).

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Tab. 1. Soil characteristics of the four field sites

	Therwil (CH)	Wiesengut (DE)	Tadcaster (UK)	Stocksbridge (UK)
coordinates	47°30'N;7°33'E	50°47' N;7°17' E		
soil type	haplic luvisol		calcic cambisol	gleysol
sand/silt/clay *[1]	8/78/14	50/38/12	48/30/22	86/6/8
pH *[1]	5.63	6.70	7.24	7.01
C_{org} (mg g^{-1}) *[1]	14.03	11.05	29.90	16.96
Sampling date	-	20.04.2004	05.05.2004	
Sampling date	17.03.2004	06.07.2004	15.10.2004	
Treatments	No fertilizer	Fresh manure	Compost	
	Mineral fertilizer	Comp. manure	Mixed chicken manure and compost	
	Biodynamic 1&2	Mineral fertilizer	Chicken manure	
	Bioorganic 1&2			
	Integrated 1&2			
Intensities	1: 0.7 LSU *[2]	85 kg N		
	2: 1.4 LSU	170 kg N	170 kg N	170 kg N
Crop	3 crops pooled	Lettuce	Onion	
Samples	8	8 + 24	4 + 12	4 + 12
Replicates	0	4	4	4

*[1]average values of all treatments; *[2]LSU: livestock units ha^{-1} yr^{-1}

Results

The DOK-long term study has been included in this program as a reference to document the reliability of our measurements and to produce an estimate of long-term effects of organic and conventional farming practice. Soil analyses of the DOK-trial have been done regularly in the last decades and may be compared to our data (Fließbach and Mäder, 2000; Fließbach *et al.*, in press; Mäder *et al.*, 2002). Microbial biomass values are similar to earlier measurements (Fig. 1). All analyses showed the same trend as earlier estimates, except for phosphatase activity, where differences between organic and conventional have become smaller than in measurements of 1991 (Mäder *et al.*, 1993). In the organic farming systems with 1.4 livestock units, soil microbial biomass and phosphatase activity was 30-80% higher than in the mineral fertilizer treatment. At reduced intensity (0.7 livestock units) the organic systems showed 20-40% higher values.

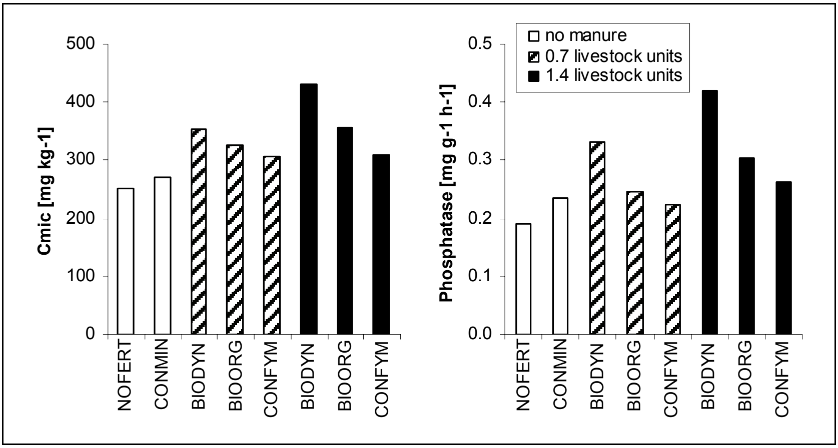

Figure 1: Soil microbial biomass and alkaline phosphatase activity in soils of the DOK-trial

At the other field sites, samples taken before fertility input and at crop harvest were compared. Lettuce was harvested 77 days and onions 163 days after the first sampling. In the lettuce trial, soil microbial biomass declined in all treatments over this time period (Fig. 2). This decline was significant for composted manure and mineral fertilizer at both intensities. Compared to these two treatments, application of fresh manure resulted in a gain in microbial biomass. This was also mirrored in phosphatase activities. Whereas all treatments showed a tendency towards increased phosphatase activities compared to the start, this increase was only significant when fresh fertilizer was applied at a high rate. Among the treatments at harvest time, fresh manure revealed higher phosphatase activity than mineral fertilizer.

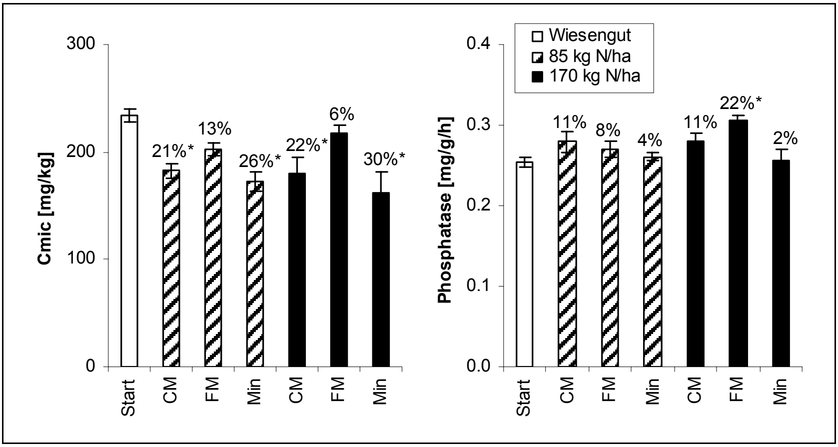

Figure 2: Soil microbial biomass and alkaline phosphatase activity in soils of the lettuce-trial at the Wiesengut of Bonn University (DE) at planting and harvest time. Standard errors of mean are shown and the numbers are % reduction relative to the start. (CM: composted manure, FM: fresh manure, Min: mineral fertilizer, *: significant difference compared to the start)

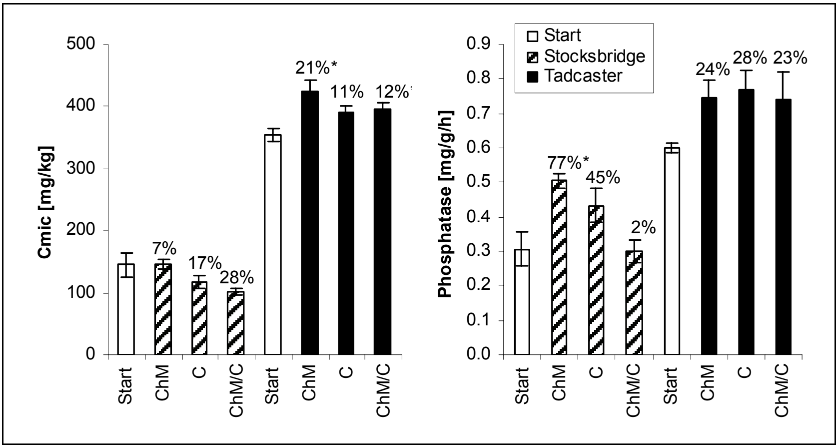

Figure 3: Soil microbial biomass and alkaline phosphatase activity in soils of the onion-trial at Stocksbridge and Tadcaster (UK) at planting and harvest time. Standard errors of mean are shown and the numbers are % reduction relative to the start. (ChM: chicken-manure, C: compost, ChM/C: chicken-manure/compost, *: significant difference compared to the start)

Sandy soils from Stocksbridge showed a relatively low level of microbial biomass. The Tadcaster site was characterized by higher clay and silt contents and a higher pH. It had 2.5 times higher microbial biomass and almost twice the phosphatase activity than Stocksbridge soil. Unexpectedly, microbial biomass and alkaline phophatase activity in Stocksbridge showed opposite trends. Whereas microbial biomass in Stocksbridge soil was slightly reduced in all treatments at harvest time compared to the start, phosphatase activity increased in all treatments. However, this increase was significant only in the chicken manure treatment (Fig. 3). After application of chicken manure alone microbial biomass was 46% and phosphatase activity was 67% higher than in the chicken manure/compost treatment. Chicken manure at the Tadcaster site enhanced microbial biomass significantly by 22% as compared to the start. Apart from this there were no significant effects of the fertility inputs on microbial biomass and phosphatase activity in Tadcaster soil. No differences were obtained between the treatments at sampling time.

Discussion

While analyses in the DOK trial were showing long-term effects that were not influenced by a growing crop, these values may be interpreted as a new steady state. This is also supported by the continuing monitoring of soil biology in the same soils. The trials at Bonn, Tadcaster and Stocksbridge comprised one single fertilizer application per treatment followed by a crop. Over time, the fertilizer for the crop may have influenced both, the soil and the crop, and interactions on soil biology are likely to occur with a higher crop biomass. Among the treatments, fresh manure at Bonn and chicken manure at the two UK sites showed some advantages, but it cannot be excluded that these effects are reflecting peak situations due to the differences in amount and quality of the fertilizers applied.

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Soil suppressiveness and functional diversity of the soil microflora in organic farming systems

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Abstract

Arable fields of 10 organic farms from different locations within the Netherlands were sampled in four subsequent years. The soil samples were analysed for disease suppressiveness against Rhizoctonia solani, Streptomyces scabies and Verticillium dahliae. Furthermore, a variety of microbial characteristics and chemical and physical soil properties were assessed. All these characteristics and different environmental factors were correlated by multivariate analyses.

Significant differences in soil suppressiveness were found for all three diseases. Suppressiveness against Rhizoctonia was more or less consistent between the sampled fields in 2004 and 2005. This suppressiveness correlated with higher numbers of Lysobacter and Pseudomonas antagonists, as well as fungal diversity in DGGE patterns. Furthermore, results of 2006 showed that one year of grass-clover clearly stimulated Rhizoctonia suppression. Also Streptomyces soil suppressiveness was consistent between 2004 and 2005, but it concerned other soils than the ones which were suppressive against Rhizoctonia. Streptomyces suppression correlated with higher numbers of antagonists in general, Streptomyces and the fungal/bacterial biomass ratio, but with a lower organic matter content and respiration. Soil suppressiveness against Verticillium was not consistent between the years and therefore probably not related to soil factors.

Introduction

Enhancement of disease suppressive properties of the soil is of great importance in organic as well as other sustainable agricultural systems. Disease suppressiveness enhances crop health and allows a reduction in pesticide use. However, not enough is known about the influence of agricultural practices and soil characteristics on disease suppressive properties of the soil and its relation with diversity, composition and activity of the soil microflora. Several techniques to characterise the microflora (composition, diversity, antagonistic properties) have been developed recently and applied to experimental fields to study the influence of crop rotation and agricultural practices (Garbeva *et al.*2004, 2006; Salles *et al.*2004).

In the present study, soil samples were from organic farms at different locations within the Netherlands, each with their own agricultural practices. The soil samples were analysed for disease suppressiveness, microbial characteristics, as well as chemical and physical properties. Our objective was to detect soils which differed in soil suppressiveness, and to identify soil factors as well as microbial characteristics which correlate with suppressiveness.

Materials and methods

Arable fields of 10 organic farms from different locations within the Netherlands were sampled in August of 2003, 2004, and 2005. All fields were cropped with grass-clover in 2003. In 2006, a selection of the previously analysed fields with the largest contrasts in disease suppression were sampled again and compared with a grass-

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clover field from the same organic farm. From each field four independent samples were taken. Several physical, chemical and biological parameters were analysed by external labs. Disease suppression and microbial characteristics were analysed as described below.

Three plant-pathogen systems were used to assess soil suppressiveness in a climate room: (1) *Rhizoctonia solani* AG2.2IIIB, a fungal pathogen causing root rot and damping off of sugar beet, (2) *Streptomyces scabies*, a bacterial pathogen causing scab on radish (as a model for potato), and (3) V*erticillium dahliae*, a fungal pathogen causing wilt in rape seed.

Molecular fingerprints of bacteria and fungi were prepared from the soil microbial communities using PCR-DGGE (polymerase chain reaction - denaturing gradient gel electrophoresis) (method as described in Garbeva *et al.*2006).

Soil bacteria were plated on an agar medium. Two days later *Rhizoctonia* was co-inoculated on these plates. The bacteria that inhibited hyphal growth of *Rhizoctonia* were selected and sequenced (part of 16S) for identification.

Multivariate analyses to correlate disease suppressiveness with environmental factors and soil characteristics were performed with the statistical program CANOCO (Ter Braak 1995).

Results

The soils differed substantially in organic matter content, clay content, pH, C/N ratio, type of manure applied, fungal and bacterial biomass (see Table 1).

Disease suppressiveness tests of 2003 had too large variations, and were optimized in the years after. Significant differences in soil suppressiveness were found for all three diseases in 2004 and 2005. The fields of the farms A, G, D were most suppressive against *Rhizoctonia*; most conducive were fields of E, F, I. The results of 2006 clearly showed the positive influence of grass-clover on disease suppression against *Rhizoctonia.*

The fields of the farms H, I, J were most suppressive against *Streptomyces* in 2004 and 2005; most conducive were fields of C, E, G. Grass-clover did not influence the suppressiveness against *Streptomyce*s (results of 2006). Soil suppressiveness against *Verticillium* was not consistent between the years and therefore probably not related to soil factors.

Every year between 80-150 isolates, which inhibited *Rhizoctonia,* were sequenced for identification. *Streptomyces*. *Lysobacter* and *Pseudomonas* were most common: resp. 41, 29 and 16 % of the isolates in 2004 and 34, 23 en 17 % in 2006. *Lysobacter* was mainly present in clay soils and was clearly stimulated by growing grass-clover.

Disease suppressiveness of soils was correlated with all measured parameters by PCA (principal components analysis). Quantity of *Lysobacter* and *Pseudomonas* antagonists, as well as the number of fungal bands in the DGGE patterns, correlated with higher disease suppression against *Rhizoctonia* (Fig. 1 left).

Soil suppressiveness against *Streptomyces* was found in other soils (i.e. farm H, I, J) and correlating microbial characteristics were: quantity of antagonists in general, *Streptomyces*, fungal/bacterial biomass ratio (Fig. 1 right). On the other hand higher organic matter (os) and respiration (O2cons) correlated with lower suppressiveness.

Table 1. Physical, chemical and biological soil characteristics in 2004

farm	years orga-nic	% clay <2 µm [1)]	% org. mat-ter [1)]	pH-KCl [1)]	C/N ratio [1)]	fungal bio-mass [2)]	bacte-rial bioma ss [2)]	F/B ratio [2)]	type of manure [3)]		
									%SA	%LA	%P
A	1	11.5	1.7	7.4	13.6	32.4	112.4	0.30	0	0	100
B	13	13.8	1.6	7.3	12.4	29.7	93.1	0.33	98	0	2
C	2	2.0	10.2	5.2	26.1	14.1	26.3	0.61	100	0	0
D	2	11.8	2.9	7.5	18.4	20.0	106.3	0.20	28	30	42
E	12	27.5	6.8	7.2	11.6	18.4	137.7	0.14	50	50	0
F	14	2.0	2.8	4.7	18.9	12.8	39.9	0.39	57	24	18
G	8	19.0	10.3	6.8	13.4	16.8	100.3	0.18	2	89	9
H	3	20.5	2.9	7.4	12.2	25.4	131.0	0.19	62	38	0
I	7	29.3	1.9	7.4	15.7	13.9	77.3	0.18	20	66	14
J	10	1.8	1.9	5.4	21.3	11.8	15.6	0.86	50	50	0
LSD		2.1	1.7	0.4	3.4	7.9	26.0	0.24			

1) analysed by BLGG (Oosterbeek, NL)
2) analysed by J. Bloem (Alterra, Wageningen, NL) (Bloem et al, 2006)
3) values per farm applied; SA = soluble animal manure, LA = liquid animal manure, P = plant derived material

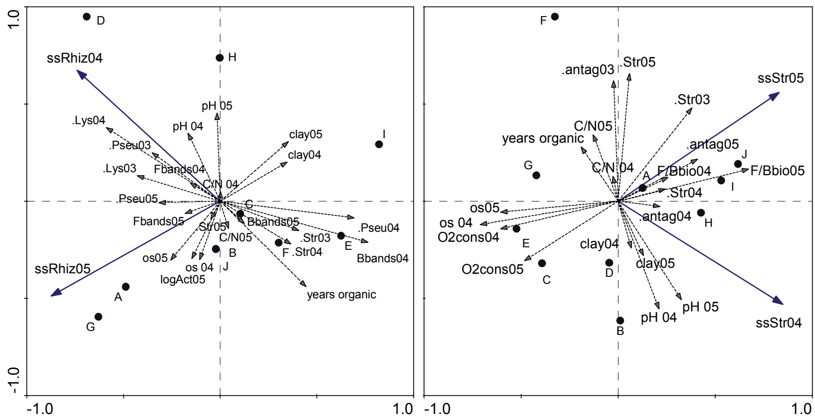

Fig. 1 Correlation between a selection of soil factors and soil suppressiveness against Rhizoctonia (ssRhiz, left) or Streptomyces (ssStr, right) analysed with PCA (principal components analysis). A-J presents the samples of the different organic farms. Arrows pointing in the same direction are positively correlated, and longer arrows have a stronger correlation.

Discussion

Soil suppressiveness appeared to differ significantly between the fields of the different organic farms. However, the suppressiveness of the fields was pathogen specific. Thus, none of the soils was suppressive for all of the pathogens tested. Consequently, different soil parameters correlated with the suppressiveness against each pathogen.

Most frequent occurring antagonists inhibiting *Rhizoctonia* appeared to be *Streptomyces*, *Lysobacter* and *Pseudomonas*. *Streptomyces* and *Pseudomonas* are known for their capacity to inhibit several fungal pathogens (Tuitert el al 1998; Whipps 2001). However, the antagonistic potential of *Lysobacter* is rather new (Folman *et al.*2003) and soil suppressiveness has never before been correlated with this genus. The presence of *Lysobacte*r was soil and probably crop dependent, since it occurred mainly in clay soils and was most abundant during and short after the grass-clover crop. Further molecular analysis of the soils will be performed to investigate the role of *Streptomyces, Lysobacter* and *Pseudomonas* composition and quantity in more detail.

Using the current approach, we could identify factors influencing disease suppression. Correlating all kinds of microbial characteristics will facilitate the development of microbial indicators for healthy soils and sustainable agricultural practices.

Acknowledgements

We thank the organic farmers for allowing us to take soil samples, and Arjan Reijneveld (BLGG) and Jaap Bloem (Alterra) for the performed soil analyses. This research was supported by the Dutch Ministry of Agriculture, Nature and Food Quality in the research program DWK432.

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Differences between spring wheat cultivars for emergence and early development after seed infection with *Fusarium culmorum*

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Key words: Spring wheat, Fusarium seedling blight, organic breeding, development of organic agriculture

Abstract

Infection of wheat seeds with Fusarium spp. causes seedling blight. As a result of this disease, fields sown with infected seeds show a reduced plant density. This is especially a problem in organic agriculture, for which currently no practical seed disinfection methods are available. In the present project we investigated whether spring wheat cultivars differ in sensitivity to seedling blight, whether the possible differences could be linked to cultivar differences in early growth rates, and what size the delay in canopy closure resulting from the plant reductions was. Six spring wheat cultivars (Melon, Lavett, SW Kungsjet, Epos, Pasteur, Thasos), containing three infection levels (averages 5, 15 and 27%) of Fusarium culmorum were obtained and were sown in a field experiment in 2006 in 4 repetitions. Measurements included percentage of emergence, light interception and above ground dry matter to calculate relative growth rates. Infection of seeds with F. culmorum resulted in lower plant densities and a delay in time to 10% light interception of up to 5 days. First preliminary results also show that cultivars differ for sensitivity to seedling blight, and that cultivars with higher early growth rates appeared to be less sensitive to seedling blight, with the exception of cultivar Thasos. If future experiments confirm this relation, it could be used to select cultivars which are more resistant to seedling blight.

Introduction and Objectives

Fusarium head blight (FHB) is caused by one or more Fusarium species, including *F. graminearum* (Schwabe) and *F. culmorum* (W.G. Smith) Sacc. Part of the seeds obtained from FHB infected crops are infected (Jones and Mirocha, 1999). Use of the infected seeds without treatment results in lower plant densities (Gilbert *et al.* 1997) due to a loss of viability, reduced emergence and post emergence seedling blight (Jones, 1999). A reduced plant density does not necessarily affect yield (Gooding *et al*., 2002). However, lower plant densities due to seedling blight could reduce the speed of canopy closure and hence make the crop less competitive against weeds. Control options of seedling blight in organic agriculture include effective hot-water treatments and biological control by micro organisms (Osman, *et al*., 2004: Johansson *et al*. 2003). However, these options are currently not available for large scale use in practice, and there remains scope for new, potentially preventative control options.

The aim of the current research is to investigate whether varieties differ in resistance against Fusarium seedling blight. Furthermore we try to link the possible variation to early development rate of the cultivars as an additional tool for future selection. Results give also insight in the importance of crop density reductions by seedling blight in terms of delay in canopy closure.

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Methods

In 2006 seeds of six spring wheat cultivars (Melon, Lavett, SW Kungsjet, Epos, Pasteur, Thasos) containing three Fusarium infection levels (5, 15 and 27 %) were used. Infection levels were created by using seeds of an experiment in 2005, in which all six cultivars were present. The experiment contained an inoculated part (inoculated with *F. culmorum*), in which 75 % of the seeds were infected, and a control part of which 15 % of the seeds were infected. Seeds of the control part were used for the 15 % infection level, and the 27 % infection level was created mixing seeds of the inoculated part with seeds of the control part. The 5 % infection level was created by warm water treatment of the seeds of the control part. Finally, precise infection levels were measured in a Blottertest (De Tempe, 1958). Seeds were sown in a field experiment on an organic farm (Colijnsplaat, The Netherlands) on a clay soil.

Percentage of seedling emergence was measured for each cultivar. Light interception measurements were done using a Sunscan light interception measurement system (Delta–T Devices, Cambridge, UK). Measurements of above-ground dry matter were done in the lowest infection treatment. The time from sowing to 10% light interception was calculated, performing a nonlinear regression analysis with the logistic equation y=A+(C/(1+exp(-B*(X-M)))) on the measured time series of light interception for each field plot. Resulting equations were used to calculate time to 10% of light interception for each plot. Relative growth rates of above ground dry matter were calculated by nonlinear regression analyses of the exponential growth equation (W_t=W_0*exp(rgr*time), in which W_t and W_0 represent plant weights on time t and 0, respectively) on measured data of above ground dry weights. All statistics were performed using GenStat Seventh Edition version 7.2.0.208, VSN International LTD.

Results

The percentage of emerged seeds of the six spring wheat cultivars decreased with increasing percentage of *F. culmorum* in seeds (Fig. 1). Percentages of emerged seeds ranged from maximally 81.9 % to a minimum of 41.3 %. Trends for all cultivars were linear.

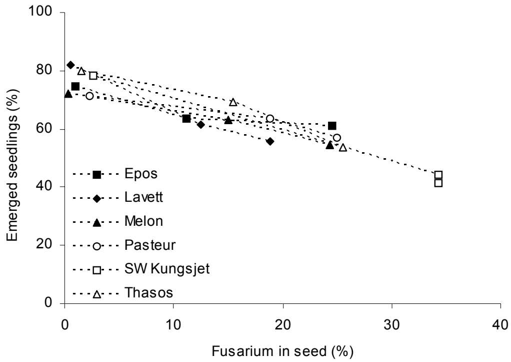

Figure 1. The percentage of emerged seeds for the six spring wheat cultivars (different symbols) in relation to percentage of seeds infected with *F. culmorum*.

Emergence reduction resulted also in significant differences in rate of increase of light interception of young crops (Table 2). Averaged over all cultivars, number of days needed from sowing to reach 10 % of light interception was 34.0 days at the level of 5

% *F. culmorum* infection. This increased significantly to 35.8 days at 15 % of *F. culmorum* infection and to 36.5 days at 27 % *F. culmorum*. If looked at each cultivar separately, it can be seen that all cultivars, except for Lavett, had the same trend. Differences were clearest (significant) for cultivar Pasteur, ranging from 33.2 to 35.8 days, and for SW Kungsjet, ranging from 32.9 to 37.4 days from sowing to reach 10 % of light interception.

Relative sensitivity of the cultivars for seedling blight, indicated by the percentage of emergence reduction per percentage of *F. culmorum* in the seed, differed significantly (Fig. 2.) Spring wheat cultivars Lavett and Thasos were the most sensitive, with 1.4 and 1.3 % emergence reduction per percent of infected seeds. Cultivar SW Kungsjet was in the middle with 0.9 % emergence reduction per percent of infected seeds, and cultivars Melon, Pasteur and Epos were the least sensitive to seedling blight with 0.7, 0.7 and 0.6 % emergence reduction per percent of infected seeds.

Table 2. Time duration from sowing to 10% light interception for the six spring wheat cultivars (in days), as calculated with logistic equations (y=A+(C/(1+exp(-B*(X-M))))) derived from non-linear regression analysis (R^2=0.975) on light interception measurement data. Different letters indicate significant differences (p<0.05).

Spring wheat cultivar	Infection level of seeds with *F. culmorum* (%)		
	5	15	27
Lavett	35.1	34.8	35.6
Epos	34.5	36.2	36.4
Melon	34.4	35.9	36.4
Thasos	34.1	36.5	37.3
Pasteur	33.2 (a)	34.2 (ab)	35.8 (b)
SW Kugsjet	32.9 (a)	37.3 (b)	37.4 (b)

Measured relative growth rates ranged from 0.0726 g above-ground dry matter per g dry matter per day for cultivar Lavett up to 0.0856 g above-ground dry matter per g dry matter per day for cultivar Thasos. Strikingly, with the exception of Thasos, the spring wheat cultivars with higher relative growth rates also had lower sensitivities to seedling blight (Fig. 2).

Discussion

F. culmorum infection in seeds caused plant density reductions, the importance of which is underlined by a significant time delay (of up to 5 days) in canopy closure. Such a delay is expected to reduce weed control (Kruepl *et al*., 2006, Olsen *et al*., 2006). In the Netherlands the infection limit for Fusarium for seed certification is 25% and indeed in years with heavy Fusarium infection organic seeds with infection levels of 20-25% are marketed. This indicates that time delays in crop closure as measured in the current experiment are not unrealistic.

Although results are preliminary and only from one growing season, and should not be used without information on resistance to FHB, it is clear that variation in sensitivity to seedling blight is present between currently available spring wheat cultivars. Furthermore, preliminary data show that this variation is potentially linked to early growth rates of cultivars. Such a relation provides possibilities for cultivar selection in organic breeding.

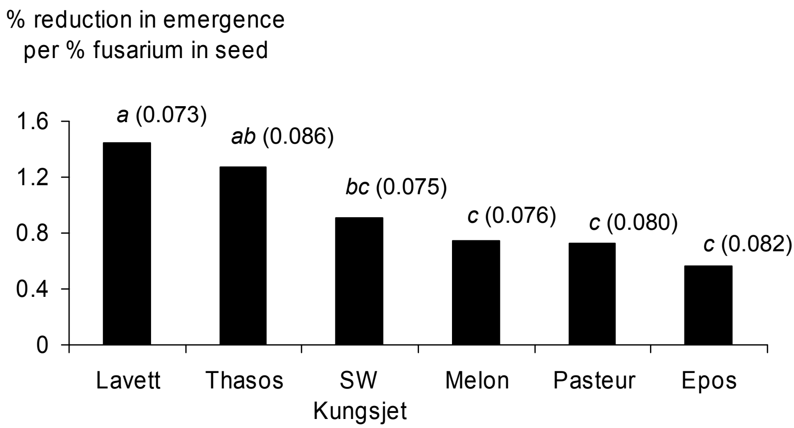

Figure 2 Percentage of reduction in emergence (compared to uninfected control) per percentage of seeds infected with *F. culmorum* for the six spring wheat cultivars. Different letters indicate significant differences ($p< 0.05$), numbers in brackets indicate relative growth rates of cultivars (d^{-1}).

Conclusion

-Relatively moderate infection rates of spring wheat seeds with *F. culmorum* caused significant delays in cannopy closure of young crops of up to 5 days.

-Between spring wheat cultivars currently available for organic agriculture, variation in tolerance to Fusarium seedling blight is present.

-This variation may be related to the early development rate of the cultivars.

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Control of *Bremia lactucae* in Field-Grown Lettuce by DL-3-Amino-n-Butanoic Acid (BABA)

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Key words: lettuce, induced resistance, downy mildew, elicitors, *Bremia lactucae*

Abstract

DL-3-amino-n-butanoic acid (BABA) was effective in controlling downy mildew incited by Bremia lactucae Regel in lettuce plants. The two isomers of BABA, DL-2-amino-n-butanoic acid and 4-amino-butanoic acid and its s-enantiomer were ineffective compares to BABA, while the r-enantiomer was more effective. The SAR compound NaSA and its functional analogue BTH (Bion) were also ineffective compared to BABA. In growth chambers, BABA was effective when applied as a foliar spray or as a soil drench. Effective control of the disease was apparent when BABA was applied up to 5 days before inoculation or 3 days after inoculation. A foliar spray of 125 mg/L reduced disease by 50% and full control of the disease was achieved with 500 mg/L. A soil drench with 1.25 mg /pot was required for >90% control the disease. In the field, 2-4 sprays with 1g/L BABA reduced disease severity by 90% as compared to control untreated plants. BABA had no adverse effect on sporangial germination of Bremia lactucae in vitro, germination on plant leaf surface or, fungal penetration into the host. However, it prevented the colonization of the host with the pathogen.)

Introduction

Downy mildew caused by Bremia lactucae is the most serious fungal disease of lettuce. The disease can be controlled by chemicals including phenylamide (e.g. metalaxyl)-based compounds but mutant isolates insensitive to these compounds have been recorded (Crute *et al.*, 1985; Crute *et al.*, 1994; LeRoux *et al.*, 1988). Disease resistance (R)-genes are also used to control the disease but recombinant isolates evading recognition conferred by the R-genes can occur.

An alternative procedure to protect plants against disease is to activate their own defence mechanisms by specific biotic or abiotic elicitors (reviewed by (Walters *et al.*, 2005). The classical type of induced resistance is often referred to as systemic acquired resistance (SAR). Sodium salicylate (NaSA), 2,6-dichloroisonicotinic acid (INA) and benzothiadiazole-S-methyl ester (BTH), are well known elicitors of SAR in various plants against disease (Sticher *et al.*, 1997).

The non-protein amino acid DL-3-amino-*n*-butanoic acid (BABA) also activates an induced resistance response. It is capable of inducing systemic resistance against numerous pathogens (Cohen 2002). One objective of this study was to evaluate the efficacy of BABA in controlling downy mildew in lettuce, especially under field conditions. Field studies with BABA in lettuce were not reported before. Another objective was to study the mechanism of action of BABA against *Bremia lactucae* in lettuce.

Materials and methods

The cultivar Noga (cup type, Hazera Genetics, Mivhor, Israel) of lettuce (*Lactuca sativa* L) was used. Isolate Isr-60 of *Bremia lactucae* Regel carrying 13 virulence

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factors (0, 1, 2, 3, 4, 5/8, 6, 7, 10, 11, 13, 15, 16, and 17) was used for inoculations (Sharaf *et al* 2007). For growth chamber studies, plants were grown from seeds in 100 ml pots containing 40g peat/vermiculite mixture (1/1, v/v), 20 plants per pot. Plants were grown in the greenhouse (18-32°C) and used one week after seeding, when have developed two cotyledon leaves. DL-3-amino-*n*-butanoic acid (BABA), DL-2-amino-*n*-butanoic acid (AABA), 4- amino- butanoic acid (GABA), sodium salicylate (NaSA) and calcofluor were purchased from Sigma, Israel. Benzothiadiazole-S-methyl ester (BTH, Bion) was a gift from Syngenta, Switzerland. All compounds were dissolved in water before use.

Four field experiments were conducted during 2005-2006 to evaluate the efficacy of BABA in controlling *Bremia lactucae* in lettuce plants. Plants were raised from seeds in Speedling trays in the greenhouse. When plants had 4 true leaves, they were transplanted into polystyrene containers (1.2×0.6×0.2 m) filled with peat + vermiculite (1/1, v/v), 8 plants/container. Containers were located in shade houses in the field at Bar-Ilan University Farm. Shade houses were covered with 50 mesh white plastic nets to avoid aphid and viral infections. At about four weeks after planting, when they reached the 10-12 leaf stage, the plants were treated with BABA and inoculated with sporangial suspension of *B. lactucae* (1×10^3/ml) on the same evening. After inoculation plants were covered with plastic sheets for the night to assure infection. BABA, of various concentrations, was sprayed with aid of a backpack manual sprayer at a rate of about 20-30 ml/plant. Experiments were done in a full randomized block design with 3-6 replicates per dose treatment. Each replicate consisted of 3 containers with 8 plants in a container. Disease records were taken by counting the number of downy mildew lesions per plant or by visual assessment of the infected leaf area in each plant.

Results

Resistance induced by aminobutanoic acids and SAR compounds. The efficacy of a foliar spray with DL-AABA, DL-BABA and GABA in protecting plants at their cotyledon stage against downy mildew is shown in Fig. 1A. Of the three isomers tested, only DL-BABA was effective. Efficacy of 70% was exhibited at a concentration of 125 mg/L and complete inhibition of the disease was achieved with 500 mg/L. Similar results were obtained in plants treated via the root system (Fig.1B): a soil drench with 2.5 mg BABA per pot (100 ml, containing 40 g of potting mixture) totally inhibited the disease. Figures 1C and 1D show that NaSA and its functional analogue BTH (Bion) applied to the foliage or the root system were both ineffective in protecting against the disease, suggesting that the protection by BABA is probably mediated by a SA-independent pathway(s).

Field experiments. Results from four field experiments are presented in Figure 2A-D. Mean percent infected leaf area at the end of the season in control-untreated plants was 31, 29 and 45% in experiments A, C and D, respectively, whereas a mean of 63 downy mildew lesions/plant was counted in control-untreated plants in experiment B. In all experiments, a significant ($P=0.05$) reduction in disease level was achieved with 125 mg/L BABA or above. The higher the concentration of BABA was, the stronger and more significant was the suppression of the disease. In experiment C, BABA of 250 mg/L or above was more effective than mancozeb of 2000 mg/L (Fig. 2C). Percent disease control by each concentration of BABA in each experiment is given in Figure 2E. Mean % disease control for all 4 experiments is shown in Figure 2F. A correlation of R2=0.95 was found between Ln concentration of BABA and mean % control of the disease (Fig 2F). The calculated dose of BABA required to achieve 50% and 90% control of the disease was 201 and 1039 mg/L, respectively (Fig. 2F).

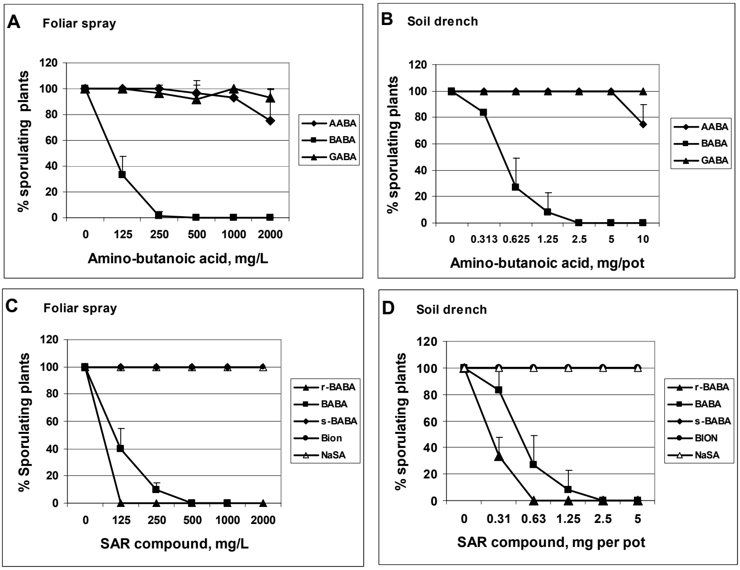

Figure 1: Control of *Bremia lactucae* in lettuce by isomers or enantiomers of aminobutanoic acid or SAR inducing compounds. Plants at their cotyledon stage (20 plants/pot, n=4) were sprayed **(A,C)** or treated by soil drench **(B,D)** with various concentrations of AABA (DL-2-amino-*n*-butanoic acid), BABA (DL-3-amino-*n*-butanoic acid) or GABA (4-aminobutanoic acid), r-BABA, s-BABA, Bion (BTH) or NaSA and inoculated with sporangia of the pathogen one day after treatment. At 5 dpi plants were transferred to 100% RH at 20°C (12h light/day) to induce sporulation of the pathogen. Two days later (7 dpi) the number of sporulating plants was recorded. In (B) and (D), 5 ml of solution (suspension in Bion) was applied to the soil surface of each pot (40 g potting mixture/pot.

Discussion

DL-3-amino-*n*-butanoic acid (DL-β-aminobutyric acid, BABA) is a non-protein amino acid shown to induce resistance against about 50 plant pathogens in a large number of annual and perennial agricultural crops (Cohen, 2002). Here we show that BABA was effective in controlling downy mildew in lettuce caused by the oomycete *Bremia lactucae*. In potted plants, a foliar spray with 250 mg/L, or a soil drench with 1.25 mg/pot, was sufficient to suppress the disease by ≥90%. The two isomers AABA and GABA were ineffective. The s-enantiomer of BABA was ineffective whereas the r-enantiomer of BABA was more effective compared to BABA. The SAR inducing compound NaSA and its functional analogue BHT (Bion) were ineffective compared to BABA. A major finding of the present study was that BABA was efficient in controlling downy mildew in lettuce under field conditions. Foliar sprays with 201 and 1039 mg/L resulted with 50 and 90% control of the disease, respectively. This may encourage the introduction of BABA to agriculture as a SAR compound against lettuce downy mildew. Due to the fact that BABA occurs naturally in tomato plants (unpublished data) it might also be considered for application in organic farming. Only a limited number of studies were conducted with BABA in the field. Our own studies showed efficacy against downy mildew in grapevines (Reuveni *et al.*, 2001), late blight in potato and tomato (Cohen, 2002), rust in sunflower (Amzalek and Cohen, 2007) and moldy core in apple (Reuveni *et al.*, 2003).

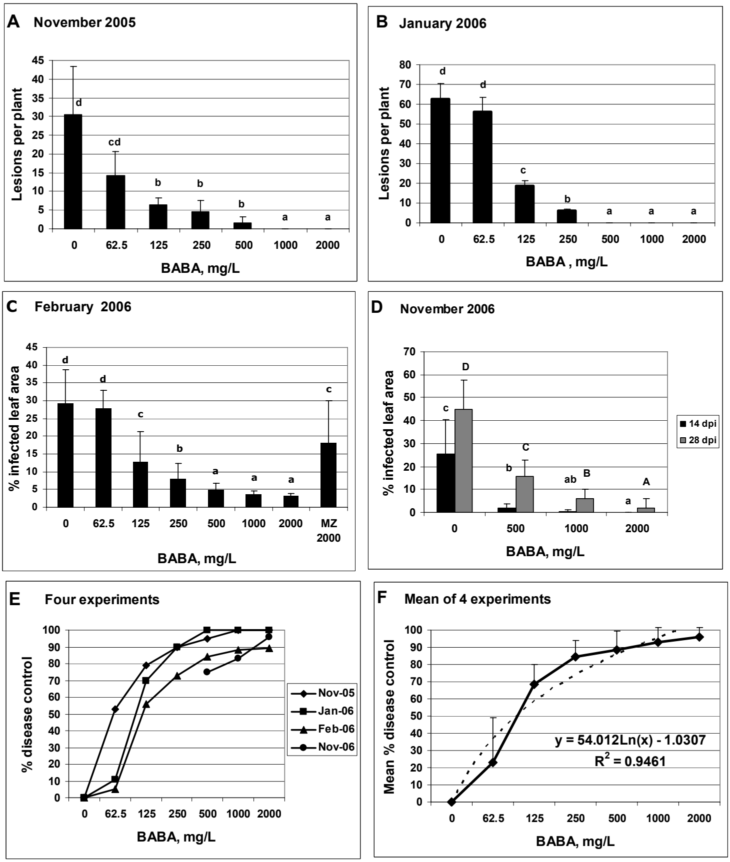

Figure 2. Control of downy mildew in lettuce by BABA under field conditions. A, B, C and D:

The effect BABA on disease development in four experiments conducted during November 2005-November 2006. Plants were grown in 1.2×0.6×0.2m polystyrene containers filled with peat+vermiculite (1/1, v/v) in four net houses (50×6 m each) located at BIU Farm. Plants were sprayed with BABA (six concentrations, 62.5-2000 mg/L, in experiments A-C and three concentrations, 500-2000 mg/L in experiment D) and spray inoculated with sporangia of *Bremia lactucae* a few hours later. To assure infection, plants were covered with plastic sheets for one night following inoculation. A total of 2, 4, 4, and 3 sprays were applied in experiments A, B, C, and D, respectively. Sprays were applied at 7-8 days intervals. In experiment C, the protectant fungicide mancozeb was included for comparative purposes. Experiments were conducted in fully randomized design with 3-6 replicates per dose treatment. Each replicate consisted of 24-48 plants, with 8 plants /container. Disease records (visual assessment of the percent leaf area covered with lesions of downy mildew in each plant, or the number of lesions/plant) were taken 17, 22, 25 dpi in experiments A-C and at 14 and 28 dpi in experiment D. Data were subjected to Anova analysis and separated according to Fisher's least significant difference test at $P<0.05$. Different letters on columns indicate a significant difference in disease levels. Percent disease control in E was calculated as 100(x/y-1), when x = mean % diseased leaf area in BABA-treated plants and y = mean % diseased leaf area in control-untreated plants.

Conclusions

BABA is shown here to effectively control downy mildew development in lettuce in growth chambers and the field. It is effective when applied to the foliage or the roots. It exhibits post infection (curative) efficacy and provides durable resistance against the disease. BABA stops disease development by suppressing fungal colonization.

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Effect of variety choice and use of resistant rootstock on crop yield and quality parameters of tomato plants grown in organic, low input and conventional production systems/growth media

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Key words: organic, low input, conventional, tomato production, resistant rootstocks, fruit quality

Abstract

Soil-borne diseases are one of the most important problems in organic and other 'low input' soil-based greenhouse production systems. While chemical soil disinfection has been the method of choice in conventional farming systems, soil steaming has been the main strategy for the control of soil borne diseases in organic production. Both methods are extremely expensive and have been increasingly restricted for environmental reasons by government and organic standard setting bodies respectively.

*The use of tolerant varieties and of grafting onto resistant rootstocks were evaluated as potential replacements for soil steaming in organic and low input systems and found to be as effective in reducing root disease and increasing root fresh weight, fruit yield and number. The effects on fruit yield and quality characteristics were then further evaluated using different varieties for grafting and different growth media typically used in **(a)** organic (soil amended with manure), and **(b)** conventional (perlite fertilised with mineral fertilisers via the irrigation system) growth media/fertilisation regimes, and also a **(c)** novel 'low input' growth medium designed to provide better aeration of the rooting zone. Fruit numbers, diameters and weights and total fruit yields were significantly different between growth media and highest for plants grown in the 'low input' system, slightly lower for plants grown in the perlite and lowest for plants grown in the organic system. The potential for replacing chemical and steam soil disinfection methods in organic and 'low input' soil based greenhouse production systems is discussed.*

Introduction

The most important reasons for yield losses in soil-based and organic tomato production systems are soil-borne root and vascular diseases, in particular corky root rot (*Pyrenocheta lycoperici*) and *Verticillium* spp. (Pegg & Brady, 2002). In conventional greenhouse production chemical soil disinfection (e.g. methyl bromide, chloropicrin, isothiocyanide) is widely used to control soil borne diseases, while soil steaming is widely used in organic greenhouse production systems (Overmans & Jones, 1986; Pegg & Brady, 2002; Georgakopoulos, 2002).

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Chemical and steam soil disinfection methods have both been linked to significant negative environmental impacts. For example, soil steam treatments were shown to significantly increase the energy/fuel use in glasshouse production and both soil steaming and chemical soil treatments were shown not only to eliminate fungal pathogens, but also the saprophytic and beneficial soil microflora and fauna (Bennett *et al.* 2003**;** van Loenen 2003). In addition, methyl-bromide treatments are known to contribute to the depletion of the atmospheric ozone layer and associated human health impacts (e.g. higher risk of skin cancer) (Workneh & van Bruggen, 1994).

The main objectives of the study reported here were to **(a)** identify alternative strategies for the control of soil borne diseases and **(b)** to evaluate the impact of such novel control methods on fruit yield, size and quality parameters.

Materials and methods

Soils and substrates: In both experiments soil shown to be infected with corky root rot and *Verticillium* (presence of root rot symptoms on >60% of plants in the previous seasons crop and confirmation of the presence of both pathogens by standard mycological tests) was collected from different parts of a commercial organic glasshouse unit and then mixed with manure and homogenised using a concrete mixer to minimise differences in substrate structure, texture and inoculum density and then placed into pots (15 L volume). In experiment 2, two additional substrates were used: Perlite (**P**) (the standard growth medium used in conventional 'out-of soil' tomato production systems in Greece) were also used and a novel 'low input' substrate consisting of equal amounts (v/v/v) of soil, gravel and perlite (**SGP**, which was developed at Theodoropoulou nurseries, Nafpaktos, Greece, and designed to provide better aeration of the rooting zone).

Treatments: In **experiment 1** the performance of plants grafted onto resistant rootstocks (the fruiting cultivar 'Star fighter' was grafted onto rootstock 'Beaufort' that is resistant to corky root rot) was compared with that of plants grown in steam disinfected (positive control) soil and non-grafted plants grown in untreated soil (negative control). For steam treatment a commercial soil-steaming machine used for horticultural substrates (Camplex HD5116 Electric Soil Steriliser, Thermoforce Ltd. Cumbria, U.K) was used. Soil was heat treated at 81°C for 30 minutes. Several other soil treatments were also included in Experiment 1, but are not reported here. **In experiment 2**, a factorial design was used with **(a)** 3 different substrates (see above), **(b)** 3 different cultivars (Belladonna, Electra and cultivar 984) with different levels of tolerance to *Verticillium* spp. and **(c)** grafting or non-grafting of the corky root rot resistant rootstock R5872 as factors.

Assessments Fruits were collected at 'uniform red' stage (according to colour charts used in commercial glasshouse production) and fruit number, weight and size recorded. At the end of the experiment the roots of all plants were rinsed under tap water and root fresh weight was determined. Finally roots were dried in an oven (at 80oC for 24h) and root dry weight was measured. The difference in root fresh and dry weights between plants grown in steam disinfected and non-steam disinfected soils was used as a measure of overall root damage caused by soil borne pathogens.

Sugar and antioxidant levels in fruit were analysed using standard protocols (FRAP, Benzie & Strain, 1996; TEAC, Re *et al.*, 1999).

Results and discussion

In experiment 1, yields, root fresh and dry weight of plants grafted onto resistant rootstocks were significantly higher compared with untreated (negative) control plants, but not significantly different from those grown in steam disinfected soils (positive controls) (Table 1).

Table 1. Effect of soil amendments, grafting onto resistant rootstocks and soil steaming on tomato fruit yield, number, and, root fresh weight in the presence of significant soil borne disease pressure (Experiment 1)

	% difference compared with negative control plants		
Treatment	Fruit yield	Root fresh weight	Fruit number
1. Untreated control	0 b	0 b	0 bc
2. Resistant rootstock	59 a	71 a	22 ab
3. Soil steam disinfection	78 a	79 a	41 a

Means in the same column followed by the same letter are not significantly different according to Tukey's Honest Significant Difference Test ($p<0.05$)

Table 2. Effect of production system, cultivar choice, and grafting onto resistant rootstocks on the yield and quality characteristics of greenhouse-grown tomatoes in the absence of significant soil-borne disease pressure (Experiment 2)

Characteristic assessed	**Production system** (% difference compared with plants grown in soil)			**Cultivar** (% difference compared with standard cultivar Belladonna)			**Root stock** (% difference compared with non-grafted plants)	
	P	**SGP**	**AN**	**Ele**	**984**	**AN**	**+RS**	**AN**
Yield	83	103	***	-13	-14	**	-6	NS
Root Fresh Weight	26	2	**	-10	-9	NS	31	***
Fruit No	44	53	***	-10	-24	***	-14	***
Mean Fruit Weight	27	32	***	-3	14	***	15	***
FRAP (1st SD)	-11	-26	**	ND	-11	*	9	T
FRAP (2nd SD)	-2	-27	***	ND	2	NS	-3	NS
TEAC (1st SD)	-13	-25	***	ND	-7	T	8	T
TEAC (2nd SD)	-3	-26	***	ND	1	NS	-2	NS
Sugar 1	-3	10	*	ND	9	**	2	NS
Sugar 2	-1	11	NS	ND	11	***	-2	NS

AN, p-value of **ANOVA**; ***, $p<0.001$; **, $p<0.01$; *, $p<0.05$; T, trend ($0.05<p<0.1$).

P: perlite; **SGP**: mixed Soil/Gravel/Perlite medium; **Ele**: cultivar Electra; **984**: cultivar 984
+RS: plants grafted onto resistant rootstocks.
SD: Sampling date; ND:, composition analyses were not carried out for Electra; FRAP: Ferric Reducing Activity Power; TEAC: Trolox Equivalent Antioxidant Capacity.

The use of resistant rootstocks had been previously observed to potentially affect fruit size and sensory quality and may also affect the nutritional composition of fruit (Theodoropoulou, personal communication). Experiment 2, therefore, tested the effect of resistant rootstocks on the yield, fruit size and nutritional composition of different tomato varieties in three substrates used for organic, conventional and low input production systems in Greece.

Compared with tomato crops produced in manured soil (substrate used organic production) fruit yields, root fresh weights, fruit number and the mean fruit weights from plants produced in perlite (P) fertilized with mineral nutrient solutions and a soil/gravel/perlite mixed substrate fertilizer (SGP) with manure were significantly higher (Table 2). In contrast antioxidant (FRAP, TEAC) levels were lower at both the first and second sampling date. Sugar levels in perlite grown plants were similar to those of soil grown plants, but slightly higher in plants grown in the mixed substrate

(Table 2.). Cultivar choice only had a significant effect on yield, fruit number and mean fruit weight, with Belladonna showing the highest levels, except for the mean fruit weight, which was higher for cultivar 984 than for Belladonna.

Grafting onto resistant rootstocks overall increased root fresh weight and mean fruit weight, reduced fruit number, but had no significant effect on fruit composition.

Conclusions

The use of resistant rootstocks is an effective method to control soil borne disease, but may affect fruit size.

The type of growth substrate used has a significant effect on fruit nutritional composition and taste (sweetness) of tomato.

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Integration of fertility management, cultivar selection and alternative spray treatments to optimize control of foliar diseases of greenhouse grown tomatoes

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Key words: *Leveillula taurica*, integrated control, powdery mildew, tomato, chitin, fertility management

Abstract

Powdery mildew caused by Leveillula taurica (Lev.) Arn. is one of the most serious foliar diseases of greenhouse and open field tomato. The disease is currently controlled with the use of organic fungicides and sulphur, the latter being the only product permitted in organic crops. The aim of this study was to investigate the potential of controlling the disease by integrating: a) hybrids of low susceptibility to the disease, b) organic fertilisers (chitin) and c) alternative spray treatments. Some of the combinations of the above factors were highly effective in decreasing the percentage of disease severity. Specifically the combination of the hybrid of low susceptibility with the addition of chitin in the substrate and the spray treatment Milsana®+chitosan, was equally effective to sulphur. These results indicate that the combination of the above factors could probably be used as an alternative to sulphur for control of L. taurica in the greenhouse.

Introduction

One of the most serious diseases of greenhouse tomato is powdery mildew. In conventional farming systems the disease is mainly controlled by sulphur and other fungicides while under organic farming standards only sulphur products are permitted. However sulphur can affect the efficacy of insect predators negatively and can be phytotoxic in the greenhouse at temperatures above 30°C (Belanger and Labbe, 2002). It may also contribute to the faster degradation of greenhouse plastic covers (Malathrakis, personal communication).

Previous studies indicated that soil amendment with chitin in combination with the use of resistant hybrids and the foliar spraying with chitosan or plant extracts, may increase the resistance of crops (e.g. cucumber) to foliar diseases (Giotis, 2006). However, the integrated use of these strategies against powdery mildew has not yet been studied. Therefore, the objective of this study was to assess the efficacy of integrating compost amendment, hybrid selection and application of alternative foliar spray treatments against the powdery mildew of tomato (*Leveillula taurica*) under greenhouse conditions in Greece.

Materials and methods

Two experiments were performed: the 1st between September 2005 and January 2006 and the 2nd between May 2006 and July 2006. The hybrids ‘Elpida’ F1 (Enza Zaden-The Netherlands), ‘less susceptible’ to powdery mildew (*Leveillula taurica*), and ‘Bison’ F1 (Golden West-U.S.A), relatively susceptible to *L. taurica,* were used. Tomato seedlings were transplanted into 15L plastic pots in a polythene greenhouse

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(10x40x4m), at the 3rd true leaf stage. Pots (28x23cm) contained a mixture of compost and soil (50:50). The compost was prepared according to the standard method for biological composts (windrow composted for 3 months, regularly turned) and contained sea algae, olive tree leaves and sheep manure at a ratio (v/v/v) of (1:1:1). Total organic matter was 22% and the pH 7.8. The soil was a sandy clay loam, medium heavy in drainage and alkaline. In half of the pots, 150ml/ pot of chitin powder (>98%), 'France Chitine' (France) were added to the growth substrate. The experimental design was a split–split plot with six replicates and three factors: (a) hybrid (main plot), (b) foliar spray treatment (subplot) and (c) addition of chitin in the substrate (sub-subplot). The following foliar spray treatments were tested: (a) Milsana® (plant extract of *Reynoutria sacchalinensis*, Biofa-Germany) at the rate of 3ml/L, (b) chitosan (Chitoplant®, 99.9%WP, ChiProGmbH-Germany) at the rate of 0.5g/L, (c) sulphur (Sulfex, 80%WP, Hellafarm S.A.-Greece) at the rate of 2.5g/L, (d) Milsana + chitosan at full rates and (e) tap water (untreated control). Plants were sprayed at 7 day intervals starting 5 days after transplanting (20 days for exp.2). Plants were infected by naturally developing epidemics of *L. taurica* in the greenhouse. Plants were checked daily for disease appearance and severity (% infected area per leaf) was assessed weekly starting when first symptoms were detected. The percentage of infected area was calculated per plant and at the end of the experimental period, Area Under the Disease Progress Curve (AUDPC) values were calculated and subjected to ANOVA. Yield per plant was also recorded, by harvesting fruits at regular intervals, in terms of number, weight and diameter of fruits (data not presented).

Results and Discussion

Disease severity: Analysis of variance showed significant differences for all 3 main factors (hybrid, foliar spray treatment and chitin soil amendment). In both experiments, 'Elpida' (less susceptible) gave lower AUDPC values than Bison (susceptible) and the addition of chitin to the soil reduced disease, regardless of hybrid. Furthermore, there were significant two and three-way interactions between the 3 main factors (individual results not shown).

Comparison between foliar spray treatments was done by Tukey's Honest Significant Difference (HSD) test and results are presented below, separately for the 2 different experiments.

Experiment 1 (Autumn 2005-2006): Sulphur was consistently the most effective treatment while the Milsana treatment was significantly better than chitosan and water control, regardless of hybrid or addition of chitin in the soil. The chitosan treatment controlled disease significantly only when chitin was not simultaneously used as a soil amendment but even then it was not proved adequately effective. Only for the less susceptible hybrid Elpida grown in soil amended with chitin the Milsana + chitosan treatment was significantly more effective than the Milsana treatment and equally effective to sulphur (table 1).

Table1: Effect of different foliar spray treatments in controlling severity (AUDPCs, % days) of powdery mildew (*Leveillula taurica*) on greenhouse tomato (exp. 1).

	Bison (susceptible hybrid)				Elpida (less susceptible hybrid)			
Treatment	**No chitin**		**Chitin**		**No chitin**		**Chitin**	
Sulphur	2326.9	a	2224.3	a	1843.2	a	1773.1	a
Mils.+Chit.	2678.0	b	2543.6	b	2315.3	b	1883.9	a
Milsana	2788.5	b	2570.3	b	2315.7	b	2188.1	b
Chitosan	3157.8	c	3214.7	c	2795.5	c	2689.1	c
Control (Water)	3504.4	d	3427.5	c	3035.9	d	2838.9	c

Means with the same letter within columns are not significantly different between them according to Tukey's HSD test (p≤ 0.05)

Experiment 2 (Spring 2006): During the period of the second experiment, the mildew epidemic was not as severe as in experiment 1 (tables 1 and 2). This probably explains why the Milsana spray treatment gave similar levels of control with the fungicide sulphur on both the susceptible and the less susceptible hybrid and irrespectively of the chitin addition in the soil. Furthermore it was shown that during a less aggressive epidemic, adding of chitosan in the spray did not improve Milsana's efficacy since the mixture was not significantly better than the Milsana treatment itself. The chitosan spray treatment reduced the disease severity significantly on both the susceptible and the less susceptible hybrid. In contrast to the first experiment, spraying with chitosan was significantly effective even when chitin was simultaneously used as a soil amendment. However, this was only observed for the susceptible hybrid Bison (table 2).

Table 2: Effect of different foliar spray treatments in controlling severity (AUDPCs, % days) of powdery mildew (Leveillula taurica) on greenhouse tomato (exp. 2).

	Bison (susceptible hybrid)				Elpida (less susceptible hybrid)			
Treatment	**No chitin**		**Chitin**		**No chitin**		**Chitin**	
Sulphur	430.7	a	368.6	a	329.7	a	252.9	a
Mils.+Chit.	431.6	a	375.4	a	354.3	a	271.0	a
Milsana	432.0	a	347.6	a	358.0	ab	337.3	a
Chitosan	656.3	b	594.3	b	490.5	b	508.2	b
Control (Water)	1186.3	c	876.8	c	644.0	c	487.4	b

Means with the same letter within columns are not significantly different between them according to Tukey's HSD test (p≤ 0.05)

Yield

Data of weight/plant, number of fruits/plant and diameter/fruit were analyzed separately for the two experiments by ANOVA. According to Tukey's Honest

Significant Difference (HSD) test, there were no significant differences between foliar sprays for any of the above parameters in any of the experiments.

Conclusions

Based on the above results it is concluded that the integrated use of the 3 different strategies tested (hybrid, soil amendment and foliar spray treatment) can be highly effective against powdery mildew development. It was clearly shown that the effects are greater during a more severe epidemic (exp1). In this case, leaf spraying with the Milsana+chitosan treatment in combination with the chitin soil amendment on a ‘less susceptible’ hybrid, was equally effective to the chemical control sulphur. In order to further clarify the effects of the integrated strategy against tomato powdery mildew in relation to disease pressure, experiments continue. Additional analyses remain to be carried out. These include quantification of effects of treatments on the nutritional composition and sensory quality of tomatoes. These characteristics are very important in the organic food market. In addition, correlation analyses between nitrogen content, leaf greenness and disease severity are planned. Finally, the mode of action of chitin will be studied in the laboratory with the use of biochemical and molecular techniques.

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Effect of clover management (*Rhizobium* seed inoculation and greenwaste compost amendments) and variety choice on yield and baking quality of organic spring and winter wheat

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Key words: yield, protein content, variety, wheat, organic farming

Abstract

Yield and protein content of wheat produced under organic standards was repeatedly shown to be between 20 and 40% lower than levels achieved in conventional farming systems. This is thought to be at least partially due to insufficient N-supply to the crop later in the growing season and poor adaptation of the currently used wheat varieties to organic production conditions. To address these problems, a factorial field trial was established to study the effect of Rhizobium inoculation of clover seeds and application of compost amendments to clover swards grown prior to different varieties of wheat. Three winter wheat and four spring wheat varieties were chosen from a range of European breeding programmes. Results showed that variety choice had the greatest effect on yields, but that fertility management practices also significantly affected wheat yields and protein quality for some of the varieties. This clearly indicates that yields in organic wheat production can be significantly increased by improved variety choice and fertility management regimes.

Introduction

Previous studies have shown that yields and protein content of wheat produced under organic standards are often between 20 and 40% lower than those achieved in conventional farming systems (Taylor & Cormack 2002). This is thought to be at least partially due to insufficient nitrogen supply during later growth stages (Dubois & Fossati, 1981; Miceli *et al.*, 1992; Ayoub *et al.*, 1994; Sowers *et al.*, 1994; Pechanek *et al.*, 1997; Mittler 2000; Taylor & Cormack, 2002). The inability to control certain diseases (especially Septoria spp.) and higher levels of competition from weeds may also contribute to lower yields and processing quality in organic systems (Mittler, 2000). Although a positive correlation between straw length and protein content has long been recognised in continental Europe (e.g. most high baking quality/protein A and E wheat varieties in the German variety list are longer straw varieties), the higher lodging risk of longer straw varieties under UK conditions has resulted in the disappearance of these varieties from the UK listing (Lochow Petkus and CPB Twyfords, personal communication; Mittler 2000).

Initial results from the Nafferton Factorial Systems Comparison (NFSC) Experiments indicated that lodging risk is significantly lower in organic production systems. It was therefore decided to re-evaluate a range of longer-straw varieties from European breeding programmes (which had not been included previously in UK variety trials; e.g. Carver & Taylor 2002; Taylor & Cormack 2002) under commercial organic farming conditions in Northern Britain.

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Materials and methods

Experimental design and agronomic methods: The experiment was established on 4 fields (= blocks) at Gilchester Organic Farm, Northumberland, UK. Each field was subdivided into 2 main plots in which pure red-clover (*Trifolium pratense*) swards were established using either seed inoculated with a commercial *Rhizobium* (Becker-Underwood, Saskatoon, Canada) preparation, or untreated seed, in March 2003. Each main plot was then subdivided into 2 sub-plots, one of which received no inputs and the other which received 5t per ha of a green-waste compost (COMVERT, Morpeth, UK). In September 2004 three winter wheat varieties and in March 2005 four spring wheat varieties were planted on the fertility management subplots, creating a wheat variety sub-subplot level. Treatments were randomised at the main plot, subplot and sub-subplot level.

Varieties: The varieties used were: **(a)** 3 long-straw winter wheat varieties (Greina, Wenga and Pollux) from an organic faming focused breeding programme developed by Peter Kunz for Sativa (Reinau, CH), **(b)** 2 short straw spring wheat varieties bred for UK (Paragon; CPB-Twyford, Cambridge, UK) and German (Monsun; Lochow Petkus, Bergen, D) intensive farming systems and **(c)** 2 long straw varieties bred specifically for high baking quality wheat production in Germany (Fasan, Lochow Petkus, D) and Norway (Zebra, Swallof-Weibull, Sweden).

Assessments: Crop yields were assessed by combining a 320 m^2 section from each variety sub-subplot using a plot-combine harvester (CLAAS, Germany). Grain fresh weights were determined by weighing grain harvested in each plot immediately after harvesting. Dry weights were determined by drying a sub-sample of harvested grain at 80°C for two days using a drying oven (Genlab Ltd, Widnes,UK). Protein analyses were carried out by the wheat breeding/seed production company Lochow Petkus GmbH (Bergen, Germany) using standard protocols (ICC Standard No. 159; ICC 2006).

Results and discussion

Overall, the use of *Rhizobium* inoculation of red clover seed (but not compost amendments) significantly (P<0.05) increased clover establishment, nodule numbers and the mean size of nodules, and the yields of wheat crops planted after grass clover crops. Protein content, on the other hand, was significantly (P<0.05) increased by compost amendment of red clover swards, but only when used in conjunction with *Rhizobium* inoculation of red clover seed (individual data not shown).

There were significant interactions (P<0.05) between fertility management practices and varieties for both winter and spring wheats (Tables 1 and 2). In the winter wheat trial *Rhizobium* inoculation and compost amendment had an additive effect on yield for Greina, while for Wenga only the combined use of both treatments resulted in a significant increase in yield, and for Pollux neither of the treatments had a significant effect (Table 1). Also for Greina, the protein content was lowest when *Rhizobium* inoculum was used without compost amendment, and increased by compost amendments to the clover ley grown before wheat crops (Table 1). In contrast, for Pollux, only the reduction in protein content associated with *Rhizobium* inoculation was significant and there was no significant effect of clover management practices on protein content for the variety Wenga.

Table 1. Yields and % protein of winter wheat varieties under standard and improved fertility management practices

	without *Rhizobium* inoculum		with *Rhizobium* inoculum	
Variety	**- compost**	**+ compost**	**- compost**	**+ compost**
Yield (t ha^{-1})				
Greina	4.94 d	5.34 c	6.35 b	6.61 a
Pollux	6.26 a	6.37 a	6.19 a	6.52 a
Wenga	5.41 b	5.29 b	5.65 b	6.20 a
Protein (%)				
Greina	11.78 b	12.07 a	11.47 c	12.00 a
Pollux	12.00 a	12.25 a	11.70 b	11.78 b
Wenga	11.85 a	12.00 a	11.95 a	12.25 a

Means with the same letter within rows are not significantly different according to Tukey's Honest Significant Difference test (P<0.05).

Table 2. Yields and % protein of spring wheat varieties under standard and improved fertility management practices

		without *Rhizobium* inoculum		with *Rhizobium* inoculum	
Variety		**- compost**	**+ compost**	**- compost**	**+ compost**
Yield (t ha^{-1})					
Paragon	SS	5.86 a	5.75 a	5.64 a	5.71 a
Monsun	SS	7.02 a	6.79 a	6.86 a	6.75 a
Fasan	LS	6.97 a	6.42 b	7.34 a	7.32 a
Zebra	LS	7.69 b	7.63 b	7.95 b	8.72 a
Protein (%)					
Paragon	SS	12.10 a	11.72 b	11.68 b	12.32 a
Monsun	SS	12.15 b	11.85 c	11.82 c	12.62 a
Fasan	LS	11.97 a	12.00 a	11.07 b	11.60 ab
Zebra	LS	11.05 b	11.40 ab	11.53 a	11.73 a

SS: Short straw variety; LS: short straw variety

Means with the same letter within rows are not significantly different according to Tukey's Honest Significant Difference test (P<0.05).

The effect of clover management practices on the yield of spring wheat was less pronounced than that observed with winter wheat, but again the effect differed among varieties. The yield of short straw varieties was not significantly affected by clover management. For long straw varieties *Rhizobium* inoculation increased the yield compared to uninoculated treatments. For Zebra only, the combination of *Rhizobium* inoculation and compost amendment resulted in significantly higher yields. For Fasan, using only compost amendments reduced yields compared to the other 3 treatments. Also, for the short straw varieties, the use of either *Rhizobium* inocula or compost amendments alone, reduced protein contents. In contrast, for the long straw varieties the use of *Rhizobium* inoculation alone reduced protein content for Fasan, while for Zebra the combined use of *Rhizobium* inocula and compost amendment increased protein contents (Table 2).

Conclusions

The results presented indicate that two of the main problems relating to the sustainability of the current organic wheat production methods (lower yields and protein contents) can be addressed by changes in fertility management practices and variety choice. Yields of 6 to 8 t/ha as recorded for the long-straw spring wheat varieties under improved fertility management were similar or only slightly below the average (7.5 t/ha) obtained with short straw winter wheat varieties (e.g. Malacca) under high input conventional conditions used in Northumbria (Lueck *et al.* 2006). However, future trials should confirm results from the 2005 season under a wider range of climatic conditions.

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Effect of weed management strategies on the risk of enteric pathogen transfer into the food chain and lettuce quality

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Key words: food quality, weed control, vegetable production, microbiology

Abstract

The hygienic quality of raw edible vegetables such as lettuce may be influenced by pathogen transfer from soil to plant, which might occur during weed control by hoeing or as splash-effects during rainfall. The hygienic quality is often discussed when farmyard manures are applied during production, as e.g. in organic farming systems. In a field experiment, the effects of weed control on pathogen transfer from soil fertilised with farmyard manure to lettuce (Lactuca sativa, var. *capitata) were evaluated. First results do not confirm pathogen transfer by mechanical weeding or splash effects during rainfall.*

Introduction

For raw edible products like lettuces, a high hygienic quality is required. Potential risks are seen in organic farming systems where use of well rotted or composted farmyard manure (FYM) is common. Cattle manure contains among others *Enterobacteriaceae*, in our investigations differentiated into coliforms, *Escherichia coli* and *salmonellae*. *E. coli* is a group of bacteria that to an unknown but presumably small degree includes human pathogenic strains that may cause severe disease especially to immuno-repressive persons. Thus, it is used as an indicator of potential health risks. *E. coli* can survive in the soil, depending upon various factors like soil type, moisture content, etc., for up to 100 or even more days after manure application (Ingham, 2004). Hence, field production of lettuce and other raw consumed vegetables that grow close to soil surface might entail health risks for consumers. Besides splash effects during rainfall events or overhead irrigation which has been shown to have no risk effect (Rattler *et al.*, 2006) another possible way of transmittance is given by soil particles that can be transported into lettuce heads during mechanical weeding. This hypothesis was studied in field experiments. First results are given by this paper.

Materials and methods

Two field trials on *Lactuca sativa* var. *capitata*, variety *Estelle*, were conducted at the organic research farm 'Wiesengut' in North-Rhine Westphalia, Germany (50°48´N, 7°17´E) in 2006. Two further field experiments will follow in 2007. The farm is located 65 m above sea level with 846 mm precipitation per year and an average annual temperature of 10.2°C. The treatments used were based on former experiments from Rattler *et al.* (2006) as potentially resulting in the highest risk of pathogen transfer. The statistical design of the field trials was a latin square with 6 treatments and 6 replications. Lettuces were planted on 5th May 2006 (9 plants m^{-1}). As the conditions were relatively dry after planting, additional overhead irrigation was used. All treatments were adjusted to a mineral nitrogen content of the upper soil layer (0-30 cm) of 170 kg N_{min} ha^{-1} using manure. Between 21st and 29th June lettuce was harvested treatment-wise because of heterogenic development. Weed management treatments varied from hoeing over flame weeding to mulching by using straw and plastic weed mats (Table1) and were evaluated in their effectiveness of reducing the

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transmittance of enteric pathogens from soil to lettuce heads by microbiological analyses.

Six lettuce samples per treatment, each one a pool sample from 6 heads, were analysed directly after harvest and a first wash in running tap water of controlled quality for total aerobic bacterial counts, *Enterobacteriaceae*, coliforms, *E. coli* and *salmonellae* by standard cultivation methods (LFGB, 2006). Results were statistically evaluated by ANOVA followed by Tukey's test.

Tab. 1: Treatments

Treatment	**Manure Incorporation**	**Manure Type**
Mechanical 1	rotary tiller	fresh FYM
Mechanical 2	plough	fresh FYM
Mechanical 3	all rotary tiller	composted FYM
Flame weeding		fresh FYM
Plastic mulch		
Straw layer		

Results

Salmonellae were not detected in any sample of soil or lettuce. As to the soil samples, in none of the microbial parameters significant differences were observed between treatments (Table 2). Positive samples of *E. coli* were found, but the level was quite low (>10<100 CFU/g). The *E. coli* counts did not differ significantly (Fisher´s Exact Test) either.

Tab. 2: Total aerobic bacterial count and level of *Enterobacteriaceae*, coliform bacteria and number of *E. coli*-positive samples in soil after harvest and in lettuce in spring 2006. Significant differences between means are indicated by different letters at p<0.05 (Tukey - test).

	Total aerobic bacterial count		***Enterobac-teriaceae***		**Coliform bacteria**		***E. coli***	
	log_{10} CFU/g		log_{10} CFU/g		log_{10} CFU/g		positive samples (total number = 6)	
Treatment	soil	lettuce	soil	lettuce	soil	lettuce	soil	lettuce
Mechanical 1	7.07	6.17	5.26	6.11	4.44	4.94 b	2	1
Mechanical 2	7.51	6.19	5.25	5.78	5.02	4.84 b	3	1
Mechanical 3	7.23	6.23	5.27	5.21	5.14	4.77 b	5	0
Flame weeding	7.21	6.49	5.54	5.34	4.61	4.82 b	2	2
Plastic mulch	7.23	6.32	5.39	5.84	4.85	5.34 a	3	4
Straw layer	6.96	6.52	5.52	5.78	4.69	5.31 a	2	1
Mean	7.20	6.32	5.37	5.68	4.79	5.00		

In lettuce, total aerobic bacterial counts and *Enterobacteriaceae* showed no significant differences between the treatments (Table 2). For *Enterobacteriaceae*, a slightly higher contamination of treatment mechanical 1 was observed, but the difference was not significant. Coliform counts were significantly higher in the treatments plastic mulch and straw layer. *E. coli* was isolated in low levels (>10<100 CFU/g) in all treatments with fresh FYM applied, but not in the composted FYM treatment. The highest number of positive samples was determined in the plastic mulch treatment (p), but the occurrence did not differ significantly from the other treatments (Fisher´s Exact Test).

Discussion

In soil, bacterial counts did not differ significantly (Table 2), indicating that manure application to the upper soil layer independent whether fresh or composted does not create higher hygienic problems compared to manure application that was ploughed into deeper soil layers (30 cm soil depth) (mechanical 2).

Concerning bacterial counts in lettuce, no differences for total aerobic bacterial counts and *Enterobacteriaceae* were observed. Counts of coliform bacteria were significantly higher in the treatments plastic mulch and straw layer, and *E. coli* counts show also an increasing, although not significantly, number of positive samples for plastic mulch (Table 2). This means, *E. coli* were detected (positive sample), but always only in very small amounts (>10<100 CFU/g) slightly above the detection limit (10 CFU/g).

It can not be excluded that a pre-contamination of the mulching materials plastic mulch and straw might have caused these results. *E. coli* was observed in only some cases in our experiments, and if so, in amounts slightly above the detection limit of 10 CFU/g.

In accordance with the results presented here a similar extent of bacteria transfer has been shown for systems using mineral fertiliser (Rattler *et al.*, 2006). No decline of bacterial counts in lettuce was caused by washing (Rattler *et al.*, 2006). Bacterial pathogens have been detected in the leaf tissue e.g. in several other investigations and were not affected by washing and probably entering the plant over the root system (Solomon *et al.*, 2002). Thus, based on the results of our field experiment even enhanced risks scenarios i.e. FYM in the upper soil layer do not create evident hygienic problems.

Conclusions

The different weed control treatments neither had an effect on soil bacterial counts nor on pathogen transfer of *Enterobacteriaceae* and *E. coli* into lettuce. *E. coli* was only detected in lettuce in low levels near the detection limit of 10 CFU/g. Coliform counts in lettuce were significantly higher in the straw layer treatment or plastic mulch, but these findings were not confirmed by a corresponding number of positive *E. coli* samples suggesting that the coliform counts are not a reliable indicator for potential contamination with *E. coli*. The determination of further causes of lettuce contamination with *E. coli* such as root uptake and insect transfer still require further research efforts.

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The Effects of Crop Type and Production Systems on the Activity of Beneficial Invertebrates

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Key words: Beneficial invertebrates, natural enemies, crop production, fertiliser, crop protection

Abstract

Beneficial invertebrate activity (13 groups) was assessed in five crop types on a split-plot experimental system in northern England using pitfall trapping and suction sampling in May-October 2005. Very significant differences were detected in activity between crop type, and in the preference of groups for individual crops. Within crop types, differences in fertiliser and crop protection approaches appeared to significantly affect activity, with preferences for either organic or conventional management differing between groups. In general, inorganic fertiliser application had more effect on activity than pesticide, herbicide and fungicide use.

Introduction

Changes in agricultural land management and in crop production systems away from intensive, chemically-enhanced, methods towards low-input or organic systems requires an understanding of the consequent changes in the farming landscape. This includes assessments of the effects of crop management systems on the activity and efficacy of beneficial invertebrates given the reduction, and probable cessation, of pesticide applications in the lower input systems.

The change from conventional to organic management is generally thought to increase the activity of predator invertebrates, but the evidence is not conclusive and, in some cases, contradictory (Hole *et al.* 2005). Crop type has been shown to affect activity more than management system (Weibull & Ostman 2003) whilst the influence of non-crop and other landscape factors has also been stressed (Fuller *et al.* 2005). The Nafferton Factorial Systems Comparison Experiments (Leifert *et al.* 2007) provides an opportunity to assess beneficial invertebrate activity at the plot scale in a system where the effects of major components of conventional farming, the use of inorganic fertilisers and crop protection chemicals, are separated from each other, within a number of crop types.

Materials and methods

The Nafferton Factorial Systems Comparison Experiments provided 128 plots (24 x 12 m) in an area converted to organic management between 2001 and 2003. In 2005 the plots contained wheat, barley, beans, vegetables (potatoes, cabbage, onions, lettuce, carrots) and grass/clover. Each plot was sampled for invertebrates using five pitfall traps (8.5 cm diameter, 10 cm deep), 0.5 m apart, part-filled with saturated salt (NaCl) solution containing a small amount of strong detergent as a preservative. The traps were set in the first week of May 2005 and five monthly samples were generated. In addition, three one-minute suction samples were taken from the crop vegetation using a modified leaf-blower on sunny days in the first week of July, August and September.

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The total numbers of Carabidae (ground beetles), Staphylinidae (rove beetles), Coccinellidae (ladybirds), predatory beetle larvae (Carabidae and Staphylinidae), Linyphiidae (money spiders) and Lycosidae (wolf spiders) were counted from the five pitfall samples. The numbers of Syrphidae (hoverflies), Neuroptera (lacewings), predatory bugs (Hemiptera) and parasitic wasps (Hymenoptera: Ichneumonidae, Proctotrupidae, Braconidae, Pteromalidae) were a product of both sampling methods. The number of individuals of each group recorded was considered to reflect activity and analyses were carried out the number recorded, transformed by $\log_{10}n+1$, using linear mixed-effects models in the R statistical environment (R Development Core Team 2005). Analysis of variance was generated using models with fertility, health and crop as fixed factors and the blocks of the trial as a random factor. Data from all plots were used to assess the effect of crop type whilst the effects of differing fertility and crop protection management (conventional and organic) were assessed within each crop type.

Results

Of the 13 invertebrate groups, the activity of 12 was highly significantly related to crop (Tab. 1) with only Neuroptera appearing to be unaffected. Considerable differences were observed in the activity of different groups in the five crops. Whilst the cereal crops had the most of some groups (e.g. Carabidae, Staphylinidae, Syrphidae), they had the fewest of others (e.g. Coccinellidae, Hemiptera) whilst the activity of the four hymenopterous groups was greatest in grass/clover for two, as with both spider groups, and in beans and wheat for the other two. Within individual crops (Tab. 2), all significant responses in wheat and most in barley were fertility related whilst significant responses to crop protection were greatest in the beans and vegetables. With the three beetle groups, two had a preference for conventional fertility management (Staphylinidae, larvae) but Carabidae were most active in organic fertilised plots. Similar differences were also seen for the two spider groups, with Linyphiidae most active on conventional plots and Lycosidae on organic.

Tab. 1: The significant relationships between invertebrate group activity and crop type, derived from linear mixed effects models, together with the trend of activity recorded in the five crops (most>least).

Group	Significance	Trend
Carabidae	***	wheat>barley>beans>vegetables>grass/clover
Staphylinidae	***	barley>beans>wheat> grass/clover>vegetables
Beetle larvae	***	barley> grass/clover>beans>wheat>vegetables
Coccinellidae	***	vegetables>wheat>beans> grass/clover>barley
Syrphidae	***	wheat>beans>vegetables>barley>grass/clover
Hemiptera	***	beans>vegetables>barley> grass/clover>wheat
Ichneumonidae	***	beans>vegetables>grass/clover>wheat>barley
Proctotrupidae	***	wheat>barley>vegetables>beans>grass/clover
Braconidae	***	grass/clover>vegetables>beans>wheat>barley
Pteromalidae	***	grass/clover>beans>vegetables>wheat>barley
Linyphiidae	***	grass/clover>wheat>barley>beans>vegetables
Lycosidae	***	grass/clover>beans>barley>wheat>vegetables

*** significant for *P*<0.001

Tab. 2: The significant effects of conventional (C) and organic (O) fertility and crop protection management on the activity of invertebrate groups within crop types derived from linear mixed effects models and the trend of activity recorded in the two management systems (most>least).

Crop and group	Factor/interaction	Significance	Trend
Grass/clover			
Staphylinidae	Fertility	**	C>O
Ichneumonidae	Crop protection	*	C>O
Braconidae	Fertility	**	C>O
Lycosidae	Fertility	*	O>C
Beans			
Staphylinidae	Fertility	**	C>O
Staphylinidae	Crop protection	**	C>O
Hemiptera	Crop protection	**	O>C
Linyphiidae	Fertility	*	C>O
Lycosidae	Crop protection	*	O>C
Wheat			
Carabidae	Fertility	**	O>C
Staphylinidae	Fertility	***	C>O
Beetle larvae	Fertility	*	C>O
Coccinellidae	Fertility	**	O>C
Pteromalidae	Fertility	**	O>C
Linyphiidae	Fertility	**	C>O
Barley			
Carabidae	Fertility	*	O>C
Staphylinidae	Fertility	***	C>O
Staphylinidae	Crop protection	**	C>O
Staphylinidae	Fertility:crop protection	**	CC>CO>OC>OO
Beetle larvae	Fertility	***	C>O
Beetle larvae	Crop protection	*	C>O
Linyphiidae	Fertility	***	C>O
Lycosidae	Fertility	***	O>C
Vegetables			
Carabidae	Crop protection	**	O>C
Hemiptera	Crop protection	**	O>C
Linyphiidae	Fertility	**	C>O

* significant for $P<0.05$
** significant for $P<0.01$
*** significant for $P<0.001$

Whilst Staphylinidae and beetle larvae were more active with conventional crop protection in beans and barley, organic management appeared to favour Hemiptera, Lycosidae and Carabidae in beans and vegetables. Only one significant interaction response was observed, in barley with Staphylinidae, with most activity in the plots with both conventional management approaches and the least with both organic. In general, fertility management had more significant effects than crop protection, with some groups more active on conventional plots and others on organic plots.

Discussion

Too much credence cannot be put on the results from the crop production plots because of their small size and of other factors such as the lack of adjacent non-crop habitat but they provided interesting insights into factors influencing beneficial invertebrate activity. The results agree with the conclusions of Bengtsson *et al.* (2005) that crop type significantly affects the activity of different groups but the more interesting observation was that the use of inorganic fertiliser appeared to have more impact on activity than the application of chemical crop protection sprays. This observation will need to be tested at the farm-scale but it does not appear to have been obvious from studies which have tended to concentrate on one crop on a number of farms (e.g. Fuller *et al.* 2005). The effects of the cessation of the use of both inorganic fertiliser and chemical pesticides, and of the time since conversion to organic management, will have to be taken into account because the efficacy of the pest natural enemy assemblage will need to be maximised. These management factors will need to be assessed in conjunction with enhancement methods such as the provision of beetle banks and conservation headlands (Landis *et al.* 2000). Another aspect to be researched thoroughly is the effect of production-linked activity increases on biodiversity because the evidence on species richness in different management systems is not consistent (Hole *et al.* 2005).

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Assessment of selected soil parameters in a long-term Western Canadian organic field experiment

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Keywords: nitrogen, phosphorous, mycorrhiza, aggregate stability

Abstract

A long-term field study was used to compare soil nitrogen and phosphorous status, and soil aggregate stability in organic and conventional cropping systems. Two rotations were tested: a grain only and a grain-alfalfa hay rotation. The organic systems had a lower nitrate leaching potential than the same rotations under conventional management. After 13 years, one organic system (the grain-alfalfa; no manure return) is suffering serious soil P depletion. However, the grain only and the grain-alfalfa with manure return to land systems had soil P levels similar to the prairie grass control treatment and showed no signs of P deficiency. Despite having lower levels of organic carbon, the organic soils had higher levels of wet aggregate stability than conventionally managed soils.

Introduction

Soil fertility and erosion risk are major concerns in Canadian organic grain production. Surveys of organic fields in western Canada indicate that while soil nitrogen (N) supply appears adequate and sometime excessive, soil available phosphorous (P) is often lacking (Entz *et al.*, 2001). Our first question regards N leaching potential in organic compared to conventional systems under the variable weather conditions experienced in western Canada. We were interested in whether the 2006 drought, which resulted in low crop N uptake that year, increased the risk of future N leaching in organic and conventional systems. Our second objective was to compare soil P in different organic farming systems and determine whether long-term organic management is depleting soil P. Western Canada is dominated by large fields and soil erosion poses a major threat to soil sustainability. Hence, our third objective was to determine the effect of long-term organic management on soil erodibility through measures of wet aggregate stability.

Materials and methods

The Glenlea study is located near Winnipeg, Canada on a Black Chernozemic soil (9% sand; 26% silt; 66% clay). Annual precipitation is 500 mm. Two, four-year rotations have been investigated at Glenlea since 1992 (grain only and grain-alfalfa). The grain only rotation consists of flax-oat-fababean-wheat, while the grain-alfalfa system consists of flax-alfalfa-alfalfa-wheat. Each rotation is conducted under conventional and organic management. The experiment also includes a restored prairie grass plot that serves as an ecological benchmark treatment. The experimental design is a randomized complete block with three replications. All grain crops are harvested for seed. Fababean is green-manured in the organic system and harvested for seed in the conventional system. Alfalfa is harvested for hay. In 2000, all alfalfa-

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grain system plots were divided and one-half received a one-time application of 10 t/ha composted manure, while the other half did not.

Measurements relevant to this study include crop yield and quality, soil carbon, soil nutrient status (N and P), mycorrhizal colonization of flax roots and wet mean weight diameter of soil (Angers and Mehuys 1988). A P balance was conducted using differences in P removed by crops, added through fertilizer (or manure) between 1993 and 2004.

Results

N content of soils to 120 cm was determined on samples taken in September 2006. The 2006 growing season was very dry and crop N uptake averaged <60 kg/ha (data not shown). Both conventional rotations had very high residual N levels (Table 1), and N leaching risk was considered high. Much lower N levels were observed in both organic rotations (Table 1); N leaching potential in organic was considered very low. Results suggest that organic systems, even those containing alfalfa, were at lower risk for N leaching than conventionally-managed systems.

A thorough examination of soil P was conducted from soil sampled in 2003. Results for total soil P indicate relatively high levels for all treatments, reflecting the natural fertility of these soils (Table 2). However, the grain-alfalfa system with no manure returned to land had lower ($p<0.05$) levels of P than other systems. Sodium bicarbonate extractable P was lowest ($p<0.05$) in the grain-alfalfa system (<10 kg/ha; data not shown). These observations suggest that a farming system that exports alfalfa hay but does not receive animal manure is at risk of a P deficiency. The results from our expected P balance analysis (Table 2) confirm that the alfalfa-grain system with no manure added had the highest level of P removal. It was interesting to observe that the grain-alfalfa with no manure treatment is showing physical signs of P deficiency in the alfalfa. For example, in 2006 alfalfa yields were reduced by 75% in the organic compared with the conventional plots (data not shown).

Mean wet aggregate stability was measured to assess soil erosion potential. The organic systems had significantly higher soil stability than the conventional systems in both the grain only and the grain-alfalfa systems (Table 3). This observation was surprising, especially given that soil C levels were actually lower ($p<0.05$) in the organic system (4.8 vs. 5.1% for conventional). Higher soil stability under organic compared with conventional management may be due to greater mycorrhizal colonization in the organic system (Entz *et al.*, 2004) in 2003 (Table 3).

Tab. 1: Soil nitrate-N (kg/ha) in three soil depths for two farming systems (grain only and grain-alfalfa) under organic and conventional management at Glenlea, Manitoba in September, 2006. Numbers followed by different letters are significantly different at P<0.05.

Soil depth (cm)	Grain only conventional	Grain only organic	Alfalfa-grain conventional	Alfalfa-grain organic
0-15	91	23	100	12
15-60	62	20	67	31
60-120	31	15	43	15
0-120	***184a***	***57b***	***210a***	***57b***

Tab. 2: Total soil P (kg/ha) measured in autumn of 2003 and expected P balance (1993-2004) for different crop rotations under organic and conventional management at Glenlea.

Crop rotation	System	Total soil P	Expected P balance
Grain	Conventional	305a*	+18
Grain	Organic	301a	-56
Grain-alfalfa	Conventional	285a	+41
Grain-alfalfa	Organic	219b	-120
Grain- alfalfa	Conventional with manure	315a	+65
Grain-alfalfa	Organic with manure	275a	-100
Prairie	Organic	310a	

* numbers followed by a different letter are significant for *P*<0.05

Tab. 3: Soil mean weight diameter and percent root colonization by mycorrhiza for two rotations conducted under conventional and organic management at Glenlea in 2003.

Crop rotation	System	Aggregate Mean Weight Diameter (Wet)	Mycorrhizal colonization (% root infected)
Grain	Conventional	0.786 b	30 b
	Organic	0.946 a	50 a
Grain-alfalfa	Conventional	0.885 ab	27 b
Grain-alfalfa	Organic	0.986 a	45 a
Prairie	Organic	-	82 a

* numbers followed by a different letter are significant for *P*<0.05

Discussion

Dry seasons often cause available N to accumulate in prairie soils. This N poses a leaching risk. Both organic rotations in the present study showed less N buildup than the conventional rotations, which means the organic system was at lower risk for N leaching. This observation contradicts some previous studies where organic rotations, especially those containing perennial legumes, were found to have a high leaching potential. P depletion was discovered in the organic grain-alfalfa hay system. Therefore, despite having adequate levels of soil N, the alfalfa hay export system is not sustainable. The problem of P depletion in the grain-alfalfa rotation appears to have been overcome by returning some composted manure to the soil (Table 2). Organic farmers who produce alfalfa for off-farm export need to monitor the soil P status of their soils and be prepared to take action to reverse P depletion.

Conventional soil science wisdom suggests that a decrease in soil C will result in less aggregated soil. In the present study, higher levels of wet aggregate stability could not be attributed to soil C since soil C was lower in the organic system regardless of rotation type. Perhaps it is the improvement in soil biology, namely glomalin production by mycorrhiza, that is responsible for more stable organic soils.

Conclusions

After 13 years, soil P levels in organic grain and grain-alfalfa (with manure) systems were similar to the natural prairie and showed no signs of depletion. Soil P depletion was observed in the grain-alfalfa rotation (no manure). Crop-livestock integration appears important on organic farms.

After a drought year, organic systems were found to be less prone to nitrate leaching than conventional systems.

Organic systems were found to have greater soil wet aggregate stability than conventional systems, despite having lower soil C concentrations. Additional soil ecology research is required to better understand these results.

Acknowledgments

We gratefully acknowledge the Government of Manitoba for long-term funding of this study. Special thanks also to Mr. Keith Bamford for technical assistance.

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Organic soil management: Impacts on yields, soil quality and economics

Koopmans, C. J.[1], Zanen, M.[1]

Key words: biodiversity, fertilization, nitrogen efficiency, organic farming, soil quality

Abstract

Understanding organic management practices is a key in developing sustainable organic farming systems. We report the results of four different organic fertilization strategies in a field trial on yields, soil quality and economic performance. We found highest yields and economic performance in two direct plant feeding strategies. One of these strategies, a newly developed strategy based on biowaste compost (GFT) and an additional fertilizer performed well in terms of yields but looks also very promising in terms of soil quality and biodiversity. The economic perspective of this strategy renders it promising in regions with little animal manures.

Introduction

In recent years a great deal of research has been done in the field of comparing organic and conventional management strategies, mainly in long-term field trials (Mäder *et al.*, 2002). Little attention, however, has been given to the fertilization strategies that are behind these system comparisons and might explain differences found in economic, ecological and environmental performance. In this study we compare different fertilization strategies. We focus on the question often asked in sustainable and organic farming whether it is better to supply nutrients to crops by building up soil fertility over time or to focus on a fertilization strategy that tunes organic inputs directly to the plant's nutrient demand within a season.

Materials and methods

In 2003 four organic fertilization strategies were set up in an organic crop rotation on a clay-loam at Colijnsplaat, Zeeland (The Netherlands). In the crop rotation of spring wheat, potatoes, grass-clover, onion, brown beans and sugar beet, four fertilization strategies were applied:

- Goat manure (GM): fertilization based on soil improvement within the regulation limit of a maximum of 80 kg P_2O_5 year^{-1} for the whole crop rotation (35 t ha^{-1} 2 years^{-1}).
- Green compost (GC): fertilization based on soil improvement through the use of very clean plant-based green compost (less 80 kg P_2O_5 year^{-1} in the whole rotation (50 t ha^{-1} 2 years^{-1}).
- Biowaste compost (GFT): fertilization focusing on soil and plant fertilization in a combination of compost (30 t ha^{-1} 2 years^{-1}) and vinasse (3 t ha^{-1}) to potato, sugar beet and wheat.
- Cattle slurry (CS): fertilization fully based on plant feeding within the regulation of less than 80 kg P_2O_5 year^{-1} for the whole rotation.

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Results

Wheat yields were lowest in 2003 in the CS strategy as a result of soil compaction due to slurry application in spring (Figure 1). Lowest sugar beet yields were found in the GC strategy in 2004, whereas no significant differences were found in onion yields in 2005. Potato yields were lower in the GM strategy compared to the other strategies in 2003 but in 2004 lowest yields were found in the GC strategy. Differences in grass-clover yields were found to be small.

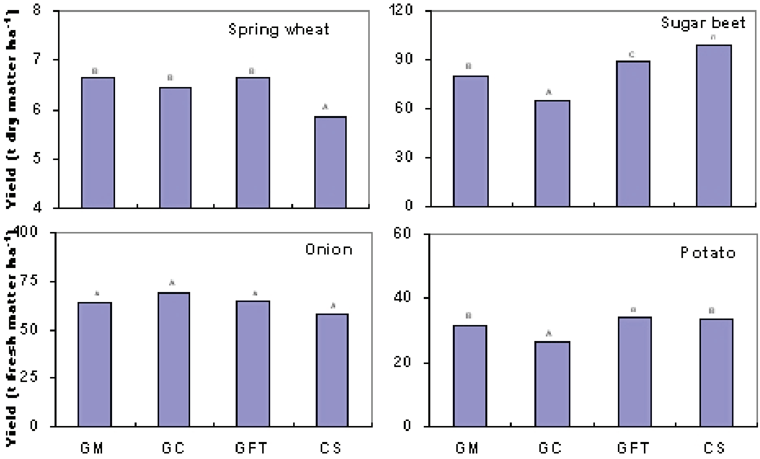

Figure 1: Yields of spring wheat (2003), sugar beet (2004), onion (2005) and potato (2004) in the management practices goat manure (GM), green compost (GC), biowaste compost (GFT) and cattle slurry (CS).

For spring wheat and sugar beat: Yield [t dry matter ha^{-1}]; for onion and potato: Yield [t fresh matter ha^{-1}]

Nutrient balances (Tab. 1) for the different fertilization strategies were calculated for the period 2003-2005 using the NDICEA model (van der Burgt *et al.*, 2006). Nitrogen in the crops differed little between the strategies. As a result considerable nitrogen surpluses existed in the strategies receiving the compost additions. With these compost additions nitrogen is applied, which is not directly available to plants.

Tab. 1: Nitrogen balance (in kg N/ha/year) for the period 2003-2005.

Strategy	Application with fertilizers	Product removal	Calculated surplus	Leaching losses[1]	Organic matter[2]
GM	175	151	24	45	38
GC	252	150	102	43	110
GFT	265	164	101	58	79
CS	87	156	-69	34	-28

[1] No full rotation was covered per strategy. Average nitrogen application for these years was higher than for the full rotation of 6 years.

[2] Leaching losses were calculated using the NDICEA model

[3] Organic matter: modelled incorporation of nitrogen into the soil organic matter

Nitrogen efficiencies were highest in both the GM and CS strategies. Using the NDICEA model, it was possible to calculate total losses due to nitrogen denitrification and leaching. Highest nitrogen leaching losses were found in the GFT strategy. Losses differed little between the GC and the GM strategies. In the GC and GFT strategies high amounts of the added nitrogen were incorporated into the organic matter of the soil. In the CS strategy a net loss of nitrogen from organic matter was calculated by the model.

The soil quality assessment (Tab. 2) showed that potential C and N mineralization were higher in the GC and GM strategies as compared to the CS strategy. In the data the low C mineralization in the GFT strategy is striking. Potential N mineralization was lowest in the CS strategy. Neither bacterial nor fungal biomass differed between the strategies. Bacterial feeding nematodes were low in the GFT strategy. Most plant feeding nematodes were found in GC, whereas lowest levels were found in the CS strategy. No differences were found in earthworm counts, soil structure and organic matter levels. Significantly higher levels of P-total and potassium were found in the CS strategy compared to the other strategies. This may be due to the spring application of the slurry as all other fertilizers were mixed into deeper soil layers as a result of ploughing in autumn. The shallow application of cattle slurry in spring did not have a mixing effect.

Tab. 2: Biological, physical and chemical soil properties of the different strategies

Soil property	GM	GC	GFT	CS	P
Microbial biomass	16.0	25.5	28.7	10.9	NS
Fungal Biomass	14.0	15.0	16.6	14.3	NS
Pot. N mineralization	2.0b	1.9 b	1.7 ab	1.3 a	0.05
Pot. C mineralization	18.5 c	15.4 b	5.2 a	5.4 a	<0.001
Bacterial feeding nematodes	781 b	590 b	346 a	527 ab	0.007
Fungal feeding nematodes	142	80	93	96	NS
Plant feeding nematodes	457 b	561 c	452 b	323 a	0.002
Earthworm biomass	88	75	50	57	NS
Soil structure	27	22	23	23	NS
Organic matter	2.3	2.3	2.4	2.3	NS
PH	7.5	7.5	7.5	7.5	NS
N-total	1075	1083	1214	1188	NS
P-total	149 ab	139 a	155 b	174 c	<0.001
Potassium	24 ab	22 a	25 b	32 c	<0.001

In the balance calculations (Tab. 3) use was made of costs and yields per crop in the 3 years of the research. Per crop a balance calculation was made. These balances were averaged per plot (Tab. 3). In the period 2003-2005 the balance was highest in the CS and GFT strategies. The spring application of fertilizers to the sugar beet in the

CS and GFT strategies resulted in particularly high yields and earnings if compared to the other two strategies.

Discussion and Conclusions

In the period 2003-2005 the GFT and CS strategies produced the best results in terms of yields and economic performance, especially in high-yielding crops like potatoes and sugar beets.

Tab. 3: Average balance (in € ha^{-1}) for different fields in the period 2003-2005

Strategy	Plot A Bean- Sugar beet Spring wheat	Plot B Potato Grass clover Onion	Plot C Spring wheat Potato Grass clover	Average
GM	2127	2465	1430	2007
GC	1833	2798	1432	2021
GFT	2424	2881	1731	2345
CS	2577	2654	1735	2322

The strategies using green compost and solid goat manure lagged behind in terms of yields but resulted in improved soil properties such as higher potential nitrogen and carbon mineralization due to build-up of organic matter. It might be expected that the soil fertility or production function of the soils improves with these strategies over time. The higher plant-feeding nematodes populations in the composts are likely to result from the high root densities observed in the compost strategies (Koopmans and ter Berg, 2005). The significant differences in bacterial and plant-feeding nematodes are likely to result in higher disease resistance in these strategies.

The calculations using the NDICEA model showed that nitrogen from the compost applications is largely built into the organic matter and does not result in high nitrogen leaching losses, necessarily. A crop rotation which is tuned to available nitrogen from these composts and use of catch crops is important in these strategies, however. In the slurry application, it was possible to tune crop demand and nitrogen availability to each other. In this strategy, the risk consists of a loss of organic matter and an increased soil compaction due to the spring application using heavy equipment.

We conclude that both fundamental strategies focusing on soil improvement and direct crop fertilization within organic farming are realistic and sustainable strategies in the short term. For further research the question remains on the impact of the different fertilization strategies on yields, soil quality and mineral use-efficiency in the long run.

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Soil structure and earthworm activity under different tillage systems in organic farming

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Key words: Conservation tillage, organic farming, soil structure, earthworms

Abstract

Organic farmers are encouraged to adopt conservation tillage to preserve soil quality and fertility and prevent erosion. However, many studies in different soil and climate conditions have demonstrated that the compaction of the untilled layer is higher in conservation tillage than in conventional tillage. As earthworm activity may help alleviate soil compaction in organic farming, the impact on the soil structure and earthworm population and activity was studied for 4 different tillage managements (1) mouldboard ploughing (MP), (2) shallow ploughing (SP), (3) reduced tillage (RT) and (4) no-tillage (NT), in 3 ƒrench areas. The first results are: (1) MP soil structure is better than SP, RT and NT, (2) water infiltration is higher at soil surface in SP, RT and NT, lower at 17 cm depth, (3) more earthworms, especially anecic species, are found in NT, (4) but more opening channels are found in MP. Then, during the first years of transition from MP to NT, soil structure is better in MP, and whereas earthworm numbers is reduced, it favours earthworm activity.

Introduction

Organic farmers are encouraged to adopt conservation tillage to preserve soil quality and fertility and prevent erosion. Conservation tillage leaves organic mulch at the soil surface, which reduces runoff, increases the soil organic matter content and improves aggregate stability which limits soil erosion (Franzluebbers 2002). These benefits can improve soil fertility, soil quality and environmental impact of organic crop production. However, Koepke (2003) reported that organic farmers generally use conventional tillage systems with a mouldboard plough, and, occasionally till to a greater depth than in conventional agriculture. Conservation tillage improves superficial soil structure and can reduce compactibility thanks to the concentration of decomposing crop residues. However, many studies in different soil and climate conditions, have demonstrated that the compaction of the untilled layer is higher in conservation tillage, with a decrease of total porosity (Kay *et al.* 2002). Earthworm quantity and activity increases in conservation tillage compared to conventional tillage. Increase of fresh organic matter in organic farming is an additional resource stimulating trophic and burrowing activity of earthworms (Gerhardt 1997). Thus, organic farming and conservation tillage may represent an efficient association to improve earthworm activity, and soil structure. To understand how earthworm activity can remediate to soil compaction due to tillage in organic farming, we study soil structure and earthworm population and activity on a large range of tillage managements.

Materials and methods

3 experimental fields associated with 2 on-farm surveys have been carried out in 3 regions of France: Rhône Alpes (area A), Pays de la Loire (area B) and Bretagne

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(area C). In this paper, we only present the results obtained on the experimental fields. On each area (table 1), 4 tillage managements are compared and a completely randomised block design with 3 replicates is used: 1) Traditional mouldboard ploughing (MP) (30 cm depth), 2) Shallow ploughing (SP) (20 cm depth for area A and B, 15 cm for area C), 3) Reduced tillage (RT) with tine tool (15 cm depth for area A and B, 12 cm for area C) and 4) no tillage (NT). At the beginning of the essay (areas A and C), no tillage was managed under a cover crop.

Table 1: Description of the 3 experimental fields.

Area	Organic farming conversion	Start of the essay	Soil type	Crop rotation
A	1999	2003	Sandy loam (luvic brunisol)	Alfalfa (3 years) – Maize – **Soybean (2006)** – Winter wheat – Soybean - Maize
B	2000	2005	Silty (cambisol)	Maize – Field bean – Winter **wheat (2006)** – Lupin crop
C	1996	2003	Silty	Maize – cereal – wheat – **winter pea (2006)** - cereal

We adopt a morphological description of the soil structure. It allows integrating and explaining temporal and spatial variation of the soil structure at the field scale. We characterise the spatial arrangement of the aggregates, peds, clods and pore space on a pit (3 m in length, 1 m deep) according to Roger-Estrade *et al.* (2004). This method permits to distinguish and quantify in the soil profile distinct structural zones in the soil profile: % of zones with loose structure noted Γ clods (visible porosity) and % of compacted zones, noted Δ clods (non-eye visible porosity).

Soil hydraulic conductivity was measured with disk infiltrometer at water potentials of 6, 2 and 0.5 h Pa which correspond to pore diameter of 0.05 cm, 0.15 and 0.6 cm.

We measure the earthworm abundance (number / m^2) and species diversity (grouped in ecological category) with the formaldehyde method (Bouché *et al.* 1984). Each sample is taken on the same spot than the morphological description of the soil structure (plumb with the pit). Moreover, at the same place, we measure the impact of earthworm activity on soil structure through the presence or absence of channels in the soil profile. Opening channels are counted at a depth of 30 cm (junction of subsoil and topsoil) in the soil pit on a 0.2 m^2 plan (corresponding to the plan where earthworms were taken at the soil surface).

Results

We present results obtained in area C, after 3 years of experiment, and results obtained in area A, after 1 year of experiment. Results of area B are not yet available.

Morphological description of the soil structure: For both areas, we observe more 'porous' soil structure in MP, and also SP, than in RT and NT soil profiles. Indeed, clods are easier to discern (table 2), especially in the layer not cultivated with RT and NT, and % Γ clod (porous) is higher.

Table 2: observed spatial arrangement and porosity of clods of soil structure created by MP, SP, RT and NT in area A and C.

Area (year of experiment)	**Spatial arrangement of clods : clods easily to discern**		**% Γ clod**	
A (1 year)	**0-20 cm :** MP=SP=RT > NT	**20-30* cm :** MP>SP=RT=NT	**0-20 cm :** MP>SP=RT=NT	**20-30* cm :** MP=SP>RT=NT
C (3 years)	0-15 cm : MP=SP=RT=NT	15-30* cm : MP=SP>RT=NT	**0-15 cm :** MP>SP=RT=NT	**15-30* cm :** MP=SP>RT=NT

*: Uncultivated layer for SP, RT, NT

Water infiltration (area C only): Hydraulic conductivity is higher in RT, NT and SP at soil surface compared to MP, and inversely at 17 cm soil depth (figure 1).

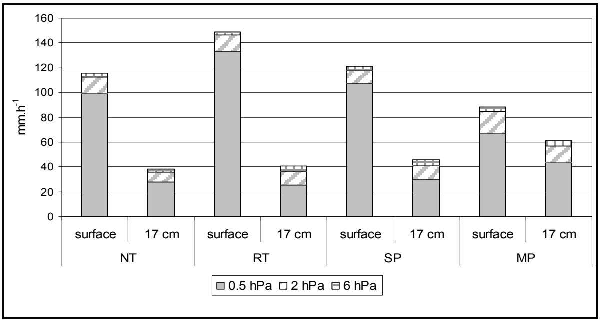

Figure 1 : hydraulic conductivity (mm.h^{-1}) at 6, 2 and 0.5 h Pa potentials which correspond to diameters pore of 0;05 cm, 0.15 and 0.6 cm respectively in soil surface and at 17 cm depth in june 2006 for the 4 tillage systems (NT: no-tillage; RT: reduced tillage; SP: shallow ploughing; MP: mouldboard ploughing) - area C.

The macroporosity (especially pore diameter > 6 mm) is higher at soil surface in conservation tillage (RT, SP, NT) and lower in soil depth compared to MP. More crop residues are left on soil surface in RT, NT and also SP, then there is no crust at the soil surface compared to MP which improves water infiltration. At 17 cm depth, more macroporosity is found in MP which is correlated with the morphological description of the MP soil profile (table 1). Then, after 1 and 3 years of conservation tillage, soil structure is more compacted than with MP. Moreover, the difference observed with morphological description is confirmed by water infiltration.

Abundance and diversity of earthworms: In area A, more earthworms were found in NT than in MP, SP and RT (significant difference with Kruskal-Wallis test) (figure 2). NT presents higher epigeic (in crop residues or cover crop at the soil surface) and anecic (vertical channels). After 3 years of experiment, identical results are found in area A and area C

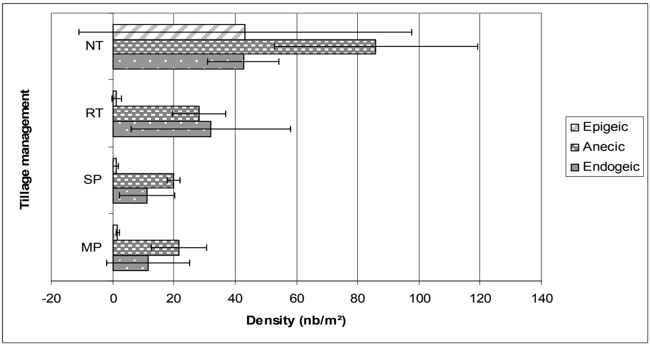

Figure 2: Number of earthworms (by ecological category) per m^2 according to the 4 tillage (NT: no-tillage; RT: reduced tillage; SP: shallow ploughing; MP: mouldboard ploughing) managements in October 2006 – area A

Earthworms Activity: In area A, there is no difference of counted opening channels at 30 cm depth whereas in area B, there is more counted opening channels at 30 cm depth in MP than to SP, RT and NT. Even if more earthworm abundance and diversity are found in NT and RT, more channels in depth (anecic) are found in MP.

Discussion and conclusion

Better soil structure is obtained with MP than with the SP, RT and above all NT after 1 year in a sandy loam soil and 3 years in a silty soil. Similar results were found by Kouwenhoven *et al.* (2002) and Munkholm *et al.* (2001) in organic farming. Even if higher earthworm abundance and diversity are found in NT and RT, more earthworm channels are found in depth in MP. At short term, earthworms are not able to improve soil structure in conservation tillage compared to conventional tillage. Results from area B may confirm these first results. On soil with low shrinking- welling effect, quality of soil structure can decrease in conservation tillage with time. Thus it is necessary to know if the long term increase of earthworms will have a positive impact on soil structure.

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Assessment of tillage systems in organic farming: influence of soil structure on microbial biomass. First results

Vian, J.F.[1], Peigné, J. [1], Chaussod, R.[2] and Roger-Estrade, J.[3]

Key words: organic farming, tillage systems, soil structure, microbial biomass.

Abstract

Soil tillage modifies environmental conditions of soil microorganisms and their ability to release nitrogen. We compare the influence of reduced tillage (RT) and mouldboard ploughing (MP) on the soil microbial functioning in organic farming. In order to connect soil structure generated by these tillage systems on the soil microbial biomass we adopt a particular sampling scheme based on the morphological characterisation of the soil structure by the description of the soil profile. This method reveals the influence of soil structure on soil microbial biomass and allows a more precise assessment of the impact of tillage managements on the soil microbial functioning.

Introduction

The soil microbial functioning is of primary importance for the quality and productivity of cultivations, especially in organic farming as nitrogen (N) supply is mainly dependent on the degradation of soil organic matter by microorganisms. Soil tillage is known to modify the biotic and abiotic conditions of soil microorganisms' environment and thus modifies qualitatively and quantitatively microbial communities (Young *et al.* 2000). Numerous studies report that reduced tillage leads to an accumulation of the soil microbial biomass and an important N release in the upper layers in comparison with conventional tillage. Usually, there is no difference when they consider the entire soil profile (Andrade *et al.* 2003, Young *et al.* 2000, Kandeler *et al.* 1998). Soil tillage induces also changes in soil structure at different scales, ranging from the soil profile to a few micrometers (Balesdent *et al.* 2000). Consequently, soil structure is greatly variable in time and space in cultivated fields, which makes it difficult to choose a convenient sampling scheme for studying soil processes (Roger-Estrade *et al.* 2004).

Our objective is to study the impact of different tillage systems in organic farming on the soil microorganisms and to consider the interactions between soil structure and the microbial functioning. In order to connect these parameters, we adopt a morphological description of the soil structure based on the description of the soil profile. This method enables to distinguish and quantify distinct structural zones in the soil profile: zones with loose structure composed by Γ clods and compacted zones, essentially composed by Δ clods. By measuring different microbial parameters on these clods with distinct physical properties (Boizard *et al.* 2004) we try to connect soil structure generated by tillage treatments with the soil microbial functioning. Indeed, this method enables to link the soil structure characteristics to the cultivation operations responsible for soil structure dynamics and to integrate the spatial heterogeneity in our analyses at the field scale (Roger-Estrade *et al.* 2004).

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Materials and methods

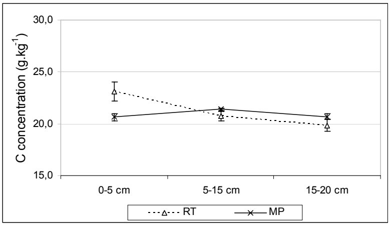
Four tillage systems are compared on a Cambisol Dystrique (FAO classification; 48% silt, 20% clay and 32% sand) located in Brittany, north-west of France. The experimental design consist in 12 plots (12*25m²) randomised in three blocs. Treatments have been differentiated since 2003. We present the results from the conventional tillage treatment with an annual mouldboard ploughing to 20cm depth (MP) and a reduced tillage treatment to 15cm without soil inversion with a chisel (RT).

Soil structure is characterised by the spatial arrangement of aggregates, peds, clods and pore space on a pit according to Roger-Estrade *et al.* (2004). We distinguish and quantify the Γ and Δ clods (structural porosity clearly visible and non-eye visible porosity respectively) in the soil profile which have distinct physical characteristics (Boizard *et al.* 2004). Their respective proportion in soil profile is an indication of the evolution of soil structure under different tillage systems (Roger-Estrade *et al.*, 2004). We measure the porosity of each type of clods by the petrol method at three depths (0-5 / 5-15 / and 15-20cm).

To connect the structural states of the treatments to their microbial functioning we measure on these Γ and Δ clods (±10cm^3) their microbial biomass (MB) (fumigation-extraction method), their labile soil organic matter (LOM) (Chaussod *et al.* 1988), and their potential C and N mineralization (Cmin and Nmin per 28 days at 28°C.). We deduce from these parameters the microbial respiration rate per unit of MB (qCO_2, mgC per day) (Nielsen and Winding, 2002). Organic carbon (NF ISO 10694) and total nitrogen (NF ISO 13878) were measured as the soil pH.

We briefly present the firsts results of the influence of MP and RT systems on the soil MB from distinct structural zones. Soil observations have been made 4 months after tillage operations. Statistical analysis is made with *statview 5.0* (SAS Institut Inc.). We use a multiple comparison test (Fischer's PLSD) using *pairwise comparisons*.

Results



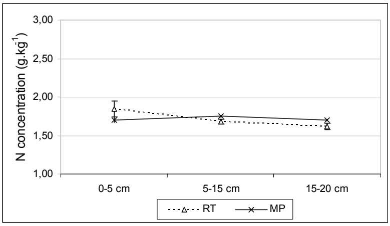


Figure 1: carbon concentration (g.kg^{-1}) and nitrogen concentration (g.kg^{-1}) of the reduced tillage (RT) and mouldboard ploughing (MP) treatments.

The concentrations in organic carbon (OC) and total nitrogen (N) (figure 1) of the Γ and Δ clods, from the same soil horizon, are not different but the porosity of the Γ clods is significantly higher than the Δ clods porosity (results not shown).

C concentration is significantly higher in the upper layer (0-5cm) in the RT than in MP ($P<0.001$). No differences appear in the other soil layers. We observe a vertical stratification of C concentrations in RT system. The C concentration in the upper layer is significantly different than the deeper one ($P<0.05$), and the 5-15cm layer have an intermediate concentration. In contrast, the C and N concentrations of the MP treatment are homogenously distributed in the soil profile, as the N concentrations in RT.

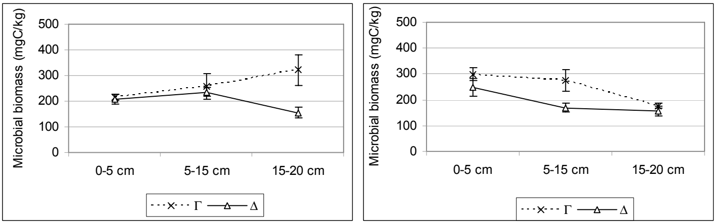


Figure 2: influence of the type of clods (Γ or Δ) and the soil depth on soil microbial biomass ($mgC.kg^{-1}$) for the MP (A, left) and RT (B, right) treatments.

Whatever type of clods, soil microbial biomass (MB) is significantly higher in RT than in MP for the upper layer ($P<0.05$). Soil MB is significantly higher in MP than RT for the Δ clods from the 5-15cm layer and for Γ clods from the 15-20cm layer ($P<0.05$ and $P<0,001$ respectively). Soil MB diminishes with the depth in RT whereas it increases in MP. Significant differences of MB appear between 0-5 and 15-20 cm in RT treatment and between all soil layers in MP when we considered Γ clods.

MB of the Γ clods is significantly higher than the Δ clods for the 15-20 cm layer in the MP treatment and for the 0-5 and 10-15cm layers ($P<0.001$ and $P<0.05$ respectively) for the RT treatment.

Discussion

We observed a vertical stratification of OC and MB in RT whereas OC is distributed homogeneously in the soil profile in MP as reported in numerous studies (Andrade *et al.* 2003, Stockfisch *et al.* 1999).

OC and total N concentrations in Γ and Δ clods are similar. Differences observed on soil MB between these two clods from the same soil layer may be due to their distinct physical properties. In a compacted environment, where microporosity dominates, O_2 circulation and substrates originating from raw materials (diffused via the soil solution) are lower (Ranjard *et al.* 2001). It could be the case in the Δ clods, where O_2 diffusion could limit the development of aerobic bacteria and poor nutrients diffusion, via the soil solution, could limit microbial growth. Indeed, Curmi (1988) demonstrated that anoxic conditions are higher in compacted clods. Besides, microorganisms are physically protected from protozoan predation in microporosity (Ranjard *et al.* 2001). So, Δ clods may physically limit this predation which stimulates microbial turn-over and accelerates nutrient cycling (Young *et al.* 2000).

Soil MB differences between Γ and Δ clods seem to be clearer in RT than in MP. The turn-over of the Δ and Γ clods between these tillage systems are different. In CT, Δ clods are subjected to an annual fragmentation by the plough pan and to climate effect (freeze and thaw) when they are replaced near the soil surface (Boizard *et al.* 2004). In RT system this in not the case and Δ clods may cumulate adverse conditions for the soil microorganisms for years, which in turn results in an easier differentiation with Γ clods. But, this distinction is not so clear particularly when we consider the deeper soil layer. Others factors like OM quality, microbial communities structure or a different mechanic in the Γ, Δ turn-over seem to interact differently at this depth.

Conclusions

In order to connect soil structural properties, induced by different tillage systems, with the soil microbial functioning we adopted a particular sampling design based on the morphological description of soil structure. This method enables to measure the soil MB (and its activities) from distinct zones: zones with loose structure and zones with eye-visible porosity. We show a vertical stratification and a horizontal one which is due to physical differences between clods. This procedure enables to integrate the spatial heterogeneity of the soil structure and to connect and quantify more precisely the soil microbial functioning with the soil structure. The study of the influence of tillage systems on the soil microbial functioning requires to consider the burial depth of OM, the degree of compaction generated by these tillage systems and the dynamics of the compacted zones.

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N released from organic amendments is affected by soil management history

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Key words: organic farming; N mineralisation; plant bioassay

Abstract

A ryegrass bioassay was conducted to investigate the effect of soil management history on nitrogen mineralisation from composted manure and pelleted poultry manure. Soils were used from 2 field experiments comparing conventional and organic/low input management systems. When composted manure was added, soils which had received high rates of composted FYM under biodynamic management released a greater amount of nitrogen for plant uptake than those with a history of mineral or fresh manure fertilisation, suggesting that biological preconditioning may result in greater efficiency of composted FYM as a nitrogen source for plants. 'Native' N mineralisation was found to be related to total soil N content

Introduction

Soil biological properties in organic and conventional production systems are frequently compared (Carpenter-Boggs *et al.*, 2000; Fließbach and Mäder, 1997; Mader *et al.*, 2002; Werner and Dindal, 1990). In general, organic production systems increase indices of soil microbial biomass and activity, while within organic systems, biodynamic practices are sometimes favourably compared to standard organic practices (Mader *et al.*, 2002). However, it is not clear whether these differences in soil biological activity parameters, result in differences in soil function. One of the key functions of the soil biological community relating to crop growth in organic systems is the mineralisation of nitrogen from added amendments. In these systems, all N must be supplied to the crop from soil reserves, biological fixation, and/or from approved plant or manure-based fertiliser inputs. This experiment was designed to investigate the relative potential of soils with different management histories to release plant-available N from added organic amendments.

Materials and methods

Soils were from the DOK long-term field experiment near Therwil in Switzerland which was established in 1978 (Mäder *et al.*, 2002), and the Nafferton Farming Systems Comparison (NFSC) experiments established in 2001 (Leifert *et al.*, 2007). Soils from the DOK trial were collected in March 2004 and included the manure based systems BIODYN, BIOORG and CONFYM receiving manure at rates corresponding to 0.7 and 1.4 livestock units (LU), a conventional mineral fertiliser based system (CONMIN) and an unfertilised control (NOFERT) (for details see Fließbach *et al.* 2007). The NFSC soils used in this study were sampled in March 2005 following a potato crop in 2004, and included samples from soils which were previously managed to (a) organic

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farming standards (OP-OF), (b) British ‘Farm assured’ conventional management practice (CP-CF), and (c) two ‘low-input’ management systems: CP-OF which used a conventional crop protection system based on chemosynthetic pesticides, but organic fertility management practices based on legumes and manure inputs, and OP-CF in which crop protection was to organic farming standards, but fertility management was based on mineral fertiliser regimes recommended for conventional farming systems. Soils were sieved (10 mm mesh) and stored at 4^{o}C until use in the bioassay.

A pot trial was set up to estimate the inherent N mineralisation potential of the soils, and also to estimate the capacity of each soil to release N from added organic amendments. A total of 300 g soil (dry basis) was placed in each pot. Mineralisation from two different amendments is reported here: composted manure, which was 2.1%N (3% NH_4^+-N+NO_3^--N) and 22.9%C, and pelleted poultry manure, which was 4.4%N (14% NH_4^+-N+NO_3^--N) and 38.6%C. An additional non-amended treatment was included. Amendments were applied to the pots at a rate equivalent to 170 kg N ha^{-1} based on the total N content of the material. Italian ryegrass was planted and the pots were maintained in a glasshouse at field capacity throughout the bioassay. Ryegrass was harvested at 2, 4, 8 and 12 weeks after planting by cutting (0.5 cm above the soil surface) and removing all shoot tissue. Total above-ground N uptake by the ryegrass (N_{up}) was determined based on the harvested tissue N content and the dry matter yield of each harvest. The mineral N content of the soil in each pot was determined at experimental setup (N_{mini}) and after the final harvest (N_{minf}).,. Net N mineralisation during the bioassay was estimated as:

$N_{min} = N_{minf} + N_{up} - N_{mini}$, expressed as mg N pot^{-1}

The inherent N mineralisation potential of each soil was assumed to be equivalent to the N_{min} values calculated for the non-amended treatments. Net N release from the organic amendments (N_{rel}) was calculated by subtracting the N_{min} value for the non-amended treatments from the N_{min} value for each amendment. Data was analyzed using a general linear model in MINITAB® Release 14.20. Means were compared using Tukey’s HSD test.

Results

For the NFSC soils there was no significant treatment effect on inherent N mineralisation potential (N_{min}) with an average value of 15.7 mg N pot^{-1}. The average N_{min} value for the DOK soils was 10.1 mg N pot^{-1}. The soil with a history of high inputs of conventionally stored FYM (CONFYM 1.4) had a significantly higher N_{min} value (12.7 mg N pot^{-1}) while soil which had received the lower rate of conventionally stored FYM (CONFYM 0.7) resulted in significantly lower inherent N mineralisation potential (8.7 mg N pot^{-1}).

There were also significant differences in the net release of N from the two different amendment types. In the NFSC soils, amendment with pelleted poultry manure resulted in an average N_{rel} value (after subtraction of non-amended controls) of 10.0 mg N pot^{-1} which was significantly higher than the average N_{rel} value for compost, of 5.9 mg pot^{-1}. The management history of the soils from the NFSC experiment had no effect on the N release potential from either amendment type.

For the DOK soils, pelleted poultry manure also resulted in higher net N release on average (5.3 mg N pot^{-1}) compared to compost (1.7 mg N pot^{-1}). There were no statistically significant differences in net N release from pelleted poultry manure among the different soil management treatments in the DOK trial; however, the

BIODYN 1.4 treatment resulted in the highest net N release numerically, while the NOFERT treatment was the lowest (data not shown). There were significant differences among the DOK soil management treatments in the net N release from composted manure (Fig. 1). The NOFERT and BIODYN 1.4 treatments had the highest net N release. BIOORG 1.4 and BIODYN 0.7 resulted in negative estimates of net N release, indicating a net immobilisation of N from these amendments in these soils.

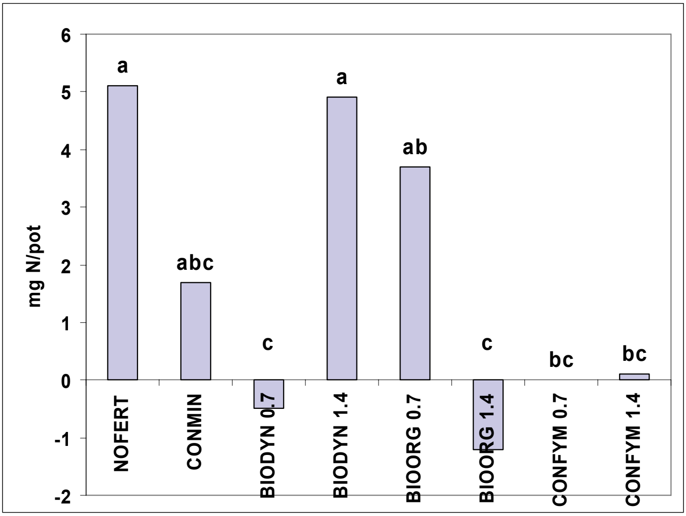

Figure 1: N released from an equal amount of composted manure, DOK soils

Discussion

The NFSC soils had an inherent N mineralisation potential that was 50% higher than the DOK soils on average. This reflects the differences in total N contents between the two soils (NFSC 2.5 g N kg^{-1}; DOK 1.5 g N kg^{-1}). Total N has been correlated with N mineralised from soils using the anaerobic incubation method (Fox and Piekielek, 1984), although it does not always correlate with crop uptake of N in the field, due to the variety of environmental factors that also control N availability to the crop.

The NFSC soils also resulted in higher net N release from both of the added amendments on average when compared to the DOK soils; however, some of the DOK treatments (e.g. BIODYN 1.4) resulted in net N release values similar to the average values for the NFSC soils. The different management practices had been applied for much longer in the DOK trial compared to the NFSC experiment, resulting in the development of distinct soil microbial communities depending on fertility management (Hartmann *et al.*, 2006). Fließbach and Mäder (1997) found higher microbial biomass, and biomass C as a percentage of total C, in BIODYN treatments, but fewer differences in microbial community function, as measured using Biology GN microplates. Our results indicate that there are differences in microbial community function among the soils of the DOK trial, as shown by the differences in the potential to release N from added amendments, depending on previous management history. It is difficult to explain, however, why the 1.4 LU rate of compost application in the BIODYN treatment resulted in enhanced net N release from added compost compared to the 0.7 LU rate, whereas the opposite was true for the BIOORG treatments. Further experiments are needed to explain how management-related effects including: differences in biomass size and activity, pre-conditioning of the biomass to different amendment types, and treatment-related differences in microbial community function, could be altering mineralisation of N from added amendments, .

Conclusions

This study has shown that soil management practices can impact on the release of N from added organic amendments. Further research is required to understand the biological mechanisms controlling net N release from these sources. These findings can then be used to develop soil management practices to optimise the utilisation of N from organic amendments.

Acknowledgments

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Improvement of the soil-crop model AZODYN under conventional, low-input and organic conditions

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Key words: nitrogen management, soil-crop model, wheat, organic, validation

Abstract

The use of mechanistic crop modelling, simulating the dynamics of crop N requirements and nitrogen supply from the soil and fertilizers, can provide sound advice to users. This paper describes a methodological way to improve soil-crop modeling used for N management of conventional and organic wheat.

Introduction

Nitrogen (N) is a key nutrient in achieving acceptable yield and quality performance of wheat bread-making. Previous results have shown that organic and conventional wheats grown with low-input practices are characterized by low and irregular grain yield and protein content (David *et al.* 2005a; Rolland *et al.* 2003). One reason is that the contribution of N from organic sources as crop residues, manures and composts, is difficult to predict and thus to synchronize with crop N requirements. Furthermore, the development of specialized cereal-based systems mostly relying on off-farm N sources, requires references to identify the best fertilization strategy according to the field characteristics. Jeuffroy and Recous (1999) had developed the AZODYN model in conventional to predict the consequences of fertilization management on yield, grain protein content and soil mineral N at harvest. Furthermore, David *et al.* (2004) had adapted the AZODYN model under organic conditions in order to build a decision making tool to assist farmers for the fertilization management. The AZODYN model is divided in three modules. The soil module simulates changes in the amount of mineral N in the soil over the crop cycle from the net N contributions of previous crop residues, humus and organic amendments. The fertilizer module simulates the daily net mineralization, volatilization and nitrogen use efficiency of the fertilizer. The crop module simulates leaf area time-course change, according to nitrogen accumulation in the crop, and above-ground parts growth on the basis of intercepted radiation. The nitrogen requirements are estimated from the crop biomass and the nitrogen dilution curve. The model simulates changes in leaf area index and above-ground biomass production over time as a function of the deficiency. At anthesis, the model calculates grain number from the characteristics of the N deficiency (duration and intensity), suggested by Jeuffroy and Bouchard (1999). After anthesis, the model simulates the accumulation of biomass and nitrogen in the grains. This model has already been evaluated in a broad range of conditions, under conventional, low-input and organic conditions. Previous results have shown the high performance of Azodyn model to assist farmers in evaluating the economic benefits of a fertilization strategy and selecting the optimal strategies according the farmers constraints and conditions (Jeuffroy *et al.* 2001; David *et al.* 2005b). The aim of this study was to improve the predictive performance of the Azodyn model through new findings on (i) the incidence

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of water stress on soil N release and crop growth, (ii) the volatilization process from organic and mineral fertilizers, (iii) the reduction of grain number linked with N nutrition dynamics and finally (iv) the grain filling process.

Materials and methods

1. Methodology

The method was based on the comparison of 32 versions of the Azodyn model, varying in one or several mathematical functions derived from literature or previous experiments, on a large database from field trials (21 trials under conventional conditions and 17 trials under organic conditions).The new versions of the model differed on:

- The prediction of the water stress on soil-crop system. Six functions were compared to predict the incidence of water stress on soil N mineralization. Twelve other functions were compared to predict the incidence of water stress on crop growth and N nutrition;
- The prediction of the NH3 volatilization from fertilizer N applied determined by the rainfall – time and quantity – and/or the crop growth rate just after the date of N application (7 functions);
- The relationship between the nitrogen content decrease in the vegetative part of the crop during senescence and the reduction of green leaf area index (3 functions);
- The reduction of grain number linked with the N nutrition index at flowering or the dynamics of N deficiency during the vegetative period (3 functions).

The validation procedure was developed in 7 steps:

Steps 1 to 3= Incidence of water stress on soil-crop system

First, the incidence of water stress on soil N contribution was tested using 7 functions including the initial model with no water stress. The different versions were run on the data base with no N application. The model giving the best predictions on crop N uptake at harvest was selected as model M1.

From the initial model, we compared the 13 versions comparing the functions of water stress on the crop system. The model M2 was selected with the best predictions on crop N uptake and above-ground biomass at harvest, on the sites with no N application.

Finally, we compared the M1 and M2 models. If M1 gave better results, we compared the 13 versions including a function of water stress on the crop system from the best M1 model, and if M2 gave better results, we compared the 7 versions including a water stress on the soil system from the M2 model. The best model, called M3 model, was selected from the prediction values of crop N uptake and above-ground biomass at harvest.

Steps 4 to 5= Prediction of volatilisation and incidence of water stress on N treatments

From the M3 model, we compared the 7 versions predicting the volatilisation process on the N fertilized treatments. We identified the best model, called M4 model, from the prediction value of crop N uptake, yield and grain protein content.

From the M4 model, we compared the 12 versions with a function of water stress on the crop system and selected model M5 from its predictive quality on crop N uptake, yield and grain protein content.

Steps 6 and 7= Prediction of grain filling process

From the M5 model, we tested the 3 versions predicting the senescence on all treatments. The model giving the best prediction on above-ground biomass at harvest was selected as model M6. Therefore, we tested from the M6 model, the 3 versions predicting the grain number on all treatments. Finally, the model giving the best prediction on grain number was selected as model M7, the final version of the model.

2. Assessment method

The comparison of the different versions of the model was based on the Root Mean Square Error of Prediction (RMSE), comparing the observed and simulated values (Wallach and Goffinet, 1987) on intermediate variables closely test (crop N uptake, grain number or above-ground biomass), but also on yield and grain protein content. The bias and the mean squared variance were determined to confirm the model choice. The bias indicates the systematic under- or over-estimation of the values by the model. The mean squared variance indicates the ability of the model to give a good account of the variability of the observed values.

3. Database

The database included field experiments on conventional and organic wheat. The experiments on conventional wheat were located in 19 various locations in France, from 1991 until 2002. The database has 9 non fertilised treatments and 82 N treatments with quantity varying from 40 to 300 kg N.ha^{-1}. The dates of application varied from the end of winter to the ear emergence. In theses experiments, diseases, insects and pests were controlled by applying pesticides. The experiments on organic wheat were located in 15 various locations in France, from 1994 until 2003. Four types of organic fertilizers were tested: feather meal (66 various N treatments), guano (11), sugar beet vinasse (26) and poultry manure (6). The rate of application varied from 0 to 210 kg N.ha^{-1}. The date of application varied from the end of winter to the ear emergence. The first results presented in this abstract are essentially extracted from the conventional database. Specific results on organic wheat will be delivered at the conference.

Results

The insertion of water stress functions on soil-crop system improved the prediction on grain protein content and yield on non fertilised treatments (N0) but also on N treatments (Steps 1 to 3 -Figures 1a and 1b). The best functions to predict water stress simultaneously affected (i) the net N contributions of previous crop residues and humus and (ii) the radiation use efficiency. The insertion of volatilisation process did not improve the prediction of yield and grain protein content on fertilized mineral-N treatments. Nonetheless, previous results have shown that volatilisation process from fertilisers can be determined by soil water availability and crop growth (Limaux et al, 1999). The highest difference between the minimum and the maximum values of RMSEP vas observed for step 5, when testing the water stress function on crop growth. On non fertilized treatments, grain protein content was highly sensitive on steps 2, 3 and 5. This means that the predictive quality of the model was highly sensitive to the water stress, particularly to its effect on crop growth on fertilized treatments. On the contrary, for steps 4, 6 and 7, there was a very low difference between the minimum and maximum values of RMSEP. In most tested models, the mean squared variance was higher than the biais, indicating a difficulty of the models to give a good account of the observed variability.

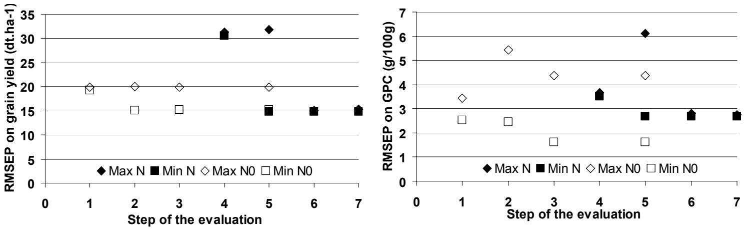

Figure 1: Evolution of the RMSEP on grain yield (1a) and grain protein content (1b) during the model evaluation: minimum and maximum values obtained on the various models tested at each step, on N treatments (N) and non fertilized treatment (N0) in conventional agriculture.

Discussion

This methodological way allows us to improve the model prediction, mainly by the insertion of a water stress function. However, the use of Azodyn model under organic conditions requires the prediction of yield limitation induced by weed competition, pest and diseases. On going research are focussed on the setting up of early indicators to assess the incidence of weed population, soil compaction and pest and disease on yield limitation (Casagrande et al, 2006).

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Effects of long-term farmyard manure applications on soil organic matter, nitrogen mineralization and crop yield – a modeling study –

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Key words: vegetable production, farmyard manure, soil fertility

Abstract

To develop sustainable cropping systems we need to predict both short-term and long-term effects of management practices on soil fertility. For this purpose agro-ecosystem simulation models are valuable tools. We used the Daisy model to simulate a three-year crop rotation (beetroot, onion, white clover, potato) over a period of 40 years. With this rotation, three rates of farmyard manure were tested (0, 15, 28 t ha^{-1} $year^{-1}$). After 40 years without manure soil organic matter carbon (SOM-C) decreased by approximately 40%, and increased by 27% with the highest application rate. SOM turnover did not reach equilibrium at the end of the experiment. Nitrogen mineralization from SOM followed in the long-term (40 years) the slowly changing time courses of SOM. However, manure applications affected mineralization and hence crop yield and nitrogen losses much more in the short-term (1 to 2 years) than in the long-term.

Introduction and Objectives

Soil fertility is strongly affected by type and amount of soil organic matter (SOM), which in turn is influenced by soil texture, by local climate and by management practices such as soil tillage, crop rotation and organic fertilization. To develop sustainable cropping systems we need to predict both short-term and long-term effects of management practices on soil fertility. Under a constant long-term management regime SOM turnover reaches equilibrium, where the properties of SOM stay constant over time. At this point rates of mineralized and added nitrogen (N) and carbon (C) are the same. Changes in soil management inevitable lead to changes in SOM and hence to changed C and N mineralization.

The objective of our study was to quantify the effects of changed application rates of organic fertilizers. The application of organic fertilizers, such as farmyard manures, affects several processes in plants and soils. However, in our study we focused on (1) the amount of N mineralized from SOM and manure, (2) the impact of mineralized N on crop yield and N losses to the environment and (3) the time span required for reaching a new equilibrium of SOM turnover.

Methods

The study was carried out with the agro-ecosystem simulation model Daisy (Abrahamsen and Hansen 2000). Parameter files for crops and manure were taken from the Daisy home page (2006). Farmyard manure was parameterized as 'Cattle manure' described in Daisy's library, but we changed decomposition rates according to Petersen *et al.* (2004), and C-, N-, NO_3, NH_4 and dry matter fraction according to KTBL (2005). Soil properties were set according to an experimental field of our

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research station Großbeeren, located near Berlin, Germany. Humus content was set to 0.009 kg kg^{-1} and fractions of sand, silt and clay to 0.91, 0.041 and 0.046 kg kg^{-1}, respectively.

We simulated a three-year crop rotation, that is customary for vegetable growers in Lower Saxony, Germany (Laber personal communication): **Beetroot** *(Beta vulgaris subsp. rapacea)* 15th May to 30th Sep – **fallow** – **Onion** *(Allium cepa)* 1st May to 15th Aug – **White clover** *(Trifolium repens)* 30th Aug to 1st May – **Potato** *(Solanum tuberosum)* 30th May to 30th Oct – **fallow**. In the simulation, farmyard manure was applied in year 1 of the crop rotation on 1st of October and 1st of May, and in year 3 on 30th of October. This rotation was repeated over 40 years. Three manure application rates were tested: (0) **no manure**, (1) **15 t wet weight ha^{-1}** [containing 75 kg N ha^{-1} and 10,500 kg C ha^{-1}], (2) **28 t wet weight ha^{-1}** [containing 140 kg N ha^{-1} and 39,200 kg C ha^{-1}]. Initially the crop rotation was simulated with historical weather data from the site in Großbeeren. However, year-to-year variation of weather interacted with the effects of fertilizer treatments. Therefore, to illustrate fertilizer effects more clearly, simulations shown in this paper were carried out with weather of a single year (1990), which was repeatedly used over 40 years. The averages of air temperature and global radiation were 10.5 °C and 117 W m^{-2}, respectively.

Results and Discussion

Under our experimental conditions an average application rate of 15 t ha^{-1} $year^{-1}$ farmyard manure lead to constant soil organic matter carbon (SOM-C), whereas application of 0 and 28 t ha^{-1} $year^{-1}$ resulted in decreased and increased SOM-C (Fig. 1 A). After 40 years without manure, SOM-C decreased by approximately 40%, and increased by 27% with the highest application rate. This shows that soil management strongly affected SOM. The time-courses of SOM for both the zero and the high manure application rates did not show saturation. Therefore, even 40 years after the onset of the experiment a new equilibrium of SOM turnover was not reached.

The long-term nitrogen mineralization from SOM followed the time courses of SOM-C (regression lines in Fig. 1 b). The long-term effect, which is shown by the slope of the regression lines, was minor compared to the short-term effects of manure applications and crop rotation, which are described by the variation around the regression lines. Time courses of nitrate leaching closely mirrored the time courses of N mineralization (Fig. 1 c). N losses of up to 60 kg ha^{-1} $year^{-1}$ indicate the need to reconsider amount and timing of manure application in order to reduce N losses. The maximum rooting depth on our site was one meter. We therefore considered N as being ‘leached’ when transported to a soil depth below one meter. N losses would be less on fields where roots can grow deeper and catch the leaching N.

Dry matter yields of beetroot, onion and potato were similarly affected by the treatments. Therefore, only beetroot is shown as an example (Fig. 2). Manure application rates had a substantial effect on yield. Highest yields were obtained with 28 t ha^{-1} $year^{-1}$. A long-term effect on crop yield was obvious only with zero manure application, where crop growth was strongly limited by N shortage.

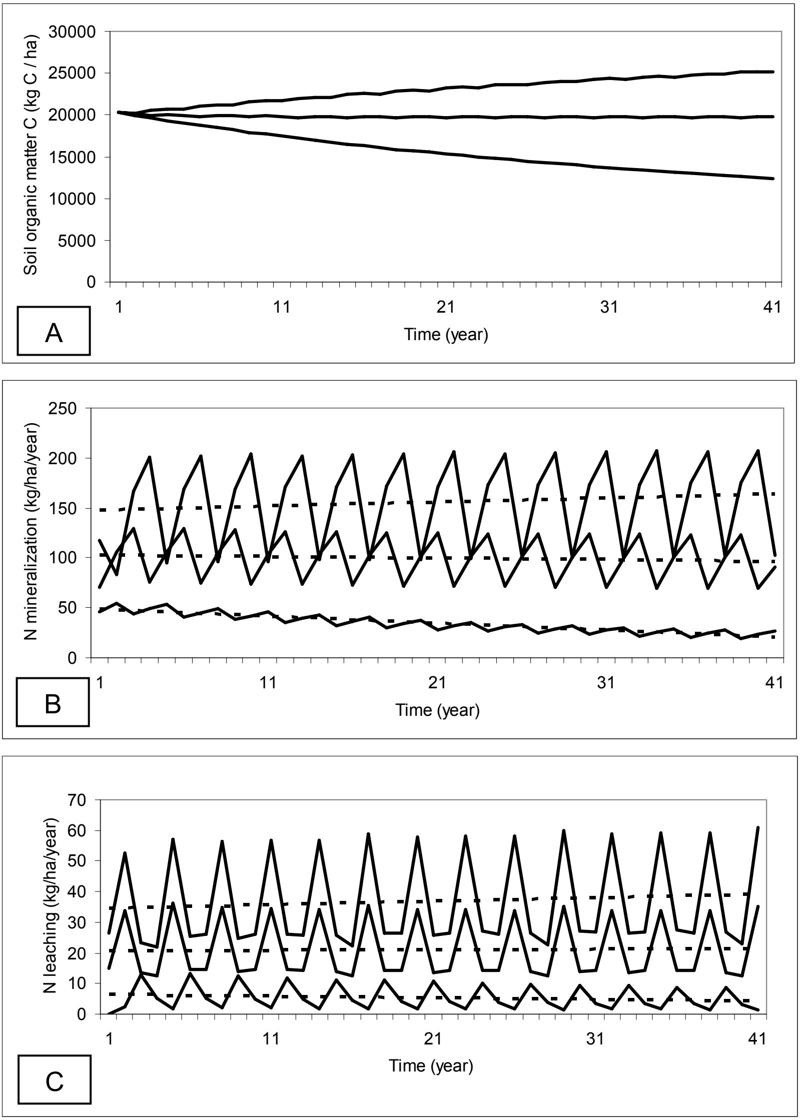

Fig. 1 Soil organic matter carbon (A), nitrogen mineralization (B) and nitrate leaching below one meter soil depth (C) as affected by time and by manure application rate. Solid lines show data for application rates of 0, 15 and 28 t ha^{-1} (bottom, middle and top line, respectively), dashed lines are regression lines.

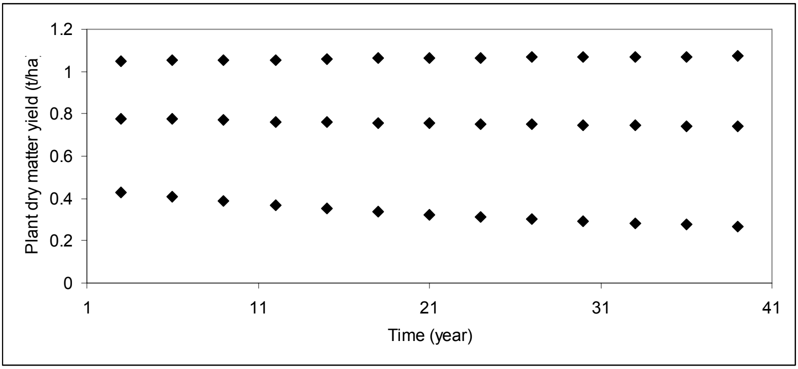

Fig. 2 Dry matter yield of beetroot as affected by time and by manure application rate. Dots show data for application rates of 0, 15 and 28 t ha^{-1} (bottom, middle and top line, respectively)

Conclusion

Modelling is a valuable tool to analyse short-term and long-term processes in agro-ecosystems. Models are able to predict effects of soil management on SOM turnover, and thereby help to identify management strategies with high crop yield and little N losses to the environment. The Daisy model has been validated successfully in agricultural crop rotations (e.g. Muller 2006). In a forthcoming study, we will compare our simulations with data from experiments with long-term vegetable crop rotations.

Acknowledgements

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N supply in stockless organic cereal production under northern temperate conditions. Undersown legumes, or whole-season green manure?

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Key words: biomass, clover, oats, ryegrass, soil mineral N, spring wheat

Abstract

Two systems for nitrogen (N) supply to organic spring cereals were compared under Norwegian conditions. Repeated undersowing of clover in the cereals in four growing seasons was compared to a whole-season green manure in the second year. Cereal yields were higher in the treatments with clover than in the controls. The yield increasing effect of undersown clover was residual. One year of whole-season green manure increased subsequent cereal yields significantly, but not enough to compensate for the loss of yield over the total four-year period. If phytopathological problems can be avoided, repeated undersowing of legumes seems to be more profitable than green manure each fourth year in stockless organic cereal production systems. The soil mineral N decreased during the study, demonstrating a negative N balance. Hence, additional N sources should be found for stockless organic cereal systems under Norwegian conditions.

Introduction

In northern temperate regions, cereal yields in stockless organic crop production systems are limited by nitrogen (N) availability, and legumes are commonly grown to supply N. Pulses such as peas and lupins are difficult to grow successfully due to short and cold growing seasons. The most common option is undersowing of clover, where clover seed is applied shortly after cereal seeding. After cereal harvest the clover acts as a combined cash crop and N accumulator. Further, it will reduce the establishment of perennial weeds and protect the soil from erosion. However, continuous growing of legumes may be questionable due to phytopathological problems. To avoid this, a whole-season green manure may be grown e.g. each fourth year of the rotation. The green manure may be undersown in cereals the previous season. In the main season it is chopped and left to decompose in the field 2-3 times to favour N accumulation and control weeds. With both methods, the clover canopy is ploughed down before a new cereal crop is established. It may be useful to mix the clover with a grass species to ensure the presence of N conserving plants in the catch crop. Mixed with grass seed, the amount of expensive legume seed per ha may be reduced.

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A project was carried out in 2002-06 to reveal the effects of repeated undersowing of clover on N supply and cereal yields under Norwegian conditions, and to assess the applicability of this method on stockless organic cereal production farms. Repeated undersowing in four years was compared to a whole–season green manure in the second year, but no legumes in other years. The effect of mixing the clover seed with a grass species was also studied. In this paper we present results of yield levels and N accumulation in biomass and soil.

Materials and methods

A field experiment comparing six treatments (Table 1) with four replicates was conducted at two experimental sites during 2002-06.

Tab. 1: Overview of treatments in the field experiments.

Treatment	2002	2003	2004	2005	2006
1, Cereals with no undersowing	Oats	Spring wheat	Oats	Spring wheat	Barley
2, Cereals undersown with ryegrass	Oats + ryegrass	Spring wheat + ryegrass	Oats + ryegrass	Spring wheat + ryegrass	Barley
3, Cereals undersown with clover	Oats + red clover	Spring wheat + white clover	Oats + red clover	Spring wheat + white clover	Barley
4, Cereals undersown with clover and ryegrass	Oats + red clover and ryegrass	Spring wheat + white clover and ryegrass	Oats + red clover and ryegrass	Spring wheat + white clover and ryegrass	Barley
5, Cereals with green manure, red clover and timothy	Oats + red clover and timothy	Red clover and timothy	Oats	Spring wheat	Barley
6, Cereals with green manure, red clover	Oats + red clover	Red clover	Oats	Spring wheat	Barley

No fertilisers were applied during the experiment. The amounts of seed used were 200 kg ha^{-1} of grain, 10 of ryegrass, 15 of red clover, 5 of white clover and 22 of timothy. For red clover, the amount was reduced to 7 kg ha^{-1} when mixed with ryegrass, and to 3 kg when mixed with timothy.

The experimental sites were Bioforsk Arable Crops Division, Apelsvoll (60°42'N, 10°51'E) and Kise (60°46'N, 10°49'E). There is only a short distance between the two sites, and the climatic conditions are comparable except from somewhat higher precipitation at Apelsvoll; annual average 609 vs. 526 mm during 2002-05. The experimental field was irrigated when required at Apelsvoll, but not at Kise. The main soil differences were a higher soil P-concentration at Apelsvoll (ammonium-acetate lactate soluble P 59 vs. 26 mg kg^{-1}) whereas the Kise soil contained slightly more clay (26 vs. 17%) and soil organic matter (organic C 2.9 vs. 1.7 %). The soil P concentration at Kise was very low due to several years of no other fertilisation than green manure.

Aboveground biomass of cereals, undersown crops and weeds was recorded in late April just before ploughing, in early July when the cereals were heading (Zadoks 49), in early September before cereal harvest, and at the end of the growing season in late October. The biomass of undersown crops was fractionated into grass and legumes. The N concentration in the dry matter (DM) of the fractionated plant material was measured. Soil mineral N (0-25 cm) was measured in late April and late October (extraction by 1M KCl). Statistically significant differences between treatments were analysed by variance analysis, and interesting relationships by regression analysis (Minitab software).

Results and discussion

There was a considerable variation in cereal yields between sites and over years, and the variation between years was different at the two sites (Figure 1). In 2002, the establishment of the field at Apelsvoll was hampered by wet soil in spring, causing a heavy soil crust. The yield differences between Kise and Apelsvoll was larger with spring wheat in 2003 and 2005 than with oats in 2004, which may be explained by the less fertile soil at Kise. It is a common experience in Norway that oats generally perform better than wheat with lower nutrient availability. In 2006, the field at Kise suffered from drought.

The yield differences between treatments were roughly as could be expected. There was a tendency of reduced yields in undersown treatments in 2002 (not statistically significant). In later years, yields were increased by the residual effect of the undersown legumes and the 2003 green manure. This is in accordance with former studies (Breland 1996; Känkänen *et al.*, 2001).

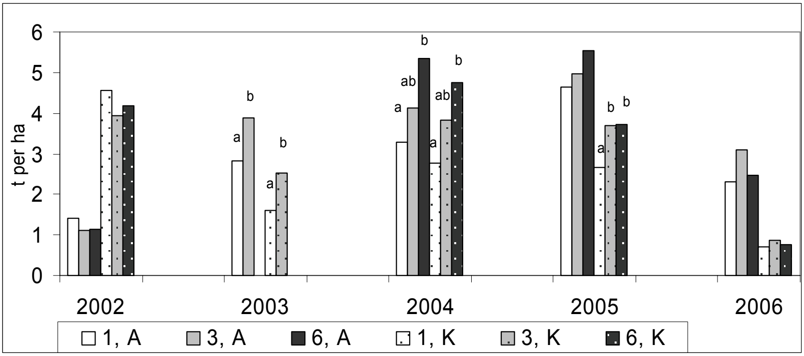

Figure 1: Cereal yields (15% water) in treatments 1, 3 and 6 (see Table 1) at Apelsvoll (A) and Kise (K) during the experiment. The cereals were oats in 2002 and 2004, spring wheat in 2003 and 2005, and barley in the residual effect year, 2006. Statistically significant differences between treatments within each year and site (when found) are shown by letters a and b.

The residual effect of undersown clover was a yield increase of about 30% in the subsequent cereal crop. The effect was not less when the clover seed was mixed with ryegrass (Table 2). For the whole-season green manure in 2003, the residual effect was considerable in 2004 and 2005. On both these years, the average yield for treatments 5 and 6 at both sites was 4.8 t ha^{-1}. However, in 2006 the residual effect of the green manure had disappeared, and over four years, the total yield increases were not large enough to compensate for the year without cereal yields.

Tab. 2: Average cereal yields at Apelsvoll and Kise, absolute values (Abs.), t grains ha^{-1}, 15% water and relative (Rel.) numbers. Treatments explained in Table 1.

Treatment	First year, 2002		Average 2003-05		After-effect, 2006	
	Abs.	Rel.	Abs.	Rel.	Abs.	Rel.
1	2.98a	100	2.96a	100	1.51a	100
2	2.83a	95	3.06ab	103	1.71a	113
3	2.53a	85	3.86b	129	1.99a	132
4	2.69a	90	3.76ab	127	1.99a	132
5	2.68a	90	3.17ab	107	1.73a	114
6	2.65a	89	3.23ab	109	1.62a	107

Yields with different letters (a, b) are significantly different ($p<0.05$).

There was a large variation from year to year in the amount of N in aboveground biomass of the undersown crops (Fig. 2). The accumulation of N in aboveground biomass was considerable in treatments 3 and 4 (with undersown clover) during the autumn of 2002 and 2003. In 2004, the amount of N in biomass was only slightly higher in the treatments with undersown legumes than in treatment 2 with undersown ryegrass. It could be speculated if the declining N accumulation was an indication of phytopathological problems. However, in 2005 the amount of accumulated N increased again and the level in the autumn of 2005 was comparable to 2003. Hence, a general decline can not be stated. As no fertilisers were added except the N fixed by legumes, the N amount in treatment 2 reflects N mineralised from soil organic matter. There was no less N accumulated when some red clover seed was replaced by ryegrass (treatment 3 as compared to 4, Fig. 2).

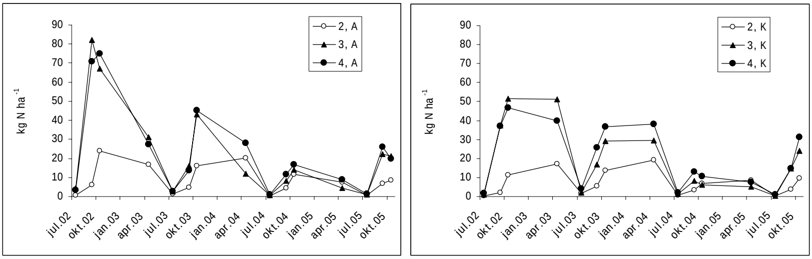

Figure 2: Amount of N in aboveground biomass of the undersown crops in treatments 2, 3 and 4 (see Table 1), from July 2002 to October 2005 at Apelsvoll (A) and Kise (K).

There was a significant and negative relationship between the amount of N in aboveground biomass of undersown plants in late autumn and the cereal yield in that growing season (r^2= 0.32 for treatment 3, 0.42 for treatment 4). This reflects the competition between the cereals and the undersown crops for light, water and nutrients. No relationship was found between the amount of N in aboveground biomass in late autumn or in spring and the cereal yields in the subsequent growing season. This is surprising, as a considerable residual effect of clover was found, increasing the cereal yields.

The amount of soil mineral N (N_{min}) was relatively high at the start of the experiment, on average for treatments 1-4, 20.3 kg N ha^{-1}. In the spring of 2005, this value had decreased to 11.5 kg, and the average value for tr. 3 and 4 was only slightly higher than for the controls; 12.5 vs. 10.5 kg ha^{-1}. Hence, repeated undersowing did not increase the N_{min} with time. At both sites, the N_{min} values in treatment 2 were generally lower than in treatment 1, which shows the capacity of the soil to mineralise some N, and the ryegrass to catch it. In spite of more organic C in the soil at Kise, the N_{min} levels were not higher at that site. Values between 25 and 30 kg N ha^{-1} were achieved in a few plots in treatments 5 and 6 in the spring of 2004. However, the average level was only 17.1 kg N ha^{-1} in late autumn 2003, and 22.1 in spring 2004. The value in spring 2004 was not much above the starting value measured in treatments 1-4. The preceding crop on both sites was spring cereals with no undersowing and no fertilisation. Hence, a larger effect on the N_{min} value was expected. As the residual effect was considerable, this result demonstrates that the N_{min} value is not necessarily a good characteristic of the soil's ability to supply crops with N. There was a weak, but significant positive relation between N_{min} in late autumn and the cereal yield in the next season (r^2= 0.06), as well as between N_{min} in spring and the following cereal yield (r^2= 0.05). A positive relationship was also found between the amount of N in aboveground biomass in spring and N_{min} in spring (r^2= 0.22), and between the same characteristics in late autumn (r^2= 0.08). These results are not surprising, and they demonstrate that legumes are important for the N supply of the cereals even if there is no straightforward relationship between the N in the green legume canopy and the later cereal yields.

Conclusions

The use of clover, undersown in cereals or as a whole-season green manure, significantly increased the subsequent cereal yields in an organic production system with no fertilisers applied. The average cereal yield over four years was larger with repeated undersowing than with green manure in the second year of the period. Hence, in organic stockless cereal production systems it seems to be a better option to harvest cereals each year with undersown clover, than to use a whole growing season to accumulate nutrients for subsequent cereals each fourth year. However, when legumes are included in most years of the crop rotation, there is a risk that phytopathological problems may arise (e.g clover nematodes, fungi). In all treatments, the soil mineral N was significantly decreased during the study, demonstrating a negative N balance. Neither repeated undersowing of clover nor one out of four years with a whole-season green manure did accumulate enough N to compensate for the N removed in cereals. Hence, there is a need for additional N sources to supply organic cereal production systems under northern temperate conditions.

Acknowledgments

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Phosphorus management on 'extensive' organic farms with infertile soils

Cornish, P.S.[1]

Key words: phosphorus, Australia, soil fertility, grain, grazing

Abstract

Two case-study farms with negative P balances maintained acceptable productivity without fertilisers, apparently by 'mining' 'available' P reserves in surface and subsoil. The question for these organic farms is 'how long before fertiliser is needed?' With six farms on lower-fertility, weakly acidic to alkaline soils and modest rainfall (380-580 mm/yr), low productivity was related to P deficiency despite positive P balances from using allowable fertilisers. Useful supplies of compost or manure were unavailable. Until effective allowable fertilisers or microbial inoculants have been developed, there is a case for using soluble forms of P fertiliser on soils where soil-solution P is low and soil P-sorption is high, so that additions of soluble P 'feed the soil, not the plant'.

Introduction

Australian agriculture has traditionally been 'low input-low output' because of the variable (risky) climate, generally infertile soils, and relative costs of land and labour (Freebairn *et al.* 2006). Low inputs have led to declining fertility in areas that were once fertile. Hydrologic imbalance has led to rising water-tables and dryland salinity in some areas, so higher water use from productive crops and pastures is needed to correct any imbalance. Organic agriculture is set against this background of inherently low or depleted soil fertility and a need for systems with increased water-use, at least on the 20 M ha used for extensive crop or mixed-farms producing grain, meat and wool. Productivity is important as there is no financial incentive to convert to organics. Soils are often low in organic matter but manures and composts are scarce, leading Penfold (2000) to conclude that problems with P constrain the adoption of organic farming on extensive grain farms. This paper tests Penfold's conclusion through farm case studies and literature, and explores broader questions of sustainablility.

Materials and methods

The case studies were grain-wool-meat producing farms from a range of soil types and agro-climatic regions. Biodynamic dairies were included (from Burkett *et al.* 2006) to contrast intensive animal-based systems. Intensive horticulture was excluded as it uses high organic inputs (Wells *et al.* 2002). Conceptually, if outputs exceed inputs over the longer-term, then to maintain production soil P must ultimately be accessed from a) presently unavailable or 'slowly available' sources, b) available but inaccessible sources like subsoil or c) transfer from other parts of the farm that need less P. Thus questions were: are the farms in P balance? If not, is productivity being sustained? If yes, but the P budget is negative, where is P coming from? If P is added, but production is low or declining, why? Eight farmers were selected with a history of organic farming and respect in the industry. Two others were well-known low input

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wool and grain farms where wheat is cropped into permanent *Medicago sativa* or native grass pasture with low inputs of superphosphate, on 10-20% of the farm area which is rotated annually. Data were used to estimate farm-scale P budgets, the intensity of production (crops/time, animals/area), areas of crop/pasture, yields, potential for movement of P around farms, farmer's perceptions of productivity and constraints from P, and attempts to deal with any perceived 'constraint'. Other data were typical rotations, sales (or retention) of grain and animals in different classes (dairy, beef, sheep for wool or meat etc.). P removal calculations used published P concentrations (Anon. 2000).

Results and discussion

The farms were moderately large for their respective areas/industries and had been organic for long periods (Table 1). All farmers said they managed P within the context of general soil fertility and whole-farm management, not as a single-issue.

Case Study farms with a negative P balance. Of the 7 *organic* farms (excluding the 5 biodynamic dairies and the non-organic mixed farm), only 2 farms had a negative P balance (Farms 1 and 7). These were the dairy (-4.84 kg/ha/yr) and one mixed farm (-3.76 kg/ha/yr), both on fertile soils. These farmers were not concerned about P.

Table 1. Description of Case Study Farms and their P balance

Farm number/ main enterprises	Years organic	Soil group	Annual rainfall (mm)	Farm area (ha)	Farm P balance (kg/ha/yr)	Farmer sees P as 'problem'
1 grain/graze	37	Vertisol	660	890	-3.76	Yes
2 grain/graze	44	Aridisol	381	1093	0.69	Yes
3 grain/graze	28	Unknown	475	506	7.15	Suspected
4 grain/graze	20	Aridisol	375	180	5.23	Yes
5 grain/graze	8	Alfisol	580	580	1.81	Yes
6 grain/graze	15	Aridisol	500	441	0.73	Yes
7 dairy/crop	16	Mollisol	900	214	-4.84	No
8 graze/grain	Low input	Sodisol	400	2100	0.28	No
9 graze/grain	Low input	Sodisol	550	1500	-0.15	No
Biodynamic dairies*	various	various	various	various	-7.10	Unknown

*Burkett e*t al*. 2006. The 5 biodynamic farms were paired with conventional farms for the study. The P balance here ignores losses in runoff and precipitation in soil, included by Burkett *et al*.

Biodynamic dairies: negative P balance. The 5 biodynamic dairies were in large negative P balance. Data of Burkett *et al.* (2006) showed that Olsen-extractable soil P concentrations in the surface (0-10 cm) were much lower than in the conventional farms with which they were paired, that subsoil P was accessed, and that pasture had lower P%. Production was lower in the biodynamic dairies (milk/cow, cows /ha).

Positive P balance of 'mixed' farms. Five of the 6 organic grain and grazing farms were in positive P balance (0.69 to 7.15 kg P/ha/yr), three substantially so. All of these farmers were concerned about P, citing visual evidence, falling productivity and low soil P tests. One (4) had just ceased farming organically after 20 years, citing low productivity due to P deficiency and no allowable fertiliser giving useful responses.

Extensive mixed farming is the main land-use in arable Australia, an area >20 M ha. Farms 2 to 6 cover the main soils, so it is a concern that such difficulty is experienced managing P on these organic farms. None used much organic P (manure, compost) due to very short local supply. With declining productivity and other evidence of P deficiency, they are hardly 'sustainable', despite inputs of P. The fundamental problem is low availability of rock phosphates due to low rainfall or insufficiently low pH (Sale *et al.* 1997). Managing P is an intractable problem on these extensive organic farms, confirming Penfold (2000). The dairy farms may have currently enjoyed acceptable productivity and profitability, but depletion of soil P is inevitable. They cannot be sustainable in the long term. Only farms 8 and 9 can be regarded as sustainable in this regard. These low input farms are mainly grazing, with small P exports in wool and lambs balanced by inputs of soluble-P to small areas of crop that are rotated.

How do the organic farms cope with P? Farms in negative balance 'mine' 'available' P that may not be accessed on conventional farms, including subsoil P. The case study dairy also set modest production targets and added value by integrating production with processing and marketing. The mixed farm on vertisol soil (1) relied on mining of once-high soil-P reserves, much as conventional farms in the area (Dalal 1997), but average wheat yields of 2.5 t/ha are low compared to the estimated potential of 4.2 t/ha (Table 2), pointing to depleted fertility. The farmer confirmed this, citing low soil-P concentrations. Profitability was maintained by integrating operations with a local cattle sale yard (cattle fattening) and a second farm. Only the grain was sold as organic. *The question for these farms is 'how long will the available sources of P last'*.

Farmers with extensive 'mixed' farms on lower fertility soils had evaluated many inputs, particularly reactive phosphate rock (RPR), guano and microbial inoculants. All of these farmers lacked confidence in these products, yet such was the problem that enough P-fertiliser was used to give a substantial P imbalance in three cases. Low yields (Table 2) suggest all but one of these farms has reason to be concerned about productivity. (This did not necessarily mean lower profitability.) A major issue for mixed farmers is the ineffectiveness of insoluble P sources and poor supplies of alternative organic sources. *For these farmers, the urgent need is for allowable fertilisers which work and are cost-effective*. These farmers coped by a) using P-fertiliser (ineffectively), b) using relatively low cropping intensities and/or c) retaining a significant proportion of the grain produced on-farm for stockfeed (Table 2). Long pasture phases allow 'unavailable' P from mineral sources to enter 'available' pools and may mobilise P from subsoil to surface through deep-rooted perennials (Farm 8,9). Export of animal products results in lower losses of P than in grain. These systems are atypical of the region. Farm economics dictate the ratio of crop/pasture (animals). Farms locked into a low ratio will suffer economic disadvantage at times.

Table 2. Details of 5 mixed enterprises, all using approved P fertilisers

Farm number	2	3	4	5	6
Cropping intensity	0.2	0.5	0.5	0.13	0.25
Grain/hay retained on-farm	>50%	<10%	>80%	~50%	>30%
Product exported Major (*minor*)	Meat, grain *wool*	Wool, grain	Meat, Wool *wheat flour*	Meat, wool *eggs, grain*	Meat, wool *grain*
Average wheat yield (t/ha)	<1.0	3.0	1.2**	2.0	1.2
Est. rainfall-limited wheat yield (t/ha)*	2.8	3.2	2.5	4.3	4.6

*Estimates based on methods in French and Schultz (1984), Cornish and Murray (1989)

** Ceased organic production 2005 due to low yields caused by P deficiency

What can farmers on relatively infertile soils do? Biofertilisers' or soil inoculants may help plants access P that is normally unavailable, but performance is variable and yield responses are mostly small (Jakobsen *et al.* 2005). Conventional farmers who wish to use less fertiliser on high-P soils may accept this, but for most organic farms this is not an option. Studies of mycorrhizae on organic farms have not shown enhanced P nutrition or access to less available sources of P (Ryan (2000 and *pers. comm*.). Early work with RPR/S mixtures showed increased P uptake and biomass of fodder mixtures (Evans *et al*. 2006). An unproven variation on an old approach is inoculation and composting RPR with C-rich material e.g. molasses. According to Evans (*pers. comm*.) this avoids early competition for substrates in the rhizosphere and soil and gives control over the supply of C and the P-solubilising organisms(s).

Conclusions

On organic farms that don't replace P, the question is 'when will fertiliser be needed?' On extensive, mixed farms with infertile soils that are weakly acid to alkaline and receive modest rainfall, P fertilisers are ineffective. Here, there is a need for cost-effective fertilisers. Composted RPR and S-amended RPR hold more promise than microbial inoculants in the future. The case studies confirm earlier reports that managing P is a major problem for many organic farmers, particularly grain growers (Penfold (2000), impeding wider conversion to organic systems.

Given the current lack of effective fertiliser options, there is a case for using soluble inorganic P sources where it can be shown that the soil solution concentrations of P are low and P sorption capacity is high, such that any added soluble P will be rapidly sorbed and find its way to plants only via slow desorption into the soil solution. This is consistent with the organic principle of 'feeding the soil, not the plant'.

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Effect of organic, low-input and conventional production systems on yield and diseases in winter barley

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Key words: net blotch (*Drechslera teres* f. sp*. teres*), powdery mildew (*Blumeria /Erysiphe graminis*), leaf blotch (*Rhynchosporium secalis),* low-input cereal production

Abstract

The effect of organic, low-input and conventional management practices on barley yield and disease incidence was assessed in field trials over two years. Conventional fertility management (based on mineral fertiliser applications) and conventional crop protection (based on chemosynthetic pesticides) significantly increased the yield of winter barley as compared to organic fertility and crop protection regimes. Severity of leaf blotch (Rhynchosporium secalis) *was highest under organic fertility and crop protection management and was correlated inversely with yield. For mildew (*Erysiphe graminis*), an interaction between fertility management and crop protection was detected. Conventional crop protection reduced severity of the disease, only under conventional fertility management. Under organic fertility management, incidence of mildew was low and application of synthetic pesticides in 'low input' production systems had no significant effect on disease severity.*

Introduction

The area farmed using organic and low-input farming practices in the UK and the rest of Europe has increased in recent years due to: incentives to adopt more environmentally sustainable practices, consumer demand, and price premiums achieved for certified organic food products (Hamm *et al.*, 2002). While organic farmers adhere to strict standards prohibiting the use of most pesticides and mineral fertiliser sources, low-input farming encompasses a range of farming practices where the use of specific inputs is reduced or omitted (Leifert *et al.*, 2007).

The severity of a range of disease problems (e.g. mildew, lodging) that cause economic losses in conventional wheat production was significantly reduced when crops were grown under organic management practice. However, one disease (*Septoria* spp.) was identified as the main factor limiting crop yield in wheat grown under organic management (Cooper *et al.*, 2006). In contrast to wheat, diseases were reported to have a more limited effect on the yield of other cereals such as barley in both organic and conventional systems (Hannukkala and Tapio, 1990). The objective of the study presented here, was to compare disease incidence and severity in barley produced under both organic and conventional management, and to investigate the effect of these diseases on crop yield.

Materials and methods

A long-term experiment comparing organic (OP-OF), two low-input (OP-CF and CP-OF) and conventional (CP-CF) systems of crop production was established in 2001 at

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the University of Newcastle's Nafferton Farm, near Stocksfield, Northumberland, in the UK. The experiment is a split-split-split plot design with crop rotation as the main plot and crop protection and fertility management as the subplot and sub-subplot factors (Leifert *et al.*, 2007). In both 2004 and 2005 winter barley of the variety 'Pearl' was established following crops of winter wheat. Rainfall between crop planting and harvest was 439 mm for the 2005 crop and 340 mm for the 2006 crop.

In the CP treatment, approved herbicdes were used post-emergence in November (e.g. isoproturon, mecoprop-P, pendimethalin) and April (fluroxypyr). Approved fungicides were applied in April (picoxystrobin, prothioconazole, fenpropimorph) and May (picoxystrobin or azoxystrobin and chlorothalonil, epoxiconazole, fenpropimorph). Under conventional fertility management (CF) P and K at rates of 64 and 96 kg ha^{-1} were applied pre-plant in November and N was top-dressed in March and April at rates of 50 and 120 kg ha^{-1}. Under organic crop protection (OP) and fertility management (OF) no pesticides or fertilisers were applied.

Visual disease assessments were conducted as described in Cooper *et al.* (2006) on the F-3, F-2, F-1 and flag leaves on five occasions (Zadok's growth stages 49, 58-59, 65, 73, 77). Diseases assessed were powdery mildew (*Erysiphe graminis* f. sp. *hordei*), leaf blotch (*Rhynchosporium secalis*), and net blotch (*Drechslera teres* f. sp. *teres*). The final level of lodging was assessed immediately prior to harvest and was recorded as % of the crop/plot lodged.

In both years the significance of fertility management and crop protection, and the interaction between these two terms, was assessed using a linear mixed effects model in R (R Foundation for Statistical Computing, Vienna, Austria 2005), with block treated as a random effect, and crop protection as a fixed effect, nested within block (Pinheiro and Bates, 2000). Correlation analysis was used to investigate the relationships between crop yield and disease incidence/severity in each of the years. Data presented in Table 1 are all expressed as percentages of the values for the fully conventional plots.

Results

In both years the conventional crops produced the highest yields (7.6 t ha^{-1} in 2005 and 10.3 t ha^{-1} in 2006). The elimination of chemosynthetic pesticides resulted in yield reductions of 15 to 18%, while eliminating mineral NPK inputs reduced yields by approximately 40%. Under organic management yields were 49.5% and 56.9% lower than conventional in 2005 and 2006 respectively. There was no interaction between fertility management and crop protection in either year.

Lodging only occurred in 2005. Conventional management increased the lodging problem with the highest percentage recorded in the fully conventional treatment (18% of the stand). The use of mineral NPK was clearly the causative factor since treatments that were organically fertilised (CP-OF and OP-OF) had no lodging recorded at all.

In both years management practices had a significant effect on the incidence and severity of disease in barley. Only results for the flag leaf are presented here, but the same trends were observed for the other leaves studied. Mildew severity was significantly higher in management systems using mineral fertiliser based fertility management (Table 1). Fertility management interacted with crop protection ($p<0.01$ in both years) with the low input system based on conventional fertility management and organic crop protection (OP-CF) resulting in significantly higher severity of mildew than any of the other treatment combinations (Table 1). Under organic fertility management, the severity of mildew was low and there was no additional benefit gained by using conventional chemosynthetic pesticide based crop protection measures.

Table 1. Barley yields and diseases (as % of conventional) under different managementsystems, 2005 and 2006

Characteristic assessed	Year	CP-OF	OP-CF	OP-OF
Crop yield	2005	61	85	51
	2006	57	82	43
Diseases				
Lodging	2005	0	37	0
	2006	NA[1]	NA	NA
Mildew severity	2005	38	509	70
	2006	0	6694	483
Net Blotch severity	2005	6	367	111
	2006	32	3286	749
Leaf blotch severity	2005	356	343	776
	2006	47	2042	3038

[1]Not present in 2006.

When compared to conventional systems, net blotch severity was highest in the low input systems using conventional fertility management and organic crop protection (OP-CF in Table 1). However, leaf blotch was significantly increased in the organically managed plots (OP-OF). There was a significant negative correlation between leaf blotch and crop yield ($p<0.0001$), but only a trend for a negative correlation in 2006 ($p=0.068$). In both 2005 and 2006, there was a positive correlation between net blotch and mildew on the flag leaf ($p=0.013$ in 2005 and 0.016 in 2006).

Discussion

The relationship between N fertilisation and the incidence of powdery mildew in the field has been well documented (Jensen and Munk, 1997). Powdery mildew is a biotrophic pathogen that thrives on succulent, N-rich, plant tissue. Cooper *et al.*, (2006) reported that even when pesticides were used, conventionally fertilised wheat had significantly higher powdery mildew AUDPC values than organically fertilised wheat. This trend was also evident in this study on barley, which again showed that the use of pesticides for the control of mildew is not economically viable in organically fertilised crops. While both powdery mildew and net blotch were highest under conventional fertility management, correlation analysis indicated that they did not have a negative impact on crop yield with only leaf blotch severity significantly correlated with lower barley yields. While a correlation does not imply a causative relationship, other researchers have also related leaf blotch damage to losses of barley yield (Khan and D'Antuono, 1985). Leaf blotch may have accounted for some of the losses in crop yield under organic management, but a larger decline in yield can be attributed to fertility management effects (Table 1). Reduced nutrient availabilities in the organically fertilised treatments may have created stress symptoms in the crop, and increased its susceptibility to disease.

Conclusions

Declines in yield were correlated with leaf blotch severity, but larger yield losses were associated with organic fertility management, than organic crop protection. Further analysis of yield, disease and nutrient data is planned using multivariate techniques, to explore hypotheses about the relationships among these variables. This information will be used to formulate improved management strategies and crop resistance breeding targets for organic barley production systems.

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Reduction of Soil-Borne Plant Pathogens Using Lime and Ammonia Evolved from Broiler Litter

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Key Words: Bell-pepper, Greenhouse, Lime, Soil pH, Solarization

Abstract

In laboratory and micro-plots simulations and in a commercial greenhouse, soil ammonia (NH_3) and pH were manipulated as means to control soil-borne fungal pathogens and nematodes. Soil ammonification capacity was increased by applying low C/N ratio broiler litter at 1–8% (w/w). Soil pH was increased using lime at 0.5–1% (w/w). This reduced fungi (Fusarium oxysporum f. sp. dianthi and Sclerotium rolfsii) and root-knot nematode (Meloidogyne javanica) in lab tests below detection. In a commercial greenhouse, broiler litter (25 Mg ha^{-1}) and lime (12.5 Mg ha^{-1}) addition to soil in combination with solarization significantly reduced M. javanica induced root galling of tomato test plants from 47% in the control plots (solarization only) to 7% in treated plots. Root galling index of pepper plants, measured 178 days after planting in the treated and control plots, were 0.8 and 1.5, respectively, which was statistically significantly different. However, the numbers of nematode juveniles in the root zone soil counted 83 and 127 days after pepper planting were not significantly different between treatments. Pepper fruit yield was not different between treatments. Soil disinfection and curing was completed within one month, and by the time of bell-pepper planting the pH and ammonia values were normal.

Introduction

The problems of maintaining adequate soil quality and fertility, and of protecting crops against soil-borne diseases are major obstacles to profitable organic production of greenhouse vegetables. In the desert Arava Valley, Israel, bell-pepper and tomatoes are grown from September to June and the areas are left barren during the extremely hot summer. This is conducive to establishment of soil-borne pathogens (Cook, 1981). Soil solarization followed by incorporation of green manure or manure compost is a primary means to prevent the spread of disease, but success is limited. Ammonia (NH_3) released from decomposing manure is used to control soil-borne diseases (Eno *et al.*, 1955; Smiley *et al.*, 1970; Tsao & Oster, 1981; Rodríguez-Kábana *et al.*, 1982; Oka *et al.*, 1993; Lazarovits *et al.*, 2000; Lazarovits, 2001; Oka *et al.*, 2006). Despite the known nematicidal and antifungal activity of ammonia, its use as a soil disinfectant is hindered by the heavy doses needed for effective pest control and consequent phytotoxicity (Rodríguez-Kábana *et al.*, 1987; Stirling, 1991). Raising soil pH alters the benign ammonium (NH_4^+) to the biocide ammonia according to the Henderson-

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Hasselbalch (H-H) equation (log [$NH_{3(g)}$ / $NH_4{}^{+}{}_{(aq)}$] = pH − 9.3). Combined application of ammonium fertilizer (at 60–250 mg N/kg) and lime (as alkaline-stabilized biosolids at 75 Mg ha^{-1}) to a neutral sandy soil in a field micro-plot trial reduced *Fusarium oxysporum* f. sp. *dianthi*, *Verticillium dahliae* below detection limit (Ben-Yephet ***et al.***, 2005). With adequate application rates, soil pH quickly decreased to normal, allowing ammonium to nitrify (Focht and Verstraete, 1977). In the present study, we examined the nematicidal and fungicidal activity of combinations of lime and broiler litter (BL) applied to neutral and basic sandy soils.

Methodology

Laboratory tests

Fungi: A sandy-loam soil naturally infested with *F. oxysporum* f. sp. *dianthi* was used. Soil samples, each of 50 g, were packed in 50-ml cups. Broiler litter was added at 0–80 g kg^{-1}on dry weight basis, and mixtures were moistened to water holding capacity and incubated at 27°C for up to 20 days. Cement kiln dust (CKD) at 1–10 g kg^{-1} was mixed with the soil 3–7 days after onset. Five grams soil samples were tested for *F. o. dianthi* counting (Ben-Yephet ***et al.***, 1996; 2005), pH and total ammonium. Sclerotia of *Sclerotium rolfsii* that were placed inside the mixtures were recovered and plated on selective growth media (PDAS). The experiment was repeated each time in triplicates.

Nematodes: The BL was pulverized and mixed with 10 g dune sand in 25-mL glass vials at concentrations of 0, 1, and 2 g kg^{-1}. Approximately 300 *M. javanica* J2s were administered in 1.3 mL of water. The vials were capped and incubated at 27°C. Three days later, CKD at final concentrations of 0, 1 and 2 g kg^{-1} was mixed with the sand, and the incubation was continued for 4 days more. Then, mobile J2s were recovered from the soil on a 60-µm sieve and counted.

Nematodes, tomato assay: One kg dry sand was amended with BL at 0, 1, 2 and 4 g kg^{-1} ratios and with 2,500 *M. javanica* eggs + J2 (at 2:3 ratio; in 5 ml water). After 4 days incubation at 27°C CKD was (factorially) mixed well with the soil at 0, 1 and 2 g kg^{-1}, and the incubation continued for 4 days. Then, one month old tomato (cv. Daniela) seedlings were planted in the pots. The seedlings were uprooted 6 weeks later, and the fresh shoot weights and number of nematode eggs on the roots were recorded. The galling index (GI) of the roots was assessed on a 0 to 5 rating system: 0, no infection; 1, 1–20; 2, 21–40; 3, 41–60; 4, 61–80; and 5, 81–100% of roots galled.

Greenhouse experiment

An organic farming greenhouse sandy calcareous soil infested with *M. incognita* was amended with commercial cattle manure compost at 10 liter m^{-2}. The plot was divided into six units; 5 m × 8 m each, each subdivided in to 5 beds, 1m × 8 m each. The initial nematode population counted by Baermann funnel method was 0.7 J2 per 50 g soil in the 20–30 cm depth. Broilers litter and slaked lime were applied (28 July, 2004) on the bed surface at 4.2 kg m^{-2} (≈ 10 g kg^{-1}) and 2.5 kg m^{-2} (≈ 0.6 g kg^{-1}), respectively, which was intended to transiently increase soil pH from 8.1 to 10. The additives were mixed into the soil to a depth of 30 cm. Two drip irrigation laterals were placed on each planting bed, and each experimental unit was separately covered with a polyethylene sheet. The plots were equally irrigated at 15 liter m^{-2}, and the irrigation was repeated 8 days later. The polyethylene cover was removed on the 12th day. After uncovering, the soil was allowed to dry out for 8 days, and the ammonia to volatilize. Irrigation with 15 liter m^{-2} was given on the 20th and 25th day.

Bell pepper (*Capsicum annuum* cv. Dimano, Makhteshim, Israel) seedlings were planted on the 29th day. Planting was in two rows in each planting bed, at 200 plants per experimental unit. Nematode-susceptible tomato plants (cv. Daniela) were planted between the pepper plants (10 plants per experimental unit) 40 days after treatment and uprooted 35 days later. Tomato plants infected with nematodes were counted. During the growth, number of the nematode juveniles per 50 g soil in the root zone (about 10 cm from the stem, and at 10 cm depth) was counted 83 and 127 days after pepper planting. Root galling index (as above) of the fifty plants was recorded 178 days after planting. The plants received guano and feather meal during the growth period as common in the region**.** On each harvest event (from 15 Dec. 2004 until 11 April 2005), pepper fruits from 10 plants per bed were sampled.

Results and Discussion

Fungi reduction in the lab: During the first 10 days after application, ammonium concentrations in the BL-amended soil ranged from 230 to 590 mg kg^{-1} (Table 1). Soil pH either did not change (at 8.4–8.7) during this period or it somewhat decreased. The addition and incubation increased *F. o.* f. sp. *dianthi* counts by up to 10 times. Mixing CKD with the soil at 10 g kg^{-1} seven days after incubation onset, raised soil pH to 9.6–11; the increase was inversely related to litter loading rate. The addition of CKD alone reduced *F. o.* counts in the soil almost below detection limit, and in combination with the manure it was reduced below it (Table 1). *Sclerotium rolfsii* was more sensitive to either high pH or NH_3 (Table 1). Peak NH_3 concentrations in the solution phase of the (manure+lime)-treated soils were 500–1065 mg l^{-1} (calculated using the H-H equation).

Nematodes, incubation study: CKD (1–2 g kg^{-1}) and/or BL (1 or 2 g kg^{-1}) addition to the sand reduced the numbers of J2s recovered (Table 2). CKD alone at 1 and 2 g kg^{-1} (pH 10 and 10.8) reduced J2 nematode respective recoveries by approx. 17% and 65% of those in the untreated controls. The combinations of BL at 1.0 or 2.0 g kg^{-1} and CKD at 1.0 g kg^{-1} increased the pH to 9.9 and reduced J2s recovery below detection levels.

Tomato assay: The tomato fresh shoot weight (FSW) increased with increasing BL application rate (1–4 g kg^{-1}). At each litter application rate, combining with CKD reduced or removed the weight increase. Increased applications of either CKD or BL alone reduced the GI of tomato roots but the combination of the two was more effective. The nematode infestation of the roots (number of eggs per root) was reduced only by combinations of higher BL and CKD doses.

Commercial greenhouse experiment: Application of lime increased the pH of the BL and compost treated soil from 7.5 to 11. The pH was $\geq$ 10 for about a week, and it decreased to less than 9 by the 12th day after treatment, and then to 8 by the 29th day. The mean ammonium concentrations in the soil persisted at > 200 mg N kg^{-1} from the 5th day through the 29th day after treatment. Estimated concentrations of gaseous ammonia exceeded 25 mg N kg^{-1} for some 20 days, peaking at >60 mg N kg^{-1}. Initial nitrate concentration was high (> 300 mg N kg^{-1}) in all plots. The concentrations reached a minimum (50 mg N kg^{-1}) on the 12th day and then increased to 600 mg N kg^{-1} or more. The increase in the control plots was steeper than in the treated plots, yet to a somewhat lower value, and it decreased later on. Nitrite (NO_2^-) concentrations in the BL treated plots were significant throughout most all this period, at 5–50 mg NO_2^--N kg^{-1} (not shown).

The efficacy of the treatment is indicated by the GI of the tomato test plants. Whereas 47% of the plants in the control plots were infected with *M. javanica*, only 7% of those in the treated plots were infected. However, 83 and 127 days after pepper planting, the numbers of nematode juveniles in the soil near the bell-pepper roots were not significantly different between the manure-treated and untreated plots. Similarly, the bell-pepper fruit yields were not significantly different between the treatments. This was probably because of upward migration of nematode larvae later in the season and from side contamination.

It should be emphasized that (i) target ammonia concentrations and pH values were obtained at both soil disinfection and soil curing stages, and (ii) damage to tomato test plants from the root-knot nematode *M. javanica* was drastically reduced. This was despite that the polyethylene cover was removed already on the 12th day due to season constraints. In the Arava Valley, 30–60 days soil solarization is used in attempt to control soil-borne diseases. Longer solarization combined with the ammonia-pH treatment could perhaps improve nematode control. Higher soil temperatures at solarization and higher ammonia vapor pressure are also expected to increase ammonia diffusion to deeper soils, improve treatment efficacy, and make it possible to reduce amendment rates (by reducing the pKa of the H-H equation).

Two additional issues are worthy of mentioning: (i) the treatment affects beneficial soil microflora too (which is worthy of assessment), and thus should be applied with compassion. (ii) No single treatment (this or another) should be expected or attempted to alleviate a chronic soil disease.

Compatibility with organic regulations

Reducing soil-borne plant pathogens using ammonia evolved from manure is an old concept in organic agriculture, often an unsuccessful one. Arid and semi-arid basic, light-textured soils are more conducive to this procedure. The compliance with organic regulations of the treatment components (lime and manure) and concept should be evaluated. **Lime**: NOP rules restrict the use of hydrated lime, $Ca(OH)_2$, for controlling crop pests, weeds and diseases (CP) (Rule reference 205.601(i)(3). The rules prohibit the use of lime as a 'crop fertilizer and soil amendment' (CF) (Rule 205.105(a)) (OMRI, 2004). IFOAM regulations permit application of quicklime for crop protection and growth regulation (OMRI, 2004; p. 101). Wood ash or basic slag which is approved as a fertilizer and soil conditioner by European and international agencies (EC reg. no 2092/91 + Council proposal 8697/98, Codex Alimentarius 99/22 and IFOAM Standards) could yet be used. **Manure/compost**: NOP rules allow application of raw uncomposted manure to edible crops if 90-120 days elapse between application and harvesting. IFOAM and EC regulations do not restrict the application of 'organic' raw manure, but the application of manure from 'factory farming' is either not allowed or allowed after composting. In this context, broiler breeding is not considered 'factory farming'. **General concept:** Arid and semiarid soils do not accumulate much organic matter despite heavy compost applications under organic greenhouse regime, certainly in the open field. More attention has to be paid to soil quality, fertility and biology under this regime, especially as crop rotation is often avoided due to lack of crop selection. Hence, soil pest might persist and adequate means (and perhaps integrated means) should be made available to growers.

Conclusions

We demonstrated that ammonia generated by ammonification of broiler litter with relatively high N content and low C/N ratio, in combination with a transient increase of soil pH, can effectively control soil-borne diseases, the manure also being source of available plant nutrients. Attention should be given to organic-approved source materials for ammonia and hydroxyls. In addition, the pest control should be well tuned with respect to target organisms and soil quality.

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Table 1: Effect of broiler litter and CKD on soil NH_4, NH_3 and pH and on viability of test fungi

Treatment	Max. NH_4 (mg kg^{-1})	Max pH	Estimated Max NH_3 (mg l^{-1})	*F.o.d.* (cfu g^{-1})	*F.o.d.* (% reduction)	*S. rolfsii* (% reduction)
Soil only	2	8.7	2	1,200	-	-
No addition	6	8.7	4	1,222	0	0
10 g kg^{-1} BL	236	8.7	156	14,000	Increase	0
20 g kg^{-1} BL	482	8.8	401	11,722	Increase	37
40 g kg^{-1} BL	588	8.5	277	3,111	Increase	20
80 g kg^{-1} BL	568	8.4	192	1,611	Increase	52.5
10 g kg^{-1} CKD	2	11.3	11	100	99	8.4
10-to-80 g kg^{-1} BL +10 g kg^{-1} CKD	104	11.0–9.6	503–1065	0	100	100

Table 2: Number of *Meloidogyne javanica* second-stage juveniles (J2) recovered from soils, and soil pH following treatment with broiler litter, with or without cement kiln dust (CKD).

		Broiler litter (g kg^{-1})		
		0	1.0	2.0
Experiment A	CKD (g kg^{-1})		J2 No.	
	0	113.2 a	31.3 a	0
	1.0	88.5 a	0 b	0
	2.0	40.0 b	0 b	0
Experiment B	CKD (g kg^{-1})		J2 No.	
	0	102.9 a	28.0 a	0
	1.0	92.8 a	0 b	0
	2.0	34.6 b	0 b	0
	CKD (g kg^{-1})		Soil pH	
	0	8.5 ± 0.1	8.4 ± 0.1	8.6 ± 0.2
	1.0	10.0 ± 0.3	9.9 ± 0.1	9.9
	2.0	10.8 ± 0.3	10.7 ± 0.1	10.3 ± 0.2

Using Copper in Organic Viticulture: Doing it best with less?

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Key words: copper reduction, copper replacement, plant resistance improvers

Abstract

*For many years, applications of copper fungicides have been used to control downy mildew on grapes. Nowadays, its intensive use is under consideration due to ecotoxicological aspects, especially in organic viticulture. As a result, this project made allowance for consumer perception about organic viticulture and is seeking suitable alternatives. The project includes an association of six research facilities, four organic wineries, several consultant agencies for organic viticulture as well as SME (small and medium-sized enterprise) partners, which are working together in four work packages. The aim of this work is to obtain an array of products that provide sufficient control of Plasmopara viticola with the lowest possible input of copper. As a longterm intention, copper-containing products should be totally replaced by other effective agents. Progress to-date suggests that some non-copper products and several copper-based products using less than 3 kg/(ha*a) have potential to effectively control the disease with less ecological residue.*

Introduction

Downy mildew on grapevines caused by *Plasmopara viticola* (Berk. & Curt.) Berl. & de Toni is one of the most important pathogens in viticulture worldwide. Generally, the control of this pathogen is achieved with fungicides or copper salt applications (Gisi, 2002). However, copper fungicides are under consideration for their harmful effects on the natural environment. In response, the Council Regulation (EEC) 2092/91 Annex II limits the use of copper compounds to 6 kg/(ha*a) from 2006 onwards. Moreover, German associations for organic farming concerted to limit the use of copper products to 3 kg/(ha*a). The cluster-project work is investigating a schedule for organic viticulture based on minimum use of copper products. It began in April 2004 and the research continues in 2007. The following aspects are included: greenhouse experiments, field trials in organically managed vineyards and on-farm tests in four organically managed wineries. Micro-vinification trials and assessment studies on side effects on beneficial organisms, phytotoxicity and *Botrytis cinerea* are part of this project. Additionally, studies including analyses of resistance genes are conducted to attain knowledge about the mode of action of selected test-agents. This paper gives an overview of the current data selected in all four aspects of this work. With respect to organic viticulture, alternatives for copper applications as well as new copper-containing products are being screened for their efficiency to obtain sufficient regulation of *P. viticola* with less than 3 kg/(ha*a) copper with regard to environmental purposes.

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Materials and methods

The cluster-project consists of four work packages: Screening under greenhouse conditions on potted vines (work package 1) and field experiments in organically managed test vineyards (work package 2) – the latter include micro-vinification trials. In work package 3, studies on four organically managed wineries are being conducted. SME and consultant partners will assure a close link between research and wineries (work package 4). By a screening process under greenhouse conditions on potted vines (work package 1), test agents should be selected for further trials in work package 2. Four potted vines (*Vitis vinifera* cvs. 'Riesling' or 'Mueller-Thurgau'; BBCH 16-18) were used for each treatment. Vines sprayed with plant protection products (Folpan 80 WDG (a.i. Folpet) and Cuprozin Flüssig (a.i. copper hydroxide)) and with distilled water alone, served as controls. Greenhouse trials were accomplished with new copper formulations (reduced copper concentration), a plant resistance improver, plant extracts, plant oils and finely ground stones. Disease assessments were made on six leaves per potted vine whereas disease severity (defined as % infection per leaf area) of the lower leaf surface was also recorded. In organically managed test vineyards (work package 2) located at six different research facilities in Germany, the selected test agents of work package 1 were evaluated. The control plots of the greenhouse experiments and the field tests were comparable: (i) untreated control, (ii) Folpan 80 WDG and (iii) Cuprozin Flüssig. In addition, sulphur applications were used to prevent powdery mildew infestation. A randomised block design with four replicates was chosen for the experiments. The sprays were applied with an air-assisted application gear (Schachtner Company, Germany). The spraying interval covered about ten days. Disease incidence (in %) and disease severity (in %) both of the lower leaves surfaces and of the berries per bunch, respectively, were recorded. Additionally, micro vinification, analyses of musts and wines and, finally, a sensory evaluation by a professional test panel of the Geisenheim Research Center were conducted. Moreover, possible side effects on beneficial organisms (e.g. *Typhlodromus pyri*) were assessed and an additional rating of *B. cinerea* was included. Work package 3 combined the results of work packages 1 and 2 and examined the applicability of different treatments under practical conditions on four German organically managed wineries (pilot sites). Furthermore, knowledge gained from this work was presented to wine growers by seminars and by publications in magazines regarding more practical aspects of viticulture (work package 4). These work packages were coordinated by Dr. Uwe Hofmann (**ECO-Consult,** Geisenheim, Germany).

Results

Greenhouse experiments (work package 1)

Based on their performance in these experiments, formulations of the substance categories ‘new copper formulations with reduced copper amount’, ‘plant extracts’, ‘plant oils’, ‘finely ground stones’ and ‘algae extracts’ were selected for further experiments in the test vineyards of the research facilities. It was possible to select about 20 substances with potential against downy mildew for the field tests in the years from 2004 to 2006.

Table 1. Overview of results and side-effects obtained in 2004, 2005 and 2006. ++ = very good efficacy; + = good efficacy, (+) = minor efficacy ,– = no efficacy and 0 = no disease pressure, n.e.= not examined.

year	products	biological effect downy mildew			side effect on					
		green house	field test	pilot site	*T. pyri*	*Botrytis cinerea*	must	wine	sensory panel	phyto-tox.
2004	control_copperhydroxide	n.e.	+	n.e.	+/-	n.e.	-	-	-	-
	standard organic schedule	n.e.	+	n.e.	+	n.e.	-	-	-	-
	copperoxychloride-1	n.e.	(+)	n.e.	+	n.e.	-	-	-	-
	finely ground stones-1	n.e.	+	+	+/-	n.e.	-	-	-	-
	phoshonate-1 *until BBCH6 8*	n.e.	++	+	+	n.e.	-	-	-	-
	phoshonate-3 *BBCH 68*	n.e.	+	n.e.	+/-	n.e.	-	-	-	-
2005	control_copperhydroxide	++	+	n.e.	+/-	+/-	-	-	-	-
	standard organic schedule	++	+	n.e.	+	-	-	-	-	-
	copperoxychloride-2	++	+	+	+	(+/-)	-	-	-	+
	finely ground stones-1 new	++	+	+	-	-	-	-	-	-
	phoshonate-1 *until BBCH 6 8*	++	++	n.e.	-	+/-	-	-	-	-
	phoshonate-3 *BBCH 68*	++	++	n.e.	-	-	-	-	-	-
	finely ground stones-2	+++	++	n.e.	-	-	-	-	-	-
	copperoxychloride-3	++	+	n.e.	-	-	-	-	-	-
	algae extract	++	--	n.e.	-	-	-	-	-	-
	algae extract + copperhydroxide	++	-	+	+/-	-	-	-	-	-
2006	control_copperhydroxide	++	+	n.e.	+/-	-	-	Data are not on hand		-
	standard organic schedule	++	0	n.e.	-	-	-			-
	copperoxychloride-2 new	++	+/-	+	+/-	-	-			-
	copperhydroxide new	++	+/-	n.e.	-	-	-			-
	finely ground stones-1 first application BBCH 13	++	+	n.e.	n.e.	-	-			-
	phoshonate-1 until BBCH 68	++	+	n.e.	-	-	-			-
	phoshonate-3 BBCH 68	++	0	n.e.	+	-	-			-
	finely ground stones-2 first application BBCH 13	++	+	n.e.	+	-	-			-
	algae extract first application BBCH 13	++	(+/-)	n.e.	-	-	-			-
	algae extract first application BBCH 13 + copperhydroxide	++	(+/-)	+	+	-	-			-
	plant extract first application BBCH 13 + copperhydroxide	++	+	n.e.	+/-		-			-
	plant extract first application BBCH 13 +finely ground stones-1	++	+	+	n.e.	-	-			-

Field trials 2004 - 2006 (work package 2)

The years 2004 and 2006 were characterized by a low natural infestation level of *P. viticola* in the wine growing district Rheingau, Germany. Therefore, the organically managed plot in Geisenheim could not be evaluated in 2004 and 2006. In 2005, an early primary infection (7th May; growth stage: BBCH 13/14) and a high infestation level of *P. viticola* occurred. In addition, secondary infection cyles started on the 21th May, 2005. However, the application intervals were started on the 25th May 2005. With the benefit of hind-sight, the start of the applications was indeed too late. Therefore, inflorescences were attacked by *P. viticola* severely. Regarding all conducted studies including side effect assessments in 2004 and 2005 (table 1), the tested products have had no impact on wine quality. Only the tested copperoxychloride-2 had an effect on the predator mite and had caused phytotoxicity on leaves and berries. A new formulation was tested in 2006 and had shown no phytotoxicity.

Discussion

In the year 2005 the efficacy of phosphonates, finely ground stones as well as new copper formulations were as successful as the reference treatments Folpan 80 WDG and 'organic standard' (standard organic treatment schedule including a mixture of copper fungicide, sulphur and finely ground stones), respectively. Considering the low amount of the total copper of less than 2 kg/(ha*a) and the delayed start of the applications, the gained results are satisfactory. Unfortunately, under high infestion levels, the new copper products achieved insufficient efficacy (unpublished data). However, the results of the investigations of the years 2004, 2005 and 2006 gained from the Research Center Geisenheim and in the vineyards of the five partner institutes indicated that plant extracts in combination with copper, finely ground stones and new copper formulations could serve as plant resistance improvers and plant protection products, respectively, to manage medium size attacks of *P. viticola*. As a result, it was possible to select several potentially useful products and application strategies for the growing period 2007.

Conclusions

Preliminary greenhouse and field studies have indicated that it might be possible to use less than 3 kg/(ha*a) copper in an effective spray program against grapevine downy mildew. Products with potential for use in this program to handle medium infection pressure from *P. viticola* include a new copper product, an improved formulation of finely ground stones, and a mixture of a plant extract with copper compounds. Up to now, it has not been possible to control high infection pressure from *P. viticola* without copper applications.

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Field efficacy of new compounds to replace copper for scab control in organic apple production

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Key words: fruit growing, *Venturia inaequalis*, disease, *Yucca*, potassium bicarbonate

Abstract

Efficacy of compounds was investigated in field experiments in Denmark and the Netherlands according to EPPO guidelines. Some Yucca *extracts and potassium bicarbonate had an efficacy similar to sulphur on leaves. Addition of sulphur to* Yucca *1 and to potassium bicarbonate increased the level of efficacy to that of copper. This confirms results from earlier years. Although a dose increase resulted in better efficacy, this was more prominent for* Yucca1 *than for potassium bicarbonate.*

Introduction

The control of scab caused by *Venturia inaequalis* in organic apple production is still mainly focussed on the use of fungicidal compounds applied in spring and summer. Copper containing compounds are among the most effective, especially under cold conditions in spring. The approach of the EU Repco project is, however, to integrate several preventive measurements, such as stimulation of earthworms and micro-organisms to degrade overwintering inoculum, and endophytes to reduce numbers of spores in the orchards. It is EU policy to phase out the use of copper and the overall objective of the EU Repco project is to replace copper compounds by a combined strategy of newly developed measures. In this paper, we present work on the efficacy, under organic field conditions, of several newly found materials including yucca extract and, also potassium bicarbonate, a product already under development.

Materials and methods

Field experiments were carried out in Denmark in 2006 (experiment 1, abbreviated as exp1) and in the Netherlands (experiments 2 and 3, abbreviated as exp2 and exp3). Exp1 and 2 were carried out in the experimental orchards of the Danish Institute of Agricultural Sciences (DIAS) at Aarslev, Denmark and at the Applied Plant Research (PPO-fruit) at Randwijk, the Netherlands, respectively. Experiment 3 was placed at a commercial organic fruit grower at Tuil, the Netherlands. Experiments were done according to the EPPO-guidelines 1/5 (3) using the scab susceptible apple cultivar Jonagold on dwarfing rootstocks, pruned as slender spindles and planted in a single row system. The lay-out of all experiments was a complete randomised block design with five, five and four replicates for exp1, 2 and 3 respectively. Materials for orchard testing were selected on the basis of results from screening assays carried out at

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LIFE, University of Copenhagen, Denmark (Bengtsson, *et al*., 2006). Materials were also subjected to preliminary database screening for toxicological risks, economic feasibility and acceptability for use in organic growing. Treatments were applied with a experimental tunnel sprayer with 8 Tee-jet 110-02 nozzles delivering 1000 l/ha in exp1, with a modified air assisted 'Urgent' cross flow sprayer, manufacturer Homeco Holland, with 2 x 5 nozzles Albuz Yellow at a pressure of 8 bar delivering 1000 l/ha in exp2 and with a handheld spray gun with a 1.2 mm ceramic hollow cone nozzle at a pressure of 8 bar, delivering a spray volume of 1000 l/ha, in exp3.

Treatments in exp1 were: 1. untreated, 2. copper oxychloride (Brøste kobberoxyclorid 51 %, 0.05 %), 3. sulphur (Kumulus S, 0.4 %), 4. rapeseed oil (Rapsodi, 2 %), 5. Yucca 1 (0.75 %), 6. Yucca 1 (2.5 %), 7. E52 (2.5 %), 8. E23 (5 %), 9. E62 (5 %), 10. Yucca 2 (0.75 %), 11. Yucca 2 (2.5 %), 12. E41 (5 %), 13. O43 (2 %), 14. V126 (5.0 %), 15. E40 (5 %), 16. E47 (5 %), 17. V101 (5 %), 18. V104 (5 %), 19. V108 (5 %), 20. V110 (5 %), 21. V111 (5 %), 22. V113 (5 %), 23. E72 (5 %), 24. Yucca 3 (2.5 %), 25. potassium bicarbonate (Armicarb 1.33 %), 26. S11 (1 %). All treatments were applied twice weekly for a total of 11 times during the primary ascospore season.

Treatments in exp2 were: 1. untreated, 2. copper hydroxide (Funguran-OH 50 %, 0.05 %), 3. sulphur (Thiovit-Jet, 0.4 %), 4. *Yucca* 1 (0.25 %), 5. *Yucca* 1 (0.5 %), 6. *Yucca* 1 (0.75 %), 7. *Yucca* 1 + sulphur (0.25 % + Thiovit-Jet, 0.4 %), 8. *Yucca* 1 + sulphur (0.5 % + Thiovit-Jet, 0.4 %), 9. *Yucca* 1 + sulphur (0.75 % + Thiovit-Jet, 0.4 %), 10. potassium bicarbonate (Armicarb, 0.25 %), 11. potassium bicarbonate (Armicarb, 0.5 %), 12. potassium bicarbonate (Armicarb, 0.1 %), 13. potassium bicarbonate + sulphur (Armicarb, 0.25 % + Thiovit-Jet, 0.4 %), 14. potassium bicarbonate + sulphur (Armicarb, 0.5 % + Thiovit-Jet, 0.4 %), 15. potassium bicarbonate + sulphur (Armicarb, 1 % + Thiovit-Jet, 0.4 %). Potassium bicarbonate and copper were applied in a more or less weekly schedule. Sulphur was sprayed preventively just before a scab infection period according to the RimPro scab warning system and the weather forecast. If treatments consisted of two products, they were applied as a tank mix. Treatments in exp1 were applied a maximum of 9 times during the primary ascospore season.

Treatments 1, 2, 3, 6, 9, 11 and 14 in exp3 were the same as in exp 2. Potassium bicarbonate and copper were applied more or less on a weekly schedule. Sulphur was sprayed similarly to exp2. If treatments consisted of two products, they were applied as a tank mix. Treatments were applied a maximum of 9 times during the primary ascospore season.

For leaf assessments, 10 and 50 randomly chosen spur leaf clusters from the 3 middle trees per plot were examined in exp1 and exp 2 and 3 respectively. Scab lesions were also examined on 30 extension shoots from the 3 middle trees. Scab incidence was calculated as the percentage of leaves diseased and severity was expressed as the mean number of lesions per leaf.

Results

Infection of leaves is shown in tables 1, 2 and 3 for exp1, 2 and 3 respectively. The number of lesions was over 100 per leaf in some treatments in exp2. If lesions fused, it was not possible to accurately count lesion numbers in such cases. Therefore these data are omitted from Table 2. In exp3, the level of scab was low at the beginning of the experiment. Even in untreated plots hardly any lesions were found on cluster leaves. Therefore, these data are omitted from Table 3. It was noted that some *Yucca* extracts at higher dosages and potassium bicarbonate had a similar efficacy on cluster leaves as standard schedules of copper and sulphur in exp1. However, these tendencies were no longer visible on extension shoot leaves in exp1. *Yucca* 1 has a similar efficacy at a dose of 0.75 % as sulphur at 0.4 % in exp2 and 3, while copper was more efficacious.

Tab. 1: Incidence (%) and severity (lesion number) on leaves of clusters and extension shoots 13th June & 11th July 2006 resp. in experiment 1 at Aarslev, Denmark.

treatment	dose	Cluster		extension	
	%	Incidence	severity	incidence	severity
untreated	-	44,3 A	4,2 ab	45,4 a	6,1 a
1. untreated	-	29,8 a-f	3,9 ab	42,1 ab	5,8 ab
2. copper oxycloride	0,05	13,4 c-g	2,2 a-g	32,1 ab	5,2 ab
3. sulphur	0,4	6,1 Fg	0,6 efg	30,0 b	4,4 b
4. rapeseed oil	2,0	12,4 c-g	1,1 c-g	39,1 ab	6,0 ab
13. O43	2,0	9,3 Efg	1,0 d-g	30,3 b	4,9 ab
26. S11	1,0	12,3 c-g	1,5 c-g	37,1 ab	5,3 ab
25. potassium bicarbonate	1,33	3,2 G	0,2 g	32,4 ab	5,0 ab
5. Yucca 1	0,75	19,1 b-g	2,0 b-g	40,8 ab	5,8 ab
6. Yucca 1	2,5	6,2 Fg	0,5 fg	30,8 b	5,0 ab
10. Yucca 2	0,75	22,0 a-g	2,8 a-e	40,4 ab	5,7 ab
11. Yucca 2	2,5	9,3 efg	0,7 efg	30,7 b	4,7 ab
24. Yucca 3	2,5	17,1 b-g	1,6 c-g	38,7 ab	5,8 ab
7. E52	2,5	20,8 b-g	2,5 a-f	37,7 ab	5,7 ab
8. E23	5,0	37,1 ab	2,3 a-g	37,6 ab	5,8 ab
9. E62	5,0	24,9 a-g	3,1 a-d	34,2 ab	6,0 ab
15. E40	5,0	28,7 a-f	3,3 abc	34,3 ab	4,6 ab
16. E47	5,0	33,7 a-d	4,0 ab	38,4 ab	5,8 ab
17. V101	5,0	33,6 a-d	3,3 abc	36,2 ab	5,8 ab
18. V104	5,0	28,0 a-f	3,1 a-d	39,2 ab	5,9 ab
19. V108	5,0	28,5 a-f	3,0 a-d	40,5 ab	6,2 a
20. V110	5,0	39,7 ab	3,3 abc	37,5 ab	5,7 ab
21. V111	5,0	34,4 abc	4,3 a	43,7 ab	6,1 ab
22. V113	5,0	32,1 a-e	3,4 abc	42,3 ab	5,9 ab
12. E41	5,0	9,8 efg	0,6 efg	34,1 ab	5,4 ab
14. V126	5,0	10,6 d-g	0,9 d-g	32,3 ab	5,1 ab
23. E72	5,0	24,0 a-g	2,2 a-g	39,5 ab	6,0 ab

Means followed with letters in common do not significantly differ ($P < 0.05$, Student-Newman-Keuls)

The tank mix of Yucca 1 and sulphur at the same dosage improved efficacy to the same level as that of copper. Potassium bicarbonate tended to be slightly less effective than copper but addition of sulphur increased its efficacy to the same level as copper in these experiments. Although a dose increase improved efficacy, this was more prominent for *Yucca 1* than for potassium bicarbonate.

Discussion

In exp1, all plots in the trial area, were treated with sulphur 4 kg/ha for apple scab control from green tip until start of the experimental treatments (24/4) and again after finish of the experimental treatments (29/5) and until end of September. This might explain the reduced differences in scab infections on extension shoots, compared to cluster leaves.

Tab. 2: Incidence (%) and severity (lesion number) on leaves of clusters and extension shoots 31st May & 18th July 2006 resp. in experiment 2 at Randwijk, the Netherlands.

treatment	dose %	Cluster incidence	Cluster severity	extension incidence
1. untreated	-	5.7 f	16.4 f	52.9 g
2. copper hydroxide	0.05	0.1 a	0.2 a	14.6 a
3. sulphur (denoted as S)	0.40	1.5 cde	3.0 cde	25.4 cd
4. *Yucca* 1	0.25	2.3 e	4.6 e	37.3 f
5. *Yucca* 1	0.50	2.2 e	5.2 e	32.4 def
6. *Yucca* 1	0.75	1.7 de	3.4 de	32.8 def
7. *Yucca* 1 + sulphur	0.25 + 0.4	1.2 bcde	2.4 bcde	22.3 bc
8. *Yucca* 1 + sulphur	0.50 + 0.4	0.6 abc	1.6 abcd	22.2 bc
9. *Yucca* 1 + sulphur	0.75 + 0.4	0.4 ab	0.8 ab	16.5 ab
10. potassium bicarbonate	0.25	2.1 e	4.8 e	36.3 ef
11. potassium bicarbonate	0.50	0.7 abcd	1.6 abcd	33.7 ef
12. potassium bicarbonate	1.00	0.5 abc	1.0 abc	29.8 cdef
13. potassium bicarbonate + S	0.25 + 0.4	0.7 abcd	1.4 abcd	29.7 cdef
14. potassium bicarbonate + S	0.50 + 0.4	0.5 abc	1.0 abc	31.9 def
15. potassium bicarbonate + S	1.00 + 0.4	0.3 ab	0.6 ab	28.1 cde
F-test		< 0.001	< 0.001	< 0.001

Means followed with letters in common do not significantly differ

Tab. 3: Incidence (%) and severity (lesion number) on leaves of clusters and extension shoots 2nd June and 17th July 2006 resp. in experiment 3 at Tuil, the Netherlands.

treatment	dose %	extension incidence	extension severity
1. untreated	-	51.1 d	394.5 c
2. copper hydroxide	0.05	5.8 a	18.3 a
3. sulphur	0.40	20.3 c	110.8 b
6. *Yucca* 1	0.75	20.8 c	98.5 b
9. *Yucca* 1 + sulphur	0.75 + 0.4	6.1 a	25.0 a
11. potassium bicarbonate	0.50	12.6 bc	48.0 ab
14. potassium bicarbonate + sulphur	0.50 + 0.4	7.6 ab	34.5 a
F-test		< 0.001	< 0.001

Means followed with letters in common do not significantly differ

Conclusions

It is concluded that potassium bicarbonate and *Yucca* 1 could contribute to the replacement of copper in apple scab control and to a more sustainable organic apple culture in future.

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Development of strategies to improve quality and safety and reduce cost of production in organic and ‘low input’ crop production systems – Posters

Effect of management spontaneous cover crop on rosy apple aphid, green apple aphid and their natural enemies in an apple organic orchard

Alins, G.[1], Alegre, S. [1], Avilla, J.[2]

Key words: rosy apple aphid, green apple aphid, natural enemies

Abstract

Cover crops have been reported as shelters for pest but also for natural enemies. Nevertheless, there is not agreement about their influence on pest presence on apple trees. An experiment was conducted in 2004-2006 in an IRTA-Estació Experimental de Lleida organic apple orchard located in Les Borges Blanques (Lleida, Spain) in order to evaluate the influence of cover crops on the presence of pest and natural enemies on apple trees. Three cover crops were tested and compared to a bare soil: (1) spontaneous cover crop where Plantago lanceolata *L. was the most abundant specie, (2) no-mowed spontaneous cover crop, (3) spontaneous cover crop mowed when weeds were 30 cm tall. Cover crops tested affected neither the presence the rosy apple aphid nor aphid natural enemies. Nevertheless, the green apple aphid was more abundant in bare soil trees than in cover crop trees.*

Introduction

Cover crops have been reported as a water, nutrient and light competitors. This competition can reduce crop growth and production (Weibel and Häseli 2003, Zimdahl 1993). On the other hand, cover crops can be a shelter for natural enemies. Trials carried out on apple tree orchards (*Malus domestica* Borkh.) have shown that cover crops and resident vegetation managed as a cover crop can attract natural enemies (Fitzgerald and Solomon 2004, Vogt and Weigel 1999, Wyss 1999, Haley and Hogue 1990, Bugg and Waddington 1994, Altieri and Schmidt 1986). However, there is not agreement on their effect on pest control.

The rosy apple aphid is one of the most important apple pests in Spain. It is a holocyclic insect that returns from *Plantago* sp. to apple trees in October (Blommers *et al.* 2004). Although spices of *Plantago* are common weeds on fruit tree orchards (Marquès *et al.* 1983), their effect on the abundance of the rosy apple aphid on apple trees has not been studied. Thus, the objective of this work was to evaluate whether the presence of *Plantago* sp. affects the abundance of the rosy apple aphid on apple trees. In addition, the effect of cover crop management on the abundance of the rosy apple aphid, the green apple aphid and their natural enemies was also studied.

Materials and methods

The trial was conducted from 2004 to 2006 in a 1.5 ha organic apple orchard located at the IRTA-Lleida Experiment Station in Borges Blanques (Spain, UTM coordinates X: 320,794, Y: 4,597,395) planted in January 2003. It comprised 'Fuji' apple trees on

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M9 rootstock and ‘Granny Smith’ apple trees on Pajam 1® as pollinators. The apple trees were irrigated by dropping and the orchard was managed upon the rules of the European organic production (EEC, 1991).

Three cover crops were tested: (1) Plantago (Pl): spontaneous cover crop where *Plantago lanceolata* L was the most abundant specie; this cover crop was mowed twice in 2004 and 4 times in 2006 to avoid weed competition. (2) No-mowed (NM): no-mowed spontaneous cover crop. (3) Mowed (M): spontaneous cover crop mowed when weeds were 30 cm tall (2, 1 and 4 times in 2004, 2005 and 2006 respectively). These cover crops were compared to a bare soil (BS) that was maintained free of weeds by hand. NM and M cover crops were composed by broad leaf species except in 2006 that grasses were more abundant.

The elementary plot was formed by 4 rows with 8 trees in each row, forming 3 alleyways taking up 134.4m^2. The treatment Pl was assigned to the elementary plot where *P. lanceolata* was the most abundant specie. The rest of the treatments were randomly arranged. The trial was performed in a complete block design with 4 replicates. Samples were taken from the 8 central trees (4 trees for each 2 central rows). Data were analysed by lineal model ANOVA using SAS® Enterprise Guide (Version 2.0.0.417). Mean values of the treatments were compared by the Multiple Range Duncan’s test (SAS Institute, 2000).

The presence of the rosy apple aphid, the green apple aphid and theirs naturals enemies were recorded by visual controls weekly on 10 shoot per tree on the 8 control trees. Rosy apple aphid was recorded from autumn 2004 to spring 2006. Green apple aphid and natural enemies were sampled from spring 2004 to winter 2005.

Results

Cover crops tested did not affect the presence of the rosy apple aphid in any season studied (Tab. 1). In contrast, the green apple aphid was more abundant in bare soil than in cover crops (Figure 1); these differences were significant in 2004.

Three aphid natural enemies were found on apple trees in 2004: parasitoides (Aphidiide), the 7-spotted lady beetle (*Coccinella septempuntata* L.) and the green lacewing (*Chrysoperla* sp.). One more natural enemy was found in 2005: *Allothrombium fuliginosum* Hermann. Anyway, neither in 2004 nor in 2005 there were differences among treatments (Tab. 2).

Tab. 1: Percentage of shoots with rosy apple aphid. Pl: Plantago. NM: No-mowed. M: Mowed. BS: Bare soil. Each value is the mean percentage of shoots with rosy apple aphid during the sampling period.

Cover crop	Autumn 2004	Spring 2005	Autumn 2005	Spring 2006
Pl	1.49	4.17	1.81	2.52
NM	1.81	3.20	2.45	2.02
M	1.72	2.10	2.30	1.43
BS	2.36	4.14	3.36	3.61

No significant differences among cover crops for $P<0.05$.

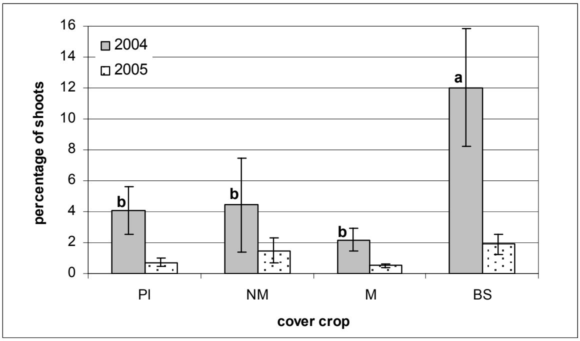

Figure 1: Percentage of shoots with green apple aphid. Pl: Plantago. NM: No-mowed. M: Mowed. BS: Bare soil. Each value is the annual mean percentage of shoots with green apple aphid. Values followed by the same letter in each column are not significantly different (P<0.05) by the Multiple Range Duncan's test.

Tab. 2: Percentage of trees with parasitized aphids, *Chrysoperla* sp., *C. septempunctata*, *A. fuliginosum*. Pl: Plantago. NM: No-mowed. M: Mowed. BS: Bare soil. Each value is the annual mean percentage of shoots with natural enemies.

	Parasitized aphids		*Chrysoperla* sp.		*C. septempunctata*		*A. fuliginosum*
Cover crop	**2004**	**2005**	**2004**	**2005**	**2004**	**2005**	**2005**
Pl	8.08	0.41	8.02	17.36	1.51	0.19	2.38
NM	8.25	0.41	8.33	18.93	2.25	0.11	2.19
M	8.48	0.00	8.68	17.27	0.44	0.13	1.92
BS	5.89	0.46	9.74	20.26	1.49	0.00	2.41

No significant differences among cover crops for P<0.05.

Discussion

The rosy apple aphid is a holocyclic aphid that migrates to *Plantago* sp. late May or June. It was expected that this aphid was more abundant in Pl cover crop apple trees because *Plantago* sp. is its secondary host. Anyway, neither the presence of *P. lanceolata*, the mowing of the cover crop, nor the absence of a ground cover affected the presence of the rosy apple aphid.

In contrast, the absence of a ground cover promoted the presence of the green apple aphid. The development of aphids has been related to nitrogen content of the host plant (Klingauf, 1987). In fact, higher levels of nitrogen in the leave were related to higher levels of green apple aphid infestation (Haley and Hogue 1990). The lack of weeds in the BS treatment avoided competition between the crop and the weed, so leaves of BS cover crop trees may have had more nitrogen content and became more attractive to green apple aphid.

As far as natural enemies are concern, no differences were observed among treatments. Brown and Glenn (1999) neither found effect of the ground cover on the tree presence of natural enemies. According to Bostanian *et al.* (2004) several years are required to increase natural enemy populations. Thus, more years will be needed to find out the effect of cover crop to attract natural enemies and control pests.

Conclusions

The conclusions of this trial are: (1) the presence of *P. lanceolata* did not affect the abundance of the rosy apple aphid on apple trees, (2) neither mowing nor the absence of a ground cover did not satisfactory help to control the rosy apple aphid, (3) any cover crop tested did not improve aphid natural enemy populations, (4) the green apple aphid was more abundant in the bare soil trees than in the cover crop trees, (5) more years will be needed in order to find out whether cover crops can attract enough natural enemies to control pests.

Acknowledgments

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Effects of the inoculation with arbuscular mycorrhizal (AM) fungus of the genus Glomus on growth and leaf mineral concentrations of grapevine (*Vitis vinifera* cv. Cabernet Sauvignon)

Bennewitz, E. von[1]

Key words: AM-mycorrhiza, vineyard, nutrient uptake, growth parameters

Abstract

The effects of root inoculation with mycorrhizal fungi (genus Glomus) on growth and leaf mineral concentrations of grapevine (Vitis vinifera cv. Cabernet Sauvignon) were studied under the growth conditions of Central Chile. Inoculation enhanced the uptake of N and K and vegetative growth but decreased the foliar concentration, but not necessarily the uptake of P.

Introduction

The beneficial effects of arbuscular mycorrhizal inoculation with respect to grapevine growth and the nutritional status have been reported by several authors (Karagiannidis *et al.* 1995, Biricolti *et al.* 1997, Karagiannidis and Nikolaou 1999). No studies have been carried out in Chile about this symbiosis in grapevines. The objective of the present study was to assess the effects of root inoculation with mycorrhizal fungi (genus Glomus) on growth and leaf mineral concentrations of grapevine (*Vitis vinifera* cv. Cabernet Sauvignon) under the growth conditions of Central Chile.

Materials and methods

The study was carried out between 2005 and 2006 at the Department of Agronomy of the Universidad Católica del Maule at the City of Curicó. Curicó is situated in Central Chile. Geographic coordinates: 34º58´ S; 71º14´ E; 228 m above sea level. An unsterilized soil from the Research Station of the University was used for the study. It corresponds to a sandy clay soil from the Vertisols class with a total humus content of 6.31 % and pH/H_2O 5.62. The soil was sieved (2mm), not sterilized and mixed with sand at a ratio of 1:1. 20 kg of the resulted substrate was employed for every plant. The mineral content of the mixed substrate (mg kg^{-1}) was: P (35.0), K (149.0), Ca (672.0), Mg (102.0), Fe (113.5), Mn (3.18), Cu (2.78) and B (1.24). The plants were planted during late March 2005 in 20 L plastic pots. 10 grapevine plants (One year old) were utilized for every treatment, with every single plant as replicate. Plants were inoculated with a commercial granular inoculant (Mycosym Tri-ton®). The inoculant is composed of AM from the Glomus genus and is made with spores and small pieces of mycorrhizal roots fixed on a mix of perlite and sand. Similar Inoculants have been positively evaluated in apple trees (Von Bennewitz *et al.* 2000a, Von Bennewitz *et al.* 2000b).

When the grapevines were planted the inoculant was mixed with the soil at different depths to assure a direct contact with the roots. The treatments applied for the experiment were the following: Control, T1.- Inoculant 2,5 ml/plant, T2.- 5,0 ml/plant, T3.- 10,0 ml/plant. The following measurements were carried out: 1. Mycorrhizal

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infection. Samples of fresh roots were taken on 28.09.5, 28.11.05 and 16.01.06 and cut into 1.0-cm segments. All segments of each treatment were massed together, cleared with 2% KOH, and stained with tripan blue (Phillips and Hayman 1970). Fifty samples for each treatment were analyzed and the percentage of root length containing vesicles was assesed by the gridline-intersect method (Giovanetti and Mosse 1980), mounted on microscope slides and estimated by observation with 200 X magnification.

2. Foliar analysis. Included: N, P, K, Ca, Mg, Fe, Mn, Cu, and Zn (leaves sampled at veraison). Chemical methods. Leaf samples were cleaned; owen dried at 60 °C and reduced in particle size. Wet digestion was utilized for organic matter destruction in the case of N, P, K, Ca, Mg and dry ashing for Fe, Mn, Cu and Zn. N (Kjeldahl), P (Colorimetric method), K (Flame photometer), Ca, Mg, Zn, Fe, Cu, Mn (Atomic absorption spectrophotometer).

3. Vegetative and generative responses included measurements of shoot extension growth (two shoots per plant), increase in trunk diameter, length and diameter of nodes. Also number and area of leaves, according to the procedure of Gutierrez and Lavín (2000) and pruning weight (fresh and dry weight). Results were subjected to analysis of variance and the Tukey‘s multiple range test was employed in the case of significant differences to separate means.

Results and discussion

Root mycorrhizal infection. Results of this evaluation are presented in Table 1.

Tab. 1: Mean mycorrhizal infection in roots of Cabernet Sauvignon grapevine (various dates)

Treatments	Date of evaluation		
	28.09.05	**28.11.05**	**16.01.06**
Control	6.0b	8.0c	16.8bc
T1: 2,5 ml/plant	6.0b	17.2b	14.8c
T2: 5,0 ml/plant	14.4a	29.6a	23.2b
T3: 10 ml/plant	17.6a	24ab	34.8a

Values marked by the same letters in column are not statistically different ($P \leq 0.05$) according to Tukey's test.

During both years (2005 and 2006) all treatments showed mycorrhizal infection, even the Control treatment where no AM were applied. These results reflect the presence of native mycorrhizas in the soil of the study, with activity in roots of grapevines. The greater degree of root infection was observed in treatment T3 (Highest doses of innoculum). The percentage of root length infected increased markedly during the second year in most of the cases, even in the control treatment (6.0%-16.8%). These results showed that the natural population of mycorrhiza of the soil can increase from year to year if appropriate conditions are given (minimal soil disturbance, no application of soil herbicides, adequate fertilization among others). According to the results of this study the AM fungus contained in the inoculant seem therefore to be able to infect grapevine roots, and the responses are significantly greater than the control without application. It seems that one application of the inoculant at the moment of plantation is sufficient, if colonization has been taken part successfully, to secure mycorrhizal root colonization, but not great differences (increase or decrease of the infection) occur from year to year once the products have been applied.

Foliar mineral content. Results of this evaluation are presented in Table 2.

Tab. 2: Foliar mineral content

T.	%				mg kg^{-1}				
	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn
C.	1.59c	0.22a	0.86b	1.17ab	0.27ab	117.6a	120.0a	5.0a	11.3a
T1	1.81b	0.18b	1.03a	1.06ab	0.27b	121.6a	85.6b	5.0a	11.3a
T2	1.96a	0.18b	1.07a	0.95c	0.24c	118.0a	74.0b	6.0a	12.3a
T3	1.60c	0.19b	0.86b	1.26a	0.28a	116.3a	126.3a	4.6a	12.0a

Values marked by the same letters in column are not statistically different ($P \leq 0.05$) according to Tukey's test.

N, K: Values were significantly higher in the case of treatments T1 and T2. These results are similar with those reached by Alarcón *et al.* (2001). These authors observed significantly higher foliar concentrations of N and K in treatments with AM in grapevine. P: Values were significantly lower in those treatments where AM were applied. In these cases the inoculation could have decreased the concentration, but not necessarily the uptake of P. We have to consider the dilution effect produced by the great shoot growth (table 4). If the P foliar content and the pruning dry weight, are considered together, we could estimate the total P concentration of the above ground section of the plant. In this case the concentration of P is significantly higher in inoculated plants (table 3). Ca: Was significantly lower in the case of treatment T2. Fe, Cu y Zn: Were not significantly affected by the treatments. Mg y Mn: Concentration decreased in the case of treatments T1 y T2.

Tab. 3: Estimation of the total P concentration in the above ground section of the plant

Treatments	mg
Control	19,2 c
T1: 2,5 ml/plant	25,1 b
T2: 5,0 ml/plant	30,4 a
T3: 10 ml/plant	30,1 a

Values marked by the same letters in column are not statistically different ($P \leq 0.05$) according to Tukey's test.

Vegetative responses. Results of this evaluation are presented in Table 4.

Significant differences were detected for the evaluations of pruning weight (up to 93% increase). No significant differences were detected for trunk diameter, length and diameter of nodes, number and area of leaves.

Tab. 4: Pruning weight (dry weight)

Treatments	
Control	8,72 b
T1: 2,5 ml/plant	13,68 a
T2: 5,0 ml/plant	16,89 a
T3: 10 ml/plant	15,34 a

Values marked by the same letters in column are not statistically different ($P \leq 0.05$) according to Tukey's test.

Conclusions

The studied inoculant has the capacity to colonize and persist in the roots of grapevine (AM-mycorrhizal fungus), enhance the concentration of P of the above ground section of the plant, the foliar concentration of N and K and improve the vegetative growth. They could decrease the foliar concentration, but not necessarily the uptake of P. These results obtained in experimental conditions and young plants have a practical importance. The studied inoculant could be applied in the nursery, where moderate amounts of colonization are often naturally achieved and in the vineyard after the transfer of these plants to a low-nutrient environment they could spread and enhance plant growth and production.

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Apparent N Balance in Organic and Conventional Low Input Cropping Systems

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Key words: nitrogen surplus, nitrogen loss, crop rotation

Abstract

The determination of nutrient surplus is one of the indicators of potential N losses from the agricultural system to the environment. An experiment was started in 1998 in Central Italy to evaluate the soil surface N balance of an organic and a conventional low input cropping system over a long term crop rotation. Results at the end of a 6-year crop rotation showed an estimated N surplus in organic system 1.3-2 times higher than in conventional system while N content in the top soil was not different in the two systems, so that organic system should have involved a higher N loss from that soil layer.

Introduction

Organic systems are expected to reduce N leaching (Haas *et al.*, 2002), but this is not always confirmed (Kirchmann and Bergström, 2001). Actually, nitrogen release from organic fertilizer and green manuring might not match crop requirement for both N total supply and timing of N release, with consequent inefficient use of supplied N and increase of residual N exposed to leaching (Benincasa *et al.*, 2004; Jenkinson, 2001; Kirchmann and Bergström, 2001). The determination of nutrient surplus (N supply minus N off-take) at a field scale is often used as an indicator of the potential loss of N (Webb *et al.*, 2000; Heathwaite, 1997; Meisinger and Randall, 1991) and can give an indication of the risks that are associated with specific farming practices. This research is aimed to evaluate the apparent N balance of an organic and a conventional low input system over a long term crop rotation.

Materials and methods

An experiment was started in 1998 at Perugia (Italy, 43°N, 165 m a.s.l.) to compare an organic (ORG) and a conventional low input (CONV) system in two contiguous fields, both clay loam and with same organic matter and total N contents. Both fields were divided in six sectors (A1, A2, B1, B2, C1, C2) to reproduce the steady-state running of a 6-year rotation in a farm and test several food crops contemporaneously. In each cropping systems a randomized block design with three or four replicates (depending on year and crop) was adopted. The same sequence of cash crops over the six years was adopted in both systems (Table 1). Nitrogen supply to the system was assured by green manuring (legumes, pure or mixed with non-legumes) and/or poultry manure in ORG and by green manuring (only until 2000) and mineral fertilizers in CONV. Above ground N accumulation of any crop and its partitioning between commercial biomass and crop residues were determined by plant sampling and analysis of organic N d. m. content (Kjeldhal method).

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Tab. 1: Six-year crop rotations in the six field sectors in organic (ORG) and conventional low input (CONV) cropping systems. Green manure crops (GM) were adopted in ORG and CONV until 2000, only in ORG afterwards. Nitrogen supply (kg ha-1) from fertilizers in ORG/CONV system is reported in brackets.

Field sectors	Years					
	1999	2000	2001	2002	2003	2004
A1	common bean (40/0)	spelt (40/40)	GM1+maize (40/150)	GM4+soybean (0/0)	GM1+pepper (0/200)	wheat (0/80)
A2	common bean (40/0)	wheat (80/80)	GM1+pepper (40/175)	GM4+maize (40/40)	GM1+tomato (0/200)	wheat (0/80)
B1	field bean (0/0)	GM3+pepper (100/100)	pea (40/0)	wheat (80/80)	GM2+maize (0/150)	GM3+tomato (60/160)
B2	field bean (0/0)	GM3+maize (100/100)	field bean (40/0)	wheat (80/80)	pea (0/0)	GM3+pepper (60/200)
C1	GM1+pepper (0/70)	common bean (40/0)	spelt (80/80)	GM1+tomato (60/200)	wheat (40/80)	field bean (0/0)
C2	GM1+millet (20/135)	common bean (40/0)	wheat (80/80)	GM1+pepper (60/200)	wheat (40/80)	GM1+maize (40/150)

GM1: field bean; GM2: field bean+rapesed; GM3: hairy vetch; GM4: barley.

In legumes, N derived from atmosphere (Ndfa) via symbiotic N_2 fixation was assumed to account for 80% of accumulated N, based on data reported by Vance (1988) and by Cazzato *et al.*(2003) for the Italian environment, and on our own data (not yet published) analysed according to Müller and Thorup-Kristensen (2002) on leguminous and grass species grown contemporarily for several years in field experiments carried out in the same location of the present trial. The Ndfa accumulated in legume roots is not considered here. For this reason, due to the different frequency of green manure crops in the two systems (Table 1) the underestimate of N input by legume roots Ndfa is most likely higher in ORG than in CONV. Apparent residual N in the soil (i.e. the soil-crop component of the soil surface budget) (Aarts *et al.*, 2000) was calculated at the end of each crop cycle as: $\Delta N = A + B - C$; where ΔN = apparent residual N in the soil per unit area (kg ha^{-1}); A = N input as mineral and organic fertilizer (kg ha^{-1}); B = estimated legume Ndfa (kg ha^{-1}); C = N off-take with commercial yield removal (kg ha^{-1}). The soil N content (both organic and mineral N) was determined in each sector at the end of the 6-year crop rotation by sampling four 0-0.40 m soil cores per each sector. Data were submitted to analysis of variance according to a hierarchical design (crops within systems).

Results

As an average over the six field sectors, the 6-year cumulated total N input (i.e. N from fertilizers + legume Ndfa) (Table 2) was similar in the two systems (594 kg ha^{-1} in ORG vs 603 kg ha^{-1} in CONV), with estimated Ndfa component in ORG about 3.5 times higher than in CONV, the N off-take was 17% lower in ORG than in CONV, while the ΔN was 34% higher in ORG than in CONV. In particular, except for sector A1, field sectors in ORG showed a cumulated ΔN 1.3-2 times higher than in CONV. Between-sectors variability was observed for all N balance components, with sectors sorted pretty similarly in both systems, except for Ndfa that in CONV was affected by occasional green manuring in some sectors.

Table 2: Cumulated 6-year N input from fertilizers, estimated legume N derived from atmosphere, N off-take and ΔN (i.e. total input minus off-take) in six field sectors of organic (ORG) and conventional low input (CONV) cropping systems.

Field sectors	N from fertilizers (kg ha^{-1})		Legume Ndfa (kg ha^{-1})		N off-take (kg ha^{-1})		ΔN (kg ha^{-1})	
	ORG	CONV	ORG	CONV	ORG	CONV	ORG	CONV
A1	120	470	335	66	284	300	172	236
A2	200	575	303	38	450	579	53	34
B1	280	490	368	151	341	486	307	155
B2	280	380	373	237	302	341	351	276
C1	220	430	386	110	345	399	261	141
C2	280	645	421	26	369	406	332	264
mean	230	498	364	105	349	419	246	184
Pooled SD	*31*	*74*	*58*	*38*	*45*	*48*	*69*	*71*

Both organic and mineral N contents of the 0-0.40 m top soil at the end of the 6-year rotation were substantially the same in both ORG and CONV (Table 3).

Table 3: Organic, mineral and total N contents in the top soil layer (0-0.40 m) in organic (ORG) and conventional low input (CONV) cropping systems at the end of the 6-year crop rotation.

Systems	Organic N Kg ha^{-1}	Mineral N Kg ha^{-1}	Total N Kg ha^{-1}
ORG	4065	29	4095
CONV	4188	34	4222
Pooled SD	*561*	*8*	*563*

Discussion

The higher 6-year cumulated ΔN in ORG with respect to CONV was determined by both the lower cash crop N off-take and the imprecise N availability from green manuring in ORG. The exception of sector A1, where ΔN was higher in CONV than in ORG, is mainly due to vascular diseases and a heavy nematode attack on sweet pepper in 2003, so that a great part of commercial yield was damaged and therefore left in the field and then incorporated into the soil. The lower cash crop N off-take in ORG resulted from a generally lower commercial yield of many crops as a consequence of lower initial growth (especially in summer crops, due to low early N availability and/or to scrubby organic transplants) and/or of higher weed competition (especially in grain legumes). The imprecise N availability from green manuring concerned both the total N supplied from green manure crops and the timing of N release from incorporated biomass which both showed a high inter-annual variability (Benincasa *et al.*, 2004). Differently from CONV, where mineral fertilizer at low rates generally allowed high N uptake efficiency, in ORG sometimes N supply by green manuring exceeded cash crop total requirements and sometimes N release from incorporated biomass did not cover cash crop early N requirements, with consequent reduction of cash crop N uptake efficiency. Since at the end of the 6-year rotation both organic and mineral N contents in the 0-0.40 m top soil layer were similar in the two systems, it can be argued that the higher ΔN recorded in ORG should have caused a higher loss of N from that soil layer.

Conclusions

In our experiment, organic system involved a higher N surplus (i.e. N input by fertilizers plus estimated legume Ndfa minus N off-take) with respect to the conventional low input system. However, the higher N surplus did not involve an important difference between systems in the top soil N content (both organic and mineral) at the end of the 6-year rotation. For this reason organic system in this experiment was estimated to involve a higher N loss from the top soil.

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Commercial plant-probiotic microorganisms for sustainable organic tomato production systems

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Key words: Plant-probiotic microorganisms; Arbuscular mycorrhizal fungi, Plant growth promoting rhizobacteria; Commercial inoculum; Organic tomato.

Abstract

Selected plant-probiotic microorganisms, produced by the company CCS Aosta at a commercial scale, are being tested in the Italian Padana plain in open field conditions for their ability to provide adequate crop nutrition and to ensure durable soil fertility for organic tomato production. In this three-years-long project the QLIF-WP 3.3.3 research team will investigate the potential of soil probiotics management as a tool to improve the quality of tomato fruits and the sustainability of organic tomato production systems.

Introduction

During the last 400 million years, terrestrial plants have not achieved the ability to grow independently from their own probiotic microorganisms (plant growth promoting bacteria, mycorrhizal and antagonistic fungi). Plant-probiotic microorganisms (PPMs) are well known for positively and directly affecting plants growth through several mechanisms, such as biological nitrogen fixation, solubilization of phosphorous, synthesis of siderophores, plant hormones, and plant hormone regulators (Picard and Bosco, 2006). The indirect promotion of plant growth can occur when soil beneficial microorganisms antagonize the action of phytopathogenic organisms. All these mechanisms are regulated by population density and diversity of microorganisms that are in direct contact with the root surface (Picard and Bosco, 2005) or in the close rhizosphere, a habitat where there is maximum microbial activity due to the release of organic components from the roots.

In fact, technological bottlenecks in organic production systems, which affect quality and safety in organic foods, as well as costs of production, still include untimely availability of nutrients and diseases biocontrol. As plants are still genetically dependent from their co-evolved soil probiotics, future applications in organic and low-input agriculture, to be sustainable, must seriously consider the biological need of plants to co-operating with PPMs.

The research approach of this study is to achieve a better understanding of the relationships between plant-probiotic microflora management, organic matter inputs, crop quality, and production costs. Our first year of investigation concerned effect of, and interactions between combined gradients of beneficial microbial inoculum (M), organic compost (C) on tomato fruit yield and quality.

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Materials and methods

Plant materials

Plant materials consisted of two tomato (*Solanum lycopersicum* L.) cultivars: 'Riogrande' and 'Gordon'. 'Riogrande' is intended for industrial processing and was chosen by the organic farmer because it already produced good yields in his own farm for the last ten years (Sabbioni, personal communication). 'Gordon' is intended for fresh use in salads and was chosen for research purposes. Seedlings of both cultivars were produced by an organic certified nursery, located near the experimental site, and transplanted at the age of 45 days.

Microbial inputs

Plantlets were treated with an experimental variant of 'MICOSAT F' by CCS Aosta, a mixed inoculum specially suitable for horticultural species, flowers, which protects them against *Pythium, Phytophthora, Verticillium, Agrobacterium, Meloidogyne, Pratylenchus*. The commercial product contains grinded mycorrhizal roots, spores and mycelia of arbuscular mycorrhizal fungi (AMF) *Glomus mosseae* GP11, *G. viscosum* GC41, *G. intraradices* GB67, as well as plant-growth-promoting-rhizobacteria (PGPR) like *Pseudomonas* sp. PN 01, *P. fluorescens* PA28, *Bacillus subtilis* BA41, *Streptomyces* sp. SB14, and the antagonistic saprophytic fungus *Trichoderma viride* TH03. For present field experiments, three selected Italian strains of free-living nitrogen-fixing bacteria belonging to the BUSCoB culture collection were also used. The inoculum was added to the soil at three increasing concentrations (zero, 40, 80 Kg per ha) just after transplanting.

Organic compost inputs

A commercial organic certified green compost (1.87 % total N, 30.8 % total C), produced by Nuova Geovis S.p.A near Bologna, was added to the soil at three increasing concentrations (zero, 5.5 ton per ha, 11 ton per ha).

Field experiments

Trials were performed at the Carioncella organic farm, in northern Italy, which holds the AIAB-ICEA certificate since 1993. Tomato seedlings were transplanted in four replication blocks, sharing the same cultural history. Each block was randomly divided into three main plots and treated with described levels of organic compost (C), equivalent to zero, 100 kg N per ha, and 200 kg N per ha, incorporated into the soil prior to planting. Each main plot was separated from the others, and protected externally, by a row of border plants. Then, three subplots of twenty plants were randomly established within each C main plot, and treated with zero and two increasing levels of plant-probiotic 'experimental MICOSAT F' inoculum (M). Each subplot was separated from the others by five border plants.

Evaluations

The effect of PPM inoculum, organic compost, on tomato fruit yield and quality were studied during the growing season by measuring the vegetative development of five randomly sampled plants per subplot, at the age of 5, 8 and 12 weeks; total and marketable fresh weight, number of tomato fruits per subplot were recorded and expressed as sums. Probiotic-microorganisms colonisation of tomato roots was monitored by molecular methods (Picard *et al.*, 2004; Picard *et al.*, 1992) before planting, 5 and 9 weeks after planting.

Results

The first of our three scheduled experiments was successfully established and completed although the 2006 summer was unusually dry. Drought effects were balanced by appropriate irrigation.

Prior to inoculation, the 15-years-long organically managed soil of the Carioncella farmwas found to be very rich in PPMs. All checked tomato seedlings were found non-mycorrhizal before transplanting. After exposure to the experimental treatments, mycorrhization indexes were significantly different between the two varieties. For both compost and inoculum inputs, mycorrhizal status was insignificantly higher for ‘Riogrande’, while insignificantly lower for ‘Gordon’. However, these results should be confirmed by a second year experiment. Non-significant differences were recorded in this first year experiment for both total and marketable tomato fruit yields. Both cultivars showed non significant higher values for compost, while only ‘Gordon’ yields were positively influenced by inoculum (not significant). Plant development patterns were positively related with compost inputs in both cultivars, without significant variations among plant ages. ‘Gordon’ development was more responsive to inoculation than ‘Riogrande’ (not significant). Other recorded rhizosphere and fruit quality parameters are still under elaboration.

Discussion

Natural organic soil richness probably reduced the differences in microbial parameters within experimental plots, and a similar explication could be given for total and marketable tomato fruit yields. The significant differences for microbial colonization between varieties agree with previous findings on different crops (Bosco *et al.*, 2006; Picard *et al.*, 2005). Further research into microbial parameters such as community diversity and structure evaluation is necessary to understand the impact and interaction of natural soil microbial levels and inoculation.

Conclusions

A second and third year of field experiments are needed to give any scientifically sound conclusion.

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Indicators of weed competition on Organic Winter Wheat

Casagrande, M.[1], David, C.[2], Valantin-Morison, M.[1] and Jeuffroy, M.-H.[1]

Key words: organic winter wheat, weeds, indicators, weed density, Shannon index

Abstract

Organic winter wheat production is limited by climatic and agronomic factors, including weed competition. The incidence of weeds on yield limitation can be characterized through various early indicators to predict weed occurrence and competition. A network of 10 fields of organic winter wheat was implemented in the South East of France in 2005-2006. Results showed that weed density, dynamics and diversity are good indicators for weed occurrence and competition.

Introduction

The low and variable organic wheat grain yields (David *et al.*, 2004a) are essentially explained by climatic and agronomic factors including nitrogen deficiency, soil compaction and weed competition (David *et al.*, 2005 and Taylor *et al.*, 2001). It is now critical for organic farmers to improve and stabilize grain yield throughout a better control of limiting factors. Optimal N fertilization strategies can be derived from the Azodyn-Org model (David *et al.*, 2004b) in order to avoid the most detrimental N deficiencies as soon as the occurrence and effect of the major limiting factors can be predicted (Casagrande *et al.*, 2006). The aim of the work presented here is to assess early indicators of weed competition on organic winter wheat.

Previous studies linked weed density to grain yield (Dew, 1972) by considering crop density (Cousens, 1985) and weed emergence period (Cousens *et al.*, 1987). Previous results tried to modelize the relationship between weed density and crop yield (Swinton and Lyford, 1996). However, all those models were assessed on field experiments using only one weed specie. The objective of this study is to work on natural (and complex) weed populations observed on organic fields to evaluate the relationship between grain yield and weed population.

Materials and methods

Experimental design

A farmers' fields network was designed for this experiment including 10 organic winter wheat fields,grown in 2005-2006 in various locations in the Southeast of France. The fields were chosen in order to cover a large range of environmental conditions (particularly soil types and water availability) and cropping systems, leading *a priori* to various weed pressures. Variations in weed pressures were increased, through controlled treatments with (no weeding) or without (by-hand weeding) weeds compared with the farmers practices. and various fertilization strategies on 2 fields. An irrigated treatment was added in 3 fields to avoid water stress.

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Measurements

An homogeneous zone (around 1000 m²) regarding soil type was identified per field. Within this area, 4 to 7 sample plots (0.25 m²) per treatment were collected at harvest to measure grain yield at 0% moisture content, thousand kernel weight (TKW) and kernel number (KN).per square meter. According to the yield elaboration, KN variations expressed the vegetative period from sowing to flowering and TKW variations expressed the grain-filling period after flowering.

On these plots weed pressure and wheat development were characterized at five stages (beginning of tillering Feekes 2.0, tillers formed Feekes 3.0, first and second nodes Feekes 6.0 and 7.0, flowering Feekes 10.0 and harvest Feekes 11.0) through several variables: weed density developmental stage, and height per specie, cover rate by visual estimation and picture analysis Leaf Area Index, aboveground biomass and N content for the whole population,. Wheat was characterized by mean height, aerial biomass and N content.

Diversity indices are used to characterize communities, taking into account the richness of the community and the evenness of each species (Magurran, 1988 in Légère *et al.*, 2005). Shannon's index (H) takes into account specific diversity and abundance (Schaepfler, 2002):

$$H = -\sum_{i=1}^{S} \frac{n_i}{N} \log \frac{n_i}{N}$$

where S is the total number of species per plot, n_i the number of individuals per species per plot and N the total number of individuals per plot.

Statistical analysis

All statistical analyses were performed by using the SAS System 8.02. Analysis of variance were conducted with the PROC GLM procedure (significance at the p=0.05 level) and the Scheffe test was used for mean comparisons when significant differences were detected (P≤0.05).

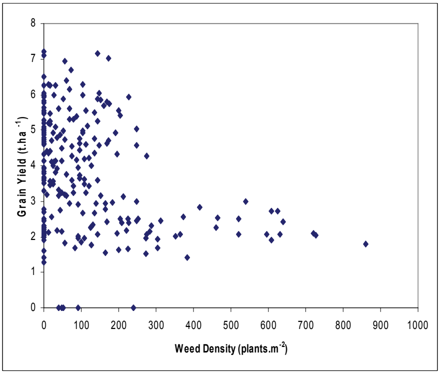
Results

Density as an indicator of weed pressure

We analysed several relationships between grain yield (GY) (t.ha^{-1}) and weed density (WD) (plants.m^{-2}) at different wheat stages. The closest relationship has been found for GY and WD at wheat flowering stage (Fig. 1). When WD ranges from 0 to 200 plants.m^{-2}, GY ranges from 0 to 7 t.ha^{-1}. When WD ranges from 200 to 300 plants.m^{-2}, GY decreases until 3 t.ha^{-1} and beyond 300 plants.m^{-2} maximum GY is about 3 t.ha^{-1}. Therefore, the high variability for grain yield, for each weed density should be explained by other limiting factors.

Weed dynamics as an indicator of weed pressure

It is difficult to link weed density at wheat flowering stage to density at prior wheat stages because evolutions of weed density are different from one field to another. For each field, weed density evolution was characterized either by 'increasing density', 'decreasing density', 'constant density' or 'increasing-decreasing density' depending on the behaviour of weed densities along the wheat crop cycle. We considered weed density evolution and weed density at different wheat stages as possible factors explaining wheat yield loss. Analysis of variance showed that the effect of weed dynamics with weed density as covariable was significant only at wheat flowering stage (Tab.1).



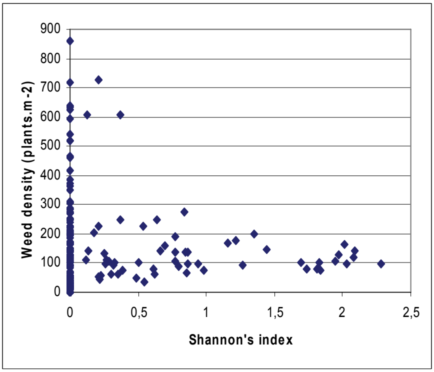


Figure 1 (left): Effect of weed density (plants.m^{-2}) on grain yield (t.ha^{-1}) in 10 fields in Southeast of France (2005-2006); Figure 2 (right): Relationship between the Shannon's Index at tillering and weed density at wheat flowering

Tab. 1: Variance analysis based on the model: GY = dynamics + WD (WD as covariable measured at wheat flowering stage)

Source	DF	SS Type III	Pr > F
Weed density Feekes 10.0	1	5427	<0.0001
Weed dynamics	3	8219	<0.0001

Grain yield was the most affected when weed density evolution was 'increasing' (mean GY: 3.40 t.ha^{-1}) and the least when evolution was 'constant' (average GY: 5.64 t.ha^{-1}). Mean comparisons showed non significant difference between 'increasing-decreasing' (average GY: 4.24 t.ha^{-1}) and 'decreasing' (average GY: 4.15 t.ha^{-1}) but significant differences between this group of dynamics and the two others: 'constant' and 'increasing'. Then weed density dynamic seems to be a good indicator of weed pressure on grain yield.

Diversity indices as indicators of weed pressure

We tried to link weed density at flowering to the Shannon's index (H), expressing the weed diversity on field, at beginning of tillering to define an early indicator of the weed composition (Fig. 2). High weed densities (over 300 pl/m²) linked with grain yield limitation yield are related with Shannon index below 0.5 (when the weed diversity was under 2 species per field). Consequently, dominant population can affect grain yield.

Discussion

Next step will be to fit a function for the relationship between grain yield and weed density in order to determine whether the function is linear, quadratic or sigmoidal. Effect of weed density evolution was significant on crop yield. This result substantiate that previous studies showed that predicting weed emergence was critical for development of crop yield loss models (Conley et al, 203). There is also a real stake at studying diversity indicators because previous studies showed that the relative impact of weed species on crop yield varies not only with density but with ratio (Swanton et al, 1999).

If we assume that we can predict weed dynamics and density when we know weed composition at early stages, there is a great opportunity to identify weed population compositions in order to predict grain yield limitation.

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Nitrogenous substances in potato (*Solanum tuberosum* L.) tubers produced under organic and conventional crop management

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Key words: potatoes, proteins, nitrates, organic crop management

Abstract

The contribution presents data on crude protein and protein, free amino acid and nitrate contents in potato tubers produced under different crop management systems – conventional and organic. Field trials were carried out with five potato cultivars on two sites of different altitudes in 2005. The mean content of crude protein was significantly higher in tubers from organic crop management than in tubers from the conventional system (10.92 and 9.76 % in dry matter, respectively). Similar results were observed in protein content (5.44 % and 5.09 % in dry matter, respectively). Cultivar was the factor having the highest direct effect on crude protein as well as protein contents. Tubers from conventional crop management showed an increased tendency to accumulate nitrates.

Introduction

The crude protein (N x 6.25) represents in tubers approximately 2 % of fresh weight basis and creates approximately 10 % of the tubers' dry matter. However, content of crude protein may range widely in dependence on genotype and growing conditions (Debre and Brindza 1996). Crude protein comprises a number of nitrogen fractions; the most important for human nutrition are the protein fraction, amides and free amino acids (Eppendorfer *et al.* 1979). The protein fraction (pure protein) constitutes in average about 50 % of nitrogen compounds of potato tubers, with ranges between 34 % and 70 % (Shewry 2003) Nitrates rank among basic plant nutrients and their presence in plant organs is thus natural. They are harmful regarding human nutrition and health.

Nitrogen has a direct effect on tuber yield and quality. In average, 50 kg of N is needed for 10 t of tuber production (Jasińska and Kotecki 1999). Nitrogen requirement is filled in conventional potato management by external nitrogen input in form of nitrogen fertilisers. In organic crop management, the crop requirement is resolved by nitrogen balance within crop rotation and nitrogen recovery from soil organic matter (Kölsch and Stöppler 1990, Vokál *et al.* 2004).

The aim of this study was to evaluate the content of nitrogenous substances in potato tubers from different crop management systems - organic versus conventional.

Materials and methods

The field trials with different crop management – conventional (CCM) and organic (OCM) - were carried out on two sites with different altitudes – Volyně (460 m; 49°

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10´N 13° 54´E) and Pacov (620 m; 49° 34´N, 14° 58´E), Czech Republic, in 2005. The trials included five potato cultivars – Rosara (very early), Marabel (early), Karin (early), Satina (semi-early) and Bionta (late). The experiments were carried out in individual small plots (plot area 6.75 m^2) which were arranged in a randomized complete block design replicated four times. Mineral fertilisers (at level 100 kg N, 35 kg P and 60 kg K per hectare), manure application (40 t ha^{-1}) and chemical control of Colorado beetle and late blight were applied in CCM, while OCM system included only manure application (40 t.ha^{-1}). The sums of rainfall and mean temperature during the vegetative period (April-September 2005) were: 556 mm and 14.8°C for the site Volyně and 507 mm and 13.8°C for the site Pacov.

Tubers were three months stored (under 4°C) after hand harvest and then following parameters were analysed:

a) crude protein content by modified Dumas method using analyzer Flash EA 1112, USA/Italy,

b) protein content by BCA Protein Assay Kit, Pierce, USA,

c) free amino acids content by RP-HPLC,

d) nitrate content by ion-selective electrode.

Contents of the determined components were expressed in tuber dry matter (DM). The obtained data were analysed with the software STATISTICA, two-way ANOVA (relative variance components) and Tukey HSD test.

Results and discussion

The results of evaluated parameters – crude protein, protein, free amino acids and nitrate contents - are given in Tables 1 to 4. Expected higher contents of crude protein and protein in dry matter of potato tubers produced under conventional crop management were not observed. Significantly higher content of crude protein was found in 6 variants of potato tubers originated from organic crop management and in only one variant of conventional crop management (Table 1).

Tab. 1: Crude protein content in potato tubers (% DM)

	Site Volyně			Site Pacov		
Cultivar	CCM	OCM	LS	CCM	OCM	LS
Rosara	12.25	12.89	*	12.75	11.61	***
Marabel	9.61	14.05	***	10.70	10.92	n.s.
Karin	10.00	12.08	***	9.38	10.07	*
Satina	8.78	11.79	***	7.52	7.72	n.s.
Bionta	9.37	8.87	n.s.	7.28	9.19	***

* significant for *P*<0.05; ** significant for *P*<0.01; *** significant for *P*<0.001; n.s. not significant (Tukey HSD test)

DM - dry matter; LS - level of significance; CCM - conventional crop management; OCM - organic crop management

Tab. 2: Protein content in potato tubers (% DM)

	Site Volyně			Site Pacov		
Cultivar	CCM	OCM	LS	CCM	OCM	LS
Rosara	4.33	4.42	n.s.	5.04	5.09	n.s
Marabel	6.14	7.90	***	6.66	4.58	***
Karin	5.38	5.50	n.s	4.60	5.51	***
Satina	5.35	7.22	***	5.25	4.95	n.s
Bionta	3.92	4.82	**	4.09	4.46	n.s.

For abbreviations and symbols see Table 1

Tab. 3: Free amino acids content in potato tubers (% DM)

	Site Volyně			Site Pacov		
Cultivar	CCM	OCM	LS	CCM	OCM	LS
Rosara	3.48	3.70	n.s.	3.32	3.08	n.s
Marabel	2.00	2.67	***	2.23	1.53	***
Karin	2.92	3.95	***	2.91	2.70	n.s
Satina	2.17	3.09	***	1.65	1.50	n.s.
Bionta	1.81	2.10	n.s.	1.87	2.09	n.s.

For abbreviations and symbols see Table 1

Tab. 4: Nitrate content in potato tubers (mg kg^{-1} fresh matter)

	Site Volyně			Site Pacov		
Cultivar	CCM	OCM	LS	CCM	OCM	LS
Rosara	327	148	***	200	153	***
Marabel	178	131	***	137	73	***
Karin	147	71	***	104	97	n.s.
Satina	139	120	*	107	108	n.s.
Bionta	243	136	***	169	167	n.s.

For abbreviations and symbols see Table 1

Mean content of crude protein was significantly higher in tubers from organic crop management (10.92 % DM) than in tubers from conventional crop management (9.76 % DM). Similar findings were observed in true protein content and free amino acids content (Tables 2 and 3). Organic crop management produced tubers with significantly higher protein content (mean 5.44 % DM) as compared with tubers from the conventional system with mean 5.09 % of true protein in DM. From three tested factors (cultivar, crop management and site), cultivar had the highest direct effect on crude protein as well as protein contents (46 and 37%, respectively). The effect of crop management showed itself particularly in interactions with other tested factors. Nitrate content was affected primarily by cultivar (351 %), but direct effect of different crop management was also important (20.9 %). In seven from ten tested variants (Table 4), tubers produced under conventional system had significantly higher nitrate content than tubers from organic crop management. The highest nitrate content was determined in the very early cultivar Rosara. The obtained results confirmed lower nitrate accumulation in tubers produced under organic crop management (Kölsch and Stöppler 1990). The Czech statutory limit of 300 mg kg-1 of nitrate on tuber fresh basis was not exceeded and there seems to be an extensive reserve. In spite of evaluation data from the only one experimental year, the results indicate that production of potato tubers in organic crop management has a better chance to obtain tubers with higher protein content and with lower accumulation of nitrates than tubers from conventional crop management. Moreover, conventional potato management is dependent on nitrogen supply from mineral fertilisers. Validity of this trend is necessary to verify in multi-annual experiments.

Conclusions

The mean content of crude protein was significantly higher in tubers produced under organic crop management (10.92 % DM) than in tubers cultivated under conventional crop management (9.76 % DM). Similar findings were observed for protein and free amino acids contents. Tubers from organic system showed a mean content of protein 5.44 % in dry matter, while tubers from conventional crop management contained 5.09 % in dry matter. Tubers from conventional system had also higher nitrate content than tubers from organic crop management. The results indicate that production of potato tubers in organic crop management has better chance for production of tubers with higher protein content and with lower accumulation of nitrates.

Acknowledgments

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Breeding for improved responsiveness to arbuscular mycorrhizal fungi in onion

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Key words: Onion, *Allium cepa* L., arbuscular mycorrhizal fungi, low input farming, *Allium* fistulosum*, Allium roylei*

Abstract

Arbuscular mycorrhizal fungi (AMF) play an important role in the uptake of nutrients and water from soil. Onions, Allium cepa L., are plants with a shallow root system. As a result, onion plants need a lot of fertiziler for their growth. Furthermore, onion plants are sensitive to drought. The aim of the current research project is to study the beneficial effect of mycorrhizal fungi on the growth and development of Allium species and to determine whether it is possible to improve onions for mycorrhizal responsiveness by means of breeding. Variation among Allium species and segregation observed in a interspecific tri-hybrid population indicate that selection and thus breeding for high responsiveness to AMF is possible.

Introduction

Arbuscular mycorrhizal fungi (AMF) are fungi that occur naturally in soil. These fungi play an important role in plant growth since they contribute to the uptake of nutrients and water from soils (Ryan and Graham, 2002). Onion (*Allium cepa* L.) is one of the leading vegetable crops worldwide. Also in Europe, the crop is of considerable economic importance. The global distribution of onions is due to the universal acceptance for food and condiment, but certainly not due to its simplicity of growing. In fact, onion is a crop that is difficult to cultivate and one of the major challenges is to provide onion plants with sufficient nutrients (Brewster, 1994). For onions large amounts of fertilizer are needed. The sustainability of large fertilizer input is highly questioned and growing onions in low-input systems with reduced fertilizer inputs are gaining ground. For low-input systems, plants have to be good nutrient scavengers. Therefore, productivity and stability of onion production in such systems can be problematic (Greenwood et al, 1982). Onion root systems consist of superficial roots that are rarely branched and lack root hairs (Portas, 1973), making them inefficient in uptake capacity of water and nutrients such as phosphate (Wininger et al, 2003). A possible route to improve the uptake of water and nutrients in onions is to improve its root system. A wild relative of onion, *Allium fistulosum* L., is known for its extensive root system. Via a bridge cross with *Allium roylei* genes from *A. fistulosum* can be introgressed into onion germplasm as was shown by Khrustaleva & Kik (2000). Subsequently De Melo (2003) studied the genetic basis of the root system of *A. fistulosum* and concluded that it is relatively easy to improve the root system of onion through breeding. Another and complementary approach is the use of arbuscular mycorrhizal fungi (AMF). From earlier studies, it is known that onion plants can associate with AMF (Stribley, 1990; Charron *et al.*, 2001). For example, the application

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of AMF in greenhouse experiments using organically managed soils resulted in yield increases of *Allium fistulosum* between 50 and 60% and significant increase of soil rooting area (De Melo, 2003).

The aim of the present research was to study the beneficial effect of arbuscular mycorrhizal fungi on the growth and development of *Allium* species, and to determine whether it is possible to improve onions for mycorrhizal responsiveness by means of breeding.

Materials and methods

A tri-hybrid population was developed as described by Khrustaleva and Kik (1998). First, *Allium roylei* (RR) was crossed to *A. fistulosum* (FF). A specific RF genotype was chosen as pollen donor in a cross with onion (CC). Consequently, a population of *A. cepa x (A. roylei x A. fistulosum)* was built (referred to as CCxRF), each genotype carrying a set of *A. cepa* chromosomes and a set of an *A. roylei* - *A. fistulosum* combination. Seventy-seven genotypes were tested for responsiveness. AMF species *G. intraradices,* was kindly provided by Dr. Y. Kapulnik, Volcani Centre Israel.

The experiment was carried out in a climate controlled greenhouse (day/night 22/17 °C), using the population, the parental species and the RF-hybrid. Each genotype was vegetatively multiplied, and transferred to individual pots containing a mixture of sterilized clay soil, sand and perlite (6:1:1, v/v/v). AMF was added to the plant hole just before transplanting. Per genotype, six replications were used with AMF (treated plants) and six with sterilized AMF (control plants, NM). After five weeks, AMF-colonization was quantified using the grid method (Brundrett *et al.* 1996). Colonization ranged from 30-40% in the AMF treatment, and no mycorrhiza was observed in roots of control plants. Plants were harvested thirteen weeks after transplantation. During their growth and also at harvest several characteristics of the plants were measured, such as: total fresh and dry weight, and their partitioning in leaves, bulb or stem, and roots. Also the number of leaves, stems, and roots was recorded, as well as plant height. AMF responsiveness was calculated as the increase in plant height or weight compared to the non-mycorrhiza treatment: $(W_{AMF} – W_{NM})/W_{NM} * 100$. Responsiveness was considered significant when the AMF and control treatment were statistically different ($p<0.05$). In this paper only results of plant height and fresh weight will be given attention. Other results still have to be analysed.

Results and Discussion

AMF had a significant effect on plant height of the tri-hybrid population. In the control plants the average height of the longest leaves varied between 21 and 45 cm, whereas this varied between 33 and 57 cm when AMF was applied (Figure 1). The frequency distribution of the individual genotypes of the tri-hybrid population for their responsiveness to AMF analysing plant height as the trait of interest clearly demonstrated genetic variation in responsiveness varying from plants that did not or hardly respond to AMF to plants that showed an increase of 100 % in plant height (Figure 2). AMF also had a positively influence on total fresh weight of plants at harvest (Figure 3). Treatments with AMF had an average fresh weight between 10 and 65 g, whereas control plants weighted between 0 and 25 g. The CCxRF genotypes segregated from no or hardly any responsiveness to 500% increase.

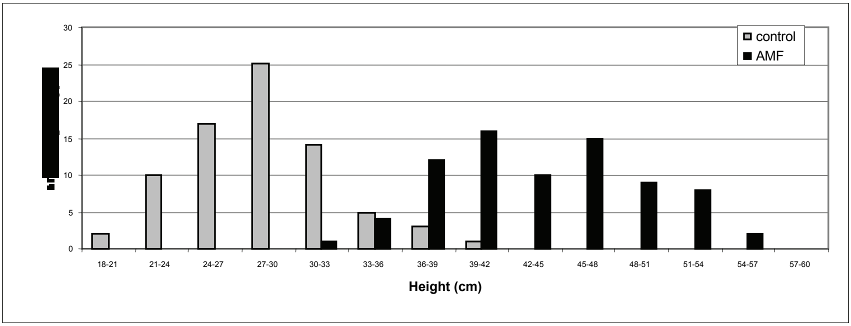

Figure 1. Frequency distribution of individual genotypes of the CCxRF population in plant height classes (longest leaf from the ground level, in cm) for the *Glomus intraradices* treatment (AMF) and the control, nine weeks after inoculation. The distributions do not include the parents.

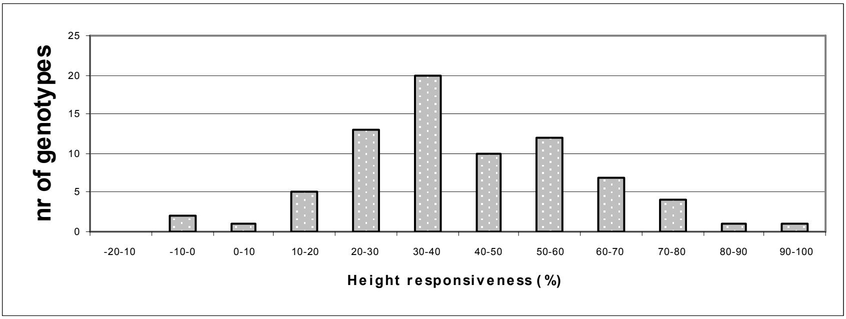

Figure 2. Frequency distribution of individual genotypes of the CCxRF population in plant height responsiveness to *Glomus intraradices* (see text for calculation), nine weeks after inoculation. The distribution does not include the parents.

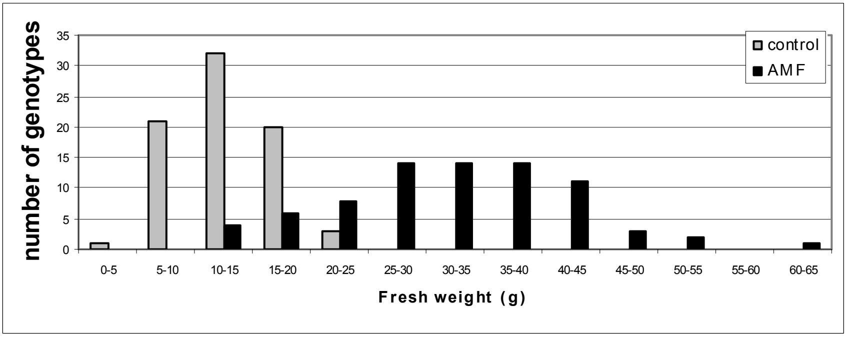

Figure 3. Frequency distribution of individual genotypes of the CCxRF population in fresh weight for the *Glomus intraradices* treatment (+AMF) and the control. The distributions do not include the parents.

Based on the aforementioned results the next step in our research will be the analysis of the genetic basis of mycorrhizal responsiveness in the CCxRF population via QTL mapping. Clarification of the genetic basis may help to find exiting possibilities for the development of onion cultivars more suited for low input farming. The reason for this is that we expect to find not only traits to improve the rooting system but also to improve the mycorrhizal responsiveness by making crosses between *A. fistulosum* and onion.

Conclusions

The results support the hypothesis that exploitation of *A. fistulosum* is an interesting option to improve onions by breeding to obtain cultivars better adapted to low input farming because of their improved rooting system and mycorrhizal responsiveness.

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Weed Management in Organic Farming in the New EU Member States and the Acceding Countries - Status Quo and Main Limitations

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Key words: EU, organic farming, weed management, weeds, alien species

Abstract

Under the EU Specific Support Action (SSA) Project CHANNEL ('Opening Channels of Communication between the Associated Candidate Countries and the EU in Ecological Farming'), a survey on the status quo in weed management was conducted in 15 new member and acceding EU states. The focus of the data collection was on three main aspects relevant for the understanding of the current situation, they are: i.) legal and administrative framework, ii.) status quo in practice and iii.) scientific basis. These aspects were covered by separate questionnaires, addressed to different authorities and target groups.

The results of the weed management questionnaire for the target group 'experts engaged in practical farming' are presented in this paper. The analysis allowed the identification of a small group of weeds as the main target species of organic weed management. Alien species were reported by almost all countries as an upcoming problem in organic farming. There was conformity among the different countries in regards to the choice of prevention tools, whereas an obvious lack of modern equipment available for practicing mechanical weed control was noted. Within the new EU member states and candidate countries, the economic constraints (lack of available machinery, lack of capital and high economic costs) were stated as the main limitations of weed management success. The economic costs of weed management in general, could not yet be covered by the market prices of organic products. Therefore, the economic pressure and the scope for improving weed management in practice are small. In most countries, the scientific sector (facilities, projects and advisory services) working on weed management issues in organic farming is relatively small. The lack of project funding in this area limits the research profoundly.

Introduction

The EU accession of the new member states in May 2004 has coincided with the review and adjustment of the main instruments of the Common Agricultural Policy (CAP). With regard to the new member states and the acceding countries, it became obvious that the state-of-the-art information of organic farming is at present lacking. The EU-SSA Project CHANNEL ('Opening Channels of Communication between the Associated Candidate Countries and the EU in Ecological Farming'), which ran between the years 2004-2006, was aimed at bridging this gap and improving the knowledge on specific situations in the new member states. 25 project partners from 15 different countries, among them all the newly accessed countries in 2004 and the acceding countries Bulgaria and Romania, as well as the old member states Austria, Italy and Germany, participated in the CHANNEL project.

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Weed management was chosen as one of the six subjects for data elevation, because it is one of the most difficult and cost-intensive problem faced in organically managed crops (Clark *et al.* 1998). In the new member states in particular, organic farming is located with a high frequency in marginal or ecologically sensitive landscapes. Organic farming is regarded there as an alternative that allows for the continuation of agricultural production, which helps prevent the abandonment of land.
The working group 'Weed Management' elevated data on the following issues: i.) land use and natural frame conditions, ii.) legal and administrative background for weed management, iii.) expert assessments on the status-quo of weed infestation, management practices and limitations in weed management, iv.) scientific and educational background, including an overview on recent research projects.

Materials and methods

The main tools for gathering data were standardised questionnaires addressed to three different target groups: a.) public authorities (governmental and regional bodies), b.) experts (e.g. advisory bodies, farmers' associations) and c.) scientists (research institutes and universities). The questionnaires were distributed to the relevant stakeholders via national representatives of each country. Only experts with a broad overview on their respective countries would be involved in the questionnaires. For countries with a large area under organic farming, multiple answered questionnaires were requested. The results of the weed management group were based on the feedback from an overall of 84 single contributions (questionnaires), among them 24 from administrative bodies, 38 from experts and 22 from the scientific sector. The incoming answers were checked for their quality and reliability using a standardised methodology that included the following parameters: completeness, plausibility, clarity/wording, scientific nomenclature, contradictions between multiple answers, professional focus of the author, spatial representation of the experts, cross checking with existing literature/data sources. Feedback loops with the national representatives were used to clarify identified problems. The country representatives had to be in agreement with the modifications resulting from the data validation and declare the reliability of their data with an official statement.

In addition to hard facts, some subjective assessments were requested, e.g. for the identification of main constraints of the current situation.

Results

Most frequent weed species on arable land

Despite differences in farm size, historical background and other frame conditions, a few weeds that occur in almost all countries had been unanimously listed to cause the main problem in weed control. These were above all *Cirsium arvense* (L.)Scop., *Elymus repens* (L.)Gould., *Chenopodium album* L., *Galium aparine* L. and different chamomile species. It was only in the Mediterranean countries where these species were not listed as being relevant in weed control. Beside the above named, the following species were listed as main targets for weed management (in brackets: number of countries, where it is frequently found): *Amaranthus sp.* (incl. *A. retroflexus* L.) (8), *Matricaria sp.* (incl. *T. perforatum* (Merat) Lainz, *M. recutita* L., *M. discoidea* DC.) (7), *Avena fatua* L. (6), *Convolvulus arvensis* L. (6), *Echinochloa crus-galli* (L.) P. Beauv. (5), *Apera spica-venti* (L.) P. Beauv. (4), *Capsella bursa-pastoris* (L.) Medik. (4), *Equisetum arvense* L. (4), *Galeopsis sp.* (incl. *G. tetrahit* L.) (4), *Sinapis arvensis*

L. (4), *Sonchus arvensis* L. (4), *Sorghum halepense* (L.) Pers. (4), *Stellaria media* (L.) Vill. (4).

Alien weed species relevant to organic farming

Most countries (11 out of 13) reported on the relevance of alien species. The following species had been named as important in organic farming (in brackets the country codes): *Abutilon theophrasti* Med. (SK, SL), *Ambrosia artemisiifolia* L. (SK, HU), *Andrachne telephioides* L. (CY), *Asclepias syriaca* L. (HU), *Avena fatua* L. (LT, LV), *Commelina benghalensis* L. (CY), *Conium maculatum* L. (CZ), *Datura stramonium* L. (AT, HU), *Heracleum mantegazzianum* Sommier et Levier/*sosnowskyi* Manden (CR, EE, LT), *Heracleum sphondylium ssp. sibiricum* (L.) A.&G. (LV), *Impatiens glandulifera* Royle (CZ), *Iva xanthiifolia* Nutt. (SK), *Nicotiana glauca* Graham. (IT), *Oxalis pes-caprae* L. (CY), *Panicum sp.* (SK), *Sorghum halepense* (L.)Pers. (HU, SK).

Measures to prevent weed infestation

Crop rotation and primary soil tillage are the main tools used in all countries included in this survey. Except for the Mediterranean countries, the choice of cultivars and sowing density and stubble cultivation were also seen as common tools. Row width adjustment, catch crop or cover crop growing and inter-cropping were common practices in two thirds of the countries. Inter-cropping had been a traditional tool in the Mediterranean countries applied more commonly in small farm holdings. Undersowing was reported by eight countries.

Machinery commonly used for direct weed regulation on arable land

Major groups of machinery were categorised to allow the comparison of machinery from different countries. They were as follows: flex-tine harrow, rotary hoe, finger weeder, flame weeder, brush hoe, cultivator, hoe and rigid tine harrow. Experts gave estimations on the countrywide distribution of the machinery using the terms ‘not common’, ‘common’ or ‘very common’.

Figure 1 summarises the application of the different tools in each country. The order is related to two main groups of machinery: first three – non-typical ‘traditional’ tools for weed management (cultivators, hoes, rigid tine harrows) and the last two – special ‘new’ tools for weed control (flex tine harrows, finger weeder, rotary hoes, …..). The availability of machinery is depending on the size of the farms. More different and modern tools were available on farms with more than 50 ha.

Importance of weed management

Weed management was considered as the main criterion for successful organic farming and as the main objective in the planning/choosing of most of the plant production measures by nearly all countries. Weed infestation is one of the main factors limiting crop yield levels in most of the new EU member states and candidate countries. The question of whether the whole cropping system or only single measures should be modified to improve weed management success depends greatly on the kind of production profile, the natural site conditions, and the available agro technological tools. It seemed that problems in cereal oriented production systems were easier to handle than in other systems.

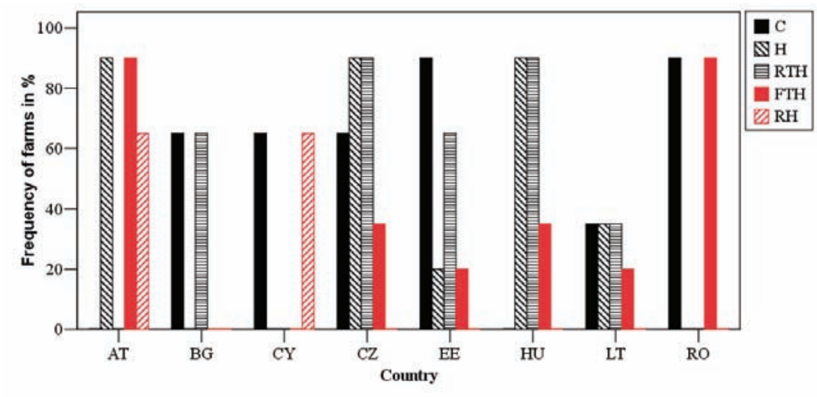

Figure 1: Machinery used for organic weed management on arable land

(N = 38 experts, legend: C-Cultivator; H-Hoes; RTH-rigid tine harrow; FTH-flex-tine harrow; RH-Rotary Hoe; country codes: AT-Austria, BG-Bulgaria, CY-Cyprus, CZ-Czech Republic, EE-Estonia, HU-Hungary, LV-Latvia, LT-Lithuania, RO-Romania)

Limiting factors for weed management success

National experts were asked to pass their subjective opinion on the most limiting factors for improving weed management success. Some pre-defined answer categories were provided to ensure comparability between the particular countries. The results of this question are summarised in Table 1.

Tab. 1: 'What are the most important limitations on improving weed management success in organic farming in your country?'

Limitations	AT	BG	CY	CZ	EE	DE	HU	LV	LT	PL	RO	SK	SI
Specific natural conditions	2-3	2	2	1-2	2	2	2	1	2	1	1	3	2
Economic costs	2	3	3	3	3	2	3	2	2	3	3	1	3
Available machinery	2	3	2	2	3	2	3	3	2	1	3	1	3
Capital for investments	1-2	3	2	3	3	2	3	2	2	3	3	1	3
Political / adm. frame conditions	1	2	1	1	1	1	1	1	1		2	1	1
Education	2	2	2	1-2	3	1-2	3	2	3	2	2	2	3
Scientific background	2	2	2	2	2	1-2	2	2	3	2	2	2	2
Advisory services	2	0	2	2	3	1	3	2	3	1	2	3	2

(categories: 3 - yes, that´s totally right; 2 - yes, that´s partly true; 1 - non, that´s not the point; intermediate values - multiple differing answers, N = 38 experts, AT-Austria, BG-Bulgaria, CY-Cyprus, CZ-Czech Republic, DE- Germany, EE-Estonia, HU-Hungary, LV-Latvia, LT-Lithuania, PL-Poland, Ro-Romania, SK-Slovakia, SI-Slovenia)

Discussion

The CHANNEL project was targeted on the promotion of communication between experts, data collection and exchange of information. The findings of the current project should therefore not be regarded as the result of a statistical farm survey or a research subject.

Weed infestation was, in most of the new EU member states and candidate countries, one of the main factors limiting crop yield. Despite differences in farm size, historical background and other frame conditions, there is a small number of the same noxious weeds that occur in almost all countries. These were, on arable land, *Amaranthus sp.*, *Cirsium arvense* (L.) Scop., *Elymus repens* (L.) Gould., *Chenopodium album* L., *Galium aparine* L. and different chamomile species. The dominance of these weeds is neither restricted to the new EU member states nor to organic farming (Becker and Hurle 1998, Salonen *et al.* 2001). However, the frequency of these weeds is some times higher on organic fields compared to conventional ones (Rydberg and Milberg 2000). The existing methods seem to be insufficient for the management of these species hitherto. Alien weed species are a considerable problem in organic farming throughout the participating countries. Monitoring of and research on control methods would be recommended. The most common machineries used, such as cultivator, hoe and rigid tine harrow, were typical for conventional farming and are not adapted to the specific needs of organic farming, e. g. for mechanical weed control in narrowly spaced crops or in crops with great crop height. As a recent trend, the use of the flex-tine harrow had spread in a number of these countries. Other modern machinery, such as the finger weeder, rotary hoe or flame weeder are not frequently used in the new member and candidate countries. Economic constraints (lack of available machinery, lack of capital and high economic costs) were stated as the main limitations of the improvement of weed management success. Education and advisory services were only partly regarded as limiting factors. Nevertheless, improvements in these sectors are needed in order for new practical methods to be developed.

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Effect of alternative seed treatments on seed-borne fungal diseases in tomato

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Key words: seeborne fungal diseases, tomato, *Didymella lycopersici,* alternative seed treatments, thiram, nitrite, resistance inducing agents

Abstract

The fungus Didymella lycopersici infects tomato seed and results in great losses before and after germination. To control the disease, seed companies use thiram preventively, although human allergy problems have been reported. For this reason as well as to address needs in organic agriculture, this study has focused on the effects of alternative methods of control. Nitrite solutions and resistance inducers were tested in a growth chamber. Results showed that soaking the seed in a nitrite solution with a concentration of 300mM (in citric acid buffer, pH 2) for 10 minutes reduced losses due to low seed germination and disease incidence in the germinated seedlings completely. When applied for longer intervals sodium nitrite proved phytotoxic whereas in shorter intervals it was not as effective. The resistance inducer Tillecur (mustard seed extract) at the rate of 0.05g/ml was as much effective as sodium nitrite inhibiting disease incidence in germinated seedlings. None of the above treatments was significantly different to thiram and they could replace the fungicide in the control of seedborne D. lycopersici in tomato.

Introduction

Didymella lycopersici Kleb. is one of the most important seedborne diseases of tomato. *D. lycopersici* infections considerably affect seed germination while seedlings die within a week of infection appearance (Khulbe *et al.*, 1991). Currently, *D. lycopersici* can be controlled by seed treatment with the fungicide thiram, although some reports associate it with human allergies (Knox-Davis, 2001; Munkvold *et al.*,1999).

The aim of this study was to assess the efficacy of alternative seed treatments such as acid activated antimicrobial compounds (eg. nitrite) and resistance inducing agents against seed borne inocula of *D. lycopersici*.

Materials and methods

Seeds used were collected from inoculated and healthy fruits (uninoculated control). After application of treatments, seeds were sown individually in plastic pots (8 x 10cm) containing peat substrate ('Favorit', Germany) and placed in a walk-in growth chamber set at 19ºC and 12/12 photoperiod in a 'Randomised block' design with 4 blocks (replicates).

Fungicides (positive control treatments) were applied at the following rates: Kocide 101 (copper hydroxide 50% WP, Griffin LLC, USA) at 0.003 g/ ml and Thirasan (thiram

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80%WP, Bayer, Germany) at 0.001g per 0.25g seed.

Nitrite was used at the following concentrations: 30, 100 and 300mM and pH 2 and 2.5 in a citric acid buffer solution and at different exposure times (2.5-30 minutes).

Resistance inducing agents used were: a) Tillekur (‘Biofa’, Germany) at the rates of 0.0125, 0.025, 0.05, 0.1, 0.2 and 0 .4g /ml, b) Chitosan (deacetylated chitin, min 85%, Sigma, Germany) at the rates of 0.0025, 0.005, 0.01 and 0.05 g / ml of acetic acid (0.05%) and c) BABA (β-aminobutyric acid, min. 95%, Sigma, Germany) at the rates of 0.005, 0.01 and 0.05 g / ml.

Records of a) percentage of emerging seedlings and b) percentage of disease incidence in seedlings were taken thirty days after sowing for all of the experiments. Data were logit transformed (logit = ln (%incidence+0.1)/ (100.1-% incidence)) assuming an asymptote of 100%.

Data were analyzed by Univariate Analysis of Variance (ANOVA). Individual treatments means were compared by Tukey’s HSD test of homogenous subsets ($P \leq 0.05$). The statistical package SPSS ed. 11 for Windows was used.

Eight experiments were performed in total: five with the nitrite solutions and three with the resistance inducers. The most effective treatments tested in the experiments applied on the seeds for ten minutes are listed in Table 1.

Table 1: The most effective treatments tested, in all of the experiments

	Nitrite (300mM, pH2)	**Tillecur** (0.05g/ml)	**Chitosan** (0.005g/ml)	**BABA** (0.005g/ml)	**Copper hydroxide** (0.003g/ml)	**Thiram** (0.001g/ 0.25g seed)
Exp. 1	*				*	*
Exp. 2	*					
Exp. 3	*					
Exp. 4	*					
Exp. 5	*				*	*
Exp. 6			*	*		*
Exp. 7		*	*			*
Exp. 8		*	*			*

Results and Discussion

Acidified nitrite, Tillecur and the fungicide thiram, at the concentrations presented in tables 1 and 2, significantly reduced disease incidence (100% inhibition of disease appearance) in young seedlings in all of the experiments. The efficacy of the above treatments to control the disease before emergence of seedlings was inconsistent and differences to untreated control were not always significant (table 2). Copper hydroxide and BABA did not provide adequate control against the disease, while Tillecur at high concentrations (0.1, 0.2 and 0.4/ml) and nitrite at times of exposure longer than ten minutes proved to be toxic to the tomato seed (individual results not shown). Chitosan at the concentration 0.005g/ml significantly reduced disease incidence in young seedlings, in all of the three experiments that it was tested. In the two out of three experiments it controlled disease completely (95-100%).

Table 2: Results of the most effective treatments tested compared to the untreated control by Tukey's HSD test of homogenous subsets (P ≤ 0.05), in all of the experiments, for the control of tomato seedborne *Didymella lycopersici*, in the growth chamber

Exposure time: 10 minutes	**% Inhibition of the disease**		
Treatment	Before germination*	After germination**	Toxicity
Nitrite (300mM, pH2)	0-24	100	Non-toxic
Tillecur (0.05g/ml)	0	100	Non-toxic
Chitosan (0.005g/ml)	0	51-100	Non-toxic
BABA (0.005g/ml)	0	17	Non-toxic
Copper hydroxide (0.003g/ml)	0-10	15	Non-toxic
Thiram (0.001g / 0.25g seed)	7-21	100	Non-toxic

* Significantly different to the untreated control: nitrite in two out of five experiments and thiram in one out of five experiments
** Significantly different to the untreated control in all of the experiments tested

Conclusions

Given the above results, both nitrite and the inducing agent Tillecur could be used as alternatives to the fungicide thiram since they provided equal levels of disease control.

Acknowledgments

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Dual roles of spent mushroom substrate on soil improvement and enhanced drought tolerance of wheat *Triticum aestivum*

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Key words: drought, spent mushroom substrate, soil remediation, wheat

Abstract

This study examines the effects of the spent substrate of oyster mushroom (SMS) for growing wheat at different drought conditions. The SMS not only served as the sole fertilizer to produce normal growth and grain yield of wheat but also improved the soil quality after harvest to raise the soil organic matter, maintain the soil alkalinity and increase field capacity unlike the synthetic fertilizer amendment. Simultaneously, SMS treatment enhanced drought tolerance of wheat by enabling germination at 8.5% soil water content and completing sexual reproduction to grain production even at 6.3% soil water content.

Introduction

Water shortage is a cosmopolitan problem that one person in five is inaccessible to safe drinking water. 70% fresh water of human activities are used in agriculture (http://www.epa.gov). Drought attacks 14% of the wheat fields in Europe and affects over 12 million acres of agricultural soil in China (http://www.fao.org; http://www.agri.gov.cn). Nevertheless, being an active and rapid nutrient depletion process, more than 140- million tons of inorganic fertilizers were used for agricultural activities (http://www.fao.org), application of which inevitably introduces contaminants especially heavy metals to the farmlands (Gimeno *et al.*1995). About 13.4% of farmlands worldwide suffer from heavy metal contamination (http://www.epa.gov). Spent mushroom substrate (SMS) is the solid residue left after harvest of the aerial crop in mushroom industry and is generated at a ratio of 2 - 5 to 1 of the edible crop (Chiu *et al.* 2000). Over 3.3 million tonnes of edible mushrooms were produced in 2005, and over 34% were grown in Europe (http://www.fao.org). With the readily available nutrients released from substrate degradation and high organic matter content, SMS has been employed as a soil amendment agent (Gong *et al.* 2006, Lau *et al.* 2003 and Law *et al.* 2003). In this study, oyster mushroom of the genus *Pleurotus* was used as it could grow worldwide on a variety of substrates (e.g. coffee pulp, sawdust, straw) (Chang *et al.* 2004 and Chiu *et al.* 2000). Wheat *T. aestivum* is the champion crop produced in China who is also the champion producer and exporter of edible and medicinal mushrooms. Thus, we aim to test the feasibility of substituting synthetic fertilizer (SYN) with the SMS of mushroom *P. pulmonarius* in growing wheat and assess the impacts on soil properties as well as determine any protective effect of the SMS on wheat from drought stress.

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Materials and methods

Preparation of the P. pulmonarius SMS

Straw, wheat bran and lime were mechanically mixed in a ratio of 86:13:1 (w/w/w) and piled up for one-week fermentation with two turnings to avoid overheat. After packed, autoclaved at 121°C and inoculated with *P. pulmonarius* strain PL-27, the culture was incubated in darkness at 28°C until the mycelium fully colonized the substrate. Then the culture was transferred to an environmental chamber under 12 hr dark and 12 light illumination cycles at 28°C with 80 % relative humidity. The solid residue after mushroom harvest, called SMS was collected for later use (Chiu et al. 1998). The characteristics of SMS in this study were listed in Table 1.

Tab. 1: Characterization of SMS used in this study (Mean±SD,n=5)

Parameter	$NOx_{water-soluble}$ (mg/kg)	$N_{Kjeldahl}$ (mg/kg)	P_{total} (mg/kg)	K (mg/kg)	pH	Salinity (%)
SMS	452 ± 101	1277 ± 82	1300 ± 50	3280 ± 346	8.0 ± 1.3	nd*

* 'nd' represents 'non-detectable'

Drought stress on wheat and the protective effect of SMS

Garden soil (pH 7.0, 0.7% total carbon content and sandy clay loam soil) was used for wheat germination. The soil was mixed with SMS to 5 different ratios from 0.0 to 10.0% (SMS in soil, w/w). The optimal soil water content (SWC) for growing wheat had previously been found to be 17.0% with the saturated water moisture at 34.0%. Five constant irrigation amounts were chosen to maintain soil water contents at 6.3, 8.5, 11.9, 17.0 and 25.5% (v/w) during the observation period. The germination frequency and seedling growth were measured according to USEPA method 712-C-96-154 (OPPTS 850.4200) (Chiu *et al.* 2006).

Effects of SMS and SYN on wheat cultivation

Synthetic fertilizer (Nitrophoska® 15-15-15, BASF Chemical Co., Germany) was added to soil to provide: 20 g N/m^2, 20 g P/m^2 and 20 g K/m^2. 5.3% SMS providing an equivalent N amount were studied in parallel. Wheat was cultivated in the University greenhouse in pots (15 cm radius and 30 cm height) from Nov. 2005 to Apr. 2006. Three replicates of each treatment were put in a completely randomized design. Five seeds per pot were sown directly to the soil amended with fertilizers or SMC and irrigated until pre-tillering stage. Drought treatments were then imposed by irrigating to different SWC at 3 day intervals. Growth and grain yield of wheat were recorded. The corresponding soil samples at different developmental stages of wheat were collected at depths of 0-20 cm for chemical and physical analyses (Chiu *et al.* 2006). Field capacity defined as the water content held in pores by capillary force was also examined (Zheng *et al.* 2000).

Results and discussion

Protective effect of SMS on wheat germination

6.3% SWC caused extremely drought and totally inhibited seed germination (Figure 1). However, without SMS amendment, no germination at 8.5% SWC was observed while the inclusion of 5.3% SMS enabled 40% seeds to germinate. In the presence of 7.7% SMS or above, seed germination was raised to 100% even at 11.9% SWC.

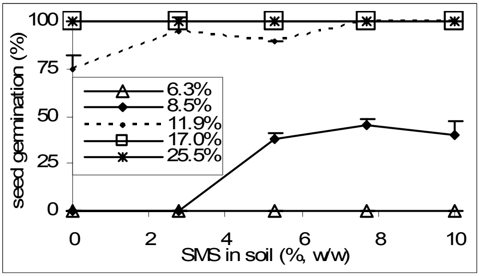

Figure 1: The protective effect of the SMS of *P. pulmonarius* on seed germination of wheat under 6.3, 8.5, 11.9, 17.0 and 25.5% soil water contents

Soil improvement and protective effect of the SMS against drought

Tab. 2: Characterization of soil before sowing (BS) and after harvesting (AH)

Parameters	**SWC (%)**	**Soil + SMS**		**Soil + SYN**	
		BS	AH	BS	AH
NOx $_{water-soluble}$ (mg/kg)	6.3	16.4± 4.6	47.6± 14.1	48.4± 4.8	14.1± 4.1
	17.0		43.6 ± 10.7		8.1 ± 5.3
$N_{Kjeldahl}$ (mg/kg)	6.3	126± 49	46 ± 4	112 ± 57	50 ± 5
	17.0		45 ± 4		20 ± 2
P_{total} (mg/kg)	6.3	344 ± 48	1734 ± 15	302 ± 25	131 ± 28
	17.0		180 ± 31		124 ± 11
K (mg/kg)	6.3	990 ± 71	482 ± 58	1007 ± 797	434 ± 90
	17.0		488 ± 98		504 ± 45
pH	6.3	7.2 ± 0.2	7.0 ± 0.1	6.8 ± 0.1	6.7 ± 0.0
	17.0		7.0 ± 0.1		6.9 ± 0.1
Field capacity (%)	6.3	36.8 ± 8.5	26.2 ± 4.8	19.4 ± 5.0	22.6 ± 4.2
	17.0		31.3 ± 7.6		17.8 ± 1.3
Aerial biomass (g/plant)	6.3	/	1.2 ± 0.1	/	0.6 ± 0.1
	17.0	/	3.9 ± 0.2	/	4.0 ± 0.2
Grain yield (mg/plant)	6.3	/	585 ± 110	/	22 ± 37
	17.0	/	8242± 441	/	6602 ± 425

Table 2 shows the soil properties of both SMS and SYN treatments and also the plant harvested under extreme drought condition (6.3% SWC) and optimal irrigation condition (17.0% SWC). SMS provided equivalent N, P and K to soil as SYN. However, the latter dropped soil pH to < 7.0 during cultivation, while SMS buffered pH above 7.0 at all soil water conditions. Furthermore, significant increases of field capacity in SMS treatment versus SYN amendment were detected at four soil water conditions (except 25.5% SWC). The greatest effect was observed before sowing: the field capacities of SMS- and SYN-amended soil were 38.6 and 19.4%, respectively. As to wheat growth, 2-fold increase of aerial biomass was observed in SMS treatment under extreme drought condition of 6.3%, while similar growth was shown at 25.5% SWC of both the SMS and SYN treatments. Almost no seeds were borne in headings of wheat grown in SYN-amended soil at 6.3% SWC while wheat produced normal seeds at the same water content but with SMS amendment. No differences of grain yields showed between 17.0% and 25.5% soil water contents (6691 kg/ha) but drought conditions of 11.9% SWC or lower significantly decreased grain yield to 20% or less in both SMS and SYN treatments. However, SMS increased grain yield by 1.1 fold (at 25.5% SWC) to 2.5 fold (at 8.5% SWC) over SYN amendments.

Discussion and conclusions

This study shows that SMS could protect wheat under drought stress at various stages: seed germination from 8.5% SWC onwards, wheat growth from tillering stage onwards and seed production from 6.3% SWC onwards. Also, the SMS could totally substitute SYN in wheat cultivation and increase the grain yields. The wheat grain yield obtained in this study was comparable to those reported in literature (6552-6772 kg/ha) (Eitzinger *et al.* 2003). Besides, such application of SMS also improves soil properties, namely: pH buffering effect and field capacity which, in return, improved water availability to plants, as well as water using efficiency and arrests yield declines and sustain agricultural productivity.

Mushroom cultivation utilizes mostly agricultural waste for production, and SMS is a waste generated from mushroom production. This waste, SMS is now demonstrated to be applicable in organic farming as a waste treatment method and also a sustainable practice.

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Effect of Rapid or slow release nitrogen supply and cover crop/weed management on crop yield, pest incidence and fruit quality in intensive organic apple production

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Key words: apple growing, planting system, nitrogen supply, fruit quality

Abstract

Apple is the commercially most important top fruit crop grown in the European Union. In spring 2001 one-year-old trees of the apple variety 'Ingrid Marie' were established in an organic production system with 3.0 m between the tree rows. Each plot consisted of three semi-plots at planting distances 0.6m (5555 trees ha^{-1}), 0.9 m (3333 trees ha $^{-1}$) and 1.2 m (2777 trees ha^{-1}). Tree growth, soil moisture, soil-, leaf- and branch analysis, diseases, fruit production, outer and inner fruit quality were measured. The healthiest trees with the best coloured fruits were produced on trees grown in weed. But the yield was so low that production was not economical. A high production combined with trees less infected with fruit tree canker and with a satisfactory colouring was produced on trees grown in intensive production system of 5555 trees per ha with no nitrogen supply.

Introduction

Fruit yield, fruit quality and disease occurrence in organic apple production are controlled by a multitude of interacting agronomic factors, the most important being supply of water and nutrition, especially nitrogen input levels and availability pattern during the growing season.

The objectives of this research were to compare single spring application of standard 'rapid release' organic fertilisers (chicken manure pellets) commonly used in organic production systems and traditional 'organic' approach based on mineralization driven N-supply from inputs such as compost, which contains very low levels of water-soluble forms of nitrogen, with respect to nutritional status, yields, disease incidence and fruit quality characteristics of apple trees.

Materials and methods

The experimental orchard is located at the Danish Research Centre Aarslev (10^0 27´ E, 55^0 18´N), on a sandy loam soil, with a clay content of 11-15 %.

In spring 2001 one-year-old trees of the apple variety 'Ingrid Marie' was established in an organic production system with 3.0 m between the tree rows.

Six fertiliser treatments were established in spring 2004 in four blocks in a randomised complete block design. No irrigation was carried out.

The fertiliser treatments were:

- No weed control between the trees in the row and no nitrogen supply.

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- Mechanical cleaning, no nitrogen supply.
- Mechanical cleaning, chicken manure pellets applied at levels equivalent to 25 kg N per Ha.
- Mechanical cleaning, chicken manure pellets applied at levels equivalent to 50 kg N per Ha.
- Mechanical cleaning, dairy manure-based compost applied at levels equiv. To 25 kg N per Ha.
- Mechanical cleaning, dairy manure-based compost applied at levels equiv. to 50 kg N per Ha.

Each plot consisted of three semi-plots of four trees separated by guard trees on rootstock M9 at planting distances 0.6m (5555 trees ha^{-1}), 0.9 m (3333 trees ha^{-1}) and 1.2 m (2777 trees ha^{-1}). The order of planting distances within the semi-plots was randomised.

A permanent cover crop of *Festuca rubra* and *Poa pratensis* was sown in the alleyways, the mixture was chosen because it improved fruit quality in a previous experiment (Pedersen and Bertelsen, 2002).

Elementary sulphur was used to control apple scab (*Venturia inaequalis*) in primary apple scab infections periods due to RIMpro apple scab warning programme (http://www.biofruitadvies.nl/RIMpro/rimpo_schurft_e.htm). Quassia was applied to control apple sawflies (*Hoplocampa testudinea)* and oil applied to control rosy apple aphids (*Dysaphis plantaginea*), pheromone disruption was used against *Cydia pomonella, Archips rosana, Hedya dimidioalba* and *Archips podana.*

The diameter of the stem was measured 20 cm above the grafting during winter. The trees were pruned according to standard. The pruned material was weighed per tree. The content of plant available inorganic nitrogen was measured in the 0-50 cm top soil layer in mid April, June and September. Nitrate-N and ammonium-N were determined colorimetrically.

The soil moisture was measured in the upper 50 cm top soil in the centre of the tree row in June-September. Leaf samples were collected four-times during the growing season in June, July, August and September and analysed for content of Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca) and Magnesium (Mg). Infection of fruit tree canker (Nectria galligena) and apple powdery mildew (Podosphaera leucotrica) was assessed every summer per tree and infected material was removed from the orchard. Apple scab (Venturia inaequalis) infections on all leaves on a single annual shoot on each tree in July 2005. Leaves are graded in 6 classes: Leaf missing, no infections, 1, 2-4, 5-9 or >10 spots per leaves.

Fruit production was measured as kg and number of fruit per tree. Fruit drop, rotten fruits and fruits infested with Rosy apple aphids was counted at harvest. Bloom, and thereby yield potential, was assessed during flowering in the spring of 2005 and 2006 by giving a score per tree from 1-9, where 1=no flowers.

Ten fruits per tree were evaluated for percentage red skin colour and examined for skin damages caused by apple scab (*Venturia inaqualis*), Monilia (*Monilia fructigena*) Fly speck (*Leptothyrium pomi*), Sooty blotch (*Gloedes pomigena*), Tortrix (different species), Codling moth (*Cydia pomonella*) and Apple sawfly (*Hoplocampa testudinea*) in 2004 and 2005.

The internal fruit quality was examined three weeks after harvest, on three fruits per tree. Fruit firmness was measured with a penetrometer. Soluble solids were determined with a digital refractometer. The starch pattern index (SPI) was estimated. The streif index was calculated. The content of major and minor minerals in the fruits was determined after removing core and stalk.

Results and discussion

Table 1: Trunk diameter, nitrogen in leaves, canker infected trees, fruits without apple scab, yield, fruit size and % surface colour as average of 2004 and 2005 for the apple variety 'Ingrid Marie' grown in 6 fertiliser systems.

	Trunk diameter 2004-2005	**Nitrogen 2004-05**	**Canker infection 2004-05**	**No apple scab infections 2004-05**	**Yield average 2004-05**	**Fruit size average 2004-05**	**Skin colour 2005**
Soil treatments in the tree row	Mm diameter $trunk^{-1}$	% of dry matter	% infected trees	% fruits	Kg $tree^{-1}$	Gram $fruit^{-1}$	% surface
1. Weed, No nitrogen	32,57 d	1,53 c	36,1 c	63,5 a	0,86 b	95 b	96,3 a
2. No nitrogen	38,56 c	2,17 b	58,3 b	49,6 b	3,24 a	131 a	85,6 b
3. Poultry manure pellets 25 kg N	40,47 bc	2,29 a	76,4 ab	46,6 bc	3,60 a	135 a	79.7 d
4. Poultry manure pellets 50 kg N	42,97 ab	2,30 a	88,9 a	43,3 bc	3,01 a	133 a	78,8 d
5. Dairy compost 25 kg N	45,52 a	2,26 a	88,9 a	41,2 c	3,06 a	138 a	78,3 d
6. Dairy compost 50 kg N	41,17 bc	2,23 ab	81,9 a	43,0 bc	3,54 a	133 a	82,0 c
LSD	2,694	0,077	16,61	7,39	0,741	7,76	2,26

Numbers followed by the same letter in columns do not differ significantly for P<0,05.

* Optimum level Nitrogen in August: 2.0-2.5 % of leaf dry matter.

Table 2: Trunk diameter, nitrogen in leaves, canker infections, yield per tree and per ha, fruit size and % surface colour as average of 2004 and 2005 for the apple variety 'Ingrid Marie' planted on three planting distances in the row.

	Trunk diameter 2004-05	**Nitrogen* 2004-05**	**Canker infections 2004-05**	**Yield**	**Yield**	**Fruit Size**	**Skin colour 2005**
Planting distance	Mm diameter $Trunk^{-1}$	% of dry matter	% infected trees	Kg $tree^{-1}$	Ton ha^{-1}	Gram $fruit^{-1}$	% surface
0.6	37,41 b	2,12 a	69,4 a	2,34 b	13,0 a	126 b	82,9 a
0.9	41,47 a	2,12 a	73,6 a	2,85 b	10,5 b	127 b	83,1 a
1.2	41,72 a	2,15 a	72,2 a	3,47 a	9,6 b	134 a	82,4 a
LSD	1,905	0,054	13,16	0,524	2,066	5,45	1,60

Numbers followed by the same letter in columns do not differ significantly for P<0,05.

Weed in the tree row competed with the trees for nitrogen, compared to mechanic weed cleaning in the tree row. This caused a smaller growth and a low yield. The slow growth also resulted in a reduced infection of fruit tree canker (*Nectria galligena*) and small strong colored fruits with reduced infections of apple scab (*Venturia inaequalis*) and monilia (*Monilia fructigena*) (Table 1).

Nitrogen supply in the tree row given as 25 or 50 kg N dry poultry manure pellets in spring caused a slightly stronger growth but not an increased yield compared to no nitrogen supply. Nitrogen supply in the tree row given as 25 or 50 kg N dairy compost in spring caused a stronger growth, but not an increased yield compared to no nitrogen supply. There was no significantly additive effect on yield or growth supplying 50 kg nitrogen compared to 25 kg. Nitrogen supply increased infections of fruit tree canker (Table 1).

A planting distance of 0,6 m between the tress in the tree row reduced vegetative growth measured as trunk diameter and weight of pruned material compared to a distance of 0,9 m. The tress had the same level of available rainfall to share per ha. Trees on a 1,2 m planting distance in the tree row had a higher supply of water per tree than trees on 0,9 m. In a high density planting water may more often become limited compared to systems with fewer trees per ha. Therefore irrigation systems are stressed in high-density plantings.

There is competition for nutrition and water in the densest planting system. The competition for space caused fewer resources for flower bud formation and fruit growth. But due to the higher number of tress per ha in the high-density system yield per ha was bigger for the trees planted with 0,6 m between the trees in the tree row.

High-density orchards are expensive to establish, because expenses for trees is high. In this trial yield reduction occurred per tree on the most dense planting distance after the first two yielding seasons. For that reason it is not likely that the high density of 5555 tress per ha is profitable on the long run.

Conclusions

The healthiest trees with the best coloured fruits were produced on trees grown in weed. But the yield was so low that production was not economical. A high production combined with trees less infected with fruit tree canker and with a satisfactory colouring was produced on trees grown in intensive production system of 5555 trees per ha with no nitrogen supply.

Acknowledgments

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Soil phosphorus status in organic and conventional vegetable farms in Southeast Queensland, Australia

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Key words: organic, vegetable production, phosphorus, soil fertility, sustainability

Abstract

The soil phosphorus (P) status (0-10 cm) of two farming systems (organic (OF) and conventional (CF) vegetable farms) at two locations (Gatton and Stanthorpe) was examined amongst a suite of soil fertility indicators. The P status was similar between farming systems, in contrast to some broad-acre organic systems. Examination of farm management records revealed substantial overlap between P inputs at both localities with CF systems also receiving organic inputs, e.g. green manure and composts. A statistical analysis of the effects of different inputs also indicated that P fertility did not vary significantly between farms. Soil P levels were medium to high across farm types indicating a potential environmental risk for vegetable producers particularly in sandy well drained soils. The three methods of extraction Colwell, Olsen and Resin were well correlated with each other and produced similar results indicating the similar nutrient pools exist between farming system.

Introduction

Organic farming is considered an alternative to conventional farming, providing sustainable crops with high export demand and less environmental effect (Wood *et al.*, 2006). In Australia, growth in organic production is estimated at 15-25% annually. Growth is expected to continue because of strong domestic demand and expanding markets overseas, especially in Asia (Alexandra and May, 2004). However, Australian organic growers face particular challenges due to infertile soils, high climatic variability and large distances between farms and input sources (Malcolm *et al.*, 1996).

Soil health is a central tenet of organic agriculture and is critical to sustainable agriculture (Widmer *et al.*, 2006). However, fertility management in Australia may not respond well to European organic methods. Of specific concern are the findings of Penfold (2000) and Ryan *et al.* (2004), who indicated that plant available P is a limiting factor in organic farming due to the low natural abundance of P and slow rate of release from organic-certified fertilisers. Organic farming may deplete soil P built up during conventional management (Gosling and Shepherd, 2005). But recent research in Australia has indicated a positive balance of P in organic vegetable production (Wells *et al.*, 2000), suggesting that the problem of P limitations in organic production in Australia are restricted to specific farming systems (e.g. broad-acre enterprises) and specific bio-physical conditions (e.g. high pH soils).

A soil survey was conducted to determine whether the P limitations faced by broad-acre grain growers in southern and western Australia are also a problem for typical vegetable growers in the east of the continent. The survey also sought to identify the different management strategies adopted by vegetable farmers to manage soil fertility.

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Materials and methods

Soil samples (0-10 cm) were collected from two different localities in south east Queensland, Gatton (Vertosols-medium clay) (27.5° S, 152° E, 94 m elevation) and Stanthorpe (Tenosols-sandy loam) (28.6° S, 152° E, 872 m elevation) from organic vegetable farms (OF) and neighbouring conventional farms (CF) on similar soils (Isbell, 1996). In February 2005, five OF and three CF were sampled at Gatton and four OF and four CF at Stanthorpe. Selected properties were resampled in 2006.

Soil samples were air-dried, and sieved (<2 mm) prior to analysis. Labile P was estimated using three common methods: Olsen (Olsen *et al.*, 1954), Colwell (Colwell, 1963) and Resin (Guppy *et al.*, 2000) in 2005. Correlations between the three methods were calculated.

All farmers completed a questionnaire about their farm practices in the last five years regarding the amount and type of green manure or cover crops (GM), bulky manure application (BM), compost application (CT) and synthetic fertiliser application (SF). Since the number of farms sampled was low and the quality of questionnaire responses was variable, the data were classified as 'Yes' or 'No' indicating if the management practice was used or not. Percentage of farms within each farming system receiving each input were calculated (Table 1).

Table 1: Percentage of farms using particular fertilisation practices and soil phosphorus levels of organic and conventional vegetable farms in Queensland (means and standard errors are given with the range in brackets)

Farm	GM (%)	BM (%)	CT (%)	SF (%)	Colwell P (μg g^{-1})	Olsen P (μg g^{-1})	Resin P (μg g^{-1})
Gatton organic	100	100	100	0	104±14.3 (62-146)	48±5.7 (37-66)	107±10.8 (64-163)
Gatton conventional	40	0	60	100	151±18.9 (126-188)	66±6.3 (55-77)	134±11.6 (110-173)
Stanthorpe organic	67	67	50	0	137±71.4 (24-341)	51±24.3 (12-122)	99±32.5 (13-236)
Stanthorpe conventional	57	71	29	100	163±79.0 (40-395)	51±14.9 (20-92)	95±25.5 (20-183)

GM-green manure, BM-bulky manure, CT-compost, SF- synthetic fertiliser

The data were subjected to a two factor ANOVA using R programming (R Development Core Team, 2003) for each management variable with location as the other factor. Sampling date was not significant for all variables ($P > 0.05$), as was the interaction term ($P > 0.05$), hence the data was pooled across years.

Results

Soils from Gatton were alkaline (pH from 7.7 to 8.6) and Stanthorpe soils were acidic to neutral (pH from 5.5 to 7.6). No difference in P status was observed between the farming systems ($P > 0.05$) and locations ($P > 0.05$). Sixty and forty percent of CF in Gatton received compost and green manure respectively. Twenty nine, fifty seven and seventy one percent of CF in Stanthorpe received CT, GM and BM respectively (Table 1). Further analysis based on different types of fertilisers revealed no difference in soil P status ($P > 0.05$) irrespective of extraction method. The three methods of available P analysis were well correlated among each other with R^2 value of 0.72, 0.84 and 0.85 for Colwell:Resin, Colwell:Olsen and Olsen:Resin respectively. The P levels were generally medium to high for vegetable production (Peverill *et al.*, 1999) both in OF and CF.

Discussion

The similar soil P status between organic and conventional vegetable farms in two locations with contrasting soil types and climatic conditions indicates that organic vegetable farmers are not at a nutritional disadvantage compared to their conventional counterparts, as has been reported for some organic broad-acre cropping systems (Penfold, 2000; Ryan *et al.*, 2004). A survey conducted by van Dienpeningen (2006) also reported no difference in P levels between organic and conventional farms in Netherlands. Also there are reports of positive P balance in different organic farming system such as vegetables in (New South Wales) Australia (yellow earth - *Luvic Ferrasol*) (Wells *et al.*, 2000) and cereal legume crop rotations (*sandy clay loam soil*) in Italy (Marinari *et al.*, 2006). Our survey confirms that many conventional growers include substantial inputs of organic fertilisers, so that the distinction between organic and conventional systems is less well defined than might be expected, a result reported earlier by van Diepeningen *et al.* (2006)

The medium to high P levels for both CF and OF (Peverill *et al.*, 1999) suggests that all are high input production systems with potential for adverse environmental effects, such as nutrient leaching, especially in sandy soil (e.g. Stanthorpe) (Zhang and MacKenzie, 1997).

The good correlation between the three extraction methods and the similar P levels between OF and CF measured by the three methods indicate that soil P pools in organically farmed soils were equivalent to those in conventionally managed soils (Watson *et al.*, 2002).

Conclusions

Results of the soil survey of organic and conventional vegetables farms in two contrasting locations revealed that soil P was similar between farming systems, partly due to the high use of organic inputs in CF. This finding contrasts with reports of P deficiencies in other Australian organic farming systems. The medium to high P levels in CF and OF confirm that these are high input systems with the potential for adverse environmental effects. The three extraction methods were well correlated and demonstrated that different pools of soil P were similar across farming systems.

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Mixtures of modern and historical wheat cultivars under organic management in western Canada

Pridham, J. and Entz, M.H.[1]

Key words: Diversity, weeds, leaf disease

Abstract

Two historic (Red Fife and Marquis) and two modern (5602HR; AC Barrie) wheat (Triticum aestivum) cultivars were assessed to determine if cultivar mixtures provided a benefit to grain yield and disease and weed suppression in Manitoba over 3 site-years. 5602HR was the highest yielding sole cultivar while Marquis and AC Barrie were the lowest yielding sole cultivars. Red Fife yielded similar to 5602HR in several cases. Orthogonal contrasts across all site-years showed that 3 and 4 cultivar mixtures yielded similar (P>0.05) to 5602HR, the highest yielding monocrop.

Introduction

Cultivar mixtures are typically used in production to maintain quality and yield while reducing pesticide inputs (Newton, 1997). Cultivar mixtures have been successfully utilized in spring barley (*Hordeum vulgare*) crops in Europe (Mundt, 2002). Few cultivar mixture studies have been conducted in Canada.

Wheat cultivars used before the advent of high input farming in western Canada (1880-1950) are considered by some organic farmers to be better suited for organic management. Older cultivars have been shown to be more responsive to mycorrhizal colonization than modern cultivars, which would enhance the cultivar's nutrient acquisition capabilities in lower fertility conditions (Hetrick *et al.*, 1992). Wheat production in western Canada is often dominated by one or two major cultivars. AC Barrie is grown on over 40% of wheat hectares in the region; in Manitoba AC Barrie is grown on over 60% of wheat hectares. 5602HR is poised to become the next dominant wheat cultivar in the region.

Materials and methods

Three site-years of experiments were conducted on organically-managed land in Manitoba in 2004 and 2005. Fifteen treatments were tested in a randomized complete block design with 4 replicates. Two historic (Red Fife and Marquis) and two modern cultivars (5602HR and AC Barrie) were used in treatments of sole cultivars; and all two, three and four cultivar combinations. The treatments were seeded proportionally to achieve a final seed population of 300 viable seeds m^{-2} at a row spacing of 15 cm. Wheat was seeded in late May. Crop and weed density were assessed 3 weeks after seeding. Leaf disease was measured on 20 flag leaves sampled during mid-grain filling; percent leaf area infected was measured. Grain yield was assessed at maturity from samples threshed with a plot combine. Statistical analysis was carried out using analysis of variance and orthogonal contrasts.

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Results and Discussion

Few significant differences in weed density were observed (Table 1). Only Marquis, of the historic cultivars, resulted in numerically fewer weeds than all other sole cultivar treatments. 5602HR, the most recently developed cultivar, had higher weed densities at Carman in 2005 than both historic cultivars; a similar trend was observed at the other two sites.

The major diseases were leaf rust (*Pucinnia tritici*), Septoria leaf botch (*Septoria tritici*) and tan spot (*Pyrenphora tritici-repens*). Surprisingly, Red Fife was the cultivar which consistently had the lowest leaf disease level (Table 1). One explanation for this observation is Red Fife's slower phonological development (7 days later), which may have allowed it to avoid disease. A full disease assessment in 2005 revealed that the lowest levels of disease tended to occur in mixtures that contained Red Fife, even when it was grown in mixtures with cultivars that in monoculture had a high disease level (e.g., Marquis and AC Barrie).

Tab. 1: The effect of wheat cultivars and wheat cultivar mixtures on weed population density and flag leaf disease severity (percent leaf area covered; %LAC) in field experiments conducted over three site-years in Manitoba. Numbers in columns followed by different letters are significantly different at P<0.05.

	Clearwater 2004		Carman 2004		Carman 2005	
	Weeds (m^{-2})	Disease (%LAC)	Weeds (m^{-2})	Disease (%LAC)	Weeds (m^{-2})	Disease (%LAC)
Red Fife	2262	89 b	2331 ab	22 b	1696b	79 de
Red Fife-Marquis	2212	-	2298 ab	-	1711b	83 cde
Red Fife-5602HR	2094	-	2320 ab	-	1554b	73e
Red Fife-AC Barrie	2532	-	2216 ab	-	1873ab	72e
Red Fife-Marquis-5602HR	2133	-	2448 ab	-	1529b	80de
Red Fife-Marquis-AC Barrie	2141	-	2215 ab	-	1873ab	82cde
Red Fife-AC Barrie-5602HR	2526	-	2238 ab	-	1847b	73e
Red Fife-Marquis-AC Barrie-5602HR	2277	-	2582 a	-	1446b	91bcd
Marquis	2099	100 a	1958 ab	89 a	1345b	99a
Marquis-5602HR	2242	-	2010 ab	-	1532b	98a
Marquis-AC Barrie	2229	-	2200 ab	-	1539b	94abc
Marquis-5602HR-AC Barrie	2365	-	2237 ab	-	1900ab	97ab
5602HR	2311	98 a	2418 ab	61 a	2478a	93abc
5602HR-AC Barrie	2496	-	1840 b	-	1786b	98ab
AC Barrie	2440	99 a	2121 ab	89 a	1640b	97ab

Few treatment differences for grain yield were observed in this study. At Carman in 2005, 5602HR has significantly higher yield than the majority of treatments (Table 2). It was interesting to note that 5602HR produced the highest grain yield at Carman in 2005, despite having the most weeds (Table 1) and the highest weed biomass (data not shown). While the modern cultivar 5602HR had a higher grain yield than Red Fife and Marquis at Carman in 2005, mixtures containing Red Fife and Marquis without 5602HR were comparable in grain yield to 5602HR (Table 2). Therefore, mixtures did display some yield compensation.

Tab. 2: The effect of wheat cultivars and wheat cultivar mixtures on wheat grain yield (kg/ha) in field experiments conducted over three site-years in Manitoba, and contrasts comparing 5602HR with 2, 3 and 4 cultivar (cvs.) mixtures. Numbers in columns followed by different letters are significantly different at P<0.05.

	Clearwater 2004	Carman 2004	Carman 2005	Combined (3 site-years)
Red Fife	2474	2368 ab	1695 b	2179 ab
Red Fife-Marquis	2419	2334 ab	1711 b	2155 ab
Red Fife-5602HR	2290	2356 ab	1553 b	2066 ab
Red Fife-AC Barrie	2769	2251 ab	1872 ab	2297 ab
Red Fife-Marquis-5602HR	2332	2487 ab	1528 b	2166 ab
Red Fife-Marquis-AC Barrie	2341	2250 ab	1872 ab	2154 ab
Red Fife-AC Barrie-5602HR	2762	2273 ab	1846 b	2294 ab
Red Fife-Marquis-AC Barrie-5602HR	2490	2622 a	1446 b	2186 ab
Marquis	2295	1988 ab	1345 b	1876 b
Marquis-5602HR	2452	2041 ab	1531 b	2008 b
Marquis-AC Barrie	2438	2234 ab	1538 b	2070 ab
Marquis-5602HR-AC Barrie	2586	2272 ab	1900 ab	2253 ab
5602HR	2526	2456 ab	2477 a	2487 a
5602HR-AC Barrie	2729	1869 b	1785 b	2128 ab
AC Barrie	2668	2154 ab	1640 b	2033 b
Contrasts				
5602HR vs 2 cvs.	0.9575	0.2599	0.0013	0.0308
5602HR vs. 3 cvs.	0.9170	0.5899	0.0072	0.1063
5602HR vs. 4 cvs.	.08864	0.6017	0.0018	0.1734

When combined across site-years, 5602HR yield significantly more than Marquis, AC Barrie and the Marquis-5602HR mixture. As Marquis and AC Barrie appeared to be the most affected by disease in all site-years (Table 1), it follows that their grain yield would be reduced compared to other treatments.

Orthogonal contrasts were used to compare the grain yield of the highest yielding cultivar, 5602HR, to mixtures with increasing levels of cultivar diversity. When combined across site-years, 5602HR significantly outyielded all two mixture treatments (Table 2). However, as the number of cultivars within the mixtures was increased, the yield gap between 5602HR and the mixtures decreased. In fact, the probability level of the contrast increased with each additional cultivar in the mixture; three and four cultivar mixtures yielded the same ($p>0.05$) as the 5602HR monocrop (Table 2).

Conclusion

This preliminary study showed that cultivar mixtures provided some advantages over wheat sole cultivars. While cultivar mixtures did not provide consistent overyielding to sole cultivars, in two of three site-years, cultivar mixtures had the highest yield. Also, in the one case where 5602HR had the highest yield among sole cultivar crops, some mixtures were comparable in yield. Some of the advantage from mixtures in this study may have resulted from lower leaf disease offered by Red Fife.

5602HR, the most recently developed spring wheat cultivar in western Canada yielded well under organic management, despite high levels of weed infestation. However, long-term production of such ‘weedy’ cultivars may allow weed populations to build up, causing future problems.

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Organic Fertilization In A 'Tomato – Pea' Rotation In Southern Italy

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Key words: *Lycopersicon esculentum* Mill., *Pisum sativum* L., fertilization, compost, seed yield, protein yield

Abstract

The use of alternative to mineral fertilizers is an important issue in organic systems. A four-year field experiment to evaluate the effects of organic fertilizers on yield and quality of processing tomato and proteic pea in rotation, was carried out in Southern Italy. The fertilization treatments aimed to supply 100 kg ha^{-1} of N for tomato and 60 kg ha^{-1} of P_2O_5 for pea and were: 1) an organic biological fertilizer (BIO); 2) an experimental compost obtained by olive residues, sludge and straw mixture (COMP); 3) a control managed with traditional chemical fertilizers (ammonium nitrate and perphosphate, MIN). At harvest, the main productive and qualitative parameters were assessed.

Tomato fruit yield did not differ among the fertilization treatments, but unripe fruit yield was higher in the MIN and BIO treatment; MIN showed also smaller fruit than BIO and COMP. The N availability during crop cycle influenced the mean fruit weight and maturity date. No difference among treatments was observed for pea in rotation with tomato and, similarly, on the wheat cropped without fertilization following the two crops.

The possibility to use organic fertilizer for processing tomato and proteic pea has been evaluated and the conclusion is that organic fertilization is comparable to mineral one from a productive and qualitative point of view.

Introduction

Fertilization and, in particular, organic one, is an important key in plant nutrition and especially in organic systems. Alternative to mineral sources of nitrogen and phosphorus have been studied and positive effects have been showed on growth, yield, chemical and physical soil properties (Bouranis *et al.*, 1995; Convertini *et al.*, 2003; Elia *et al.*, 2006**a**). Organic sources such as agricultural and agro-industrial wastes, after processing treatments, could be valuable alternatives in organic systems fertilization. The compost technique can further improve quality of fertilizer product.

The objectives of this research were: 1) to evaluate the effect of different organic fertilizers on yield and quality of processing tomato and proteic pea by comparison with the traditional mineral fertilizer and 2) to study the residual soil fertility effect of repeated applications on the productivity of a following durum wheat crop.

Materials and methods

A field experiment was carried out in 2002-2006 period at experimental farm of the Institute (Foggia, Southern Italy). The soil was classified as a vertisol of alluvial origin,

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Aridic Haploxerert (USDA 9th, 2003), fine, mixed, thermic, silty-clay. The climate is 'accentuated thermomediterranean' (UNESCO-FAO), with minimum temperatures below 0°C in the winter and maximum above 40°C in the summer. Annual rainfall (average 550 mm) is mostly concentrated during winter months.

A rotation 'processing tomato-proteic pea' was fertilized for four years using two organic fertilizers compared to a control, a mineral one. The treatments and the amount of fertilizer were assessed considering nitrogen content for tomato and phosphorus for pea, in order to apply a rate of 100 kg of total N ha^{-1} for tomato and 60 kg of P_2O_5 ha^{-1} for pea. The treatments were: **COMP** = experimental compost derived from olive mill residues and leaves, sludge, straw and orange wastes; **BIO** = biological fertilizer, used in organic agriculture, coming from slaughterhouses wastes (Tab. 1); **MIN** = ammonium nitrate (34.5% of N), broadcasted half before transplanting and half at fruit formation in the first truss for tomato; mineral triple perphosphate (46%) in pre-sowing for pea. A completely randomised block design with four replications and a plot size of 50 m^2 (5 x 10 m) were adopted, with both crops in rotation sown at the same time every year, to minimize yearly variability.

The tomato plantlets (cv. Perfectpeel) were transplanted at the end of April using a density of 3 plants m^{-2} with a twin-row distribution. Irrigation was applied with the drip method. At harvest (August), the tomato fruits were weighed and graded in: 1) mature, 2) overripe and 3) unripe. Total soluble solids (° Brix) and citric acid (%) as qualitative parameters on fruit's juice were also measured. The proteic pea (Aravis, semileafless variety), was sown in December at the density of 100 seeds per m^2. At harvest, plant population, straw and seed yield, protein content were measured. In the 5th year (2005-06), on the same plots a not-fertilized durum wheat (cv. Simeto) crop was sown, and main productive and qualitative parameters at harvest were assessed, with the aim to evaluate residual soil fertility. Data were analysed using ANOVA for the four years, considering the '*year*' as a random effect; mean comparison was performed by using LSD test (SAS Inst., 1987).

Table 1. Main chemical characteristics of fertilizers used in the experiment (averages of four years).

Fertilizer	Fertilization	Total N	P_2O_5	C ($g \cdot kg^{-1}$)	C/N ratio	Amount for tomato ($t\ ha^{-1}$)	Amount for pea ($t\ ha^{-1}$)
		(%)					
Compost	COMP	2.0	3.1	38.3	19	5.0	2.1
Organic biological	BIO (Tomato)	12.7	3.2	48.7	4	0.8	-
Organic biological	BIO (Pea)	4.0	15.0	19.0	5	-	0.4

Results

The statistical analysis showed a not significant '*year x fertilization*' interaction and a '*year*' effect always significant for both crops and examined variables. The yearly variability, due to rainfall, temperature and pests, is not analysed in this paper. Only the results of '*fertilization*' effect are reported and discussed. It resulted significant for unripe fruit yield at tomato harvest, showing a superiority of MIN (for the late N availability) and BIO (for the slow mineralization of N) respects to COMP (Tab. 2). Commercial, overripe and total yield did not differ among treatments, showing the equivalence of organic and mineral fertilizations from a productive point of view. Similarly, important qualitative parameters for processing tomato, soluble solids and citric acid content, resulted the same for the three fertilization scenarios. The fruit weight was the only productive parameter that differed, in the MIN treatment resulted lower than COMP and BIO, probably for an availability of nutrients better in organic than in mineral treatments (Tab. 2). For pea, no fertilization effect has been detected for all the examined variables (Tab. 3). The soil mineral N content did not change after four years of COMP and BIO treatments, but increased in MIN one (from 19.5 to 24.2 mg kg^{-1}) (Rinaldi *et al.*, 2006). This residual fertility due to four years of fertilizers application, did not influence the following durum wheat, neither for productive nor qualitative aspects (Tab. 4).

Table 2. Main productive and qualitative parameters of processing tomato.

Fertilization treatments	Fruit					Total soluble solids (° Brix)	Acidity (% of citric acid
	Mean weight	Total	Mature	Unripe	Overripe		
	(g)	(t ha^{-1})					
BIO	67.3 a	111.9	91.6	16.5 a	3.8	4.8	0.84
COMP	67.9 a	109.1	94.1	10.9 b	4.1	4.8	0.82
MIN	63.5 b	109.2	89.4	16.2 a	3.6	4.7	0.86

Numbers in column followed by different letters are different at P < 0.05 (LSD test).

Table 3. Main productive and qualitative parameters of proteic pea.

Fertilization treatments	Plant population	Straw biomass	Seed yield at 10% moisture	Seed protein content	Protein yield
	(p m^{-2})	(t ha^{-1})	(t ha^{-1})	(%)	(t ha^{-1})
BIO	57.5	2.7	3.5	31.8	1.10
COMP	59.2	2.9	3.5	32.3	1.13
MIN	56.4	2.7	3.4	31.2	1.06

Discussion

The significant result of unripe fruits, greater for BIO and MIN than COMP, indicated a delayed maturity date explainable for BIO for the slow N mineralization and for MIN for the late N availability with split application, respect to COMP treatment, that released nutrients matching better the plant requirements. This latter treatment, also for the larger amount of material applied to the soil (Tab. 1), showed beneficial effects on the soil hydrological properties, increasing soil water retention capacity (Elia *et al.*, 2006**b**). For pea, the organic fertilization did not modify plant growth and yield and protein accumulation in the seed, for the greater dependence of this processes by nitrogen supply, sufficient in this species for atmospheric N-fixation capability.

Table 4. Main productive and qualitative parameters of durum wheat cropped without fertilization after 4 years of fertilization experiment.

Fertilization treatments	Seed yield at 13% moisture	Volumetric seed weight	Seed protein content	Glutin content
	(t ha^{-1})	(kg hl^{-1})	(%)	(%)
BIO	4.74	81.7	12.93	26.7
COMP	5.09	81.0	12.68	26.2
MIN	5.29	80.1	12.74	26.4

Conclusions

The organic fertilization of a ‘tomato-pea’ rotation has been evaluated during a 4-year field experiment; the results indicated that the pre-sowing application of organic fertilizers and composted materials did not influence negatively fruit yield and quality. In addition, the slow and more regular release of nutrients, the distribution of other nutritive elements other than nitrogen and the single application using organic fertilization can involves several important benefits for tomato crop management. For a N-symbiotic crop like pea, no difference was observed. The first year of evaluation of residual fertility effect resulted not significant, but further years could be necessary to show some effects.

In conclusion, organic fertilization showed to be competitive with mineral for tomato and pea yield; in addition, this type of fertilization should be supported for two reasons: to reuse and dispose vegetal and animal wastes and to maintain or/and increase soil fertility.

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Monitoring Soil Characteristics in Organic Farming: A Comparison of Field vs. Laboratory Methods

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Key words: soil, quality, chemical and biological properties

Abstract

Soil quality plays a key role in organic farming. In practice its evaluation is not so simple because there are many indicators that could be used. In our research we used simple field methods (soil quality test kit) and compared the data with traditional evaluation used in the laboratory.

Introduction

Soil quality plays a key role in organic farming; often the term ‘soil health’ is used instead. Soil health is the base presumption for growth and development of healthy plants, animals and man. In practice the evaluation of soil quality is not so simple because there are many indicators that could be used. This is why we attempted to track selected characteristics of the soil (physical, chemical and biological) and the overall state of the soil by using simple field methods, according to Doran, with the use of a soil quality test kit. We then made a comparison of these methods with traditional ones used in laboratories. The results could suggest some recommendations for practical monitoring of the evolution of soil properties during the transfer process to organic farming.

Materials and methods

Soil samples were taken during each spring (March, April, May) and autumn (September, October, November) of 2004-2005 on two farms, located near Dobruška, the Czech Republic; both of which are enrolled in the organic farming system. A large number of properties were tested on parcels with potatoes, spelt, as well as on pastures (one of which was newly planted). These properties included physical (infiltration), chemical (pH, CEC, mineral nitrogen content) and biological (soil respiration) components. These measurements were subsequently supplemented by properties measured in the laboratory, these were: porosity, volume weight, pH, CEC, mineral nitrogen content and soil respiration. The results were evaluated by means of comparative analysis wherever possible (pH, CEC, mineral nitrogen content).

Results and conclusion

Comparisons of the studied values show that the use of a soil quality test kit for approximate monitoring of field state in a selected locality is possible. Results of individual types of analyses differ depending on local conditions. This fact could be demonstrated with two examples: conductivities are similar regardless of the field or lab results (Fig. 1), the trends of soil respiration are always the same (Fig. 2), but the resulting respiration is different. This is due to the measurement in the field, which

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consists of following the actual CO_2 production by both soil and roots with soil organisms – thus the results are greater than with sifted lab samples. Fig. 3 shows correlation between field and laboratory measurements of the CO_2 production. Similar correlation gives conductivity evaluation. If the soil is frequently sampled throughout the year it is possible to compile an image of the soil in a selected locality for an entire season, depending on farming activities, on weather, on pasture, etc. This can be very useful for the organic farmer in planning his activities better. This assessment method could be used in high school or university education as well. This method offers new possibilities for monitoring soil. An assortment of new applications will be tested, and a methodology for organic farming consultants will be prepared.

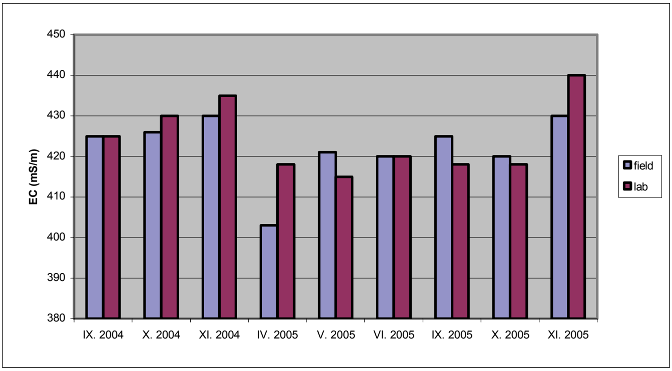

Figure 1: Conductivity (measured in the field and lab conditions)

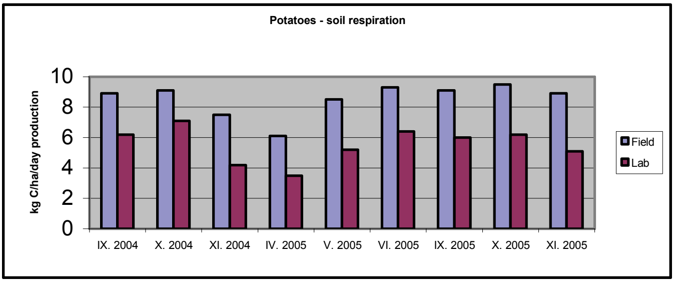

Figure 2: Soil respiration (measured in the field and lab conditions)

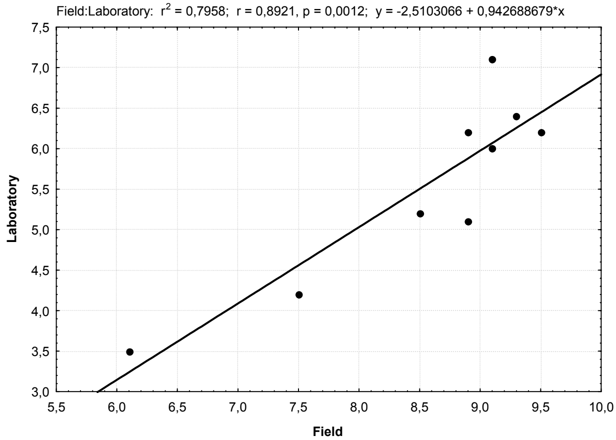

Figure 3: Correlation between field and laboratory measurements of the CO_2 production

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Development of strategies to improve quality and safety and reduce cost of production in organic and ‘low input’ livestock production systems

Development of strategies to improve quality and safety and reduce cost of production in organic and 'low input' livestock production systems

Spoolder, H.A.M.[1], Maurer, V.[2] and Sundrum, A.[3]

Key words: organic husbandry, animal health, meat quality, animal nutrition, probiotics

Abstract

The demand for organic livestock products is still increasing. To support this growth and to help remove potential obstacles the fourth Subproject of QLIF addresses several themes related to livestock farming. In this overview paper the main results to date are presented. It briefly discusses progress made on preventative treatments against pig and poultry parasites, as well as the reduction of rodent burdens on farm. The activities on probiotics and nutribiotics experiments are listed, as are studies undertaken to improve the meat quality of pigs through different protein sources and diet composition. Finally, work is being presented aiming to reduce the incidence of mastitis, and the reduction of faecal shedding of pathogens in cattle. The overview concludes that much work has been done, but that the main task of increasing competitiveness of the organic and low-input livestock sector through the implementation of our knowledge, still lies ahead of us.

Introduction

There is an increasing demand for organic and 'low input' food from livestock production systems (Verbeke and Viaene, 2000; Andersen et al, 2005). The major reasons for this are consumer perceptions about health, animal welfare and environmental benefits. It is perceived, for example, that organic farming is associated with

- healthy livestock without the excessive use of veterinary medicines,
- behavioural freedom (space allowance) for the animals,
- more 'natural' (outdoor) rearing systems,
- species specific diets which meet the needs of the animals,
- the absence of GM-based feeds.

Organic farming can meet these expectations, but there are at least two important concerns that need to be addressed if the current development is to be continued. First of all, consumer may be reluctant to purchase organic products of animals' origin due to high premium prices for meat from poultry, pork and beef production systems in particular. Secondly, there are a number of concerns raised by scientists with complaints about the lack of resources and specific management skills that are

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required to handle the demanding organic livestock production (Vaarst et al, 2006). Correspondingly, deficits in the management may increase health risks for livestock when kept in relatively 'open' organic husbandry systems (Spoolder, in press). In addition to the reduced animal welfare, this could lead to human health risks if zoonotic pathogens are implicated. These concerns will need to be addressed as they both affect consumer demand for organic livestock products.

The QualityLowInputFood project, QLIF, addresses these issues in its fourth Sub-project on organic livestock production systems. Six main themes are dealt with in subproject 4, one per Work Package (WP).

WP 4.1 Development of improved preventive management strategies for endo- and ectoparasites and bacterial zoonoses of pigs and poultry.

Organic production standards for pigs and poultry require outdoor access. As a result, animals are exposed to a wider range of potential endo- and ectoparasites infection sources and challenges than animals kept under conventional indoor conditions. Preventing contact with these vectors are a first line of defence against parasites and disease.

In a two year study by Meerburg *et al.*(2005) rodents and insectivores (n=282) were trapped on ten organic farms by using live-traps. *Salmonella* and *Campylobacter* infections were encountered in house mice and Norway rats, but not in other species. Further more, *Toxoplasma gondii* antibodies could be detected in 6.4% of the blood samples taken from 235 wild small mammals. Rodent control therefore appears to be of significant importance, and during the autumn of 2005 a study was set up 20 organic pig farms whereby two different rodent control methods were compared. Ten farms used conventional rodenticides and ten farms used live traps. Both treatments did not differ significantly, indicating that the use of live-traps may be a good alternative for rodent control on organic farms.

At present the effects of rodent control on T. gondii *seroprevalence (on farms with a know* T. gondii *presence) are investigated, and appear to give promising results.*

To investigate the effect of outdoor run management on poultry parasites, Maurer (2005) compared three different types of outdoor runs with increasing grass cover in small flocks of laying hens. In year 1, hens with helminth field infections had been used to contaminate the runs. In years 2 and 3, parasite naive young layers were put on the contaminated runs. The runs were managed according to different three regimes: 'overused' old poultry run, 'ideal' new run and an 'extensive' run with structures and natural or artificial shelters, not mown. *Ascaridia galli* and *Heterakis gallinarum* were present on all farms and in all flocks. Tapeworms and *Capillaria spp.* occurred in a substantial proportion of the hens. The prevalences of Ascarids as well as the average faecal egg counts FECs were lowest in the 'extensive' runs, whereas FECs of the 'overused' and 'ideal' runs were on a comparable level.

Work on indoor litter management to reduce worm burden is ongoing.

For pigs a different strategy was applied. Vermeer *et al*. (2006) aimed to reduce the infection pressure in the outside dunging area by directing pig dunging behaviour in such a way that infected faeces would be concentrated (localised) in the pen, rather than spread out over the whole area available. Eight groups of 14 pigs each were allocated to one of 4 treatments in 4 batches lasting about 4 months. The treatments were designed to provide increasingly strong stimuli in the outdoor run to direct dunging behaviour towards the part of the run which was furthest from the outside pen wall, and easiest to clean manually. The study showed that dunging behaviour can be directed (pigs will use a designated ‘toilet area’), but no difference in *Ascaris suum* infection was found between the four treatments applied.

Work is now concentrating on the frequency of cleaning required to minimise the infection burden of these localised dunging areas.

The second preventative strategy against pig endoparasites is to use carbohydrate sources with high contents of fructooligosaccharides (FOS) by Meijer, Thamsborg and co-workers. FOS are expected to significantly reduce female worm fecundity and worm numbers of both *Oesophagostomum* and *Trichuris* in pigs without affecting pig growth or production costs. The trials so far showed an effect on the egg excretion and worm burdens of *Oesophagostomum* only, with dried chicory roots being more effective against the parasite than Jerusalem artichokes.

Currently work is underway to follow the egg excretion patterns of sows during and after a short feeding period to evaluate if environmental contamination can be reduced.

WP 4.2 Development of alternative treatment strategies versus endo- and ectoparasites of pigs and poultry

In its second year, the project has made a start with the investigation of alternative solutions to conventional anthelmintic drugs. In several experiments carried out by Maurer and co-workers, either laying hens naturally infected with A. galli and H. gallinarum or pullets with artificial A. galli infections were fed with promising anthelmintic plant products, identified in a literature survey. To date, none yielded a significant reduction in faecal egg count or reductions of A. galli burdens.

Control of the poultry red mite Dermanyssus gallinae is a challenge for organic as well as conventional egg producers. In organic poultry production, control should be attempted by mechanically acting substances (e.g. oils or diatomaceous earth), before acaricides are applied. In experiments by Maurer and Perler (2006), diatomaceous earth (DE) without acaricides was at least as effective as DE supplemented with pyrethrum or essential oils and a liquid formulation of silica in vitro. On farm, DE was effective during a limited period only, whereas the liquid formulation had a very good residual effect over several weeks.

Tests with higher concentrations and different application schemes of the respective products are ongoing.

WP 4.3 Develop strategies to augment non-immune system based defence mechanisms against gastrointestinal diseases in the pig

The use of antibiotic growth promoters is not permitted in organic and most ‘low input’ conventional pig and poultry production systems (EC Regulation 1804/1999). A range of studies has shown that probiotic treatments based on Lactic Acid Bacteria (LAB e.g. *Lactobacillus*, *Pediococcus* and *Bifidobacterium* spp.) can reduce the risk of gastrointestinal infections and diarrhoea caused by enteric bacterial pathogens.

The addition of certain compounds (e.g. oligosaccharides, lactose containing whey) was shown to increase the competitiveness and population density of LAB in the intestine after weaning, by providing selective nutrient sources for LAB. Such ‘nutribiotics’ are thought to improve the establishment of probiotic inocula when added in combination to the feed of newly weaned pigs. The most active probiotic strains had been identified in an earlier work by Biavati and co-workers, and recent work has concentrated on the effect of possible combinations of pro- and nutribiotics on the population densities of LAB in the intestine. It appears that the use of a fibre supplementation in the pig’s diet did not interact with the probiotic dose. However, the presence of FOS can stimulate bifidobacteria in the caecum, but it does not give additional growth stimulus when it is supplemented with the increasing dose of supplemented bifidobacteria.

In a subsequent trial, Biavati *et al.*investigated if a strain of *Bifidobacterium animalis* would have beneficial effects for piglets challenged with *Salmonella enterica* serovar *typhimurium*. They found that by using the probiotic inocula the number of bifidobacteria in the caecum content significantly increased. There was, however, no significant effect of the probiotic on the *Salmonella* population, even though growth performance in the probiotic group was positive when compared to the control.

Bifidobacterium spp. with high resistance to low pH conditions are expected to survive better during transit in the acidic environment of the stomach. Although their susceptibility to acidified nitrite or thiocyanate solutions has not been determined, it is likely that the presence of nitrite or thiocyanate in the stomach acid will reduce the viability of *Bifidobacterium* cells during transit. Carlini *et al*. tested the susceptibility of strains of *Bifidobacterium* spp. from various origins for sensitivity to eight pH-values and combinations with 6 concentrations of nitrite and thiocyanate. From this, a ranking was determined of best surviving strains, and the strains with the best resistance profiles were subjected to various compositions of cultural medium (different sources of nitrogen and carbon) and cultural conditions (temperature, inoculum percentage, incubation time, pH of neutralization, etc.) to establish optimal growth conditions for each strain. Again, a ranking was determined.

A total of 24 kg of one of the most promising probiotic cultures was shipped to another project partner (BOKU) to support feed trials on growing-finishing pigs.

Apart from probiotics, diets containing significant amounts of nitrate and/or isothiocyanate (e.g. green plant materials, Brassicas and/or Cassava) have recently been shown to increase the antimicrobial activity of the stomach acid. This may increase the resistance of monogastric animals to pathogens like Salmonella enteritidis, Escherichia coli, Salmonella typhimurium, and Yersinia enterocolitica, whereas acid alone has only a bacteriostatic effect. An in vivo study was conducted by Biavati et al. (2007), in order to assess the effects of dietary nitrate on the microbiota and on the health of the gut (particularly in stomach and small intestine). Preliminary results showed no effect on the population densities of microbial groups either from the challenge or from the nitrate intake. However, increasing the time from challenge decreased either the counts of LAB in the stomach and jejunum or of Clostridia in the stomach.

WP 4.4 Development of nutritional strategies to improve production efficiency, sensory quality and food safety in organic pork production systems

The availability of protein feeds and sources of essential amino acids are the main limiting factor in organic pig production. This is due to restrictions concerning bought-in feedstuffs, and to the ban on GM-crop based feed, on synthetic amino acids, and on the use of chemically extracted soybean meal. As a result, organic pork production is dependent on a relatively high product price to compensate for the lower production efficiency compared to conventional production. Two principal strategies have been chosen to address this problem.

The first strategy aims to develop a quality oriented production system with an emphasis on sensory quality in order to justify the higher prices.

Trials by Sundrum *et al.*in the first two years of QLIF indicate that a feeding regime only based on cereals and home-grown grain legumes without further supplementation with high quality protein resulted in a reduction in pig performance compared to the control group but in an increase in the intramuscular fat content (IMF). The results indicate that it is possible to increase the IMF content by the use of specific feeding regimes, thereby playing a major role in relation to eating quality features. With respect to other possible factors they found that except for a positive relationship between birth weight and growth rate, no effect of the birth weight was found on performance nor on carcass traits and meat composition.

These results were the basis for an on-farm study by Abel *et al.*(2007) in which a total number of 12 farms were involved, six in Germany and six in Austria. Two dietary treatments (a control and an experimental diet) were used simultaneously in the fattening period. The Control group were fed a diet representing the traditional feeding regime of the respective farm and based on cereals, grain legumes and by-products. The Experimental groups were fed a diet formulated to obtain a high IMF content in the pork. It contained a high portion (> 40 %) of grain legumes (lupines and faba beans) in Germany, and in Austria the rations contain 36 % of a mixture of peas and faba beans. Data analyses have not been completed yet, but preliminary results suggest that variation is higher between farms than between treatments within each farm.

Future work is aiming to find answers in relation to the suitability of feed rations to increase the IMF content of pork under practical farm conditions.

The second strategy identified protein crops which can provide additional sources of suitable protein and essential amino acids to improve the production efficiency and reduce production costs.

In an extensive literature review special attention was given to new genotypes (created using classical plant breeding) of candidate protein crops with reduced contents of ANFs, and to processing techniques that could be used under organic farming rules (Van der Peet-Schwering *et al.*, 2006). Further more, fourteen samples of protein rich crops (8 x faba beans, 5 x lupins and 1 x quinoa) were analysed for ANF's, mycotoxins, lectins and phytoestrogen activity. Samples were from protein crops raised in the Netherlands, the UK, Belgium and Switzerland. This study shows that with the genetic improvement in some alternative protein crops, the occurrence of ANFs in new cultivars has been reduced, also under organic farming conditions. With organic farming conditions, yields are lower than with conventional farming, but still high enough to achieve a cost price of home-grown protein feeds that can compete with imports of for example oil seed meals, albeit at relative low margins per ha.

Continued plant breeding will be able to create further improved cultivars with higher yields, less susceptibility to plant diseases, especially soil borne plant pathogens that will be easier to combine with other crops in crop rotations.

A dose-response study was also performed to investigate the optimal inclusion levels of field beans, white lupins and quinoa. A soy based control diet served as negative control. Van der Peet-Schwering *et al.*(2006) conclude that an inclusion level of up to 20% tannin-free field beans can be recommended in diets for weanling piglets. For alkaloid-low lupins the recommended inclusion level is up to 10%. However, it is questionable if quinoa is a 'protein crop' because the protein content in quinoa is much lower that in other protein crops.

More knowledge on the digestibility of protein, amino acids and energy in organically grown protein crops is highly required.

WP 4.5 Development of efficient farm and/or farmer group specific mastitis prevention plans

Mastitis is a chronic disease of dairy cows, which can also be a factor affecting milk quality, especially somatic cell count and shelf life of milk. Many candidate strategies to improve udder health are not widely implemented in organic dairy farms. An important reason is the lack of scientific based knowledge on management measures and on the efficacy of non-antibiotic therapies.

In a study by Klocke *et al.*(2006) comparing the effectiveness of a teat sealant, a homeopathic remedy and no treatment (control), it was found that treating all healthy cows with SCC values below 200 per ml lead to best results after homeopathy (76%) and only to 50% protection rate in the teat sealant group compared to 44% in untreated cows. Teat sealants helped to reduce environmental infections, and are perhaps useful when applied to sub-clinically infected quarters. By sealing the teats and avoiding super- or re-infections during dry period, an 'undisturbed self-cure' may occur. This results in the following recommendations to dairy farmers:

- Usage of teat sealants in problem herds (environmental mastitis) in healthy quarters
- Usage of herd homeopathic remedies in infected cows in non-problem herds
- No treatment at all in healthy cows of non-problem herds
- In case of sub-clinical mastitis targeted strategic antibiosis discussable.

In the most recent QLIF work by Klocke *et al.*(2007) the effects of homeopathic treatment on sub-clinical mastitis during lactation were investigated. There was no significant effect by the remedies at all. The cow somatic cell count over three months after treatment showed no significant difference in the five groups. The authors conclude that further work is needed to investigate if other factors like age, microbial agents or individualized protocols are responsible for the lack of success when using homeopathic remedies.

A second line of investigation is followed by Wagenaar and co-workers. They hypothesise that cows and their calves can be considered more 'robust' or less 'disease susceptible' if they have a more natural suckling period. They argue that early weaning of calves can have a profound effect on disease incidence in later life, as well as on stress of the mother. In their study, Wagenaar and Langhout (2007) compared three calf rearing methods: bucket feeding of milk replacer, bucket feeding of tank milk and suckling at their mother. There initial aim was to determine whether the technical results of suckling systems in calf rearing were satisfactory. Calves reared in a suckling system reached significantly higher live-weights at weaning (90 days). Although growth performance between weaning and the age of 1 year did not differ significantly, live-weight at 365 days did still differ significantly. Compared to both bucket fed rearing groups, suckling did not have a significant effect on Somatic Cell

Count (SCC) of the mother cows. During the period of observation suckling systems did not result in increased problems with animal health.

In 2007 the evaluation of the milk production performance of the calves raised in the three rearing methods will be completed.

WP 4.6 Development of bovine feeding regimes which improve production efficiency, microbiological safety and/or sensory quality of milk

Escherichia coli O157 is an enteric pathogen which rarely causes disease in cattle, but can cause life-threatening gastro-intestinal infections in humans. Several recent studies have shown that the dairy feeding regime significantly affects the risk of pathogen shedding in the faeces of dairy cows. Recent studies from the USA indicated that calves fed a diet high in Bermuda grass hay (*Cynodon dactylon*) had on average 10-fold fewer *E. coli* O157 than those fed a pre-dominantly grain diet. Factors other than the proportion of grain in the diet may also affect *E. coli* shedding. Bakewell *et al.* (2007) have studied eight Hereford x Friesian steers prepared with rumen and duodenal cannulae, offered increasing proportions (increase of 33% each period) of red clover to grass over four periods with grass silage fed throughout. They were compared to 4 steers as an experimental control. Feeding red clover appeared to reduce pathogen loading but this was confounded by variation in the pathogen populations in the feed.

In their ongoing work they will aim to elucidate the different effects of red clover and feed pathogen load on the gut and faecal pathogen populations. Furthermore, Davies et al.are currently analysing data of trial on the effects of increasing proportions of red clover in the diet of dairy cows on the nutritional and organoleptic qualities of the milk they produce.

Conclusion

Although many new insights on livestock production have been generated during the first three years of the QLIF project, some of the main questions still remain to be answered. Questions related to the socio-economic consequences and the perceived health risks and benefits of new management, housing and feeding techniques have yet to be explored in collaboration with others within and outside the QLIF project. Answering them will further increase the competitiveness of the organic livestock sector. However, at this point in time, with new data and analyses results coming in faster than ever, it looks like the project is on track to deliver significant additional knowledge to the organic and low input livestock farming community.

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Schwering, A. Jongbloed). The credit for what has been achieved should be shared by all those mentioned above, whilst any mistakes or inaccuracies in this overview paper are the sole responsibility of the authors.

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Prevention and treatment of parasitic infections in organic pigs

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Key words: pigs, parasite control, *Ascaris suum*, rodent control, *Oesophagostomum dentatum*

Abstract

Organic and free range pigs are potentially exposed to a wider range of parasites and zoonotic challenges. The livestock Subproject QLIF addresses 4 strategies to combat these challenges, and the present paper describes the initial results. Rodent control is the first strategy, and a survey concludes that Salmonella *and* Campylobacter *infections were encountered in house mice and Norway rats, but not in other species.* T. gondii *antibodies could be detected in 6.4% of the blood samples taken from 235 wild small mammals. To reduce the presence of rodents around farms, the use of live-traps may be a good alternative for the use of rodenticides on organic farms. A second strategy is aimed at directing pig dunging behaviour in such a way that contact with (infected) faeces is minimised. The study showed that a rooting area resulted in a cleaner outdoor are and an extra outdoor drinker led to a cleaner area around the drinker, but to a dirtier indoor area. However, no difference in* Ascaris suum *infection were found. The nutritional strategy tested showed that pure inulin appeared the most effective as* Oesophagostomum dentatum *presence was reduced by 91%. Finally, as part of Strategy 4, a mixture of dried* Thymus vulgaris*,* Melissa officinalis *and* Echinacea purpurea *in a dosage of 5% in the diet showed to be preventive against a mild round-worm infection. The same mixture, however, was not effective in a lower dosage (3% in the diet) against a serious round-worm infection. Work is continuing to develop the above strategies further.*

Introduction

Organic and many 'low input' production standards for pigs require outdoor access. As a result animals are exposed to a wider range of potential endo- and ectoparasite infection sources and challenges (in particular faeces from small mammal vectors) than animals kept under conventional indoor conditions. Organic regulations claim that animal health should be assured through good management and prevention practices, instead of conventional (allopathic) medication. However, effective alternative methods for parasite control in pigs are almost completely missing, and use of conventional antiparasitic drugs is the rule on organic farms (Baumgartner *et al.*, 2001).

It is therefore essential to develop improved management strategies for outdoor systems (e.g. improved rodent control). WP's 4.1 and 4.2 review 4 preventative and curative strategies that will be helpful in reducing the incidence of parasitic and zoonotic infections in pigs: rodent control, dunging behaviour, carbohydrates and herbal remedies.

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Rodent control

The first strategy studied is to reduce the infection pressure through a tighter control of vectors such as rats and mice. Livestock farming can be prone to rodent infestations as it provides unlimited amounts of shelter, water and food to commensal rodents. The aim of this strategy is to obtain a better understanding of the risk of rodent presence on farms for transmission of pathogens to (organic) livestock in the Netherlands and to investigate their potential influence on the safety of food products we consume.

This work is carried out as WP 4.1.3, and has three main objectives.

Objective 1 was to provide insight into the contamination levels of wild rodents (and insectivores) with *Salmonella, Campylobacter* and *Toxoplasma gondii* on organic livestock farms, as these food-borne pathogens cause a high disease burden for humans.

Objective 2 was to find a method for sustainable though effective rodent management in (organic) livestock farming.

Objective 3 was to investigate the effect of stringent rodent control on *Toxoplasma* seroprevalence in slaughter pigs.

The following results are obtained.

Contamination of wild rodents

Rodents and insectivores (n=282) were trapped on ten organic farms (nine pig farms, one broiler farm) by using live-traps between August-October 2004. *Salmonella* and *Campylobacter* infections were encountered in house mice (8 of 83 Campylobacter-positive and 1 of 83 Salmonella Livingstone-positive) and Norway rats (1 of 8 Campylobacter-positive), not in other species. The results showed that *T. gondii* antibodies could be detected in 6.4% of the blood samples taken from 235 wild small mammals. Highest seroprevalence (9.1 %) was found in the White toothed shrew.

Comparing rodent control methods

During the autumn of 2005 we set up an experiment in 20 organic pig farms whereby two different rodent control methods were compared. Ten farms used conventional rodenticides and ten farms used live traps. The amount of rodents present on the farms before and after the experiment was assessed by measuring the amount of non-poisonous pealed oats taken up from bait boxes. The efficacy of rodenticides versus life traps was not significantly different. This indicates that the use of live-traps may be a good alternative for rodent control on organic farms.

Effects of rodent control on Toxoplasma

In the first experiments from this workpackage we showed that transfer of *Salmonella* or *Campylobacter* from rodents to livestock cannot be ruled out but is probably not the major transfer route. In the last part of the project we therefore decided to confine ourselves to the effect of stringent rodent control on transfer of *Toxoplasma* infections to slaughter pigs. On a selected number of organic pig farms (n=3), with a rodent control problem and presence of *Toxoplasma* infected pigs we performed stringent rodent control and followed *Toxoplasma* seroprevalence at slaughter. Although the experiment has not been completed, the first data indicate that adequate rodent control is associated with a decrease in *Toxoplasma* seroprevalence in the slaughter pigs.

Dunging behaviour and cleaning of pens

The second strategy deals specifically with the contamination of finishing pigs on farms with outdoor access to concrete runs, and the transmission of parasitic eggs between pigs and pens. Key factor is that transmission occurs through faeces. The approach uses the pig's intrinsic need to keep its lying area separate from the dunging area: if dunging behaviour can be properly directed, the area in the pen which is soiled will be strongly reduced in size. In theory, this serves two purposes: it reduces the risk of contact between pigs and faeces, and it facilitates the cleaning of an infected area.

Ascaris is the most prevalent helminth on organic farms (Carstensen *et al.*, 2002). It is transmitted mainly via the dung of infected pigs, but is only infectious to other pigs after an incubation period in the dung of at least 4 weeks.

Effect of rooting area design on dunging behaviour

In WP 4.1.1, 8 groups of 14 pigs were allocated to one of 4 treatments in 4 batches of 4 months. A 2x2 factorial design was used. The treatments are randomly assigned to the 8 pens of the finishing pig building. They were designed to provide increasingly strong stimuli in the outdoor run to direct dunging behaviour towards the part of the run which is furthest from the outside pen wall. This location is easiest to clean manually. The outdoor runs measured 4 x 4 m with 50% part slatted concrete floor with open pen divisions halfway down the length of the pen, on the run half which is furthest from the pen wall (and nearest to the outside inspection passage). In experiment 1 (batch 1 and 2) the factors were the presence/absence of a rooting area and the presence/absence of a drinking bowl on the outdoor run. In experiment 2 (batch 3 and 4) the factors were a separate exit/entrance or a combined exit/entrance and the presence/absence of a playing device as environmental enrichment. In the second week of each finishing period, infectious *Ascaris* eggs were spread on the dunging areas of the outdoor run in the first experiment. In the second experiment only half of the pigs of each pen were infected orally. A standardised protocol will be used to provide minimal but regular cleaning of the outside area. At the end of each finishing period, all pens will be cleaned and disinfected thoroughly.

The study showed that a rooting area resulted in a cleaner outdoor are and an extra outdoor drinker led to a cleaner area around the drinker, but to a dirtier indoor area. Unfortunately, no difference in *Ascaris* infection was found between these four treatment combinations.

Ongoing work on cleaning of pens

Regular (every three weeks) cleaning is more likely to achieve an *Ascaris* free status without medication (Roepstorff and Nansen, 1994), but this is time consuming and often unpractical. Cleaning once during a batch of pigs might be a way to break the lifecycle of *Ascaris*. Therefore, in WP 4.1.2, the hypothesis will be tested that the overall worm burden for organic finishing pigs can be reduced in a practical way by cleaning the outdoor run once, at a time just before the eggs have become infectious. During 2006 and 2007 4 batches of 120 pigs will be tested. Eight groups of 15 pigs will be allocated to one of 2 treatments. The treatments are randomly assigned to the 8 pens of the finishing pig building. The pens have 4 x 4 m outdoor runs with 50% part slatted concrete floor. They are designed to provide strong stimuli in the outdoor run to direct dunging behaviour towards a limited part of the run. The two treatments are 'no cleaning' and 'thorough cleaning at week 10 (of 16)'. At the start at 25 kg half of the pigs per pen are infected with worm eggs (mixed in the feed). The batches of 8 groups will be repeated 4 times over one 16 month period (32 groups, 8 replicates per treatment, a total of 480 pigs). At the beginning of each finishing period, 7 artificially infected piglets will be added to the group to provide a controlled and identical level of infection in each group. The 8 non infected pigs serve as focal animals. A standardised protocol will be used to provide minimal daily cleaning (mucking out) of the area. At the end of each finishing period, all pens will be cleaned and disinfected thoroughly. At the end at a slaughter weight of 110 kg the non infected animals are examined at the slaughterhouse for the infection with *Ascaris*.

Carbohydrates

The third strategy is to use carbohydrate sources with high contents of so-called FOS (fructooligosaccharide). The hypothesis is that these will significantly reduce female worm fecundity and worm numbers of both *Oesophagostomum* and *Trichuris* in pigs without affecting pig growth or production costs.

Earlier studies have shown that fructans that are easily fermented by some beneficial bacteria in the caecum and colon may influence parasite egg excretion and parasite establishment and persistence. The mechanism is not known but it is hypothesised that the fermentation changes the physico-chemical properties of the intestinal contents of the hind gut and that this is detrimental to the parasites. One highly effective source of fructans is the commercially available product called inulin (Raftilin HP®, Orafti). However, it is very expensive and of little relevance for the organic pig producer. Inulin is primarily produced from chicory roots and studies have shown that feeding dried chicory roots to pigs may also affect helminth infections in pigs.

Methodology

WP 4.1.4 is divided into 2 experimental trials and 1 on farm trial validating the findings from the first 2 trials. In the trial 1, 7 groups of pigs (n=8/10) pigs were infected twice weekly with large round worms (*Ascaris suum*), whip worms (*Trichuris suis*) and nodular worms (*Oesophagostomum dentatum*) from week 0-7. The pigs were fed an organic control diet of barley, wheat, oats, peas, soybeans, rape seed cake, and minerals weeks -2 to 5. Weeks 7-11, part of the cereals were substituted with dried chicory roots (15%, 25% or 35% of the daily energy intake), dried Jerusalem artichokes (25%, also rich in fructans) or potato starch (25% or 35%). The last group remained on the control diet throughout the trial. All pigs were slaughtered for worm recovery week 11.

In the second trial, 5 groups of 10 pigs were infected twice weekly with large round worms (weeks 0 to 7) and nodular worms for (weeks 2 to 7) while fed a control diet of ground barley, protein and minerals. Week 7, 3 groups were given a diet where part of the barley was substituted with dried chicory roots (38% of the feed or approx. 35% of energy intake) for 1 week (weeks 7-8), 2 weeks (week 7-9) or 4 weeks (week 7-11) before they were returned to the control diet. The fourth group was given a diet where part of the barley was substituted with pure inulin (19% of the energy intake). Overall fructan were 16-17% in both the chicory and inulin diets. The fifth group remained on the control diet. All pigs were slaughtered for worm recovery week 11.

Results

The 2 trials only showed an effect on the egg excretion and worm burdens of the nodular worms. The reason may be that the adult large round worm establishes in the proximal small intestine were fermentation does not take place. The front end of the whip worm is partially embedded in the intestinal wall of the caecum and colon and this may provide some protection. In contrast, the adult nodular worms may be more susceptible as they move freely in the intestinal contents of the hind gut. The nodular worm infections appeared negatively affected by the whip worms and the latter was therefore omitted from the second trial.

Dried chicory roots were more effective against the nodular worm than the Jerusalem artichokes. Also fructans appeared more effective than starch. Combined with previous experiments it also appears that the other feed components may modulate the efficacy of the easily fermentable carbohydrates. In the second trial, egg excretion was almost completely eliminated within two days but once the dried roots were removed from the diet egg excretion increased again within 2 weeks. The 35% dried chicory reduced nodular worm establishment by 74-82% in the 2 trials. Statistically 1, 2, and 4 weeks of feeding with chicory was equally effective in reducing worm burdens. The pure inulin appeared the most effective as worm burdens were reduced by 91% perhaps reflecting a more effectively fermentation compared to chicory.

Ongoing work

Based on the above it will be most relevant to the organic farmers to target sows in the on farm trial as older animals have the overall highest infection levels with nodular worms. It is therefore planned to follow the egg excretion patterns of sows during and after a short (2 weeks?) feeding period to evaluate if environmental contamination can be reduced. However, due to unresolved production problems the quality of the last batch of dried chicory roots is below standard. The trial has therefore been delayed until further supplementary root samples have been analysed and compared to determine if and how the dried roots can best be used.

Herbal medication

Finally, the fourth strategy investigates the use of herbal medication to combat infections with round-worm (*Ascaris suum*) as an alternative to chemically produced medicines like benzimidazoles, levamisole or macro cyclic lactones.

Herb mixes seem to be able to reduce round-worm pressures. A mixture of dried *Thymus vulgaris, Melissa officinalis* and *Echinacea purpurea* in a dosage of 5% in the diet showed to be preventive against a mild round-worm infection. The same mixture, however, was not effective in a lower dosage (3% in the diet) against a serious round-worm infection.

The mode of action of the tested herbs was probably based on their anti microbial activity that improved general gut health. The mode of action of this herb mixture can be broadened by the addition of black tea. Black tea contains tannins that seem to prevent round-worm to attach to the gut wall and to develop from worm egg phase to adult round-worm in the pig. Until now, we don't know whether the earlier tested herb mixture, without or with addition of black tea, in a lower dosage is also effective in preventing round-worm infections in pigs.

Methodology

As part of WP 4.2.1 an experiment has started to test the preventive effect of addition of a herb mixture to the diet of *Thymus vulgaris* (1%)*, Melissa officinalis* (1%) and *Echinacea purpurea* (1%), with or without addition of black tea (1%) against a mild

Ascaris Suum infection in growing finishing pigs, compared with a negative (no treatment) or a positive control (treatment with Flubendazole).

In this experiment 32 individually housed pigs are allotted to one of four treatments (8 pigs per treatment):

1) Negative control group; no treatment after infection with *A. suum*;

2) Positive control group; treatment with conventional medication (Flubendazole) after infection;

3) Herbs group A; treatment with Thymus (1%), Melissa (1%) and Echinacea (1%) after infection;

4) Herbs group B: herbs of treatment 3 + black tea (1%) after infection.

Active components (phenols) of herbs and diets will be analysed. Initial weight of the pigs is about 25 kg and absence of *Ascaris* at the start will be checked by faecal egg counts. Before infection, pigs of treatment 3 and 4 were fed herb-rich diets during 14 days. The other pigs are fed a common organic starter diet during the whole experimental period. Then, pigs are mild infected by oral administration of 200 worm eggs/pig over 5 days. Herb diets will be supplemented until 22 days after infection. On day 42 after infection, Flubendazole medication is given to pigs of treatment 2. All pigs are slaughtered on day 50 after infection (± 75 kg life weight), after which number of worms in the GIT are countered. The experiment starts on the 25th of December ’06 and finishes on the 21st of February ’07.

When treatment 3 and/or 4 seems to be effective in preventing a mild *Ascaris* infection, we will test the herbs under practical conditions (phase 2). Therefore, 4 organic pig farms (2 with low and 2 with high slaughter scores for liver rejection) will be selected to test the herbs versus conventional treating against *Ascaris suum*.

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A list of references is available from the first author.

Characteristics of Organic Pig Production and risk analysis concerning *Toxoplasma* infection

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Key words: food safety, pigs, *Toxoplasma gondii*, cats, outdoor run, rodent control

Abstract

A short written questionnaire was used to study certain characteristics of the organic pig production chain in The Netherlands and the circumstances on the farm that might play a role in the transmission of Toxoplasma infection to the pigs. Of the 81 certified organic slaughter pig farmers present in the Netherlands in 2006, 52 responded to the questionnaire (64 % response).

The farms could be divided into two populations. One population was represented by small organic pig farms with a mean number of 55 slaughtered pigs per year. These farms covered 40% of the total number of investigated farms, but only represented 2.5 % of the total number of slaughtered pigs. The second population had a mean annual production of 1460 animals. Almost 95% of these animals are currently slaughtered and further distributed by the Vion Food Group (de Groene Weg). A small part of the pigs (4%) is directly delivered to a slaughter company in Germany (Thönes) and 1% is sold via farm home sales.

For each farm an arbitrary Toxoplasma risk factor analysis was performed. Factors included the type of outdoor run (concrete or soil), feeding goat or sheep whey, number of cats, access of cats to outdoor run, stables and feed, rodent control and covering roughage fed to the animals. Calculation of the total risk score (summation of chance times severity scores for several factors) showed that many farmers already used management factors that decreased the risk for Toxoplasma infection. Analysis of a possible relation between risk score and farm size showed that a poor score was often seen on small farms. Because these farms mainly sell their meat in a frozen condition via home sales, this is not considered to represent a problem for food safety.

Further research is needed to investigate whether the risk for Toxoplasma can be maintained via on farm prevention or whether a Toxoplasma monitoring program should be implemented at slaughter, possibly with post slaughter decontamination. The fact that a recent report by the RIVM on food related infections has concluded that Toxoplasmosis has a markedly higher disease burden than Campylobacter or Salmonella, emphasizes the priority this subject should be given on the research agenda.

Introduction

The consumption of organic meat has shown a strong rise in The Netherlands in 2006 and now has a market share of 2.4%. The motivation of consumers to step over to organic is partly due to the fact that they strive to improve their own health and at the same time chose a product that benefits animal welfare.

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Recent studies from the Animal Sciences Group of Wageningen University and Research Centres have shown that animal friendly pig production systems are associated with an increased incidence of *Toxoplasma* as compared to conventionally held animals (Kijlstra *et al.* 2004a). A follow up study performed in 2004 showed that approximately half of the organic farms were *Toxoplasma* free, whereas the incidence in the positive farms varied between 1 and 93% (figure 1; Meerburg *et al.* 2006). This subject thus illustrates the dilemma between animal welfare and food safety. To find a solution to this dilemma more information is needed about the characteristics of the organic pig meat chain and the distribution of food safety risk factors within the chain. In the study described here we focussed on the parasite *Toxoplasma gondii*, since toxoplasmosis has recently been shown to produce the highest disease burden amongst food borne pathogens (Kemmeren *et al.*2006).

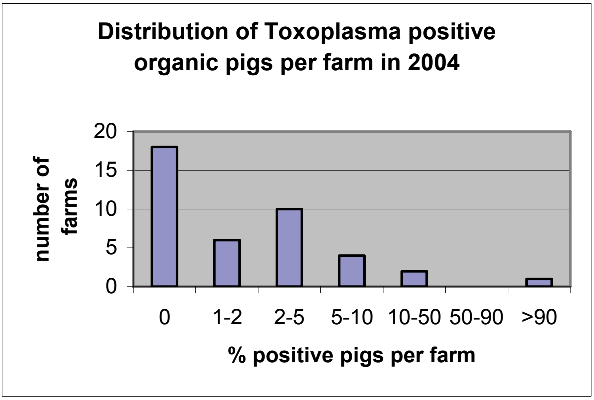

Figure 1. Distribution of *Toxoplasma* positive pigs per farm in The Netherlands in 2004.

Materials and methods

A short questionnaire was sent to all certified organic pig owners in the Netherlands. Information was obtained concerning the main activities on the farm, membership of the Dutch Organic Pig Farmers, number of pigs expected to slaughter in 2006, the slaughterhouse used and where the meat was distributed/sold. Furthermore information was obtained about a number of risk factors known from literature (Weigel *et al.* 1995; Kijlstra *et al.* 2004b) to play a role in *Toxoplasma* infection of pigs. *Toxoplasma* risk factors were each assigned a risk score which was calculated by multiplying the chance whether the described risk occurs on the farm with the severity. The severity gives an estimate of the number of animals possibly affected when the risk becomes manifest.

Results

Of the 81 eligible organic pig farms, 52 sent in their questionnaire (64% response). Analysis of non responding farms showed that these were often farms with less than ten pigs. These farms considered themselves too small to be a representative of the organic pig meat chain. Farms could be divided into two populations depending upon their size. Small farms with between 1-250 slaughtered pigs (mean 55) represented approximately 40% of the farms but only contributed 2.5 % of the number of animals produced. None of these small farmers is a member of the Dutch Society of Organic Pig Farmers. The large farms produced between 250 and 2800 pigs per year with a mean of 1460 per farm. Within the large farms one can also discern two separate subpopulations: one slaughtering between 1100-1650 pigs and the other producing between 2200-2800 animals. Most large farms have organic pigs as their main enterprise, although a combination with dairy farming is quite common. As mentioned earlier the very small farms (< 10 pigs) are under represented in our study.

Most of the pigs (95%) from 34 farms were slaughtered and further distributed by the Vion Food Group (Groene Weg). Of the other 18 farms, three exported their pigs to a German slaughterhouse (Thönes) and the other 15 used a local butcher. Most of the small farms sell their meat (frozen) from the farm itself.

Of the *Toxoplasma* risk factors, we attributed the highest number of points (9 points) to the use of an unpaved outdoor run. Only a few small farms use this type of outdoor run, whereas the larger farms all use a concrete paved run, which can easily be cleaned. Feeding animals goat or sheep whey was also given a large number of points (6 points). The presence of more than 3 cats was given 3 points. Various other factors concerning the presence of cats on various locations were given between 1 and 2 points each. In total a farm could obtain 32 points. Most of the farms had less than 10 points (33 farms) in total whereby five farms even had 0 points. Nineteen farms had a score higher than 10. The highest score was 24 points. Figure 2 shows that a relation exists between *Toxoplasma* risk score and the size of the farm. Of interest is that the middle size farms score best.

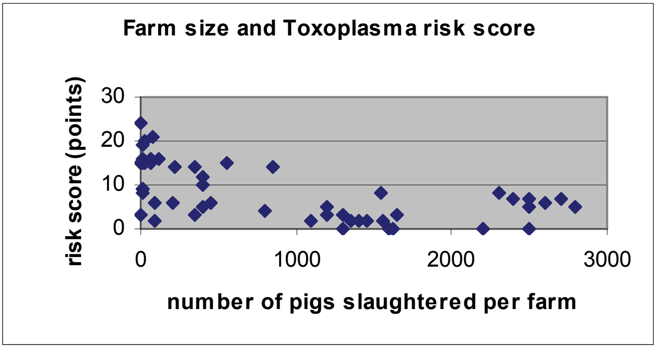

Figure 2. Relation between *Toxoplasma* risk score and farm size (number of expected pigs to be slaughtered in 2006).

Discussion and Conclusions

- The organic pig farms in The Netherlands can be divided into a group of large professional farms and a group of small farms. The latter group represents a large number of farms but only produces a limited amount of animals. These small farms are not member of the Dutch Society of Organic Pig Farmers and may not have access to knowledge concerning food safety issues.

- 95% of the Dutch organic pigs are slaughtered and distributed by one company.
- Cats are frequently present on organic pig farms. We recommend to keep cats away from the outdoor run, stables, feed, water and straw bedding materials. A feasibility study is needed to investigate the effect *Toxoplasma* vaccination of cats.
- A small number of pig farmers feed whey obtained after cheese making to their pigs. As long as transfer of infection via milk has not been excluded we advise not to feed non pasteurised whey.
- It can not be excluded that mice in the roughage transfer *Toxoplasma* infection to pigs. It is advised to cover roughage to prevent mouse access. Rodent control should be a continuous focus of attention on the farm.
- Pigs from small scale pig producing farms have a higher chance to be infected with *Toxoplasma*. Meat from these farms should preferentially be frozen (which kills the parasite) before it is sold to the consumer.
- Further research is needed concerning the usefulness of the developed risk score and the actual presence of infectious parasites in the meat. The density of infectious *Toxoplasma* cysts in organic pig meat has not yet been investigated and little is known about consumer handling of organic meat (barbecues, thoroughness of cooking procedure, kitchen hygiene). Further issues include the question whether a *Toxoplasma* monitoring should be set up at slaughter, the type of monitoring (serology versus parasite detection), or whether risk meat can be decontaminated post slaughter.

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Development of prevention and treatment strategies for parasites in poultry

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Key words: poultry, parasite control, *Ascaridia galli*, *Dermanyssus gallinae*

Abstract

*Parasitic infections are likely to be more important in organic and other free-range hens than in birds kept indoors. Several workpackages of QLIF aim at improving prevention and therapy of helminth (*Ascaridia galli *and* Heterakis gallinarum*) and arthropod (*Dermanyssus gallinae*) parasites of laying hens. This paper is a summary of the work undertaken in the first 3 years of QLIF.*

Introduction

The risk of parasitic infections is elevated in hens and pigs in free-range systems, as required in organic farming, compared to systems without outdoor runs (Permin *et al.*, 1999; Thamsborg *et al.*, 1999; Permin *et al.*, 1999). Effective alternative methods for controlling parasites in monogastrics are almost completely lacking and the use of conventional antiparasitic drugs is the rule on organic as well as on conventional farms, although the extent of use may vary.

Two WPs in QLIF are dedicated to this subject. This paper gives an overview of the work carried out with poultry parasites and presents some results obtained so far.

Endoparasites

Introduction

The parasitic situation is particularly critical in the control of helminths of laying hens, because only one anthelmintic (Flubendazole) is registered for this indication. This extensively used substance leads to residues in eggs; managing this issue presents a major problem for organic egg production. The roundworms *Ascaridia galli* and *Heterakis gallinarum* are the most important parasitic species in the intestines of poultry. Routine anthelmintic treatments are usually applied in laying hens in order to control these Ascarids, whose eggs generally have a long survival rate in the environment, and thus a high infection potential.

Preventive strategies are less effective in monogastrics than in ruminants, because of the different epidemiology of the helminth species involved, but still proper management is the basis for the prevention of helminth infections. Good hygiene of houses is essential for the prevention of an accumulation of the long-lasting infective parasite eggs over time. Thorough cleaning of the house and 'wintergarden' is only possible between flocks. The outdoor run cannot be disinfected in order to destroy infectious stages and, therefore, alternative strategies have to be elaborated.

Results of a Danish study (Schou *et al.*, 2003) suggest that the epidemiology of *A. galli* infections in chicken may be influenced by a genetic component of the host.

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(Gauly *et al*., 2002) observed significantly higher fecal egg outputs in white laying hens than in brown hens; they estimated sufficiently high heritabilities for fecal egg counts to allow for selection for *A. galli* resistance in chicken. However, parasite resistance is not a major criterion in poultry breeding at present.

Worldwide, a variety of plants have been shown to affect survival and/or reproduction of helminths of chicken and pigs *in vitro* or *in vivo*; in some cases, severe side effects on the host have been observed after the administration of certain plant products (e.g. Akhtar and Riffat, 1985; Javed *et al*., 1994; Satrija *et al*., 1994).

Coccidia (protozoan parasites in the intestines of poultry) are considered as one of the most severe health and welfare problems in poultry. In the last years, a vaccine based on attenuated strains of the relevant *Eimeria* spp. has been successfully implemented in organic production of chicken and additional measures are usually not necessary.

The following sections briefly describe the QLIF-experiments aiming at prevention and control of *A. galli* and *H. gallinarum* under organic farming conditions.

Materials and Methods

In a three-year study, the effects of three different types of outdoor runs with increasing grass cover on helminths were assessed in small flocks of laying hens (WP 4.1.1.1). In year 1, hens with natural helminth infections had been used to contaminate the runs. In years 2 and 3, parasite naive young layers were put on the contaminated runs. The runs of the groups were managed according to different regimes:

- ‘overused’ old poultry run, large areas without grass cover
- ‘ideal’ new run, almost no bare areas and a regular grass cover
- ‘extensive’ run with structures and natural or artificial shelters, not mown.

The experiment was replicated on 4 farms in Switzerland. Fecal egg counts were performed monthly and worm burdens were determined in each flock after slaughter. The infectivity of the runs was repeatedly determined directly and with tracer animals and the vegetation in the runs was recorded monthly.

In a second experiment, the effects of three different litter management regimes on helminth infestations are assessed by means of fecal egg counts and worm burdens of tracer animals (WP 4.1.1.2). The experiment will finally include 6 farms and is still ongoing.

A third experimental series is dedicated to finding alternatives to conventional treatments of *A. galli* (WP 4.2.1.2). In several experiments, either laying hens naturally infected with *A. galli* and *H. gallinarum* or pullets with artificial *A. galli* infections are fed with promising anthelmintic plant products identified in a literature survey. Fecal egg counts are made during the feeding period and worm burdens are determined after slaughter at the end of the feeding period. In a second step, selected plant products are tested under semi-practical or practical conditions in layer flocks.

Results

The run management experiment is finished, but complete results are only available from the two first flocks at present. Hens on one farm had low prevalences of Ascarids and a low average FEC. On the other farms the prevalences of Ascarids as well as the average FECs were lowest in the ‘extensive’ runs, whereas the ‘overused’ and ‘ideal’ runs were comparable. *A. galli* and *H. gallinarum* are present on all farms and in all flocks; the low FEC on one farm reflect low numbers of *A. galli* found in the hens of this farm. Tapeworms and *Capillaria spp.* occur in a substantial proportion of the hens. At the end of the second vegetation period, the proportion of bare soil has increased in all the runs on all farms except for the ‘ideal’ runs on farm 1, 3, and 4. As after the first season, the proportion of bare soil is higher in the ‘overused’ runs (up to 100%) than in the other two run types.

Data of the litter management experiment are not presented, because the experiment is still running on most of the farms.

Six plant products were fed to layers naturally infected with *A. galli* and *H. gallinarum* in two experimental series. In four other series, nine products have been administered in various concentrations to hens artificially infected with *A. galli*. None yielded significant fecal egg count reductions or reductions of *A. galli* burdens. Tests with higher concentrations of the respective products are ongoing.

Discussion

Developing management measures for prevention of Ascarid infections in poultry is a difficult task due to the epidemiology of the species involved. It may be possible to identify advantages of some management elements after the completion of the experiments undertaken in QLIF, but it is still a question whether those are efficient if applied alone.

Ectoparasites

Introduction

The poultry red mite *Dermanyssus gallinae* is the most important ectoparasite of laying hens in organic as well as in conventional egg production in Europe (Maurer *et al*., 1993, Höglund *et al*., 1995). The haematophagous mite is a nocturnal feeder and spends the day in the surroundings of the hens. At high population densities poultry red mites can cause severe anaemia; already low mite populations irritate the hens to an extent that they refuse to go into the henhouse or rest on the perches. Controlling the mite during flocks is difficult.

In Switzerland, a three-stage management system for the control of *D. gallinae* on organic farms is currently applied. As a first step, the empty houses are cleaned and disinfected between flocks. Second, mechanically or physically acting substances (e.g. oils or silicas) are applied preventively or as a treatment when infestations are first detected. As a third step, acaricides of natural origin are applied if necessary.

Within the project QLIF, the effectiveness of measures including all three stages is evaluated.

Materials and Methods

Different levels of cleaning and disinfection are evaluated in commercial layer houses in a split farm design with 3 levels on 5 farms (WP 4.1.2.1). Mites are sampled monthly in mite traps placed in the houses.

Promising alternatives to conventional treatments of *D. gallinae* are tested *in vitro* and on farm (WP 4.2.1.1). In an *in vitro* assay, silicas (5 products), plant and mineral oils (4 products), plant extracts (14 products), and commercially available products declared as natural acaricides for red mite control (5 products) have been tested in several concentrations. The effects on survival of female mites are described by means of

AUDPC-values, an integration of the survival curve. The 2 most promising alternatives will be tested in 5 layer houses and the effects on mite populations evaluated by means of mite traps.

Results

The experiments in WP 4.1.2.1 have only started in autumn 2006, data on the effects of cleaning and disinfection are therefore not yet available.

In the *in vitro* tests (WP 4.2.1.1), several plant extracts and oils significantly reduced the survival of *D. gallinae* females, but not all the commercially available products were more efficient than their controls. Diatomaceous earth (DE) without acaricides was at least as effective as DE supplemented with pyrethrum or essential oils and a liquid formulation of silica *in vitro*. In the first on farm experiments undertaken, DE was effective during a limited period only, whereas the liquid formulation had a very good residual effect over several months (Maurer & Perler, 2005).

Discussion

The strategy for red mite control based on cleaning and disinfection and use of mechanically acting substances can be improved by the dispersion of liquid silicas, when they are available for organic farmers. Several effective acaricidal products of natural origin are available or under development. Incorporating those in artificial aggregation sites for *D. gallinae* as described by Chirico & Tauson (2005) and Lund *et al*. (2002) is possibly a more efficient application than spraying poultry houses with those relatively expensive products.

Conclusions

Endoparasites

In the second half of QLIF, tests with feed components with potential anthelmintic properties will continue (WP 4.2.1.2) and the experiments for evaluation of preventive measures (WP 4.1.1.2) will be finished. In parallel, epidemiological studies will be started and the genetic component of the hen will be evaluated in order to fill gaps of knowledge which are constraining the development of preventive measures.

Ectoparasites

The remaining experiments will focus on the further development of preventive strategies against *D. gallinae* (WP 4.1.2.1) and on the application technique for natural products in commercial poultry houses (WP 4.2.1.1).

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References : A list of references is available from the first author.

Dietary Nitrate: Effects on the health of weaning pigs and Antimicrobial activity on seven probiotic Bifidobacterium spp. strains

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Key words: Nitrate, isothiocyanate, probiotic bifidobacteria, pigs, gut microbiota.

Abstract

The potential role of nitrite as an antimicrobial substance in the stomach may be of some importance in the ecology of the gastrointestinal tract and in host physiology. It has been shown that nitrite, under the acidic conditions of the stomach, may kill gut pathogens like Salmonella enteritidis, Escherichia coli, Salmonella typhimurium, and Yersinia enterocolitica, whereas acid alone has only a bacteriostatic effect. An in vivo study was conducted in order to assess the effects of dietary nitrate on microbiota and on the health of the gut (particularly in the stomach and small intestine). 96 weaning pigs were fed a diet containing high nitrate levels (15 mg and 150 mg) and then challenged with Salmonella enterica serovar typhimurium.

Differences in composition of the gut microbiota were assessed by analysing samples from the pigs: To date analysis of 48 pigs has been completed. Preliminary results demonstrated no effect on the population densities of microbial groups either from the challenge or from nitrate intake. However, increasing the time from challenge decreased either the counts of LAB in the stomach and jejunum or of clostridia in the stomach.

Bifidobacteria also decreased in the stomach contents as nitrate supplementation increased. Supplementing the feedstuff with high dietary nitrate intake and then challenging with Salmonella did not affect the gastric pH or the degree of ulceration in the pigs.

The synergistic bactericidal effects of pH, nitrite and thiocyanate on seven probiotic Bifidobacterium spp. strains were also investigated in an in vitro study.

The results of the in vitro study demonstrated that an inhibitory effect exists on the seven probiotic bifidobacteria investigated with an exposure longer than 2 hours and pH values < 5.0. Addition of thiocyanate also increased the susceptibility of the tested strains. In this in vitro study, the most resistant strains at all conditions were B. animalis subsp. lactis Ra 18 and P32 and B. choerinum Su 877, Su 837 and Su 891.

Introduction

Some beneficial effects of dietary nitrate on the physiology of the intestinal tract have been shown (McKnight G.M., *et al.* 1997). Recent studies also suggest a new non-

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immune host defence mechanism involving nitrite, which prevents pathogens from entering the bowel.

The mechanisms of this bactericidal effect are still unclear. However, the effect seems to be due to the production in acidic stomach conditions of some reactive nitrogen compounds like nitrous acid, peroxynitrite, nitrogen dioxide (NO_2) and frequently nitric oxide (NO) from nitrite (Xu J, *et al.*, 2001).

The potential role of nitrite as an antimicrobial substance in the stomach may have some importance for the ecology of the gastrointestinal tract and host physiology, modifying normal microbiota and/or ingested probiotic viability (Xu J, *et al.*, 2001).

The aims of these studies were to:

- assess the impact of high nitrate levels in the diet of weaning pigs on ulceration levels, on antimicrobial activity of the stomach acid against gastrointestinal diseases and on population levels of normal stomach and upper intestine microflora;
- quantify the resistance of probiotic bifidobacteria cultures to simulated gastric juice containing different concentrations of nitrite and isothiocyanate.

Materials and methods

Experimental design: *In vivo* study

A 2-factorial experiment was conducted to test the effect of three different doses of nitrate (supplied as a potassium salt) on normal stomach and upper intestine microbiota, on ulceration levels in the stomach and on gastric pH in pigs challenged or not with *Salmonella enterica* serovar *typhimurium* (orally supplied by 1.5 ml of broth containing 1 $\times 10^9$ CFU).

A total of 96 pigs (Landrace x Large White), weaned at 21 days, were randomly assigned (16 pigs each) to one of the following treatments: (1) base diet; (2) base diet + 15 mg/kg nitrates; (3) base diet + 150 mg/kg nitrates; (4) base diet + *Salmonella*; (5) base diet + 15 mg/kg nitrates + *Salmonella*; (6) base diet + 150 mg/kg nitrates + *Salmonella*.

The animals were sacrificed and stomachs removed for quantification of the ulcerae. The gastric contents were then rapidly harvested and pH was measured.

Microbiological analyses are currently in progress to enumerate five microbial groups in the stomach and in the jejunum contents: Lactic Acid Bacteria (LAB), *Bifidobacterium* spp., *Enterobacteriaceae*, *Clostridium* spp, and yeasts. Quantitative detection of *Bifidobacterium* spp. was performed by a dilution PCR method.

Experimental design: *In vitro* study

Concentrations of nitrite characteristic of those found in saliva were tested on seven probiotic bifidobacteria of various origins (Tables 2,3).

Determination of the bactericidal (MBC) and bacteriostatic activities (MIC) of acidified nitrite was performed on disposable microwell plates using the method described by Dykhuizen *et al.*(1996). Nitrite solutions with final concentrations of 0, 0.05, 0.125, 0.2, 0.25, 0.375, 0.5, 1, 1.5, 2, 2.5, 3, 4, 6, 10mM in the microwells and TPY broth solutions acidified by hydrochloric acid with different final pH values were prepared.

Results: *In vivo* study

Ability of supplementation with nitrate to enhance stomach acidity and impact on ulceration levels in pigs fed with high nitrate concentration

The effects of diet, challenge, and time from challenge on average values of gastric pH and on ulceration levels are presented in Table 1.

Table 1. Effect of diet, challenge and time from challenge on average values of gastric pH and ulceration levels in pigs fed high nitrate concentration

	Treatment			SEM	Challenge		SEM	Sacrifice, days after challenge		SEM
	Control	Ni15	Ni150		No	Yes		2	20	
Gastric pH	2.86	3.31	2.88	0.165†	3.04	2.99	0.134***	3.35	2.69	0.133 ***
Ulceration score	1.36	1.24	1.33	0.204 ns	1.29	1.33	0.165 ns	1.26	1.35	0.164 ns

† Between nitrate supplementations, approaching significance (P=0.066); *** P<0.001; ns = P>0.10.

Effect of different nitrate concentrations on the population levels of normal stomach and upper intestine microbiota

The diet did not affect the contents of cultivable LAB, Clostridia and yeasts in either segment, nor did it affect *E. coli* contents in the jejunum. The time from challenge had an important effect on the counts of LAB which decreased with age in the stomach (P<0.001) and in the jejunum (P< 0.05). In addition, *Clostridia* spp. in the stomach were reduced.

With respect to *E. coli* contents in the stomach, only 35 – 40% of the subjects of each diet had a bacteria concentration sufficient to be recoverable with the cultivation, and the values in the positive samples were very low (3.12 log cfu on average, data not reported in table). In the older pigs, a trend of decreasing bifidobacteria count in the stomach (P=0.07) was noted.

Results: *In vitro* study

Resistance of probiotic bifidobacteria cultures to simulated gastric juice containing different concentrations of nitrite and isothiocyanate

Susceptibilities to acidified nitrite solutions expressed as MIC values ranked as follows: Su 905>Su 932/1>Ra 18>P32>Su 837>Su 877 and Su 891 (Table 2).

The MBC was determined at three different times (Tables 2,3). Increasing time of exposure, all strains survived unless nitrite was present in the solution but their susceptibility increased at all pH settings. (Table 2). Susceptibility as MBC_{24h} was: Su 905>Su 932/1>Su 837, Su 891, Ra 18, P 32> Su 877.

The addition of sodium thiocyanate (10mM) resulted in a reduction in the amount of acidified nitrite required to accomplish bacteriostatic and bactericidal activity.

Increasing time of exposure, the bacteriocidal effect of thiocyanate was more evident. All strains were killed within 24 hours at a pH of 2.5. MBC_{24h} was different for each strain and the susceptibility at all pH settings ranked as follows: Su 905>Su 932/1>Ra18, P32>Su 837>Su 891>Su 877.

Table 2. Activity of nitrite acidified with HCl at various pH values on select probiotic *Bifidobacterium* spp. strains

Strain (Species and origin)	Antimicrobial activity	Exposure time (h)	Antimicrobial nitrite concentration (mM) at specified pH							
			2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
RA 18	MBC	0.5 h	6	10	>10	>10	>10	>10	>10	>10
B. animalis		2	3.5	4	8	>10	>10	>10	>10	>10
subsp. *lactis*		24	1	1.5	2	4	6	>10	>10	>10
(from rabbit)	MIC	24	0	0	0	0	3	6	>10	>10
P 32	MBC	0.5 h	6	>10	>10	>10	>10	>10	>10	>10
B. animalis		2	3.5	4	8	>10	>10	>10	>10	>10
subsp. *lactis*		24	1	1.5	2	4	6	>10	>10	>10
(from chicken)	MIC	24	0	0	0	0	3.33	7.33	>10	>10
SU 905	MBC	0.5 h	4.5	6	>10	>10	>10	>10	>10	>10
B. suis		2	2.5	3	6	>10	>10	>10	>10	>10
(from pig)		24	0.2	0.75	1	1.5	2	8	8	≥ 10
	MIC	24	0	0	0	0	1.25	3	5	5
Su 932/1	MBC	0.5 h	5	≥8	>10	>10	>10	>10	>10	>10
B. suis		2	3	4	8	>10	>10	>10	>10	>10
(from pig)		24	0.75	1	1.25	1.75	4.5	≥8	>10	>10
	MIC	24	0	0	0	0	1.5	3.5	6	10
Su 837	MBC	0.5 h	6	10	>10	>10	>10	>10	>10	>10
B. choerinum		2	3	4	8	>10	>10	>10	>10	>10
(from pig)		24	1	1.5	≤2	3.5	6	>10	>10	>10
	MIC	24	0	0	0	0	4	7.33	>10	>10
Su 877	MBC	0.5 h	8	>10	>10	>10	>10	>10	>10	>10
B. choerinum		2	4	5	8	>10	>10	>10	>10	>10
(from pig)		24	1	1.5	2	4	6.67	>10	>10	>10
	MIC	24	0	0	0	0	4.67	8.67	>10	>10
Su 891	MBC	0.5 h	6	>10	>10	>10	>10	>10	>10	>10
B. choerinum		2	3.5	4	8	>10	>10	>10	>10	>10
(from pig)		24	1	1.5	2	4	6	>10	>10	>10
	MIC	24	0	0	0	0	4	8.67	>10	>10

Table 3. Activity of nitrite acidified with HCl at various pH values on select probiotic *Bifidobacterium* spp. strains with the addition of 10mM KSCN in the solution

Strain (Species and origin)	Antimicrobial activity	Exposure time (h)	Antimicrobial nitrite concn (mM) at pH 2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
RA 18	MBC	0.5 h	5	8	>10	>10	>10	>10	>10	>10
B. animalis		2	3	3	6	>10	>10	>10	>10	>10
subsp. *lactis*		24	0	0.83	0.83	2	4	6	7,33	>10
(from rabbit)	MIC	24	0	0	0	0	2	2.5	6	10
P 32	MBC	0.5 h	5	8	>10	>10	>10	>10	>10	>10
B. animalis		2	3	3	6	>10	>10	>10	>10	>10
subsp. *lactis*		24	0	0.83	0.83	2	4	6	7.33	>10
(from chicken)	MIC	24	0	0	0	0	2	2.83	6	10
SU 905	MBC	0.5 h	3.5	5	8	>10	>10	>10	>10	>10
B. suis		2	2	2	3.5	10	>10	>10	>10	>10
(from pig)		24	0	0.25	0.25	0.5	1.25	4	4	6
	MIC	24	0	0	0	0	0.75	1	3	3
Su 932/1	MBC	0.5 h	4	7.33	≤10	>10	>10	>10	>10	>10
B. suis		2	3	3	4	10	>10	>10	>10	>10
(from pig)		24	0	0.57	0.57	1.25	2	4	5.33	8
	MIC	24	0	0	0	0	1	2	4	6
Su 837	MBC	0.5 h	5	8	>10	>10	>10	>10	>10	>10
B. choerinum		2	3	3	6	>10	>10	>10	>10	>10
(from pig)		24	0	0.87	0.87	1.67	4	6	10	>10
	MIC	24	0	0	0	0	2.16	3.50	6	10
Su 877	MBC	0.5 h	5	8	> 10	>10	>10	>10	>10	>10
B. choerinum		2	3.5	3.5	7.33	>10	>10	>10	>10	>10
(from pig)		24	0	1.25	1.25	2.5	4	6	10	>10
	MIC	24	0	0	0	0	2.5	5.33	≥8	10
Su 891	MBC	0.5 h	5	8	>10	>10	>10	>10	>10	>10
B. choerinum		2	3	3	6	>10	>10	>10	>10	>10
(from pig)		24	0	1	1	2.5	4	6	10	>10
	MIC	24	0	0	0	0	2	4	6.67	10

Discussion
In vivo study

A trend of increase in gastric pH can be expected with the addition of dietary nitrate, whether challenged by Salmonella or not. More experimental data are required to explain this observation and why this increase was not observed for a dose ten times higher. The dietary addition of nitrate and challenge with *Salmonella* do not affect the degree of ulceration.

On the average the supplementation of the diet with nitrates did not affect bifidobacteria concentrations in the two digestive tracts. However, the trend of decreases in bifidobacteria and LAB could be related to the suspension of milk intake after weaning and the consequent reduction of substrates favourable for growth of this kind of bacteria.

Salmonella enterica serovar *typhimurium* was found in almost all pigs challenged with this pathogen. Nitrates did not show good resistance to pathogen colonisation, even though some unchallenged pigs also resulted positive for Salmonella in the lymph nodes.

In vitro study

Antibacterial potential of swallowed salivary nitrite at low pH values has already been demonstrated by various studies. Our work confirmed that an inhibitory effect also exists on the seven probiotic bifidobacteria strains investigated for time exposures greater than 2 hours and pH values < 5.0. The addition of thiocyanate increased the susceptibility of the tested strains. Overall, the most resistant strains were Ra 18, P32, Su 877, Su 837 and Su 891 at all conditions studied.

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Effects of a feeding strategy to increase intramuscular fat content of pork under the conditions of organic farming

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Key words: feeding strategy, pork quality, intramuscular fat, on-farm research

Abstract

In an ongoing study, the effect of the implementation of a specific feeding strategy using a high portion of home-grown grain legumes on the intramuscular fat (IMF) content of pork, is assessed under different conditions on organic farms in Germany and Austria. Preliminary results indicate that variation in the IMF content seems to be higher between farms than between treatments within each farm.

Introduction

Considering the various aspects, the issue of intrinsic and extrinsic pork quality is a very complex and multifactorial concept. It encompasses both objective carcass and organoleptic measures and subjective perceptions about the product and the production methods (Edwards and Casabianca 1997). Beside the various factors influencing the different quality traits and their potentially synergistic or antagonistic impacts, the variability within the traits aggravates reasonable and valid conclusions from the previous data available. It is commonly acknowledged that meat quality is a difficult characteristic to assess as many different aspects, both objective and subjective, make up the overall trait (Hofmann 1994). All the various characteristics of pork quality can not be assessed directly in each carcass because those measurements and assessments would be too expensive. Therefore, the previous scientific access for quality assessment of meat is primarily an indirect approach based on a few numbers of easily detectable quantitative traits and on the prescription of minimal standards in relation to the product in terms of size or composition and in relation to the production process. Specifications and exclusion criteria vary between countries or between label programs.

Consumers are interested in many aspects related to meat quality, such as appearance, freshness, taste, nutritional value and food safety. According to Andersen (2000), appearance often has become the customer`s single factor to evaluate the quality of pork. However, the IMF content is the prominent criterion for eating quality of pork. It has been defined among others as flavour carrier (Affentranger *et al.* 1996). The fat finely distributed in the muscle and recognizable in higher contents as marbling, makes it possible to differentiate between differently treated animals in relation to eating quality. Previous studies showed that the texture and the taste of pork was improved with an increased IMF level (Affentranger *et al.* 1996) while low-fat meat has shown to be almost taste-neutral. The authors concluded that the positive effect of increased IMF holds true as long as it is not associated with an increase in the level of visible intramuscular fat.

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An increase in IMF level is associated with an increase in visual perception of fat and a corresponding decrease in the willingness of consumers to purchase the meat (Fernandez *et al.* 1999). Consumers also show a huge variability in their eating preference to non-visible IMF. In a hedonic test panel, nearly one third of the consumers behaved indifferently while the majority preferred the pork with the highest IMF (Sundrum and Acosta Aragon 2005).

The non-consideration of this trait and the unidirectional selection for lean meat resulted in IMF-contents in *M. longissimus dorsi (M.l.d.)* which on average are clearly below the desirable content of more than 2 % (Fernandez *et al.* 1999). Modern slaughter pigs currently show an average IMF content of only 1% (Köhler *et al.* 1999). Nutritional effects on intramuscular fat characteristics and IMF content are clearly greater than genetic effects (Sundrum and Acosta Aragon 2005, Cameron *et al.* 2000). Feeding is an important tool as many dietary components are readily transferred from the feed to the fat tissue. The fatty acid (Wood and Enser 1997) and vitamin composition (e.g. Vitamin E) in the diet (Buckley *et al.* 1995) have a direct influence on the quality of the meat. Pig producers primarily try to approach maximal rates of lean tissue deposition and carcass index values by means of providing diets formulated to meet the requirements in relation to the limiting amino acids. In the growing period, protein accretion increases as the supply of the limiting amino acid increases (Heger *et al.* 2002).

While in general farmers are striving to increase the IMF by breeding methods, investigations of Sundrum *et al.* (2000) showed that it is possible to achieve an IMF content higher than 2.5 % by feeding rations enriched with grain legumes such as lupines and faba beans.

Materials and methods

On farm research

In this study, a total number of 12 organic pork producers in Germany and Austria are involved. Following the concept of phase feeding, two dietary treatments, a control diet and an experimental diet are used simultaneously in the fattening period. On each farm separate pens are used in the same time period for the control and the experimental diet. On each farm one replicate is conducted.

Animals

Genotypes vary between the farms, but belong to those genotypes which are also used in conventional pig production.

Feeding strategy

In Germany all pigs in the experimental groups on the different farms receive the same diet. The single components for the experimental diet are stored and mixed immediately before the transfer to the farms. The feedstuff is packed into bags (20 kg) and is transported to the farms. Counting the bags enables to estimate the amount of feed used and thereby the feed conversion ratio. Each formulated mixture is analyzed by Near Infrared Spectroscopy (NIRS) and controlled regarding its crude protein and metabolizable energy content. The amino acid supply is separately determined by HPLC method.

The experimental diet, which is formulated in order to obtain a high IMF content in the pork, contains a high portion (> 40 %) of grain legumes (lupines and faba beans) in

Germany, in Austria the rations contain 36 % of a mixture of peas and faba beans. The diet supplies restricted amounts of essential amino acids while at the same time increasing the supply with non-essential amino acids to values clearly above the requirement. The control diet represents the feeding strategy followed on the individual farm. The recording of growth performance data starts at the beginning of the finishing phase with about 70-80 kg and ends before slaughtering with about 115-120 kg live weight. Carcass parameters such as carcass weight (kg), carcass classification, lean meat content (%), fat and meat area (mm) and pH-content are assessed at the abattoir. Individual samples of *M.l.d.* of 10 pigs per treatment are taken from between the 13th and 14th rib and frozen at -20 °C before analysis. Afterwards the samples are analyzed for IMF content by NIRS. Furthermore feed intake and net feed conversion ratios are assessed.

Preliminary Results

The preliminary results show a huge variation in the IMF content of the *M.l.d.* of carcass between the farms. The variation seems to be higher between farms than between treatments within each farm. Source of variation is expected to be due to different live weights in the feeding groups, different feed intake and different feeding strategies such as *ad libitum* feeding or restricted feeding.

Furthermore feed intake of the experimental diet in groups fed *ad libitum* tended to be higher than in groups fed the control diet. The data pool of several farms is not yet completed and samples of *M.l.d.* are not tested in total until now.

Conclusions

A number of factors can affect pork quality. Particularly live weight at the beginning of the fattening period and the duration of intake of the relevant feedstuff have to be considered. In the ongoing study results are expected that provide answers in relation to the suitability of feed rations in order to increase the IMF content of pork under practical farm conditions. Based on the results, recommendations for the farmers will be elaborated on how to optimize pork quality in dependence of different farm conditions.

Acknowledgements

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Treatment of bovine sub-clinical mastitis with homeopathic remedies

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Key words: dairy cattle, sub-clinical mastitis, homeopathy

Abstract

Considering the positive results of homeopathic therapy of bovine mastitis, the presented study should evaluate the effects of two standardized homeopathic methods in sub-clinical mastitis using a prospective randomized double-blind placebo control study design. A number of 124 dairy cows from 17 herds with increased somatic cell count were selected and randomly associated to 5 treatment groups. Two groups received a peroral therapy with (a) a homeopathic combination over 5 days and (b) a single treatment with a homeopathic nosode (Tuberculinum). To each treatment group a placebo control group was established with the same treatment frequency. A fifth group served as an untreated control. The bacteriological cure rate after 4 and 8 weeks was 28% and the total cure rate additionally regarding a normalized somatic cell count was 14% and 18%, respectively. There was no significant effect by the remedies at all. The cow somatic cell count over three months after treatment showed no significant difference in the five groups. Standardized homeopathic combinations and Tuberculinum nosodes are not able to control sub-clinical mastitis during lactation. If other factors like age and microbial agent are responsible for the success of homeopathy or if more individualized protocols provide better results has to be answered in further investigations.

Introduction

Mastitis is the most common health problem in Swiss organic dairy herds. The regulations and consumer presumptions claim a minimal chemo-therapeutic intake to control udder health although antibiotics are very effective under certain conditions. On the other hand there are existing problematic mastitis causing micro-organisms which are resistant to antibiotics. Thus, the preferred complementary treatment methods in organic dairy farms are an important research field for alternatives in conventional mastitis control, too. There are three areas of therapeutic mastitis control strategies, (a) therapy of acute clinical mastitis, (b) therapy of chronic and sub-clinical mastitis and (c) prophylaxis at drying off. Besides a huge potential of self-cure and physical methods like milking-out and cooling ointments, homeopathically supported treatment of <u>acute mastitis</u> could provide satisfying results (Klocke *et al.*, 2004; Klocke *et al.*, 2000; Merck *et al.*, 1989). <u>Dry-off therapy</u> (prophylaxis) in conventional herds is commonly conducted by intra-mammary application of long-term antibiotics to (a) treat sub-clinical mastitis and (b) prevent for new infections during the critical dry time. Alternatives like teat sealants has been established as a hopeful concept to close the teat ends and prevent environmental microbial invasion (Woolford *et al.*, 1998), but did not always lead to the required effects (Klocke *et al.*, 2006). Homeopathy based dry-off concepts only provided satisfying results in the prevention against certain micro-organisms (Klocke *et al.*, 2006) or in combination with antibiotics (Klocke *et al.*, 2000). Preventive effects by using so-called ‘homeopathic nosodes’ produced by potentized

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microbial cultures or other pathologic secretions are very limited (Barlow *et al.*, 2001; Fidelak *et al.*, 2007). However, the treatment of sub-clinical mastitis during lactation is an uncommon concept because of the sub-sequent withdrawal time after antibiosis. Thus, the idea of using residual-free agents like homeopathics during lactation could be an acceptable method to avoid additional costs and provide an alternative to the discontenting period of rest between sub-clinical mastitis detection and dry-off. Although there is no evidence of effectiveness of these concepts (Egan, 1995), there is a huge gap of knowledge on this field. The prospect of a cheap additional mastitis control concept especially for organic farmers justifies further research about this. Consequently, in this presentation two common concepts should be evaluated in terms of their effects in case of sub-clinical mastitis on subsequent somatic cell count (cow level) and infection state (quarter level) hypothetically expecting a higher cure rate on quarter level in the verum groups compared to the other and a significant lower somatic cell count on cow level during the observation period of 3 months.

Materials and methods

From a national swiss udder health improvement project network a number of 17 recently recruited organic dairy herds with identified sub-clinical mastitis problems were chosen for the investigation. In these herd a total number of 150 cows were selected which matched the following criteria: (a) monthly recorded somatic cell count beyond 100’000 cells/ml for 3 subsequent times or continuing after calving, (b) no sensory aberrations of milk or udder tissue, (c) no acute or reconvalent udder or teat injuries. A number of 125 cows matched all these criteria. After cow selection a randomization of trial cows for each farm was conducted and the cows were classified in 5 treatment groups as shown in Table 1.

Tab. 1: Treatment group definition and treatment protocols

Group	Remedy and dilution	Treatment protocol
H	Combination of Calcarea carbonica D30 & Phosphorus D15 & Pulsatilla pratensis D6 & Atropa Belladonna D6 & Lac vaccae D60	Peroral treatment of 10 globuli diluted in 5 ml tap water for 5 days
N	Nosode: Tuberculinum Koch C30	Peroral treatment of 10 globuli diluted im 5 ml tap water one-time
C_H	Corresponding placebo to Group H	Like in group H
C_N	Corresponding placebo to group N	Like in group N
U	Untreated control group	-

The group H was treated with remedies as recommended especially for bio-dynamic farms (Spranger and Walkenhorst, 2006).

Before treatment quarter milk samples for bacteriological and cell count investigations were taken and repeated approx. 4 (C1) and 8 (C2) weeks after treatment. The results of the quarter findings were categorized in (a) not suspicious quarters with no positive cultural findings and somatic cell count (SCC) below 100’000/ml, (b) cell count elevated quarters with no cultural findings and cell counts >100’000/ml and (c) sub-clinically infected quarters with > 100’000 SCC and cultural positive results. The basic laboratory results were compared to those of the control samples. The bacterial cure rate (BCR) was calculated as the number of quarters with no bacteriologic positive results in the respective control investigation by all treated quarters, the total cure rate (TCR) represented the bacteriologically cured quarters with normal somatic cell counts <100.000/ml. The cure rate comparison was analysed by using a univariate logistic regression model with the independent variable 'treatment group' with 5 levels. Milk records of monthly routine milk test data were documented over 3 months before (T-3 to T-1) and after (T1 to T3) treatment and the logarithmic transformed somatic cell counts (Linear Score) were compared to the mean of cell counts 3 months before treatment or from calving to treatment using ANOVA analysis. The general significance level was set to α=0.05. All data analysed by the statistic software package JMP (SAS institute).

Results

A total number of 124 cows entered the study. After laboratory investigation a number of 84 cows (149 quarters) were assessed as sub-clinically infected, all other cows showed only a cell count increase (n=31) or normal secretion (n=9). On cow level the bacteriological cure rate (10.7 and 4.8% in control investigation 1 and 2, resp.) and the total cure rate (2.4 and 4.8%, resp.) was poor in all treatment groups (see Table 3) for both control investigations. There was no effect by the verum therapy on cow level at all. Quarters in the Nosode control group showed a significant higher Cure rate in the first control investigation compared to untreated control.

Tab. 2: Data of quarter bacteriological cure rates (BCR) and total cure rates (TCR) in the control investigations C1 and C2.

Parameters	Treatment Group					Total
	H	N	C_H	C_N	U	
# cows	25	24	24	26	25	124
# quarters	100	96	96	104	100	496
# subclinical infections	34	33	32	26	24	149
BCR C1 (4 wks)	35% [a] (n=12)	27%[a] (n=9)	16%[a] (n=5)	42%[b] (n=11)	17%[a] (n=4)	28% (n=41)
BCR C2 (8 wks)	41%[a] (n=14)	24%[a] (n=8)	19%[a] (n=6)	31%[a] (n=8)	25%[a] (n=6)	28% (n=42)
TCR C1 (4 wks)	12%[a] (n=4)	12%[a] (n=4)	3%[a] (n=1)	31%[b] (n=8)	4%[a] (n=1)	12% (n=18)
TCR C2 (8 wks)	24%[a] (n=8)	12%[a] (n=4)	6%[a] (n=2)	19%[a] (n=5)	17%[a] (n=4)	15% (n=23)
Values with different superscripts a,b within one line are significantly different with p<0.05 compared to untreated control in the logistic regression						

As seen in Figure 1 there is no effect on the somatic cell count after treatment. All 5 groups showed a stabilizing effect compared to development of SCC in the three months before treatment.

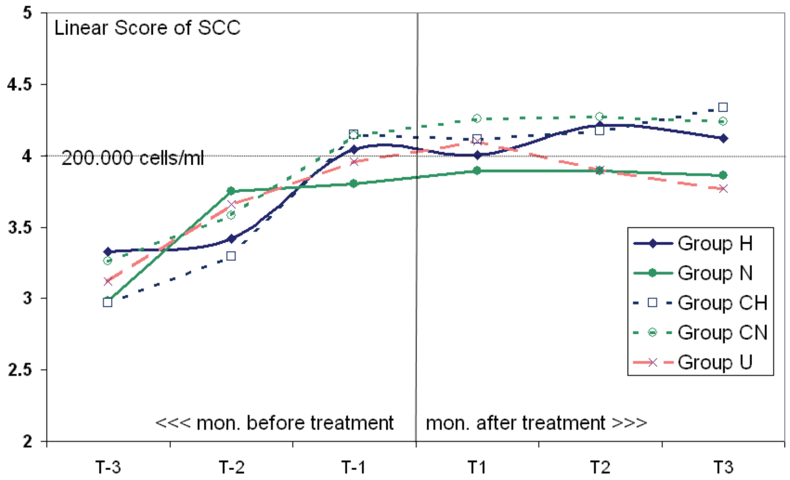

Figure 1: Logarithmically transformed somatic cell counts of cows three months before and three months after treatment in the five treatment groups; standard deviations not shown due to clearness.

Discussion & Conclusions

In general there are no beneficial effects after the treatment with combined homeopathics and the tuberculinum nosode on sub-clinical mastitis. It has to be analysed if there are differences of treatment success depending on species or other factors like age and farm. It has to be analysed if classical homeopathic methods or other remedies are able to provide better results. On the other hand, taking into account the results of other studies, the prognosis of cure sub-clinical mastitis is poor. Anyway, the hypothesis of efficient treatment with the presented remedies has to be rejected.

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Suckling systems in calf rearing in organic dairy farming in the Netherlands

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Key words: natural behaviour, weaning, liveweight, milk quality

Abstract

In an on-farm experiment three calf rearing methods were compared: bucket feeding of milk replacer, bucket feeding of tank milk and suckling of mother or nurse cow up to three months of age. Aim was to determine whether the technical results of suckling systems in calf rearing were satisfactory. Calves reared in a suckling system reached significantly higher liveweights at weaning (90 days). Although the average growth rate between weaning and the age of 1 year did not differ significantly, liveweight at 1 year did still differ significantly. Compared to both bucket fed rearing groups, suckling did not have a significant effect on Somatic Cell Count (SCC) of mothers. Suckling systems in calf rearing in organic dairy production show satisfactory technical results. Calves have the potential to grow fast and no negative effect of suckling on SCC or general animal health were observed.

Introduction

The lives of calves in current organic dairy herds can still considered to be very 'un-natural'. As with conventional systems, organic calves are separated from their mothers shortly after birth, they are bucket fed and raised according to a housing concept that reduces contact with animals of other age groups. Old habits, efficiency in terms of feed cost, as well as labour input and minimizing the risk of disease transmission, play an important role in the traditional calf rearing approach. In the case of calf rearing, organic standards only specify minimum requirements for stocking density, space requirements, specifications to the design of buildings and prohibition of tethering. Critical consumers find it hard to understand that there is little attention for natural behaviour in organic calf rearing. Some farmers realized the importance of trying to make changes to the existing calf rearing method. Together with researchers they developed a calf rearing system in which calves were allowed to suckle their mother and were raised within the dairy herd (Wagenaar and Langhout, 2006). In order to study the potential of suckling systems in modern dairy farming, suckling was compared with two traditional calf rearing systems. The expected result was that suckled calves perform as well as, or even better, than traditionally reared calves in terms of liveweight development and animal health and that suckling had no negative effects on milk production performance and mastitis problems of mothers. This article presents the results of the monitoring of traditional parameters in an ongoing on-farm experiment.

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Materials and methods

In an on-farm trial, initiated at the end of 2004, three calf rearing methods were compared at three farms. Calf rearing methods tested were: bucket feeding with milk replacer, bucket feeding with tank milk and a suckling system.

Between October 2004 and April 2005 newly born calves were alternately allocated to one of the rearing groups. Each rearing group involved 5-8 calves per farm. Farms were allowed to apply their own suckling system, but apart from that had to follow identical calf rearing and data collection protocols. All calves were weaned at 90 days of age. In order to assess liveweight development, a weighing scale was installed at all farms. Calves were weighed at 0, 30, 60, 90 and 365 days of age. In case calves were not weighed at exactly the right age, liveweights were corrected by extrapolating the weight to the exact ages using the growth-rate of individual calves in the period before the measurement. Data on calf and cow health were recorded in individual logbooks. Recording of milk production was carried out at 4 or 6 weekly intervals. Bacteriology and determination of Somatic Cell Count (SCC) in milk of cows in all the treatments were carried out at 0, 30, 60 and 90 days after birth. Thereafter SCC and bacteriology were carried out during routine milk quality control. Liveweight and milk data were analysed in GenStat version 7.2 using Regression Analysis and ANOVA.

Results

Liveweight development

Calves reared in a single suckling system, even if their mother is being milked twice a day, have the potential to grow very fast. Liveweight monitoring indicated that more than 1 kilo growth per calf per day was possible. Table 1 shows the average liveweight development of calves raised in the 3 different rearing methods. Up to weaning (90 days) suckling calves had a higher growth rate compared to bucket fed calves on tank milk or milk replacer. Average liveweight at weaning was 136 kg, 101 kg and 95 kg for suckling, bucket fed tank milk and bucket fed milk replacer respectively. Average pre-weaning growth rate of suckled calves was 1.080 kg per day vs. 0.658 kg per day for bucket fed calves on tank milk and 0.630 kg per day of calves on milk replacer. Rearing method ($P<.001$) and farm ($P<0.01$) had a significant effect on pre-weaning growth and liveweight at 90 days (weaning age). Rearing method had no significant effect on growth between 90 and 365 days. Liveweight at 365 days, however, did differ significantly ($P<0.01$) between rearing methods.

Tab. 1 Average liveweight (kg) and standard deviation (kg) of calves in different rearing groups at 5 ages and Dutch general liveweight norm for dairy cattle.

age	**0 days**		**30 days**		**60 days**		**90 days**		**365 days**	
Rearing group	avg.	std.	avg.	std.	avg.	std.	avg.	std.	avg.	std.
Tank milk	42	3	58	7	77	11	101	17	316	39
Replacer	40	6	52	7	71	10	95	15	288	30
Suckling	40	5	65*	12	100*	14	136*	13	343*	38
Liveweight norm			59		77		104		330	

* significant for $P<0.05$

Milk production and quality

Because data on milk production and SCC were incomplete at the time this paper was prepared, only the results for one farm are presented. Although milk production in the first 3 months of lactation was significantly lower for cows suckling calves, there was no significant difference in milk production between rearing groups from the fourth month onwards. Figure 1 shows the mean natural logarithm of the SCC and standard error for the mothers of calves in the different rearing groups. Due to missing data SCC at day 0 could not be depicted. There were no significant differences in SCC between rearing groups up to 180 days. SCC levels were always below the upper critical value of 400,000 for all rearing methods. The percentage of milk samples in which no bacteria were found was 63%. The highest percentages of positive samples were found just after calving.

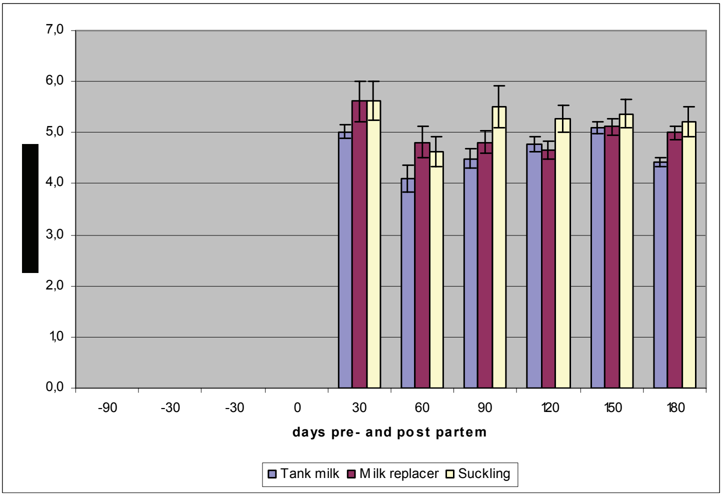

Figure 1: Mean natural log and standard error of somatic cell count (SCC) of cows whose calves were included in the calf rearing method comparison.

Calf health

Diarrhoea, an important cause of mortality in conventional calf rearing, was found to be a less frequent problem in suckling systems. Farmers observed that sometimes suckling calves drink too much milk. This resulted, compared to the type farmers observed in bucket fed calves, in ‘a different type’ of diarrhoea. According to farmers most calves learned quickly and stopped consuming too much milk. In the cases that diarrhoea was a problem, farmers did not observe that calves dirtied their backsides, like in diarrhoea of bucket fed calves. These diarrhoea cases were therefore spotted relatively late. However, even in these cases diarrhoea did not result in mortality. During the limited period of observation suckling calves which grazed together with their mothers or nurse cows, showed no problems with intestinal worms. During the research period one out of 3 farms tested positive for Para-tuberculosis. At some point during the research cross-suckling heifers did occur at all farms, however, not to an extent that this could be linked to the use of suckling systems.

Discussion

For farmers the first requirement of a calf rearing method is achieving optimal calf growth and development, resulting in healthy dairy heifers. Suckling systems in calf rearing result in high initial growth rates of calves. Jaspar and Weary (2002) found that ad libitum milk intake had no detrimental effects on intake of solid food after weaning. Nauta (2006) found that the age of organic Holstein heifers at first calving is up to 1.7 months higher compared to conventional heifers. This difference can be the result of individual farmers' feeding regimes and management. However, results presented in this study show that suckling systems have the potential to produce well developed heifers, calving down at the same age as traditionally reared heifers. In order to obtain good results, appropriate weaning practices are of crucial importance.

Our study showed that there was no difference in SCC between suckled and non-suckled mothers. In theory suckling can have a curative effect on mastitis because frequent drinking keeps the udder empty. On the other hand suckling might have a negative effect on mastitis because of cross-contamination. Moreover, frequent drinking can inhibit proper teat closure which makes it easier for pathogens to enter. Farmers in our study expected that exposure to a wider range of pathogens in early life would make dairy cows less susceptible to mastitis in later life. Our research is currently inconclusive in this regard, but the 2007 evaluation of the milk production performance of the calves raised in the different rearing methods will provide useful information.

Conclusions

Calves have the potential to grow fast and no negative effect of suckling on SCC or general animal health was observed. In order to obtain good results, appropriate weaning practices are of crucial importance. Suckling systems in calf rearing in organic dairy production show satisfactory technical results. In 2007 the evaluation of the calves raised in the three rearing methods will be completed.

Acknowledgments

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Effects of inclusion of red clover silage on the carriage of gut pathogens in steers

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Key words: Red Clover Silage, pathogens, steers, diet, faecal shedding.

Abstract

Eight Hereford x Friesian steers prepared with rumen and duodenal cannulae were offered increasing proportions (increase of 33% each period) of red clover to grass over four periods with grass silage fed throughout to 4 steers as an experimental control. Numbers of Escherichia coli and Listeria were enumerated in silage from rumen, duodenal digesta and faecal samples at time points throughout each period. The results indicated that no silage contained E.coli whilst all silages had high populations of Listeria. Pathogen populations were lowest in the duodenum and highest in the rumen, although large populations were also found in faeces. The populations of E.coli were generally 10 fold lower than those of Listeria. Feeding red clover appeared to reduce pathogen loading but this was confounded by variation in the pathogen populations in the feed. Thus in conclusion, further research is required to elucidate the different effects of red clover and feed pathogen load on the gut and faecal pathogen populations.

Introduction

Despite recent public health scares associated with pathogenic bacteria such as *Listeria*, verotoxigenic *Escherichia coli* (VTEC's) plus numerous other potentially hazardous micro-organisms they are still often low in priority for control and remediation. Nevertheless, in the UK and USA several outbreaks of gastro-enteritis in humans have been sourced to livestock operations and the link between disease and livestock production is well documented (Pell, 1997).

In the case of *Escherichia coli* 0157:H7 less than 700 cells (Tuttle *et al*., 1999) and as few as 10 are required to cause human disease which is frequently associated with food borne disease resulting from beef and milk products yet is rarely associated with animal disease. Little work has focused on the control and eradication of *E.coli* 0157:H7 in the animal on farm and this must be the primary point for combating the problem.

Listeria monocytogenes is a well documented pathogen as a main contaminant of forage (Fenlon *et al.,* 1989). It can survive and multiply during ensiling and storage, even where there is a very low oxygen concentration during the silage fermentation process (Donald *et al.,* 1995). At feed-out where silage is exposed to oxygen the rise in pH often causes a rise in the numbers of *Listeria*.

There are a number of factors that need to be investigated to assess the significance of pathogenic organisms and to elucidate critical points to break the cycle of contamination and thus reduce the pathogen load within the cycle. Waste manure and sewage sludge added to land to enrich the soil with nutrients and promote crop growth

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still contain pathogens in high numbers and these lead to contamination of soil and crops. The animals then consume contaminated grazed or ensiled forages. These pathogens then enter the gut, multiply and are deposited in faeces. Humans may then become infected by direct contact with the contaminated animal or by consuming infected meat and dairy products. It is this faecal shedding that results in environmental and food contamination and methods need to be found to reduce these processes.

Red clover and grass/clover-based forages are already widely used in feed rations for beef cattle and dairy cows. Red clover is a mainstay of organic rotations in many systems and its N fixation is an important source of N for low input and organic systems. There is limited evidence to suggest that Red Clover may impact negatively on pathogen growth (Garber *et al*., 1995). Furthermore, components such as Formenonetin in red clover have been shown to inhibit *E.coli* in laboratory cultures (Duncan *et al*., 2000). This study aims to investigate this effect further.

Materials and methods

Eight Hereford x Friesian steers (300kg approx. weight) prepared with rumen and duodenal cannulae were offered either perennial ryegrass (*Lolium perenne*) silage throughout or an increasing mix of a red clover (*Trifolium pratense*) silage (RC): perennial ryegrass silage (G). The experiment was a continual design consisting of 4 periods of 21 days 4 animals were maintained on a grass silage diet throughout and a further 4 animals received grass silage in period 1 then G66:RC33, G33:RC66, RC100 in periods 2-4 respectively. Due to the simple nature of the diets, dietary treatments (silages) were switched from one to the other with immediate effect, with no gradual changeover. The animals were housed in individual pens and had access to fresh water and salt licks (Rockies) throughout. Animals received their daily food allocation in two equal meals at 08.30 and 15.30. Refusals if any were removed before early morning feed and dry-matter (DM) intake determined.

Microbial analysis

Rumen, faecal and duodenal digesta were collected post early morning feed on days 0,1,2,4,8,16 and 21 and enumerated for *Listeria monocytogenes* using Listeria Isolation Medium (LAB M) and total *Escherichia.coli* and *E.coli* 0157 using Sorbitol McConkey with B.C.I.G Agar (OXOID).

Results

Whilst the forage fed to the steers had no detectable *E. coli* at any time during the 12 week experimental period there was a large and variable population of *Listeria* associated with it. The grass silage over the 12 week period had a mean of 1.12 x 10^7 CFU/g DM (minimum 1.11 X 10^5; maximum 1.17 x 10^7 CFU/g DM), whilst the feed containing various proportions of red clover had at least 10 fold fewer *Listeria* at 1.2 x 10^6 CFU/g DM (minimum 3.16 X 10^4; maximum 1.05 x 10^7 CFU/g DM). The results also showed that greater the red clover inclusion level the lower the *Listeria* population with populations of 3.6 x 10^6 and 2.2 x 10^5 CFU/g DM respectively for diets containing 33:66 grass:red clover or 100 % red clover. Thus it is likely that the level of *Listeria* load on the forage fed will have had a confounding effect on the populations of *Listeria* present in the digesta and faeces of the animals consuming it.

The figures show the variation over time in rumen (Figs 1a and b) and faeces (Figs 2a and b) of populations of *E. coli* and *Listeria*. The results are shown for all 8 animals used in the experiment and thus considerable time dependant variation within each animal can be seen. However in general all animals follow the same trend but it must be noted that by increasing the level of inclusion of red clover in the diet Listeria numbers tend to decline in all animals on this treatment.

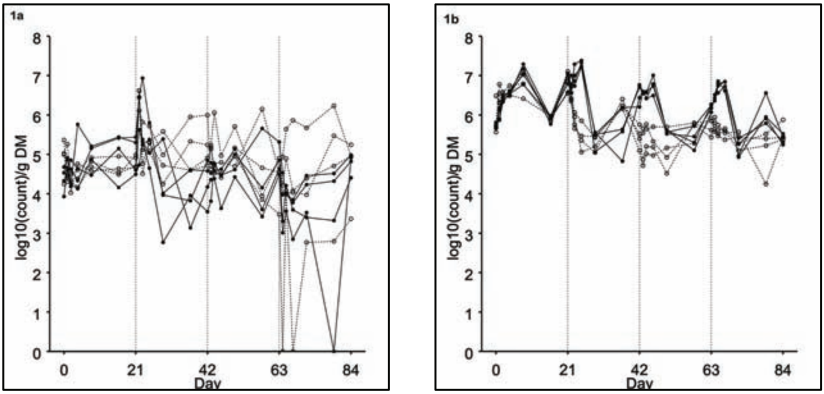

Figure 1 Variation in populations of *E.coli* (a) and *Listeria* (b) in the rumen of steers fed either grass silage (solid lines) or increasing proportions of red clover silage (dotted lines) with time over a 12 week period.

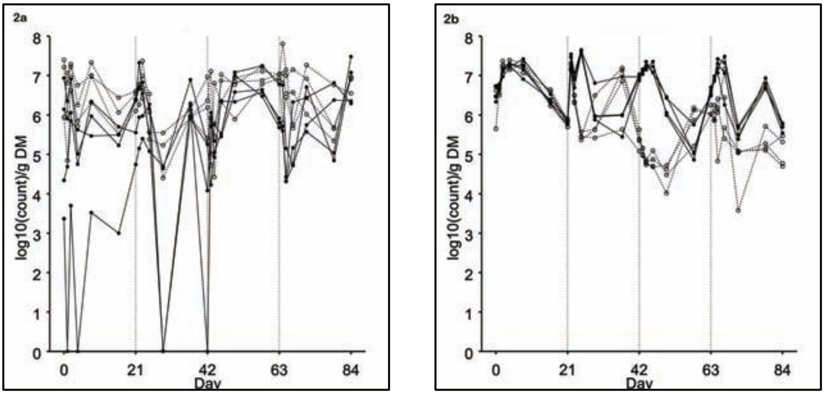

Figure 2 Variation in populations of *E.coli* (a) and *Listeria* (b) in the faeces of steers fed either grass silage (solid lines) or increasing proportions of red clover silage (dotted lines) with time over a 12 week period.

Discussion

The results indicate that there is considerable variation in shedding of pathogens with time over the 12 week experimental period. There appeared to be a reduction in the faecal shedding (Figure 2b) of *Listeria* with increased incorporation of red clover in the diet, whereas the effect on *E.coli* was less marked. However, there was also considerable variation in the load of both *E. coli* and *Listeria* entering with the feed. It is highly probable that the burden of bacterial pathogens entering the mouth affects the magnitude of the pathogen populations present both in gut digesta and faeces.

Conclusions

The results outlined above do not give a clear indication of how diet may influence food borne pathogens in the gut of ruminants. Within this experiment two factors appear to be contributing to the pathogen load in gut digesta and faeces these are pathogen load of the feed as fed and in the case of *Listeria* the proportion of red clover in the diet.

Further work is required to elucidate which of these factors is exerting the biggets effect before practical on farm approaches to reduce pathogen carriage by ruminants can be introduced.

Acknowledgments

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Development of strategies to improve quality and safety and reduce cost of production in organic and ‘low input’ livestock production systems – Posters

Status quo of animal health of sows and piglets in organic farms

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Key words: Animal health, pigs, on-farm assessment

Abstract

In an ongoing study, which focuses on the implementation of animal health plans in organic pig production, the status quo of animal health of sows and piglets in 20 organic farms in Germany was assessed. Standard livestock data showed distinct variations. The on-farm assessment brought up weak-points in hygienic, nutritional and animal health management. Gathered data will be used to develop stock customized optimisation strategies with the aim to achieve superior health standards, including an assembly of cost- benefit relationships.

Introduction

Production diseases are a major problem in organic as well as in conventional livestock production. Inquiries performed in the past showed great variations in the health status on organic sow farms (Leeb 2001, Löser 2004). These data, however, do not provide comprehensive information about the main constraints and problems on organic farms to ensure a high animal health status.

When trying to achieve superior health standards in pig production numerous factors with direct impact on animal health have to be considered. These include improvement of management, husbandry and nutrition as well as optimised arrangements in disease prevention by hygiene and vaccination protocols. As a first step to a weak-point analysis, a detailed status quo data acquisition is required. Furthermore, animal health and performance data have to be monitored continuously by parameters to be suitable for the evaluation of the effectiveness of taken actions.

In an ongoing study focussing on the implementation of animal health plans for organic piglet producers, the results presented in the following are used to develop stock customized optimisation strategies.

Methods

In the present study 20 organic piglet producers in Germany with stock sizes between 24 and 170 sows are involved. The selected farms are representative of organic sow farms in Germany. Half of them operate in a closed system including fattening pigs. Detailed on-farm assessment based on a modified Critical Control Point (CCP) concept according to von Borell *et al.* (2001) was carried out as a first step. This includes acquisition of data from animal husbandry, hygiene- and animal health management as well as performance and nutrition parameters.

Weak-points are identified via data analysis and specified with further diagnostic methods such as blood, faeces and swab sampling to gather more information on animal health status. Nutritional parameters are concretised with feed analyses.

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Results and discussion

Due to the fact that organic piglet farming in Germany currently underlies intense changes to fulfil the demands of the EC-Regulation, standard livestock data showed distinct variations. Computer-based programs to achieve precise data were used on 12 farms (see figure 1). Hence this can not be considered standard in organic piglet production. This goes along with results published by Bicker (1992). and Vaarst *et al.* (2000)

An extract of the accessible livestock data is shown in Table 1. In comparison to conventional farming mean values of the results from organic farming are to explain by specific factors of organic animal husbandry (lower means of farrows / sow / year due to longer lactation periods). The increased losses demonstrated by organic sow farms compared to conventional pig farming must be seen as indicators for lower animal health status which is confirm with the results obtained in the studies by Leeb (2001) and Löser (2004).

Table 1: Livestock Data of organic sow farms in comparison to conventional data

Livestock Data	mean values	min	max	conventional mean values
live born piglets / farrow	11,4	9,8	14,5	11
weaned piglets / sow / year	19,6	17,1	23,1	23
farrows / sow / year	2,11	1,7	2,25	2,4
farrowing interval (days)	175,6	163,6	206	162
farrows / sow / life	5,7	3,5	8	4
losses / farrow in %	18	8,9	25	10
losses of weaned piglets in %	5,15	1,4	18,8	<3

Cleaning and disinfection measures taken in the barn, the run or open yard were performed in different, partly reproduction- or calendar-based intervals. Cleaning measures were performed by every farm; however disinfection was carried out by only 25% of the farms. Constructional or organisational handicaps and the lack of information of the necessity are wide spread reasons for the over all unsatisfactory hygienic conditions found. Animal husbandry following the ‘all in / all out’ concept, enabling an effective hygiene regime, is established on only 25% of the farms often due to inadequate stable arrangement and stable size (no pen vacancies scheduled).

The proclaimed alternative medicine in organic farming was performed by 60% of the surveyed piglet producers or their veterinarians respectively. Basic health management measures are summarised in figure 1. The emphasised parasite burden (Leeb and Baumgartner 2000) was antagonised with deworming regimes performed by 90% of the surveyed farms. Unfortunately, a regular control via faeces-analysis or other parasitological diagnostics was established only on 40% of the assessed farms. Vaccination protocols were in use at 85% of the farms

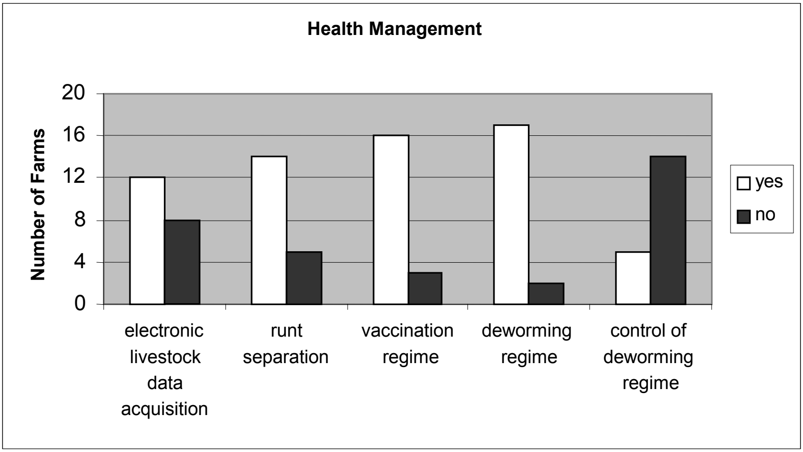

Figure 1: Basic health management measures performed on organic sow farms

Collected animal nutrition data (summarised in figure 2) showed that analysis of feed rations was not practised on a regular basis in most organic piglet producing farms. As a consequence, nutritional values often differed highly from calculated nutrient requirements of the respective animals. Since balanced diets are known to be a key to animal health in general, the necessity of precise demand-depending feed is to be pointed out.

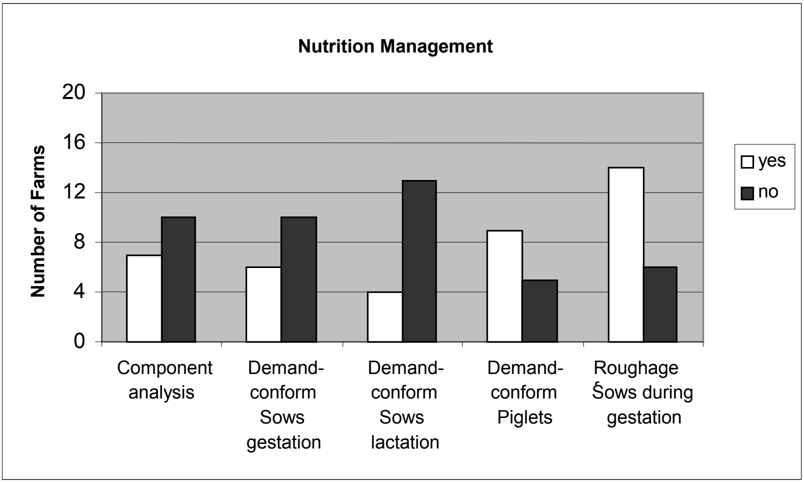

Figure 2: Nutrition management and feeding ration composition of organic sow farms

The nutritional values from the farm-derived feedstuffs were not in correspondence with the expected values. In consequence, adequate composition of the diet can only be achieved when the diet formulation is based on derived from the analysis of the specific feed compounds used.

Conclusions

Results of the status quo analysis showed that a number of factors can be improved in the organic piglet production. Particularly hygiene conditions appeared far off from average reached in conventional farming. In the ongoing study different strategies and their suitability to achieve better health standards within an acceptable cost-benefit relation will be elaborated.

Acknowledgements:

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Effect of probiotic inocula on the population density of lactic acid bacteria and enteric pathogens in the intestine of weaning piglets

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Key words: probiotic, *Bifidobacterium* spp., *Salmonella enterica* serovar *typhimurium*, *E. coli* K88.

Abstract

Because antibiotic resistance occurs in bacteria at an alarming rate, significant research has been focused on finding alternative treatments which do not involve the use of antibiotics.

The promotion of beneficial gut bacteria can increase the resistance of animals to possible intestinal infections.

Probiotics can be administered to humans or animals, offering preventive benefits of protecting the host from various types of intestinal diseases, providing positive effects on digestive processes and stimulating influence on the growth of organism, strengthening the barrier function of the gut microbiota and/or non-specific enhancement of the immune system.

A study was designed to screen potential probiotic Bifidobacterium spp. strains with the ability to multiply in the intestine of weaned piglets and then to assess their health promoting effects when challenged with two enteric pathogens.

Three series of trials were conducted with 60 weaning pigs fed one of 12 different Bifidobacterium spp. strains either once or twice a day.

The most effective probiotic treatment (Bifidobacterium animalis subsp. lactis, strain Ra 18, at a dose of 1011cfu twice a day) was then challenged in two series of experiments with the enteric pathogens, Salmonella enterica serovar typhimurium and E. coli K88.

Bifidobacterium animalis subsp. lactis strain Ra 18 significantly increased (p<0.01) the number of viable bifidobacteria in the cecum contents. When it was challenged with Salmonella, Ra 18 reduced excretion of this pathogen with the faeces. On the whole, supplementation with Ra 18 had a positive effect on the growth performance of pigs except after challenge with E. coli K88 where pigs susceptible to ETEC adhesion were lighter than pigs not susceptible.

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Introduction

Infectious diarrhoea of neonatal animals is one of the most common and economically devastating conditions encountered in livestock production.

The infection of pigs with *Salmonella enterica* serovar *typhimurium* and enterotoxigenic *Escherichia coli* (ETEC) K88 is associated with enteric disease and occurs in pigs from weaning to about 4 months old (Naughton P.J., et al, 2001).

The potential removal of growth – promoting antibiotics from farm animal feeds has led to renewed interest in the use of live microbial cultures (probiotics) as growth promoting agents in addition to their current role in controlling enteric disease.

Probiotics have been used to reduce colonisation of pathogens in the intestines of animals and some studies have focused on their anti-infectious effects, particularly the inhibition activity against enteropathogens (Zhong S.S., *et al.*2004).

It has often been shown that certain lactic acid bacteria within the pig intestinal microflora possess an inhibitory activity towards coliform pathogens and the addition of large numbers of these bacteria to the porcine microflora *in vitro* results in a consistent and reproducible increase in the rate of removal of the pathogen (Hillman *et al.*, 1995).

In this study we quantified the ability of different strains of *Bifidobacterium* spp. to grow in the intestine of weaned piglets and then assessed the effect of the best probiotic treatment in challenge experiments with two strains of enteric pathogens.

Materials and methods

A total of 136 pigs (Landrace x Large White) were weaned at 21 days and assigned to different treatments based on starting live weight and litter. A good weaning diet was designed and all pigs were individually fed.

The experimental design included 2 phases. In the first phase (*probiotic series*), the probiotic effect of twelve different *Bifidobacterium* spp. strains from the species *B. breve*, *B. suis*, *B. animalis subsp. lactis* and *B. choerinum* was evaluated.

The probiotic effect of 3 strains per *Bifidobacterium species* at the dose of 10^{10} cfu was assessed in 60 pigs supplied to the pigs either once or twice a day. Four pigs were designated as the control group.

In the second phase (*probiotic in challenge tests series*), we analysed the effect of the best probiotic *Bifidobacterium* spp. strain on pig growth and health when it was challenged with two enteric pathogens which are indicator bacteria for infection risk, *Salmonella enterica* serovar *typhimurium* and *E. coli* K88.

Four groups composed of 8 pigs each were tested in the trial with *Salmonella enterica* serovar *typhimurium.* The first group (*challenge-no additive)* each received 1.5 ml of a solution of the pathogenic *Salmonella* (10^9 cfu/ml). The second group (*challenge-bifidobacteria*) received *Bifidobacterium animalis* subsp. *lactis* (10^{11} cfu twice a day) and *Salmonella.* The third group (*challenge-atb*) received *Salmonella* and an antibiotic (Gentamycin 60 g / 100 kg of feed) and the last group served as a control.

In the trial with *E. coli,* three different treatments were tested on 40 weaning pigs. The first group of 16 pigs (challenge-no additive) each received 1.5 ml of a broth containing 10^9 cfu/ml of *E. coli* K88. A second group of 16 pigs (challenge-

bifidobacteria group) received 10^{11} cfu of *Bifidobacterium animalis* subsp. *lactis* Ra18 twice a day supplemented in the feed and *E. coli* K88. The other 8 pigs served as a control group.

In all trials performed, the enumeration of *Bifidobacterium* spp. and non pathogenic *E. coli* was determined using plate counts with solid selective media. The quantitative detection of *Bifidobacterium* spp. was also performed by dilution PCR method.

All data were analyzed by SAS.

Results

Probiotic series

Upon evaluation of the effects of different *Bifidobacterium* spp. strains on bifidobacteria counts in the caecum contents, two strains of *Bifidobacterium animalis* subsp. *lactis* (Ra 18 and M 354) with the highest growth profiles were identified. The decision was made to utilise one of these strains, Ra 18, in the subsequent challenge trials with enteric pathogens.

Probiotic in challenge tests series

Bifidobacterium animalis subsp. *lactis* Ra 18, identified as the most active treatment in the previous series of experiments, demonstrated different effects on the health of the pigs when challenged with *Salmonella enterica* serovar *typhimurium* and / or enterotoxigenic *E. coli* K88.

Only in the first challenge with pathogenic Salmonella did the probiotic inocula maintain the same growth performance as the pigs not challenged, even if the daily weight gain was lower than in pigs fed with the antibiotic (Table 1). The challenge did not affect the frequency of diarrhoea, but with the exception of most of the antibiotic-supplemented subjects, all challenged pigs were positive for the presence of *Salmonella typhimurium* in ileocecal lymph nodes. A low frequency of diarrhoea was noted in all groups tested in this series. In the group supplemented with Ra 18, a decrease was also observed in the number of pigs which tested positive for *Salmonella* in the faeces.

In the second trial, when Ra 18 was challenged with *E. coli* K88, faecal consistency was reduced and the addition of the probiotic did not prevent this effect. As expected, supplementation with *B. animalis* subsp. *lactis* significantly increased the viable bifidobacteria in the cecum contents in both experimental series (table 1).

Table.1 Effect of probiotic supplementation on microbiota and on growth performance of already weaned pigs (LW=live weight), before and after challenge (Ch) with Salmonella enterica serovar typhimurium (a) or with Escherichia coli K88 (b)

(a)

	Treatment				SEM
	Control	Challenge	Ch+Probiotic	Ch+Antibiotic	
Starting LW, kg	6.75	6.66	6.81	6.46	3.07
Final LW, kg	9.79	9.60	10.18	10.15	4.71
Daily LW gain post-challenge, g	314.8	274.9	299.3	320.2	26.6
Total daily LW gain, g	187.7	177.5	192.8	221.5	24.7
LAB (Plate counts, log_{10} CFU/g of cecum contents)	8.17	8.02	7.80	7.69	0.31
E. coli (Plate counts, log_{10} CFU/g of cecum contents)[1]	7.31	6.11	6.28	7.01	0.29
Bifidobacteria (Plate counts, log_{10} CFU/g of cecum contents)[2]	3.90	4.90	6.87	4.96	0.33
Bifidobacteria (Quantitative PCR, log_{10} CFU/g of cecum contents)	7.85	8,23	8.43	8.22	0.36

1 Effect of challenge, P <0.05; Antibiotic vs no supplement, P <0.05.

2 Effect of challenge, P <0.01; Probiotic vs no supplement, P <0.01.

(b)

	Treatment			SEM
	Control	Challenge	Ch+Probiotic	
Starting LW, Kg	6.46	6.62	6.77	3.20
Final LW, g	7.98	8.05	8.24	3.48
Daily LW gain post-challenge, g	186.9	182.2	196.9	28.5
Total daily LW gain, g	109.0	102.5	104.7	16.0
LAB (Plate counts, log_{10} CFU/g of cecum contents)	8.61	8.10	8.40	0.17
E. coli (Plate counts, log_{10} CFU/g of cecum contents)	5.93	6.77	6.57	0.24[1]
Bifidobacteria (Plate counts, log_{10} CFU/g of cecum contents)	4.70	4.98	7.18	0.22[2]
Bifidobacteria (Quantitative PCR, log_{10} CFU/g of cecum contents)	7.34	7.04	8.89	0.25[3]

[1] Co vs (Ch+Pr), P<0.05.

[2] Co vs (Ch+Pr), P<0.01; Ch vs Pr, P<0.01.

[3] Co vs (Ch+Pr), P=0.085; Ch vs Pr, P<0.01.

Discussion

Post - weaning diarrhoea associated with enteric pathogens, *E. coli* and *Salmonella*, is a major disease in pig husbandry during the first 2 weeks post weaning. To prevent this condition, serious consideration should be given to probiotic supplementation with the feed. However, results obtained in experiments conducted to date has been variable.

Although the mechanism of action of probiotics is not well understood, it is generally accepted that probiotics exert their influence on the host by the intestinal microbiota (Biavati, B., *et al.*, 2000).

Therefore, the ability of 12 *Bifidobacterium* spp. strains to grow and persist in the intestine of weaned piglets was investigated. The most active treatment identified was then challenged against the two enteric pathogens.

The results demonstrate that the same strain may have variable effects on the health of different hosts.

In the first trial, the most promising probiotic treatment identified (*B. animalis* subsp. *lactis* Ra 18) showed the greatest ability to multiply in the intestine of weaning piglets, affecting their daily weight gain. This was even the case when challenged with *Salmonella*. However, the same strain, when administered with *E. coli* K 88, increased the number of viable bifidobacteria cells in the cecum contents but did not induce other probiotic effects.

Conclusions

Dietary manipulation using probiotic preparations is claimed to have potential for improvements in health and performance in growing pigs (Collier C.T., *et al.*, 2003).

Strain selection and dose of supplementation need to be considered with this approach.

The results of this study support the concept that supplementation with probiotics as alternatives to antibiotics might ideally promote the growth of beneficial commensal bacteria while suppressing those that are deleterious.

Acknowledgement

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Development of a framework for the design of ‘minimum’ and ‘low input’ processing strategies, which guarantee food quality and safety

Development of a framework for the design of minimum processing strategies which guarantee food quality and safety - Principles, concepts and recommendations for the future

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Key words: Food processing, regulations for organic food processing, consumer perception, organic food

Abstract

Principles of processing of organic and 'low input' food have been analysed in the EU funded QLIF project. A literature survey showed that some of the principles are generally accepted (e.g. the use of certified organic ingredients, a certified production chain and minimal use of additives), others are shared broadly (e.g. more careful processing methods, naturalness) and some principles are in discussion mainly in the private sector (e.g. environmental management concepts, social requirements, regional focus). Recent studies showed that consumer associate organic food with the following dimensions/attributes: health, high quality, the use of natural raw materials, welfare orientated animal husbandry as well as environmentally friendly land use and processing techniques. The challenge will be to consider such wider consumer perceptions and expectations, in particular when revising the EU regulation No 2092/91 on organic food and farming. In the current draft for revised regulation, agreed generally by the EU Council on 19-20 December 2006, some of these elements are included, but not all. How detailed such aspects should be regulated in implementation rules is seen quite differentiated by processors and non-processors which were asked in a Delphi Survey, depending on the different areas. At the EU regulatory level, the top priority mentioned was the minimal use of additives, followed by minimal and careful processing. Quality/sensory aspects, however, were not seen as primary objectives at the EU level, because companies should have the chance to develop individual sensorial profiles for their products. However, regarding the minimum use of additives this is clearly perceived to be an EU level issue. There is also a tendency to prefer additives of certified organic origin, both among 'processors' as well as 'non-processors' points of view. The challenge in the future will be to develop regulations with the right balance between authenticity, health orientation and convenience to maintain the confidence of consumers and credibility of the products in the use minimum and careful processing strategies permitted under organic farming standards.

Introduction

This synthesis paper contains the final results of work done in a subproject on processing within the EU-funded integrated QLIF Project (Quality Low Input Food). A special work package dealt with the 'Development of a framework for the design of

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‘minimum’ and ‘low input’ processing strategies, which guarantee food quality and safety’.

Materials and methods

The synthesis of this work is based on: a literature survey; a Delphi expert survey; an analysis of consumer studies and the relevant regulatory framework; and the elaboration of recommendations by the consortium involved in the sub-project.

Between October 2004 and May 2005 a two-step expert survey was conducted using the Delphi method. In the first round, 250 experts in 13 countries in Europe were involved, and were asked to respond to a standardised questionnaire. The Delphi expert survey was designed in such a way that the most important and currently discussed aspects regarding organic food processing were taken up. One hundred and twenty experts from 13 countries responded in the first round and 83 experts from 13 countries responded in the second round. The experts were chosen in such a way as to have a good representation of food processors from different sectors, with different field of activities. In the first round, 55% experts from food processing companies and 45% experts from non-processors (e.g. research, consultation, certification, consumer information, government agencies), and in the second round 46% experts from food processing companies compared to 54% experts from non-processors participated.

Results

a) Literature survey on underlying principles of organic and ‘low-input’ food processing:

The literature survey (Schmid *et al.* 2005) focused on the underlying principles of organic food processing. These were shown to be quite different depending on the type of product, the level/standard of processing and marketing concepts. Some of the principles are generally accepted (e.g. the use of certified organic ingredients, a certified production chain and minimal use of additives), others are shared broadly (e.g. more careful processing methods, naturalness) and some principles are under discussion mainly in the private sector (e.g. environmental management concepts, social requirements, regional focus).

Clearly there was - until 2006 - a lack of guiding principles and related criteria needed to make a decision about the various processing methods under discussion.

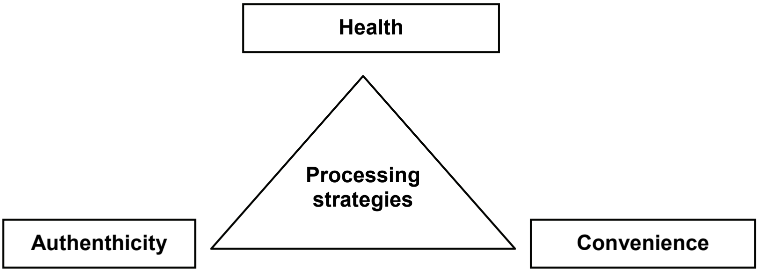
The report shows that the current EU Regulation 2092/91 covers a number of consumer perceptions such as certification system, traceability, minimal use of additives, labelling concepts and the use of organic raw materials. However, other consumer expectations such as careful processing, freshness, healthy nutrition and fair trade are not fulfilled.

b) Consumers perception towards processed organic foods: Food Quality in the triangle between authenticity, convenience and health.

Results from QLIF-subproject 1, which is dealing with the ‘Consumer attitudes towards the quality and safety of organic and low input foods’ (Midmore *et al.*, 2005), indicate, that consumer attitudes to organic food quality are often vague, unstable and link food to health, environment, ethics and identity. The literature surveys on organic consumer characteristics, consumer knowledge and product perception (Midmore *et al.*, 2005;

Wier/Calverly, 2002; Woodward/Meier-Ploeger, 1999) emphasis that 'merit good' features are associated with organic quality dimensions such as: use of natural raw materials; welfare orientated animal husbandry; environmentally friendly land use and processing techniques, contributing not only to individual benefits in terms of healthy eating, but also to social and environmental goals. The authors state that the most intangible aspects of quality perception are found in the emotional sphere.

On the other hand the development of the organic market shows a trend to more and more convenience and highly processed foods, because of lifestyle changes among consumers buying organic products (Michelsen et al, 1999; Hamm et al, 2004). Can these different concerns and expectations be addressed at the same time? Is it time to re-assess carefully the meanings of 'natural' and 'authentic' of organic foods in growing markets (Gallmann, 2000; Holt, 1993; Meier-Ploeger, 2002; Nielsen, 2000)?



The concepts of a natural (whole-food) and sustainable nutrition in the global organic food market are therefore currently under discussion. This includes the topics of authenticity of foods and health aspects of organic processed food. The question is, if technical developments in food processing as well as revisions of standards or EEC regulation 2092/91 could influence and develop organic food production systems towards: (a) shorter and local supply chains, (b) minimum processing, (c) the introduction of environmental management systems in organic processing companies. Such steps would be necessary to improve the match between the currently available organic processed foods, the current consumers perceptions and expectations towards such foods and the aims of EU regulation 2092/91!

c) Relevant regulatory framework

The new EU regulation 1924/2006 on nutrition and health claims of the EU Parliamant and Council (Brussels 2006) focuses on authenticity, product quality and health.

In the revision of the EU regulation 2092/91 for organic food and farming, which was lively discussed since December 2005, principles and criteria for organic food processing were elaborated. In the version, that was generally agreed by the Council in it's meeting in December 2006, but will still have to be ratified in spring 2007 a number of interesting elements can be found. The overall principles agreed, strengthen the focus on a system approach to organic farming, which is based on using system internal resources, instead of external inputs. If such inputs are used they should be preferably from organic production or natural or naturally-derived substances and only in exceptional cases synthetic products. The proposed processing principles for organic food require the use of organic inputs and restricting the use of food additives, non-organic ingredients, micro-nutrients and processing aids. Substances and processing methods which may mislead consumers regarding the true nature of the product shall be excluded (e.g. reconstituted fruit juice with a claim ‘natural fruit juice’). Food, but also feed, shall be processed with care, preferably by use of biological, mechanical and physical methods. The proposed general rules for processed food require that ‘substances and techniques, other than by adding natural flavourings, that reconstitute properties which are lost in the processing and storage of organic food, that correct the results of negligence in the processing of these products or that otherwise may mislead regarding the true nature of these products shall not be used’ (Brussels 2006). The criteria for authorisation of certain products/substances in processing are that these substances **(a)** are technologically needed, **(b)** are found in nature and **(c)** may only have undergone mechanical, physical, biological, enzymatic or microbial processes, except for cases in which products and substances from such sources are not available in sufficient quantities or qualities on the market. It is, however, currently unclear how exceptions from the production rules regarding additives and other substances will be handled.

The proposed principles, rules and criteria for substances to be used in organic processing reflect to a high degree the concerns of consumers as well as those of processors (see below). The principle of authenticity is clearly stated, but without using the term as well as the principle of care in the processing of food. The minimum use of additives, mainly from natural origin, remains one of the key issues, whereas environmental objectives are mentioned, but not defined as rules. Social rules are missing. Much will depend from the planned implementation rules, which the EU Commission will elaborate for 2009, when this new regulation should be put in force.

d) Approaches Used in Organic and Low Input Food Processing – Impact on Food Quality and Safety. Results of a Delphi survey from an expert consultation in 13 European countries.

One focus of the survey was to narrow and clarify definitions which are often used to characterise organic food processing. Based on the feedback from the experts, we can conclude that instead of a final definition of the terms ‘careful processing’ and ‘authenticity’, a more elaborated definition of the production methods, as well as good labelling would be more helpful for the producers, as well for the consumers. The intent of the two principles/terms of ‘careful processing’ and ‘authenticity’ would then be addressed indirectly.

An important question was ‘Which aspects should be regulated’ on an EU regulation level and which ones should be addressed at other levels (national, private company or label level) or should not be regulated at all. The feedback from the experts was quite varied, depending on the food processing area they were working in.

At the EU regulatory level, the top priority mentioned was the minimal use of additives, followed by minimal and careful processing. Quality/sensory aspects, however, were not seen to be primarily an issue that would need to be regulated at the EU level, because companies should have the chance to develop individual sensorial profiles for their products. We can conclude, based on the feedback from the food processing specialists and processors in the Delphi survey, that for the future revision of EU Regulation 2092/91 a more differentiated approach is necessary.

Which criteria are important for an organic product to be successful in food markets? For most experts the most important criterion is the sensory quality. The second most important criterion is the minimal use of additives and processing aids and the third most important criterion is the freshness, followed by authenticity.

In general, most of the experts expect special processing methods to be used in the production of organic food. But when experts were asked more specifically what processing methods would be appropriate for organic food, they found it difficult to select those methods that are usable/suitable or not usable/suitable. However the use of additives was clearly seen as an issue that needs to be regulated at the EU level. There was also a tendency to prefer additives of certified organic origin both from the processors' and 'non-processors' points of view.

e) Code of Practice

The expert consultation has shown that there is a lack of clear guidance for operators on how to translate given regulations into practices at the company level. A 'code of practice' for the organic food sector is seen to be a good instrument which would eliminate the need for describing all the issues in detail in EU Regulation 2092/91. A number of problems which occurred in the last years were caused by insufficient implementation of the rules of EU Regulation 2092/91. Guidance is needed on the management level, but also for inspection/certification bodies, if more responsibility is given to the operators (Beck, A. 2005).

Recommendations

The final recommendations for the development of organic food processing are addressed to different groups of actors. The following examples are to highlight possible activities:

a. Recommendations for the European Commission: Minimising the use of additives (maintain a restricted list); defining and promoting careful processing and the authenticity of food; revising the regulations for organic food and farming based more on principles, support for research projects.

b. Recommendations for competent national authorities: national code of practice for organic food processing through initiating platform structures; support for research projects.

c. Recommendations for the private sector: new labelling concepts; food safety prevention and monitoring; sensory quality improvement; environmentally friendly processing techniques.

It is important that there be an ongoing debate regarding how it might be possible to respond better to consumer expectations while maintaining the principles of authenticity of organic food production.

Conclusions

The results of this research program will provide a good basis for the further discussion in this area. One conclusion is that further research is needed from the experts' point of view, in particular on careful processing, minimal use of additives, and practical concepts of authenticity. The development of a code of practice would be a good practical instrument for the implementation of the existing regulation in practice as well to test and implement planned modifications (Beck, A. 2005). The challenge is to find a good balance between authenticity, health orientation and convenience.

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For information on the QLIF Subproject 5 see http://www.qlif.org/research/sub5/index.html. The publications listed above can also be downloaded from the following website: http://orgprints.org/view/projects/eu_qlif_sub5.html.

Assessment of processing technologies which may improve the nutritional composition of dairy products – Overview of progress

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Key words: Conjugated linoleic acid, CLA, dairy products, processing, organic

Abstract

Among consumers there is a growing demand for food products with a natural nutritional-physiological advantage over comparable conventional products. As part of an EU funded project, ALP is examining the possible impact of processing on nutritionally valuable milk components, using the example of conjugated linoleic acids (CLA). The extent to which processing influences the CLA content of the end product was determined by literature research and own investigations of organic and conventional butter. Furthermore, new chemical, sensory-based and bio crystallization methods were evaluated by ALP and the University of Kassel to determine the oxidation stability of butter. In a further step the storage stability of CLA enriched and conventional butter was examined and the different methods will be compared. As a third objective a process for low-input CLA enrichment of milk fat (with a focus on alpine butter) has been developed. Since the process selected for the work is a physical enrichment process, it is accepted by international organic farming and food groups. Among the many benefits ascribed to CLA, it is believed to be an effective agent against cancer. The demand for foods with properties that promote human health is growing. The dairy industry has the opportunity to meet this demand by developing new dairy products with a nutritional-physiological function for the functional food market.

Introduction

Recent studies indicate that conjugated linoleic acids (CLA) naturally present in milk and dairy products may have anti-mutagenic, anti-carcinogenic, anti-diabetic and anti-atherosclerotic effects on human health. Processing standards for organic food aim at preserving or enhancing specific bio-active or functional components of the raw material and discourage or prohibit processing methods which may have a detrimental impact on the nutritional quality. Our work package addresses the topic of processing strategies and examines the potential effects of processing on nutritionally high-value milk components, using CLA as an example, with a view to making the findings available to the food industry.

Objective 1: Composition - Overview of progress

The aim of the study was giving an overview of the present knowledge on the influences of dairy processing and storage on the content of CLA and to pay attention to possible differences between milk products of organic origin compared to conventional milk products. A comparison of organic with conventional milk products

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shows a higher CLA content in organic dairy products, furthermore higher contents of linoleic acid, trans-vaccenic acid, β-carotene and α-tocopherol. In newer studies on the effect of storage and heating steps during dairy processing, no changes of the CLA content or the CLA isomer profile was observed with the exception of microwaving. In commercial dairy products undergoing fermentation like yoghurt, butter made from fermented cream and cheese no effects of the fermentation on CLA content or the CLA isomer profile could be observed. CLA content was stable during butter making from CLA enriched milk. This was confirmed by own investigations on butter made from fermented cream both of conventional and organic origin. Within these investigations, significant differences in total CLA content between cream of organically produced milk and conventional milk have been shown (Table 1). Recent studies on cheese showed no changes of the CLA content during manufacturing or ripening. In several more recent investigations with probiotic bacteria (lactic acid bacteria like *Lactobacillus rhamnosus* or *Lactobacillus acidophilus*, propionibacteria and bifidobacteria like *B. breve* and *B. dentium*) or other strains of these bacteria groups in laboratory scale, an increase of CLA could be observed under the condition that free linoleic acid (LA) was available in the media. Specific procedures allow the increase of the CLA content in a fraction. These procedures are dry fractionation, fractionation using supercritical carbon dioxide and urea complexation, whereas micro filtration did not increase the CLA content.

Table 1: Own investigations of fermented butter (Objective 1)

Origin	n	CLA cream [g/100 g fat]	CLA butter [g/100 g fat]	Difference butter - cream [g/100 g fat]
integrated farming	7	1.35^{ax}	1.31^{cx}	-0.04
organic	5	1.54^{by}	1.48^{dy}	-0.06

a, b and c, d: different letters in columns mean significant differences ($p < 0.005$); x,y: different letters in rows mean significant differences ($p < 0.01$); n: number of samples

Objective 2: Methods and Shelf-Life - Overview of progress

PUFA/CLA-enriched butter was produced at the pilot plant of ALP to study its oxidative stability and its sensory quality versus conventional butter, also produced at the pilot plant of ALP. Different methods to assess oxidative stability and sensory quality of raw materials and end products with a focus on milk fat were evaluated and established by ALP and the University of Kassel, partner within WP 5.3. A gas chromatography olfactometry (GC-O) method, which enables the detection of the aroma-active compounds of butter originating from lipid oxidation (see paper ‘Aroma-active secondary oxidation products of butter’ by Silvia Mallia) and a sensory-based method were evaluated by ALP. Within the sensory-method, terminology and the respective references were specified by the certified sensory panel of ALP to assess sensory changes during storage regarding olfactometry, flavour and texture (spreadability). In addition, a systemic (holistic) laboratory method was developed by the University of Kassel. The bio crystallization method is based on a crystallographic phenomenon generating biocrystallograms with reproducible crystal structures. This method enabled a significant differentiation of the two types of butter at all points of degradation (shelf-life). The developed methods were applied to monitor the oxidative stability of PUFA/CLA-enriched butter during storage. The results obtained by chemical, sensory and holistic methods will be compared and the shelf-life of the different butter samples will be evaluated and discussed.

Tab 2: Extract of results of series of experiments (Objective 3)

Product	T [°C]	n	CLA content [g/100 g fat]
anhydrous butterfat	**-**	**1**	**0.768 b**
First fat fractions	20	8 *sx*	0.866 a *0.009*
First fat fraction	22	1	0.866 a
First fat fractions	24	3 *sx*	0.868 a *0.020*
First fat fraction	28	1	0.872 a
average difference compared to anhydrous butterfat		13 *sx*	0.1 *0.01*
ANOVA			***
First fat fraction	20	1	0.860
Second fat fraction	12.5	1	1.017
difference compared to first fraction		1	0.16
highland butter	**-**	**1**	**2.159**
First fat fractions	20	2 *sx*	2.277 *0.005*
average difference compared to highland butter		2 *sx*	0.12 *0.005*
ANOVA			*
First fat fraction A	20	1	2.281
Second fat fraction A1	12.5	1	2.512
Second fat fraction A2	12.5	1	2.447
First fat fraction B	20	1	2.274
Second fat fraction B1	12.5	1	2.51
average difference compared to first fraction		3 *sx*	0.21 *0.04*
t-Test			*

n: number of experiments; sx: standard deviation; significance: *p ≤ 0.05; **p ≤ 0.01; ***p ≤ 0.001; ns (not significant); a, b: different letters indicate significant differences (Fisher LSD test p ≤ 0.05); ANOVA: analysis of variance; t-test: students t-test

Objective 3: Novel Processing - Overview of progress

As a third objective, in cooperation with the University of Applied Sciences, College of Agriculture, Zollikofen and the dairy industry, a process for low-input CLA enrichment of milk fat (with a special focus on alpine butter) has been developed as part of a diploma thesis. Alpine butter provides a suitable raw material since it has a significantly higher CLA content than conventional butter. Suitable fractionation conditions were evaluated with anhydrous butterfat. The optimal time and temperature of the selected CLA enrichment process were obtained from the various fractionation conditions tested. The milk fat crystallization was influenced by changing crystallization time (between one and 20 hours) and temperature (between 32°C and 9.5°) as well as by means of multiple fractionation. The aim of the physical separation process was to obtain a higher CLA content in a fraction while optimally separating the two fractions, and to achieve a commercially interesting yield of the fraction with the higher CLA content. Fatty acids and the CLA content of the olein and stearin fraction were determined in the laboratory using gas chromatography. CLA isomers were analyzed by Ag+-HPLC (high performance liquid chromatography) and compared against the CLA content of the respective raw material. The resultant olein fraction achieved a CLA content for conventional anhydrous butterfat of 10.2 mg per gram of fat with two fractionation steps at the optimal times and temperatures. This is 2.5 mg CLA per gram of fat more than the CLA content of the raw material anhydrous butterfat. The resultant olein fractions of alpine butter achieved an average increase of CLA of 3.3 mg/g fat corresponding to an increase of 15.3% in the olein fraction compared to the raw material alpine butter (Table 2). Triglycerides containing CLA are found both in the olein and the stearin fraction. However, the test results show that a higher content is found in the olein fraction in both types of butter.

Conclusions

Objective 1: Processing and storage of dairy products generally do not change the concentration of CLA in milk fat. A certain potential to increase the CLA level is given by using selected strains for fermented dairy products supplemented with free LA and different chemical and physical processes.

Objective 2: The GC-O analysis and sensory-based method show its ability to characterise the aroma and detect the odour differences from oxidative processes in the produced PUFA/CLA-enriched butter and conventional butter. The bio crystallisation method enabled a significant differentiation of the two types of butter at all points of degradation (shelf-life). These findings will be made available to food industry to assess oxidative stability and sensory quality of raw materials and end products with a focus on milk fat. The shelf-life of the two types of butter can be evaluated by these methods.

Objective 3: Tests conducted demonstrate that the selected physical separation process accepted by international organic farming and food groups enables CLA enrichment. The test results show that a higher content is found in the olein fraction in both types of butter. While a CLA enrichment of 32.5% was obtained in the olein fraction for conventional anhydrous butterfat, alpine butter shows only 15.3% enrichment. Given the costly and complex process involved, this is low, and furthermore too minor to achieve any decisive positive impact on human health.

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Aroma-active secondary oxidation products of butter

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Key words: Butter, Aroma, PUFA, CLA, Olfactometry

Abstract

Butter contains vitamins, minerals and unsaturated lipids, such as polyunsaturated fatty acids (PUFA) and conjugated linoleic acids (CLAs). However the oxidative stability and consequently the shelf-life of milk products are inversely correlated with their PUFA and CLA content.

The objective of this study is the evaluation of the oxidative stability and sensory quality of PUFA/CLA-enriched butter versus conventional butter, with both types of butter being produced at ALP. For this purpose, new chemical and sensory-based methods will be developed, as well holistic complementary methods.

This paper focuses on a preliminary study achieved using conventional butter, subjected to a long storage and to oxygen and light exposure, to develop a gas chromatography olfactometry (GC-O) method able to detect the aroma-active compounds originated from oxidation. This will be one of the methods used for the evaluation of the oxidative stability of PUFA/CLA-enriched butter.

Introduction

In the frame of the EU Research Project 'QualityLowInputFood' (QLIF), Work Package 5.3, ALP addresses the topic of processing strategies and examines the potential effects of processing on nutritionally high-value milk components, such as PUFA and CLA. They are desirable constituents of milk products for their beneficial effects on human health (Whingham *et al.*, 2000). PUFA and CLA are naturally present in milk from ruminants but their content can be further increased to obtain dairy products with a higher nutritional value. PUFA/CLA enriched butter was produced at the ALP pilot plant, supplementing the diet of cows with sunflower seeds, rich in unsaturated fatty acids (Collomb *et al.*, 2004). Conventional butter (not enriched in PUFA/CLA) was also produced and compared to the PUFA/CLA-enriched butter. These suitable components in milk fat may, however, cause faster oxidation and thus shorter shelf-life of butter. For this reason, the oxidative stability and the sensory quality of PUFA/CLA enriched butter are investigated and new chemical and sensory-based methods are developed at ALP. In addition, holistic methods are developed by a research group at the University of Kassel, partner of ALP. The present part of the project focuses on the development of an instrumental combined to a sensory method, gas chromatography olfactometry (GC-O), able to compare the aroma profiles of the PUFA/CLA-enriched butter to the conventional butter. In this first study a GC-O method was developed using conventional butter samples, subjected to a long storage or to oxygen and light exposure, to test the sensitivity of this method to the aroma compounds originate from oxidation. The GC-O method was able to characterise the aroma profile of the

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oxidised kinds of butter and to detect the odour-active compounds formed from lipid oxidation. This method will be applied to monitor the oxidation of PUFA/CLA-enriched butter during storage and to define the shelf-life of this product.

Materials and methods

Conventional sweet cream butter was produced in March 2006 at the ALP pilot plant. This butter was then analysed fresh, after storage of 1, 8, 20 and 35 days at 6°C and after induced oxidation by oxygen and light. Oxidised butter samples were obtained by exposure of fresh butter to a continuous flow of oxygen for 1, 3 and 12 hours and to fluorescence light (Philips TL40W/33RS) with an intensity of 2000 lx. The room temperature was in both cases 6°C. The aroma compounds were extracted by solid phase microextraction (SPME). After extraction, the fiber was desorbed in the injection-port of a gas chromatograph which was equipped with a mass selective detector, a flame ionisation detector and a sniffing port for the olfactometric analysis. The GC-O analysis was carried out by three trained panellists.

Tab 1: Selected odour-active compounds detected in fresh butter and in 35 days stored butter

RI	Odour descriptor	Fresh	35 days	Compounds
581	butter, cream	x	x	2,3 Butandione (Diacetyl)
645	milk, chocolate	x		2-Methylbutanal
708	acetic, vinegar		x	Acetic acid
800	green		x	Hexanal
867	meat, broth	x		2-Methyl-3-furanthiol
902	soapy	x	x	Heptanal
980	mushroom	x	x	1-Octen-3-one
997	cheese, rancid		x	Hexanoic acid
1091	hot milk	x		2-Nonanone
1163	green	x	x	(*E*)-2-Nonenal
1170	hay	x	x	(*Z*)-2-Nonenal
1293	fried oil		x	(*E,E*)-2,4-Decadienal

RI= linear retention index determined on a HP-5MS capillary column

Results

A total of 19 odour-active compounds were detected in the headspace of the fresh butter by GC-O. The odour-active compounds of this butter were diacetyl, giving a buttery and creamy odour, 2-methylbutanal, with milk and chocolate notes, 2-methyl-3-furanthiol, with meaty odour and 2-nonanone, characterised by a hot milk odour. The aroma profile of the butter changed during storage, showing after 35 days, fatty, oily, fried and rancid notes, mainly due to lipid oxidation. Acetic and hexanoic acid as well as hexanal and (*E,E*)-2,4-decadienal are mainly responsible for the odour impression of long term stored butter. Table 1 compares the odour-active compounds found in the fresh butter with those of butter stored for 35 days. Butter samples subjected to oxygen and light exposure developed quickly off-flavours. The GC-O analysis showed that the butter exposed to oxygen for 12 h developed a fatty odour, probably due to (*E*)-2-hexenal and decanal, as well a sweaty odour, originated from pentanoic acid. Intense green, metallic and rancid notes characterised the butter exposed to the light. In the samples exposed for 12 hours aldehydes and ketones, such as pentanal, hexanal, (*Z*)-3-hexenal and 3-pentanone, 3- and 2-hexanone, play an important role, conferring chemical, green and metallic odours. A potato-like odour was detected only in the light-exposed samples, due to the methional. Table 2 summarises the GC-O results found for the butter samples exposed to oxygen and light.

Tab 2: Selected odour-active compounds detected in butter exposed to oxygen and to fluorescence light for 12 h

RI*	Odour descriptor	O_2	Light	Compounds
581	butter, cream	x	x	2,3 Butandione (Diacetyl)
650	chemical		x	3-Pentanone
715	green		x	Pentanal
775	green, metallic		x	3-Hexanone
791	green		x	2-Hexanone
800	green, fresh		x	(*Z*)-3-Hexenal
800	green, metallic	x	x	Hexanal
820	boiled potato		x	Methional
841	grass, fatty	x	x	(*E*)-2-Hexenal
852	green		x	(*E*)-2-Hexenol
857	flower, green	x	x	(*Z*)-3-Hexenol
902	soapy, fatty	x	x	Heptanal
915	sweaty	x		Pentanoic acid
980	mushroom	x	x	1-Octen-3-one
1090	mushroom	x	x	3,5-Octadien-2-one^T
1181	green, metallic	x	x	(E)-4,5-Epoxy-(E)-2-octenal^T
1211	fatty	x		Decanal

RI= linear retention index determined on a HP-5MS capillary column

T= tentatively identified, based on comparison of the mass spectra with the ones of a mass spectra library.

Discussion

Many studies are already accomplished on butter aroma, but only few have used GC-O to evaluate the oxidative stability of butter. Butter samples showed a change in flavour during 35 days of storage, mainly due to off-flavours developing from lipid oxidation. Hexane and hexanal that increase during storage may considered as markers of oxidative processes. Hexanal, originating from autoxidation of linoleic acid, often predominates in the volatile fraction of oxidised foods (Belitz *et al.*2004) and was already chosen as an indicator of lipid oxidation in butter during storage (Christensen and Holmer 1996). (*E,E*)-2,4-Decadienal, responsible for fried-oily odour in butter stored for 35 days, was also found as off-flavour in butter oil stored 42 days at room temperature (Widder *et al.* 1991). After 35 days of storage, butter showed a more intense mushroom notes, due to an increasing of 1-octen-3-one, developed from linoleic acid (Ullrich and Grosch 1987); these findings are in agreement with other authors (Widder 1994, Widder *et al.* 1991, Badings 1970). Butter samples were sensitive to oxygen and particularly to light that induced green, fatty and metallic notes. Pentanoic acid and decanal were only found in samples exposed to oxygen. Methional, with a boiled potato-like odour, was only detected in samples exposed to fluorescence light. This compound from the photodecomposition of methionine, is mainly responsible for the light-activated flavour in dairy products (Bosset *et al.* 1993, Azzara and Campbell 1992).

Conclusions

This preliminary study demonstrated that GC-O analysis is able to characterise the aroma and detect the odour differences in fresh butter, stored butter and butter exposed to oxygen and light. This GC-O analysis will be used to study the odour-active compounds originating from oxidative processes in the PUFA/CLA-enriched butter and conventional butter. These results will be compared to those obtained with chemical, sensory and holistic methods and the shelf-life of the two types of butter will be evaluated.

Acknowledgments

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Effect of ozonated water on the microbiological physical and nutritional quality parameters of minimally processed lettuce during shelf-life

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Abstract

Since chlorine is not accepted for treatment of organic products, alternative sanitizing agents are needed to assure the safety and shelf-life of fresh-cut organic vegetables. Therefore, the effect of ozone on the microbiological, nutritional ands sensory quality of lettuce were studied during shelf-life at 4ºC in this project. Ozone gas was produced from extra dry oxygen by means of a corona discharge generator. After spinning, samples were packaged using 35 µm oriented PP bags and stored at 4ºC for 13 days. Sampling was done on days 0, 3, 8, 10, and 13. Analyses include aerobic plate count and psychrotrophic bacteria, vitamin C and sensory quality. One chlorine (100 ppm, 2 min) and one organic acid (0.25% citric acid plus 0.50% ascorbic acid, 2 min) disinfected sample were used as control samples during the shelf-life study, as chlorine is the generally used disinfecting agent in conventional processing and organic acids are one of the few alternatives that can be used for organic products. No significant difference was detected between the microbial quality of ozone, chlorine and organic acid disinfected lettuce samples. Although the vitamin C loss in 3 ppm ozone treated samples were significantly higher than the other samples, no significant difference was observed between chlorine washed and 1 ppm ozone treated samples. At the end of 10 days of storage, at a level of 5 %, no significant difference was observed between chlorine washed and the samples treated with 1 ppm ozone for 2 min.

Introduction

There has been an increasing demand for minimally processed products in recent years. Similar trends are valid also for organic products. Consumers now seek for processed organic products. Therefore, interest on the production of minimally processed organic vegetables has been also increasing. This results in a need for processing methods that enable minimally processed organic products with a comparable shelf-life and quality with their conventionally produced relatives. Due to the environmental and health risks that are posed by the use of chlorine (1,2), its use in organic production is forbidden in Europe. Moreover, in some European countries, use of chlorine has been forbidden even for conventional products. Thus, there is a need for alternative sanitizers to be used for the sanitization of fresh-cut vegetables not only for the organic food sector but also for the conventional food processors.

Organic acids have been investigated because of their bactericidal activity, and because they are generally recognized as safe (GRAS). However, antimicrobial activity changes very much among organic acids. Antimicrobial properties of acetic acid has been shown in inactivating *E.coli*, *L. monocytogenes*, *Salmonella* Typhimurium and *Yersinia enterocolitica*. Citric acid in the form of lemon juice has been demonstrated to reduce *S. Typhi* populations on fresh fruit. Common household sanitizers such as distilled water, apple cider vinegar (%5), lemon juice (%13), bleach

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(%4), and white vinegar (%35) decreased the numbers of aerobic bacteria by avarages of 0.6, 1.2, 1.8, 1.9, and 2.3 log/g, respectively, without causing severe effects in sensory quality of lettuce (3,4,5,6).

Previous studies on ozone proved that it has an antimicrobial activity higher than that of chlorine (7,8). It is a strong oxidant that can react with contaminants directly as molecular ozone or indirectly through the free radicals derived from it (9). Ozone acts more quickly than permissible levels of chlorine which makes it more suitable for washing procedures with short contact times. Moreover, since it does not pose a residue problem and does not create any by-products (7,8), it has been suggested as a good alternative for chlorine and have a potential to be used as a sanitizing agent for organically grown fresh cut vegetables.

Currently, ozone is accepted to be used in direct contact with foods in USA and in Europe for conventional products. But its use in organic products is not allowed in Europe yet. However, it is important to note that in the IFOAM norms for organic production and processing, ozone is listed as a disinfectant to be used in direct contact with foods (10).

The previous studies on the use of ozone on lettuce were generally concentrated on the antimicrobial activity and did not include data on the effect of nutritional quality of the product. Only Beltran *et al.* (11) studied the effect of ozone treatment on the antioxidant constituents, besides other microbial and sensory quality parameters during the shelf-life of shredded iceberg lettuce. Therefore the aim of the current study was to assess the effect ozonated water washing on the microbiological, nutritional and physical quality parameters of minimally processed lettuce in comparison to aqueous chlorine and organic acid treatments during the shelf-life of the products.

Materials and Methods

Lettuce. Loose-leaf lettuce (*Lactuca sativa* L.) was purchased from a local producer. The core and the wrapper leaves were discarded. Leaves were shredded into about 3 cm pieces with a sterile knife. Then the leaves were first washed with tap water, and then with sterile deionized water. After the sanitizing treatment, a kitchen type vegetable spinner was used for spinning to remove excess water on the lettuce leaves.

Washing solutions and procedure for treating lettuce. All the glassware used were washed and rinsed with deionized water, autoclaved and then dried to obtain ozone and chlorine demand-free glass-ware. Ozonated water was prepared by ozonating sterile distilled water. Gaseous ozone was generated using a corona discharge ozone generator (model Micronix, Mikron Makina Ltd., Istanbul, Turkey) from purified, extra-dry oxygen gas. The ozone generator has a capacity of 15 g ozone h^{-1}. Water was ozonated by using a Mini Ozone Injection System (Ozone Solutions, Inc., Sioux Center, IA, USA) equipped with a pump, a contact tank having a water inlet tube, pressure gauges and regulators, safety release valve, liquid withdrawal tube and gas inlet tube fitted with a venturi-type injection dispenser unit. Ozone was introduced to the water by means of the injection system until the required ozone concentration was attained. Sodium hypochlorite solution (100 ppm free chlorine) and 0.25 % citric acid plus 0.50 % ascorbic acid solution were also prepared using sterile distilled water. Ozone and chlorine concentrations were measured by colorimetrically (Spectroquant Colorimeter Picco, Merck, Darmstadt, Germany).

Microbial analysis. Total aerobic plate count, *Enterobactericeae*, and psychrotrophic bacteria were enumerated immediately after the sanitizing treatment and at regular intervals during the shelf-life. Total aerobic plate count was determined on plate count agar (PCA, Oxoid, Basingstoke, England) following the pour plate method by incubation at 35 ^{o}C for 48 h. Psychrotrophic bacteria were determined on plate count agar (PCA, Oxoid, Basingstoke, England) following the pour plate method by incubation at 4^{o}C for 10 days. The number of *Enterobacteriaceae* was determined on Violet Red Bile Glucose Agar (VRBGA, BioRad, Marnes la Coquette, France) using the pour plate method. The results of the microbiological analyses were expressed as the logarithm of colony-forming unit per gram of fresh weight of lettuce (log cfu/g lettuce).

Analysis of vitamin C. Vitamin C was analyzed according to the modified indophenol titrimetric method as described in AOAC (1995). The results were expressed as mg/100 g of fresh lettuce.

Shelf-life study. Samples were packaged using 35 μm oriented PP bags and stored at 4ºC for 13 days. Sampling was done on days 0, 3, 8, 10, 13. Analyses include aerobic plate count, *Enterobacteria*, vitamin C, colour and sensory analysis. One chlorine (100 ppm) and one organic acid (0.25% citric acid plus 0.50% ascorbic acid) disinfected sample were used as control samples during the shelf-life study.

Statistical analysis. All the given results were obtained from duplicated samples, and each point was replicated twice. Analysis of variance (ANOVA) was performed followed by post hoc Tukey’s test with a level of significance at $p < 0.05$ using STATISTICA.

Results and discussion

Effect of Sanitizing Treatment on Microbial Quality

The results of microbial analysis were demonstrated in Figure 1. No significant difference was observed between the sanitizing treatments, in terms of change in the microbial load of the product during the shelf-life at 4°C. Even at the end of the 13th day of storage, the microbial load was lower than 10^{7} CFU/g. The ozone treatment was found to be as effective as chlorine wash in terms of microbial inactivation.

3 ppm ozone treatment resulted in a significantly ($p<0.05$) higher reduction in Vitamin C content compared to 1 ppm ozone and 100 ppm chlorine treatments (Figure 2.). No significant ($p\geq0.05$) difference was observed between the Vitamin C contents of 1 ppm ozone and 100 ppm chlorine treated samples.

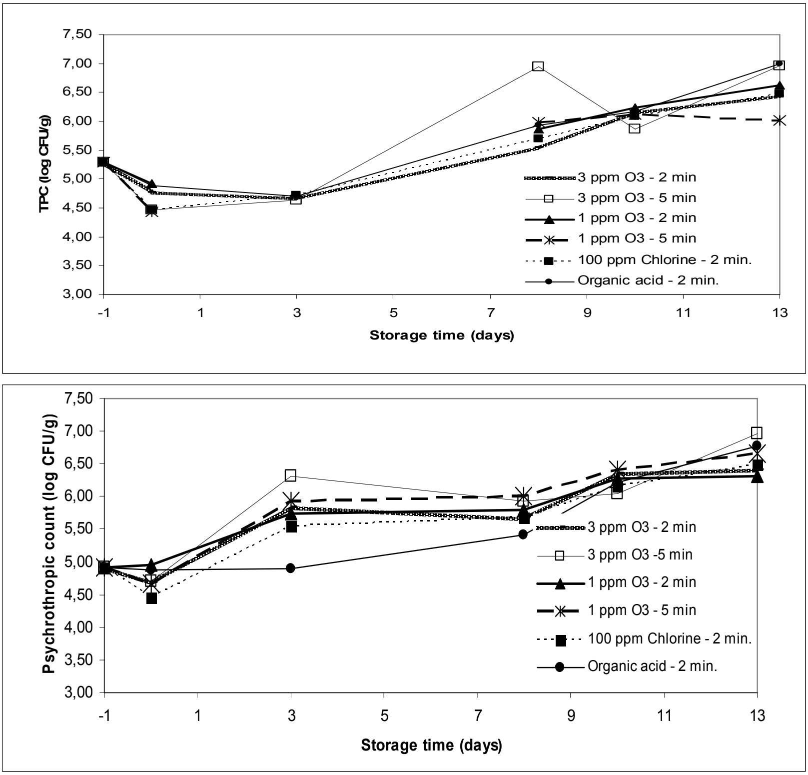

Figure 1. Changes in microbial load of lettuce washed with ozone compared to that treated with chlorine (100 ppm) and organic acid (0.25 % citric acid + 0.50 % ascorbic acid) during the shelf-life 4ºC for 13 days.

Sensory analyses were done by 8 trained panellists, in which the samples were ranked according to overall appearance, odour, and taste. Samples were taken at days 5 and 10. Since a high discoloration and tissue softening occurred in the samples treated with 3 ppm ozone, they were discarded after 2-4 days of storage and were not included in the sensory analysis. Moreover, all the samples were discarded at day 13, since unacceptable browning and tissue softening developed. No significant difference (at a level of 5 %) was observed between the rest of the samples in terms of appearance and odor, whereas taste of the 1 ppm O_3 – 2 min sample was found to be superior at day 5. The appearance of chlorine washed sample was significantly better than the others at day 10. Moreover, the organic acid treated and the 1 ppm O_3 – 5 min. samples were ranked to be the lower than the other two sample in all aspects at day 10.

In terms of retarding microbial growth and slowing down organoleptic changes, washing with 1 ppm ozone for 2 min at 10°C was found to be a good alternative for chlorine disinfection of minimally processed lettuce.

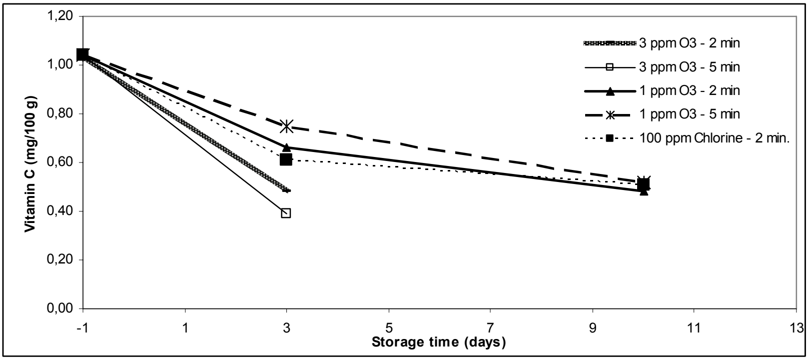

Figure 2. Changes in Vitamin C content of lettuce washed with ozone compared to that treated with chlorine (100 ppm) during the shelf-life 4ºC for 13 days.

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Changes in sensory profile and microbiological quality during chill storage of cured and uncured cooked sliced emulsion-type sausages

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Key words: processing, food quality, curing agents

Abstract

Nine batches of cooked sliced emulsion type sausages, produced from organic meat with or without the use of nitrite, were packed under N_2/CO_2 (7:3) and vacuum, respectively, and stored at 8°C. During two weeks of storage, the microbiological quality was determined, as well as the sensory quality by using profile analysis. The spoilage flora consisted of lactic acid bacteria and Brochothrix thermosphacta, without clear evidence of an inhibitory effect of nitrite on the growth of these organisms. The sensory profile showed an increase of the sour and rancid aroma and flavour, in parallel to the growth of these microorganisms. These changes were more pronounced in the batches prepared without nitrite. Spots of red discolourations were occasionally observed during storage of uncured sausage slices. These may have been caused by reduction of traces of nitrate from spices by psychrotrophic Enterobacteriaceae.

Introduction

The use of curing agents in the processing of organic meat is still a controversial issue (see Lücke 2003). The Regulation (EC) 780/2006 only permits the use of nitrite and nitrate if 'no technological alternative giving the same sanitary guarantees and/or allowing to maintain the specific features of the product is available'. Nitrite may extend the shelf life of meat products by preventing oxidative deterioration of lipids and inhibiting spoilage bacteria. There are indications that the shelf life of chilled emulsion-type cooked sausages ('Brühwurst') is longer if nitrite is used (Graubaum *et al.* 2003; Friedrich 2006). If so, this could seriously affect the acceptance of uncured sausages both by retailers and consumers. On the other hand, there was no clear correlation between the overall microbiological quality of Brühwurst sausages and the methods of production (organic vs. conventional, cured vs. uncured; Albert *et al.* 2003).

The aim of this study was to elucidate which microbiological and sensory parameters are best suited to determine the end of the shelf life and 'sell-by-date' of cured and uncured cooked sliced vacuum- or modified atmosphere (MA) packed emulsion-type sausages, and to investigate the effect of nitrite on shelf life.

Materials and methods

Batches of cooked sliced emulsion-type sausages ('Brühwurstaufschnitt') were prepared by two manufacturers (A and B) from organic meat, by use of formulations and processes common in Germany (Leitsätze, 2001). Manufacturer A prepared 'cured' (with 2% nitrite curing salt containing 0.4-0.5% sodium nitrite) and 'uncured' (with 2% sodium chloride) sausages whereas manufacturer B used 1.83% sodium

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chloride and slightly more lean meat in the formulation. Sausages had been stored for up to 4 weeks before slicing, and post-process handling and slicing was without the usual precautions against bacterial recontamination. Manufacturer A packaged the sliced sausages under modified atmosphere (MA; N_2:CO_2 = 7:3), manufacturer B under vacuum. Packages were stored in a chill cabinet at 8°C and continuous illumination, reference packages were stored in the dark at 2°C.

For each batch and date, representative samples were taken from two packages and analysed for lactic acid bacteria, *Brochothrix thermosphacta, Enterobacteriaceae* and pH by official methods (Amtliche Sammlung; Baumgart 1999). For sensory evaluation, a panel of 12 individuals was recruited and trained on perception of product-specific traits. The panel identified 15 parameters as important to characterise the sensory profile of the sausages. Sensory profiling was done according to German standards (DIN 1999), using appropriate references for each parameter. 5 – 10 panelists participated in each individual session. Means and standard deviations of observations were calculated using FIZZ Calculations 2.10 Software (Biosystemes, Couternon, France).

Results

Results are summarized in Table 1. Lactic acid bacteria (*Leuconostoc spp., Lactobacillus spp.*) grew from 50 - 5,600 colony-forming units (CFU)/g to about $5*10^6$/g within 5-9 days in all products, without clear evidence for an inhibitory effect of nitrite. The pH decreased somewhat faster in the uncured sausages. In these sausages, *B. thermosphacta* reached high counts somewhat earlier than in the cured sausages; however, this could also be due to higher counts directly after slicing and packaging. Later during storage, growth of *B. thermosphacta* and *Enterobacteriaceae* ceased. Of 14 attributes used in sensory profiling, 'sourness' and 'rancidity' were found to be most important to assess shelf life. These characters were more pronounced in the uncured sausages.

After 7 days of storage, areas with pink discolorations appeared in some packages of uncured sausages from manufacturer A. On discoloured slices, *Enterobacteriaceae* were found at levels up to 10^5/g.

Discussion

The emulsion-type sausages analysed had a shelf-life of about 1-2 weeks under vacuum or modified atmosphere at 8°C after being sliced without the usual precautions taken to avoid recontamination. On sausage slices produced by manufacturer A, lactic acid bacteria reached $5*10^6$/g (performance standard according to DGHM 2005) about 2-3 days before the onset of sensory deviations. Spoilage indicators were off-odours and aromas described as 'sour' and 'rancid'. In uncured sausages, these deviations were more pronounced and observed some days earlier. As observed by Kröckel (2000) and Albert *et al.* (2003), there was only a loose correlation between the counts of lactic acid bacteria, the pH value and the attribute 'sourness'. This may be due to differences in the composition of the lactic flora and their metabolic products.

Tab. 1: Spoilage of sliced bologna-type sausages, packaged under modified atmosphere and stored at 7-8°C

Batch*	Nitrite added	Lactic acid bacteria**		Days until pH <5.8	*Brochothrix thermosphacta***		Days until CFU of *Entero-bacteriaceae* >10^3/g	Days until deviation in	
		CFU/g, day 0	Days until >$5*10^6$ CFU/g		CFU/g, day 0	days until >$5*10^6$ CFU/g		ranci-dity	sour-ness
ASW1	+	5,600	9	10	60	>15	>15	>15	>15
ASW2	-	4,500	8	9	$1.6*10^6$	4	>15	10	10
ASW3	+	70	6	11	70	>13	13	13	13
ASW4	-	760	6	5	5,600	7	7	7	7
ALY1	+	50	6-7	9	50	10	10	13	13
ALY2	-	1,260	5	5	2,200	7	7	10	7
BJW1	-	not determined (analysis of other batches from manufacturer B indicate lactic acid bacteria and *B. thermosphacta* as spoilage agents)						7	7
BSW1	-							7	7
BLY1	-							7	7

* A and B indicate manufacturers A and B, respectively. SW indicates 'Schinkenwurst', LY indicates 'Lyoner' (emulsion-type sausages with and without visible meat particles, respectively).

**arithmetic mean from 2 determinations

Data from experimentally prepared emulsion-type cooked sausages ('Brühwurst') indicate little effect of nitrite at usual ingoing levels (80-100 mg $NaNO_2$/kg) on lactic acid bacteria, and some effect both on *B. thermosphacta* and *Enterobacteriaceae* (Nielsen 1983; Graubaum *et al.* 2003). Our data are in accordance with this, but gave no unequivocal evidence for an effect of nitrite on growth of these organisms because slices of uncured products had higher counts of *B. thermosphacta* right from the start (possibly due to differences in the organisation of the slicing process by manufacturer A). However, our data confirm that the accumulation of acids by lactic acid bacteria limits further growth of *B. thermosphacta,* as shown by Grau 1980, and Cayré *et al.* 2005.

'Rancidity' was observed in both cured and uncured sausages. It is probably due to metabolic products of *B. thermosphacta* (short-chain fatty acids, butane-2,3-diol, 3-methyl propanol and similar compounds; Stanley *et al.* 1981). Apparently, the inhibitory effect of nitrite on oxidative fat deterioration is of little significance in perishable cooked sliced meats packaged under exclusion of oxygen. Psychrotrophic *Enterobacteriaceae* in the recontaminant flora are able to reduce traces of nitrate possibly present in uncured sausages, and thus may cause pink spots on a greyish product. This defect will further reduce shelf life and acceptability.

We confirmed that the spoilage flora of cooked sliced vacuum- or MA packed meats consists of recontaminant bacteria (see Borch *et al.* 1996). Therefore, aseptic conditions during post-process handling of these products are much more relevant to shelf life than the use of nitrite.

Conclusions

We recommend that manufacturers of cooked sliced emulsion-type sausages ('Brühwurstaufschnitt') from organic meat determine shelf life of these products by standardised sensory analysis, using sourness and rancidity as critical parameters. In addition, pH value and cell densities of lactic acid bacteria, *B. thermosphacta* and *Enterobacteriaceae* are useful indicators. These bacteria normally do not survive the cooking process. Hence, shelf life of longer than 1-2 weeks at 7°C is difficult to achieve without special precautions (aseptic techniques) in post-process handling and slicing of the sausages. Sensory analysis and data from the literature indicate a significantly shorter shelf life of nitrite-free cooked sliced emulsion-type sausages. However, we could not show a clear inhibitory effect of added nitrite on the bacteria contaminating the sausages after processing.

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Development of strategies to improve quality and safety and reduce costs along the food supply chain

Strategies to improve quality and safety and reduce costs along the food supply chain

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Key words: food quality, food safety, economics, supply chain

Abstract

The paper aims at contributing to a better understanding of the linkage between supply chain performance and possible performance improvement with respect to food quality and safety. Therefore, the paper addresses the question whether the level of collaborative planning and close supply chain relationships could help improve quality and safety of organic supply chains. The three main weaknesses in the performance of European organic supply chains identified are high logistic and transport costs, the level of input costs and low expenditure on research and product development. While we found a high level of collaboration for information sharing, there is almost no collaboration with respect to joint decisions on optimal order quantity and inventory requirements as well as for all cost relevant issues of the supply chain. As the potential to benefit from economics of scale on a company level is often limited in organic supply chains, we suggest to make use of the cost reducing potential of collaboration.

Introduction

Members of organic food chains face several challenges in managing and linking profitability and the quality of their products (Zeithaml 2000). The complex configurations of food chains and their actors complicates quality assurance on the one side and the equitable and efficient allocation of costs and returns to the supply chain actors on the other (King and Venturini 2005).

Petersen *et al.* (2005) found that supply chain and company performance is positively influenced by collaborative planning with the degree of trust between buyers and suppliers impacting on collaborative planning effectiveness. Collaborative planning processes are conceptualized as the joint buyer – supplier relationships that require bilateral information flow between supply chain partners. Effective collaborative planning is expected to improve supply chain performance by facilitating decisions that reflect a broad view of the supply chain and take into account interactions among the firms in the supply chain. Performance improvements are particularly to be expected in the form of increased inventory turns, reduced purchase prices, and/or reduced total cost and better food quality.

Synthesising research results which were conducted as a part of the EU project ‘Improving quality and safety and reduction of cost in the European organic and ‘low input’ food supply chains’, this paper aims at contributing to a better understanding of the linkage between supply chain performance and possible performance

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improvement with respect to food quality and safety. Therefore, the paper will focus on the question whether collaborative planning and close supply chain relationships could help improve quality and safety of organic supply chains. The paper will conclude by describing a preliminary set of cost effective strategies to improve quality and safety of European organic supply chains.

Materials and methods

While Porter's concept of the value chain (Porter 1985) focuses on the enterprise in the first place, for this study we adapted the concept of Supply Chain Management (SCM). SCM is defined as the integration of key business processes from end user through to original suppliers/retailers that provide products, services, and information that add value for customers and other stakeholders (Lambert and Cooper 2000). SCM views a company as a part of a network of suppliers and customers. Thus, as deficiencies of food systems to deliver high quality and safe food are of systemic nature, we were primarily interested in studying the system, the network and nodes of suppliers and customers rather than analysing individual companies.

In a case study approach, six different supply chains in eight European countries were analysed: milk (CH, UK), apples (DE, CH), pork (UK, NL), eggs (DE, UK), wheat (HU, IT, FR) and tomatoes (IT, NL). Data were collected by semi-structured interviews with individuals representing all supply chain actors involved in the relevant supply chain (producers, packers, processors, transporters, traders, retailers). The questionnaire included a structured SWOT-Analysis, a partial value chain analysis and an analysis of supply chain relationships (Simatupang and Sridharan 2004, Roberts and Stimson 1997).

Results

The structured SWOT-Analysis showed the strengths of European organic supply chains with respect to adoption of traceability procedures, costumer feedback procedures, labour force and managerial skills as well as adoption of additional quality management systems. On the other hand, three main weaknesses in the performance of European organic supply chains were identified: high logistic and transport costs, high levels of input costs and low expenditure on research and product development (figure 1). While input, logistic and transport costs are considered to have only a low impact on food quality and safety the situation is different for expenditures on research and product development. Increased expenditure on research and product development offers the greatest potential for quality and safety improvement in organic food supply chains. Furthermore, high operating costs were mentioned as a weakness with a high quality impact in wheat and apple supply chains, while we found a low quality impact for milk and pork supply chains.

Impact on quality and safety	weaknesses	strengths
high	> Expenditure on research and product development > Profitability (wheat) > Competitiveness within the market (wheat) > Operating costs (wheat, apples) > Level output price (wheat) > High integration in conventional supply chain infrastructure (wheat)	> Adoption for traceability procedures > Customer feedback procedures > Labour force skills > Managerial skills of supply chain members (milk, apple, eggs, wheat) > Adoption of QMS additional to organic certification schemes (milk, apples, tomatoes) > Delivery times (eggs, wheat) > Availability of raw material (apples, eggs, wheat, tomatoes NL) > Use of a fully organic supply chain infrastructure (wheat, apples) > High integration in conventional supply chain infrastructure (eggs, tomatoes) > Ability to exploit economies of scale (eggs, pork, apples)
low	> Logistic and transport costs > Level input price > Marketing costs (wheat) > Ability to exploit economies of scale (wheat, tomatoes) > Availability of raw material in organic quality (pork, tomatoes IT) > Operating costs (milk, pork)	> Competitiveness within the market (pork, eggs, tomatoes) > Profitability (eggs, tomatoes) > Marketing costs (pork, tomatoes) > High integration in conventional supply chain infrastructure (pork) > Use of a fully organic supply chain infrastructure (pork, tomatoes)

Figure 1: Strengths and weaknesses of organic supply chain performance aspects and their impact on food quality and safety

But how do the supply chain actors react on this stated problem in operating, input and logistic costs? Collaboration between supply chain actors is a proven means to reduce these costs. In our analysis of supply chain relationships we therefore investigated the level of collaboration with respect to three dimensions (Simatupang and Sridharan 2004): information sharing, decision synchronisation (joint decision making in planning and operational contexts) and incentive alignment (degree to which chain members share costs, risks and benefits) (figure 2).

While we found a high level of collaboration on information sharing with respect to prices, delivery schedules, product quality and product safety, the supply chains surveyed showed a very low level of collaboration with respect to incentive alignment and decision synchronisation. Indeed, there is almost no collaboration with respect to joint decisions on optimal order quantity and inventory requirements as well as for all cost relevant issues of the supply chain (analytic, traceability, logistics, inventory). Analogous to the findings in the structured SWOT-Analysis, collaboration with respect to research and product development was found to be very low.

As a consequence of the high operating costs which are one of the most important weakness of organic supply chains and the low level of collaboration with respect to cost reducing activities the level of satisfaction with the financial performance of the respective supply chains was negatively ranked from the supplier perspective (figure 3). On the other hand, the highest degree of satisfaction was found for the trust dimension which is a necessary condition for successful collaboration.

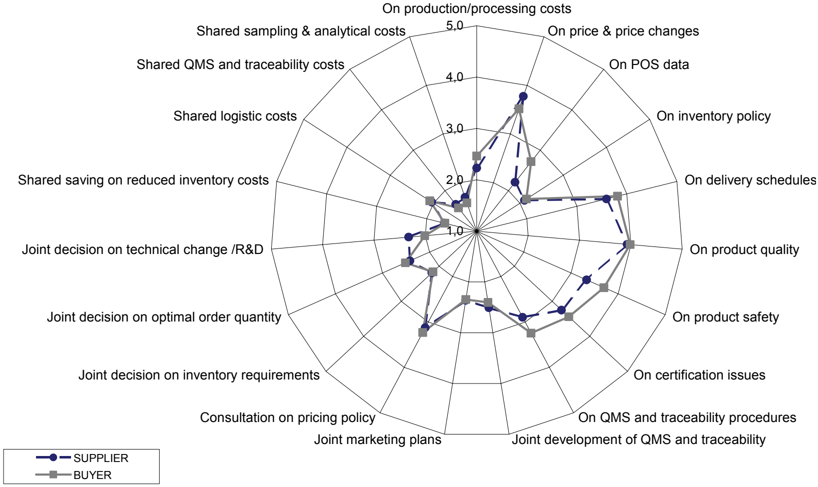

Figure 2: Level of collaboration between organic supply chain actors (collaboration index)

Scores: 1=never; 2=seldom; 3=sometimes; 4=often; 5=always

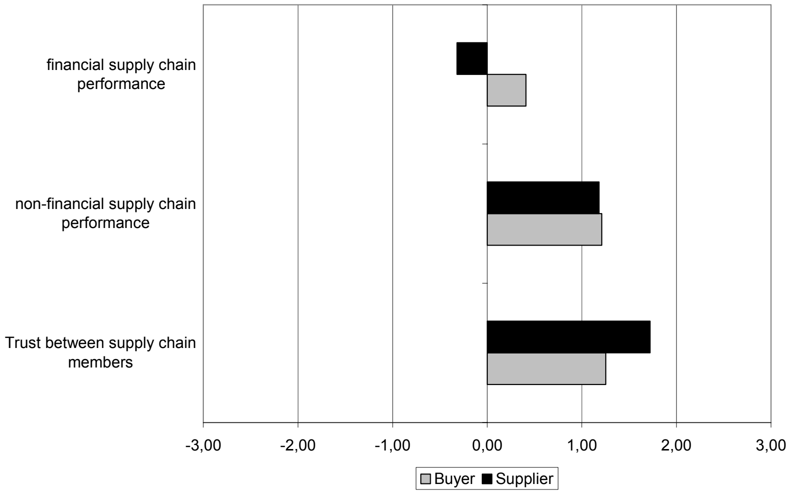

Figure 3: Level of satisfaction in organic supply chain relationships

(Scores: 3=strongly agree; 1=agree; 0=neither agree/ disagree; -1=disagree; -3=strongly disagree)

Discussion

Operating costs covering manufacturing, inventory, logistic and distribution costs cover approximately two thirds of the selling price of the organic commodities analysed in this study and represent one of the most relevant financial weaknesses in organic supply chains in Europe. On the other hand, our study showed that collaboration between supply chain members aimed at reducing costs is poorly developed. Thus, the European organic supply chains analysed take little advantage of this important cost reducing strategy. However, the supply chain actors interviewed did not recognise that the poorly performing cost categories have an impact on the quality and safety of the supply chain's products. The majority of interviewees stated that product quality is not an issue for improvement. However, the pressure on operating costs limits the leeway for investments in product research and product development, which in turn are highly relevant to product quality. Investment in product development for quality improvements is one of the key issues to stay competitive and to keep market share. Moreover, economic pressures on the supply chains not only derive from increasing costs, but are also due to decreasing margins as a result of market competition and/or decreasing sales. No wonder, that the supply chain actors see a negative economic cycle/trend to be one of the most relevant risks for quality and safety in organic supply chains.

Conclusions

From our analysis we can suggest the following set of strategies to improve the performance of organic supply chains:

The organic share of the total food turnover in the EU is about 1% (Hamm and Gronefeld 2004). In this niche market, the potential to benefit from economics of scale at the individual company level is often limited. Therefore, a key strategy for companies in the organic market should be to make use of the cost reducing potential associated with improved collaboration.

Collaborative product development is a delicate issue which needs to be based on a high level of trust and on a long term perspective in the partnership. According to our survey however, the latter is only found in milk and apple supply chains while in wheat, tomato and pork supply chains the long term perspective of partnerships was negatively ranked. Strategic partnerships are therefore particular relevant to these supply chains.

According to Petersen (2005), supply chain actors should recognise the difference between truly strategic suppliers and other suppliers. Collaborative planning and trust should be further enhanced particularly with strategic partners. In these partnerships the level of information sharing and joint decision making needs to be improved.

In these strategic partnerships, supply chain members should establish action steps to achieve targeted performance levels. For the supply chains analysed this applies particularly to inventory planning, logistics and product development.

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HACCP based quality assurance systems for organic food production systems

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Key words: HACCP, Assurance, Organic, Food, Safety

Abstract

HACCP provides an effective, logical and structured means of assuring food safety. Although first used in food manufacturing operations, HACCP can be – and, increasingly is – applied to food production and handling operations at all stages in the food chain. This includes the primary production sector. The purpose of this paper is to illustrate how the principles of HACCP can be applied to organic production with special reference to the primary sector.

Introduction

HACCP (Hazard Analysis and Critical Control Point) is a system which identifies, evaluates, and controls hazards which are significant to food safety. The HACCP system is based on seven principles (Codex 2003), and when conducting a HACCP study in organic production the seven principles may be applied in a number of stages. These include essential preparation tasks and establishing the HACCP plan.

A HACCP study can be applied throughout the food chain from primary production to final consumption. Revised EU hygiene legislation, which has in large part applied since January 2006, is based on a number of key measures including: implementation of an 'farm to table' approach; and introduction of a HACCP system in all sectors of the food businesses except for the primary sector. In addition, a HACCP approach to food safety is an increasing feature of food industry self regulation, including for the primary sector. Although a HACCP approach to food safety assurance is not a legal requirement in the primary sector, it is increasingly recognised as an effective and logical means for food safety control throughout the food chain, including farming.

An additional consideration for organic producers is to ensure compliance with specific EU regulations which lay down detailed rules for organic production. However, the products of organic origin are also subject to the EU hygiene legislation. In terms of food safety, therefore, there is no difference between organic and conventionally produced food materials. In practical terms food safety hazards in organic production are likely to be the similar whereas market placing attributes may differ. A HACCP approach to food safety assurance is equally applicable to organic as well as other production sectors.

The aim of this paper is to provide a brief description of the stages that need to be considered in sequence to develop a HACCP system in organic production. The focus is on agricultural operations (including crop and animal husbandry, harvesting and post-harvest handling of organic products on farm) with special reference to food safety and organic market placing attributes. The guidance is drawn from the Codex

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Alimentarius Commission (Codex 2003), CCFRA Guidelines Nos. 10 and 42 (Knight & Stanley 2000, Gaze 2003) and the ISO 2200 Standard (ISO 2005).

Planning stages to enable hazard analysis

1. Define the terms of reference

In order for the HACCP study to be developed, implemented and fully effective it is essential that the scope of the study is clearly understood and outlined at the outset. It is necessary to consider factors such as: the study objective; the product and production details; which hazards are to be managed by the study; and the prerequisite programmes (PRPs) that underpin the HACCP study.

All the food safety, and other hazard types under consideration, that are reasonably expected to occur in relation to the type of product and production operations should be identified and recorded. The identification may be based on the experience of the organisation, industry norms and guidance, and legal and customer requirements. The aim is to assess and establish the hazards that are reasonably expected to occur, taking into account the severity of the consequence of occurrence and the likelihood of occurrence.

Tab. 1: Example Food Safety and Quality Issues in Organic Production

Food safety issues †	**Quality/market placing attributes ‡**
Biological, e.g. food-borne poisoning organisms (E.coli, Salmonella, etc.) *Chemical*, e.g. food-borne contaminants above prescribed levels (pesticides, mycotoxins, heavy metals, nitrates, etc.) *Physical*, e.g. food-borne foreign bodies (glass, metal, wood, etc.)	*Organic integrity*, e.g. compliance with adopted production standards, traceability *Visual defects*, e.g. blemishes, rots, presentation criteria (size, shape, etc.) *Sensory defects*, e.g. colour, flavour, texture

† Agents with the potential to cause an adverse health effect

‡ Attributes with the potential to cause an adverse reaction on the acceptance of the product

In an organic production operation there are few, issues that are specific to the organic product. The food safety issues will be similar to conventional products. Similarly product quality issues will not be significantly different at least in terms of how these are addressed in a HACCP system. For example quality issues such as visual defects or sensory attributes will be specific to the nature of the product and production operation, and are too specific to highlight in this paper. This is the same in non-organic products and production systems, where product quality is a function of the nature of the specific production systems. Examples of typical hazards in organic production are given in Table 1.

The one area where organic products do differ from other production systems is in the market placing attributes, that is in relation to compliance with adopted production standards. For example, free range laying hens have specific requirements in terms of the number of animals per area, the number of animals with access to perch and nest sites. These may be defined as quality attribute hazards in the HACCP system. Similarly conversion period in crop production or animal rearing systems may be a quality hazard that can be addressed in the HACCP system.

Tab. 2: Example Organic Integrity Issues

Animal prodution	**Crop production**
Free range laying hens	
Indoors: max. 6 birds per m², min. 18cm perch per animal, max. 8 hens per nest	2 years conversion before sowing of crop or 2 years before use of a grass crop
Outdoors: 4 birds per m²	3 years before harvest for perennial crops
Maximum number of laying hens: 3000 per unit	segregation of organic and non-organic areas
Provision of maximum of 16 hours light per day	use of different varieties in organic and non-organic crops
Empty houses after each batch of poultry	limits on heavy metals in compost
Leave outside runs empty for 2 months to allow vegetation to regrow	

It is important, therefore that in determining the scope of the HACCP in the Terms of Reference, that careful consideration is given to both food safety and quality attributes. These will be dependant on the nature of the product and production operation. In any event it is desirable to distinguish clearly between safety and quality attributes in the HACCP system. For example the objective of the HACCP system may be stated as covering food safety issues and key quality attributes and where this is to be applied, such as at the point of distribution or consumption. It must be stressed that in terms of how these are addressed in the HACCP system is no different be they food safety or specific quality and market placing attributes. In this paper therefore it is the HACCP system that is described and not hazards which are specific to organic products. Some examples of specific organic quality attributes as they relate to organic integrity are given in Table 2.

2. Select the HACCP team

Depending on the size and nature of the operation, development and implementation of the system should, wherever possible, be undertaken by a team who have adequate knowledge and expertise in order to conduct the study, including the knowledge of the product sector and an understanding of HACCP. It is feasible for one person to develop the system but this individual should have full understanding of the operation, and should wherever necessary seek specialist support or information.

3. Describe the essential product characteristics

A full description of the product(s) understudy should be prepared, including defining key parameters which influence the safety and/or quality of the product. For example, a description of the product, production activities, storage and transport conditions and intended use of the product.

4. Define the process

Prior to the hazard analysis beginning it is necessary to define the production process. This will involve careful examination of the process and operations under study and the production of a flow diagram around which the study can be based. In the flow diagram all the operational steps in a logical sequence should be defined. The flow diagram should provide sufficient technical detail for the study to proceed.

Establishing the HACCP plan

5. Hazards and controls

5.1 Hazard analysis

Using the flow diagram as a guide, all the potential hazards, as defined in the terms of reference, that may be reasonably expected to occur at each step in the process should be identified. This consideration should include hazards that may be:

- present in raw materials used in the production operation, e.g. introduced in stages prior to the operation;
- introduced during the production operation, e.g. from people, equipment or the environment; and
- changed during the production operation, e.g. proliferate or survive a step designed to eliminate or reduce the hazard to an acceptable level.

The role of the hazard analysis is to determine which hazards are of such a nature that their elimination or reduction to acceptable levels is essential to the production of the food product. In practice, the decision process will need to take into account the risk associated with the hazard identification, i.e. the likelihood of the hazard causing an adverse effect taking into account the severity of that effect.

This is not an exhaustive list of hazards, nor is the risk (likelihood and severity of occurrence) of the hazards the same for different product types or in all production situations.

Two approaches are possible in undertaking the hazard analysis. The first is a classical HACCP approach whereby each hazard at each process step is identified in turn. The alternative approach is where hazards in general are identified then considering whether these are linked to specific steps or generic to the process. The latter is perhaps more applicable to the primary sector where few, if any steps, in organic production are specifically designed to eliminate or reduce a hazard to an acceptable level, that is at a Critical Control Point. An example of this approach is given in Table 3.

These approaches to the hazard analysis are applicable to food safety issues and organic product quality attributes. For quality issues it may be mainly a case of either presence of the hazard in the materials used, that is a hazard that has been introduced in previous stages, or introduction in the production operation due to people, equipment or environmental influences. In both these respects organic production is not unique in terms of how the hazard analysis is addressed in the HACCP system. The uniqueness in terms of HACCP comes in the nature of the particular product and production operation.

5.2 Control measures

The next stage is to specify what control measures should be applied for each identified hazard. Controls are actions or activities that are applied to prevent or eliminate a hazard or reduce it to an acceptable level. For practical purposes control measures may be divided into distinct groups: prerequisites (including operational PRPs) and measures applied at Critical Control Points (CCPs).

PRPs and operational PRPs tend to be activities associated with the production process, i.e. policies and procedures that reduce the likelihood of the introduction and/or proliferation of food safety hazards. These activities have an indirect influence on hazards in products. Actions as controls on the other hand are measures that prevent or eliminate food safety hazards or significantly reduce the level in the product, i.e. have a direct effect on hazards in products. These actions may be applied at CCPs. In practice most if not all control measures in an organic crop production operation are PRPs or Operational PRPs. That is, the basis of food safety management in crop production is to minimise the likelihood of introducing and/or proliferation of hazards, as opposed to eliminating or reducing a hazard already present in the crop product.

The hazard analysis determines the appropriate control measures and allows for their categorisation into PRPs or measures applied at CCPs. PRPs that manage the basic environmental and operating conditions underpin the hazard analysis and are identified in the HACCP system as in place, maintained and reviewed. This categorisation of control measures facilitates the application of different management strategies in respect to monitoring, validation and handling of non-conforming control measures and resulting products.

Tab. 3: Typical food safety and quality hazards in organic production

Hazard descriptor	Significant hazard	Cause or source
Presence on raw materials, inputs, production site (e.g. soil)	Food poisoning organisms	Due to contamination at previous stages (e.g. by supplier)
	Organic integrity is compromised	Due to failure at previous stages (e.g. by supplier)
	Chemical hazards	Due to contamination at previous stages (e.g. by supplier)
Introduction from people at harvest and during post-harvest handling	Food poisoning organisms	Personal hygiene and medical condition of food handlers
	Organic integrity is compromised	Due to people not competent to make decisions or not complying with adopted standards
Introduction from equipment at harvest and during post harvest handling	Food poisoning organisms	Unclean machinery, tools, containers used to handle product
	Organic integrity is compromised	Equipment is not dedicated to organic use, used in the correct sequence or cleaned prior to use for organic materials
Introduction from the environment during production and post-harvest handling	Food poisoning organisms	From pests, domestic and stock animals, farm buildings
	Organic integrity is compromised	Production facilities are not segregated spatially or by time for organic use
Growth of hazards (change of pre-existing hazard) during post-harvest handling	Food poisoning organisms	Due to time and temperature abuse in chill storage
Survival of hazards (change of pre-existing hazard) during post-harvest operations	Food poisoning organisms	Due to ineffective heat treatment, e.g. milk pasteurisation

6. Determine CCPs

For each hazard identified in Stage 5 determine whether the process step is a CCP or operational PRP. The identification of CCPs/operational PRPs requires professional judgement and may be aided by the use of a decision tree.

In practice, there are few if any steps in a primary production operation that are specifically designed to eliminate a food safety hazard or reduce it to an acceptable level, that is at a CCP. There may however be a number of steps where control is applied at a specific step and is necessary to reduce the likelihood of introducing a hazard, that is by an Operational PRP

7. Establish critical limits

For each CCP, the critical limits for the control measures should be identified. The critical limit is the predetermined value for the control measure applied at each CCP, and is the criterion which separates acceptability from unacceptability (e.g. safe from unsafe). It should represent some measurable related parameter that can be assessed quickly and easily in monitoring. It may also be helpful to identify working limits or targets for operational PRPs as these are similar to CCPs in respect of their importance as a control measure at a specific step.

8. Establish a monitoring system

Monitoring is a planned sequence of observations or measurements of control measures. The monitoring system describes the methods which confirm that all CCPs are under control. It also produces a record of performance for future use and should be supported by adequate record keeping. Monitoring must also be able to detect loss of control at the CCP so that corrective action can be taken to regain control.

PRPs and operational PRPs should also be checked to ensure they are effective. It may, therefore, be helpful to establish monitoring systems for these PRPs. In many instances the frequency of checking PRPs will be at a rate below that which is relevant for a CCP.

9. Establish a corrective action plan

If in the process of monitoring, it is found that there is a loss of control, it is important that appropriate action is taken. Corrective actions should aim to bring the production process back under control and deal with non-conforming product where appropriate. It is important that the action taken is logical and rational and should involve a thorough review to determine what necessary action needs to be taken.

If when PRPs are checked they are found not to be effective then appropriate remedial action should also be taken in the same way that corrective action for CCPs is taken.

10. Establish verification procedures

Verification procedures are used to demonstrate compliance with the HACCP system - that is, that it is operating correctly and effectively. Verification demonstrates conformance (e.g. with stated procedures) and gathering information that the HACCP system and prerequisites are effective (i.e. safety requirements are being met). Verification should, therefore, examine the entire HACCP system including records.

Verification should aim to answer three questions:

- am I doing what I say;
- does the product and process meet the defined criteria; and
- is the HACCP plan up to date.

A periodic review of the HACCP plan should be carried out to ensure it is up to date. Typically this is annual or once a production cycle for primary production. It is essential that the review should consider any changes which affect the HACCP plan or crop production process be these internal or external. In addition, there should be an automatic assessment to determine if a review is required when a change occurs outside the normal review period, such as during crop development.

11. Documentation and record keeping

It is important for the organic production business to be able to demonstrate that the principles of HACCP have been applied correctly, and that documentation and records have been kept in a way appropriate to the nature and size of the business. The key document is the HACCP plan and any associated procedures. Records provide evidence that systems operate as specified. The retention period for documents and records should also be considered and defined.

Discussion

There are no specific rules for the format of a HACCP plan (presentation is a matter of preference). The plan should, however, clearly outline in a logical sequence the process whereby hazards which are significant for food safety are identified, evaluated and controlled. The HACCP plan should provide sufficient technical detail for the study to be effective.

An organisation can focus on having as many control measures as possible managed by PRPs and only a few managed at CCPs, or the opposite. It should be noted that in some operations, no CCP can be identified and control of identified food safety hazards is by PRPs and Operational PRPs. Where this is the case such prerequisites must be defined as part of the HACCP system and verified to ensure their effectiveness. Primary production may be such an operation where no CCP is identified, in this case control of food safety hazards is reliant on PRPs and Operational PRPs.

The HACCP technique is primarily applicable to issues of product safety associated with biological, chemical and physical hazards. There is also an increasing interest in the application of the HACCP technique to identify hazards and control measures associated with quality, that is market placing attributes. The philosophy inherent in the HACCP technique is equally applicable to these food safety and quality issues. However, it is desirable that HACCP is focussed on safety issues, and where quality issues are included a clear distinction between safety and quality is shown.

As stated previously there is little if any difference compared to other product types as to how food safety and quality hazards in organic production are addressed in a HACCP system. The key in an organic HACCP is in clearly defining the hazards, that is in terms of the scope of the HAACP. The significant hazards in an organic production operation will depend on the nature of the production and production operation. Many food safety issues and product quality attributes (product acceptance criteria including visual and sensory attributes) will be no different, except where there are specific issues which relate to market requirements. The area of most difference will be in terms of the integrity of the production system. These may be defined in the adopted production standard be that based on regulatory requirements or a private organisation’s standard.

It is necessary not only to clearly define the hazard but also understand the cause or source of the hazard. This will be important when undertaking the hazard analysis. This will be more straight forward for food safety and product quality attributes such as presentational and integrity criteria but will be more problematic for attributes where the cause is less obvious or understood, in which case the controls and monitoring activities will be less easy to define. Sensory attributes or perceived hazards are a particular case in point. Care should be taken when deciding whether the significance is sufficient or understood to be addressed in the HACCP study.

An effective HACCP system in organic production will take time and resources to develop. However, the benefits that can be derived from and effective system include meeting legal and food safety requirements and customer expectations, and continuous improvement of the management of the production operations. A HACCP approach is an effective (and cost-effective), logical and structured means of providing an organic production food safety control system. The level of sophistication of the HACCP system will depend on the nature and size of the business. A larger business may reasonably be expected to have a more detailed system than a small or medium sized operation.

More detailed guidance including worked examples to demonstrate the application of the HACCP technique in specific production sectors (field vegetables, cereals, apples, eggs, pork and dairy) will be published in due course. For those with an interest in organic food processing a useful Code of Practice which describes the most important requirements for the organic food sector with special reference to food safety and quality has been produced as part of the QLIF project report (Beck 2005).

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Organic Industry Challenges in the Face of Negative Media Reports

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Key words: Consumer, quality, research

Abstract

As the organic industry continues to grow in volume and profile, so too does the resistance to the industry by vested interests, aided by the sensationalist media. Information and misinformation concerning the quality and safety of organic foods is being conveyed to consumers via the mass media and the Internet. Although the organic industry is defined by process standards, detractors of the industry are focusing on product quality and safety issues. Reactive responses by the organic industry may be justified and may or may not include critiquing the disparaging research and the negative media reporting. Proactive responses involving disseminating favourable research are more desirable but must be based on well designed research. Reducing opportunities for critics can be accomplished through rigorous organic product quality control and ensuring that the touted product benefits match the actual product attributes.

Introduction

The old adage that success breeds contempt holds true for the organic industry. Friction between conventional and organic agriculture was inevitable given that the organic industry has leveraged sales by differentiating organic products based on food safety, quality, sustainability, and animal welfare. Market research indicates that 57% of respondents in Europe and 68% globally were motivated to buy organics because they are perceived to be healthier for consumers and their children (AC Nielsen 2005). To protect the financial interests of conventional agriculture, some players in the industry including suppliers and industry funded institutions have resorted to issuing reports and press releases discrediting organic product quality and safety. The media have been all too happy to promote this agenda either out of ignorance or to exploit negative and controversial news. Since the merits of organic foods are being judged in the court of consumer perceptions, the industry must respond carefully to avoid damaging credibility and stunting market growth. Misinformation and propaganda require an appropriate response in order to avoid consumer confusion and disillusionment. While it is unlikely that hard core purchasers of organic products could be swayed by the media, light and non-users can be affected. The continued growth of the industry will likely depend on expanding this consumer segment.

Reactive Response

When the media reports on research denigrating organic food quality and safety, the onus is on the organic industry to decide whether to respond. Deciding on how and whether to respond to negative media allegations is partly dependant on the complexity and gravity of the reported findings. For example, if the government or media reports that a food born illness was traced to organic product, this is easily understood by consumers and is likely to elicit a prompt negative consumer response.

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A similar response could be expected for a research report that determines that there are toxic substances in organic foods. Less likely to have a swift and detrimental impact on consumer buying habits would be the reporting of unhealthy substances that impact consumer health on a dose basis and over time, such as increased cholesterol levels in food products. Revealing that organic foods contain equal or lower amounts of healthful substances than conventional foods is not an immediate life threatening issue, but it does attack one of the core beliefs of organic consumers. A more nebulous and subjective critique of organic products involves issues of taste. This is a very subjective parameter and one that current organic consumers are not likely to be swayed by someone else's opinion. However, non-users of organics could be negatively persuaded.

Motivation to ignore attacks on the industry could be triggered by not wanting to wedge the consumer in a public relations war. Consumers can grow weary when bombarded with contradictory information about a food or food category. This can have the effect of desensitizing the consumer to additional positive or negative messages. If the consumer has turned away from organics or decided not to try them, this can present a barrier to market expansion.

Should the industry decide that a response is necessary, one option would be to avoid engaging the research study and findings in question and rebut the negative research with other positive research findings. This presents the consumer with the difficult task of deciding which research to believe and which source of information is more credible. The longer the battle between opposing views, the more likely the consumer is to tune out the issues.

Another option for the organic industry is to expose the flaws in the negative research and media presentation of the research. One of the difficulties in dissecting a research report is in determining the origin, fate, and testing protocol of the sampled food products. 'Organic' can refer to product that was certified by any number of agencies or governments based on process standards. The complex dynamics of farm inputs, management, environmental factors, and global sourcing leave some latitude in the attributes of the organic products. The effects of time of harvest, post harvest storage, processing methods, distribution and merchandizing conditions, and possible fraudulent organic production or labelling can also result in quality variations. For a given research study, the product could have been sampled at farm gate, or sampled at retail and subjected to handling and cross contamination issues, or biased by the researchers in the method of preparation (e.g. cooking of meat products). Each of these factors may or may not be identified in the research methodology.

Another complicating factor is in scrutinizing the validity of the testing protocols, methods, and results. Compounding the problem in a comparative (organic versus non-organic) study are the product attributes to be measured and the determination of what is an acceptable value and/or significant difference between organic and non-organic products. Even if a difference is identified there is the problem of interpreting the impact of such a difference. And finally, there is the difficulty of extrapolating data for limited product samples (due to research budgetary constraints) to characterize an entire industry or production system.

Having dissected the research study and findings and determined their shortcomings, the task of relaying this information in a useful and understandable manner to consumers can be challenging. Most consumers are not scientists or engineers and have little interest in understanding statistics or testing protocols.

In all cases, the response from the organic industry must be done in a manner that does not undermine consumer beliefs. An industry group in the UK responded to allegations that organic chickens were less healthful than conventionally raised chickens. Their message was that organics is not predominantly about healthier food, but about animal welfare and environmental sustainability. This strategy could have negative consequences considering that health concerns are the primary consumer motivator for purchasing organics.

The burden of who should respond to negative media depends on the specifics of the research. If a retailer, product brand or company is targeted or named in the negative research, then a direct response from these companies would be in order. In the case of generic accusations against the industry or a product category (e.g. organic chicken) then trade associations would be the logical choice to respond. Industry experts could also be called upon to provide support, including members of academia or the organic industry.

Proactive Response

Pre-emptively providing the consumer with well documented and researched benefits of organic foods and farming is one method of buffering consumers from the negative media. Unfortunately getting the message to the consumer can be a costly endeavour. Press releases to stimulate free news stories are more likely to be successful when announcing contrarian or sensationalistic information. Likewise, consumers are more apt to take notice of food stories that are based on adverse rather than positive health impacts. Funding proactive research can be an expensive proposition depending on the level of government and industry support. Posting information on websites is useful although a more passive means of educating the consumer. In any case the available information should be based on research to date as well as responses to up-to-the-minute issues.

Individual farms, processors, or retailers can insulate themselves from potential real, fabricated, or perceived problems in the industry at large by implementing rigorous process and product standards. Routine product testing to detect deleterious substances or deficiencies should be included in QA/QC or HAACP plans. Unfortunately there are no tests at present to detect fraudulent organic product. Indirectly, testing for banned substances could be used an indicator. More holistic tests such as biocrystallization could be of use although the test methodologies are complex and more research is needed in order to standardize the test results.

The organic industry must be careful to only support and promote product claims that can be substantiated, even though government standards are only process based. Creating a gap between consumer expectations and product performance can only open the door to more scrutiny and criticism.

Conclusions

Attacks on the organic industry are not likely to disappear as long as market share is cannibalized at the expense of other market segments. Maintaining the credibility and growth of the industry will depend on carefully orchestrated responses. More importantly, implementing rigorous quality assurance through product testing and standards will diminish the opportunities for organic critics.

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Development of strategies to improve quality and safety and reduce costs along the food supply chain –Poster

Co-existence in maize supply chains in Spain and Switzerland

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Key words: co-existence; GMO, maize; supply chain

Abstract

The debate about co-existence usually focuses on the situation of neighbouring farms. Organic producers take the position that co-existence affects the whole supply chain. Therefore, this paper compares the maize grain supply chains in Switzerland and Spain in order to identify which factors influence the segregation of genetically modified (GM) maize from non-GM maize, and discusses how organic production copes with the challenge of GM maize. Considerable differences exist between Spain and Switzerland with regard to grain maize as a component of animal feed. In Spain, where GM maize is grown, it is the feed industry that defines standards in the supply chains. Since the trading co-operatives are unable to supply GM-free maize, independent and separate infrastructures have been developed for a GM-free maize supply (e.g. for maize starch). In Switzerland, the retailers define quality standards for suppliers, and these standards exclude the use of GM plants for feed. Therefore, the feed industry has to segregate GM from non-GM feed.

Introduction

In November 2005, the Swiss people voted for a 5-year moratorium on genetically modified (GM) crops. For the duration of this moratorium farmers are not permitted to grow genetically modified organisms (GMOs). While the import of some specific GM food and feed products[3] is permitted, these products need to be declared. Due to the GM-free strategies of the Swiss retail sector, the question of co-existence in Switzerland has been a rather hypothetical one up until now. However, the situation could change completely once the moratorium has expired, and GM crops could be introduced into Swiss agriculture. GM crops have already been introduced in Spain. Thus, the experience gained with co-existence within maize supply chains in Spain may be significant for the Swiss organic sector if the current moratorium is not extended.

Building on research conducted as a part of the EU-funded CO-EXTRA project, the aim of this paper is to compare co-existence strategies for genetically modified and non-genetically modified conventional and organic maize products in Switzerland and Spain. The paper focuses on the situation with regard to collection points, transportation, milling and retail. The production level is not included.

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[3] Approval in Switzerland: Maize: Bt11, Bt 176, Mon 810/; Soy Ready Soy; Maize gluten for feed: all traits approved in the European Union, Canada and USA.

Materials and methods

The results are based on a case study of Swiss and Spanish maize supply chains. For the purposes of this case study, the supply chain starts when the product leaves the farm (collection points) and ends at the retailer. A series of key informant interviews were conducted in 2006 with actors in the maize supply chains. These included operators of collecting points (elevators), dryers, feed mills, animal feed manufacturers and the retailers. The interviews took about 3-4 hours each. The information presented is backed up with data from official statistics.

Results

Maize is one of the most important feed crops in Switzerland. In 2004, 18,816 hectares of grain maize were planted. Of these, 290 hectares were grown organically. To date, no GM maize has been produced in Switzerland. In Spain, GM maize has been grown since 1998. The share of GM crops currently amounts to barely 0.3% of the total agricultural area (MAPA 2006), while 2.9% of the agricultural area is managed organically (Willer *et al.* 2006). Overall, 60,000 hectares of GM maize are cultivated in Spain (MAPA 2006). In Catalonia the share of GM maize amounts to more than 50% of all maize production. In contrast to this, the total share of GM maize in the EU is 0.5 % (Transgen 2006).

To ensure GM-free products, the Swiss agricultural sector has implemented a process-oriented quality management system. The driving force behind its implementation are the retailers and the Swiss Farmers' Union. The overall strategy is to ensure the supply of non-GM products for both food and feed. For example, the labels 'Suisse Garantie' (milk, cheese), 'M 7 Punkte Plan' (meat) or 'Coop Natura Plan' (meat) exclude GM-feed components during production.

In the food sector, the responsibility to deliver GM-free products lies with the supply side, in particular with importers, exporters and exporting farmers. Up until now, the price difference between GM and non-GM material has been negligible for the food processors. As a result, prices for the final product do not differ either. Unlike in the food sector, feed importers have the advantage that Switzerland collects custom duties for feed imports and that the higher price for GM-free feed imports is absorbed by these duties.

In Switzerland, where no GM maize has been planted up to now, the critical issues are Grain maize imports and the supply chain infrastructure (transport) in which domestic and imported grain maize is dealt with in parallel. A further critical issue exists with regard to the processing level. Here, it is possible for maize by-products from food industries and imports to enter the supply chain. For instance, imported maize starch and gluten could be produced from GM maize.

Grain maize for organic farms is imported by the same companies that import conventional feed, but delivery takes place in specific containers to avoid GM-specific contamination. As no GM food or GM feed is traded in Switzerland, there is zero risk of GM contamination after importation. For organic producers, who are bound by law to avoid GMOs, maize supply is clear and transparent.

As far as maize supply chains in Spain are concerned, the situation is quite different. Due to the fact that GM maize is grown in Spain, we found that there is a greater risk of admixture. Indeed, the critical issues with regard to admixture and contamination are not only transport but also collecting points, such as elevators, drying centers, transfer points and storage facilities. A further important difference between Spain and

Switzerland is that the Spanish feed industry does not require GM-free maize for their feed products, as products from animals fed with GM-feed do not need to be labelled. Due to the fact that 78% of maize in Spain goes into the feed mill industry, the trading co-operatives are not forced to guarantee a GM-free supply of maize. These trading cooperatives control about 95% of Spanish maize production and run the majority of the collecting points and drying centres.

Discussion

While GM-free strategies were found to predominate in the Swiss food and feed sector, bulk maize production for feed and the subsequent supply chain levels are unable to guarantee a GM-free supply of maize in Spain. Two questions may be relevant for discussion against this background:

1. Is the Swiss process-oriented strategy effective?
2. How is the supply of guaranteed GM-free maize organised in Spain?

Reviewing the governmental and private laboratory results of the Swiss feed industry controls, we found that the share of adventitious traces of GMOs in animal feed has been decreasing over the last 4 years (Wüthrich *et al.* 2006). Thus, in Switzerland, the current process-oriented GM-free strategy is working effectively.

We have no information in the CO-EXTRA project regarding organic maize growers in Spain or contamination of organic maize with GM-maize. However, information about GM contamination and segregation has been gathered and made available by several NGOs in Spain (Greenpeace 2006). A survey conducted by the NGOs on organic and conventional farms during 2005 shows that there is GM contamination from seeds or adjacent fields in organic (and conventional) maize harvests. Unlike in Switzerland, there is no independent system to monitor GMOs in food and feed. It is thus not possible to analyse data in the way Wüthrich *et al.* (2006) did for Switzerland.

The Swiss retailers' GM-free strategy is a consequence of Swiss citizens refusing GM food. Indeed, GfS (2003) showed that 53% of Swiss citizens refuse GM, while 27% have a positive attitude towards genetic technology. Ten years of public debate on GMOs finally led to the GM moratorium by referendum - showing the clear position of the Swiss people against GM. As a consequence, Swiss retailers will continue their GM-free strategy as long as there is no change in public opinion towards GMOs.

Whereas in Switzerland consumers are asking for GMO-free food, 75% of people in Spain, according to Euro barometer survey on biotechnology, are optimistic with regard to biotechnology. They have one of the highest outright and risk-tolerant support for GM food in all the 25 member states of the European Union (Gaskell *et al.* 2006).

Most of the GM maize produced in Spain is used for feed. Neither the Spanish nor Swiss legislation requires livestock products (milk, meat) produced using GM feedstuff to be labelled as GM food. Therefore, it is not transparent to consumers whether a livestock product is produced using GM feed or not. For soya, Teuscher *et al.* (2006) report how a sustainable soybean supply chain was established in Switzerland after consumers pressed the food industry to exclude GM soybeans from their products. This soya is used for privately labelled livestock products in Switzerland.

The Spanish starch industry (wet milling), which supplies the European food industries, is asking for guaranteed GM-free maize because the EU regulation on genetically modified food and feed requires labeling for starch derived from GM maize. Up until now, the food industry has preferred to avoid labelling GM products. To guarantee a GM-free maize supply, the starch industry is pursuing two different strategies: i) import of certified GM-free maize, particularly from France, and ii) contracting independent Spanish farmers who do not deliver to the trading co-operatives. The entire chain of production and transport is monitored (field level, harvest, transport). Furthermore, the transport is done completely through the wet milling industry in order to minimise commingling of GM and non GM harvests.

Conclusion

In our investigation, there are two major conclusions to draw: The more important is, that the supply chain leader has the most powerful position in the supply chain and is thus able to set the parameters for the up- and downstream supply chain partners. We can conclude from our study that in Spain the feed industry is the most powerful actor within the supply chain, whereas in Switzerland the retailers occupy this position.

In addition to this fact co-existence is a reality in Spain whereas it is rather hypothetical in Switzerland. Whereas in Switzerland organic producers benefit from the overall GM-free market strategy, organic farmers in Spain have to organise their supply chain among themselves in order to ensure that organic products are GM-free.

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Environmental Impacts

Effect of crop management practices on the sustainability and environmental impact of organic and low input food production systems

Thorup-Kristensen, K.[1]

Key words: Sustainability, nitrogen leaching, crop rotation, model simulation, catch crop

Abstract

While organic farming can reduce many of the environmental problems caused by agriculture, organic farming also includes some practices which are questionable in terms of environmental effects. Organic farming practices (rotations, fertilisation regimes, cover crop use) can differ significantly and this leads to large differences in its environmental effects. This leaves considerable scope to improve the environmental effects of organic farming. The environmental aspects of organic farming are discussed, and model simulations are used to illustrate how even moderate changes in organic rotations can have large effects on sustainability, here measured by a simple index of nitrogen lost by leaching relative to nitrogen harvested by the crops. In WP 3.3.4 we are working to improve model simulation of organic rotations, and in WP 7.1 we are making environmental assessment of organic cropping practices tested in the QLIF project, using model simulations and other approaches.

Introduction

Organic crop production methods are defined by the absence of chemical fertilizers and artificial pesticides. The easy access to fertilizers and pesticides has lead to many of the environmental problems faced by conventional farming today. This is due to direct environmental effects of using fertilizers and pesticides, but also due to indirect effects, not least through the dramatic changes in agricultural practices and specialization they have allowed.

Organic agriculture will of cause remove the direct negative effects of the use of chemicals; no pesticides will pollute the ground water if none are used. However, the more indirect effects of changing to organic practices are more uncertain, and depend on how organic agriculture is practiced. To make sure that organic farming will be of maximum benefit to the environment, it is not enough to comply with current organic farming standards, but essential to optimize the agronomic practicies (e.g. rotation design; type, levels and timing of permitted input used) in organic farming systems.

In this presentation, the main focus will be on the management of nitrogen, as a critical nutrient for the crop production as well as for environmental impact. But there are many other aspects to this subject, e.g. in terms of the pesticides actually accepted in organic farming, of energy use, and of total land use for food production.

Among pesticides, the use of copper and sulphur compounds against insect pests or fungal diseases are obvious examples. Both are broad range pesticides, killing off

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many other organisms in addition to the target organisms. Copper can accumulate in the soil, leading to a risk of permanent reductions of soil fertility. Thus, organic production methods, which can reduce or remove the need for copper or sulphur, will be more sustainable than systems organic where these compounds are used.

Another main topic has been the fact that yield levels are lower in organic farming than in conventional farming. This means that more land must be used for agriculture to supply food for the world population if the crops are grown organically. There are many aspects to this discussion, and it is not as clear cut as just indicated. However, it seems clear that organic systems should be adopted which at least on the longer term produce reasonable yields. Long term green manure is an example of a measure used in organic rotations, which may improve yields of subsequent crops, but at the same time they take up land, and can therefore reduce overall production from the farm.

Without inorganic nitrogen fertilizers, the total nitrogen supply and the nitrogen surplus (kg N ha^{-1}) are typically lower in organic than in conventional farming. Therefore, at least when calculated on an area basis, nitrogen losses to the environment will generally be lower than in conventional farming.

However, in organic farming legumes are grown extensively to add nitrogen to the system. In this way substantial amounts of nitrogen are added, and this can lead to serious losses of nitrogen, if not managed correctly. The use of organic manures adds to long term nitrogen mineralization, and some nitrogen will be mineralized at times when it cannot be used by crops. The manures and green manures are of variable quality and their effect is difficult to predict, making optimization of nitrogen supply difficult (Knappe *et al.*, 2002). Green manures must be grown where the rotations allow this, rather than when it would most optimal due to crop nitrogen demand.

Nitrogen is a more dynamic nutrient in the soil than P or K. Nitrogen in the soil is affected by processes of mineralization, immobilization, denitrification, volatilization, crop uptake and by leaching. Thus, when nitrogen management is not successful, available nitrogen can be lost from the soil in a short time. But this also means that farming practice can strongly influence how much of the soil nitrogen is lost, and how much is used by crops (Torstensson & Aronsson, 2000).

When farmers try to manage nitrogen better, it is mainly the inorganic nitrogen in the soil they should try to manage. This is the nitrogen taken up by the plants, but also the nitrogen which is important in most loss processes. The attempt should be to have available nitrogen in the soil only when crops need it (synchronization), and that the nitrogen is present where the crop can reach it with its root system (synlocation).

A lot of work has been made on the synchronization aspect, studying how the nitrogen mineralization in the soil can be affected, so that nitrogen is released when the crops need it. Another aspect of synchronization is to immobilize nitrogen into organic compounds when it is not needed by main crops, as it can be done by growing autumn catch crops (Thorup-Kristensen *et al.*, 2003).

Much less work has been done on the synlocation aspects, but this is equally important, and especially so when growing catch crops. When catch crops are grown, they change the distribution of nitrogen in the soil profile by leaving available nitrogen in the topsoil and less in the deeper soil layers. It will therefore be an advantage to grow catch crops before shallow rooted main crops. Using deep rooted main crops and catch crops strategically in a crop rotation, and using catch crops before shallow rooted main crops, to ‘lift nitrogen’ to the topsoil layers where they can reach it, are powerful tools in optimizing nitrogen use efficiency in a crop rotation (Thorup-Kristensen *et al.*, 2003).

Materials and methods

The simulations presented are made with a model just developed in the European EU-rotate project. The model has been made with a focus on simulating rotation effects in rotations with a wide range of crops including vegetable crops. The conditions used for the simulations are a typical Danish weather situation, and a Danish sandy loam soil. The rotations are described in Table 1 and 2. There are two groups of rotation comparisons. In the first group of rotations (Table 1), alternative rotation options are tested, to improve the amount of N used for crop production, and reduce the amount of N lost by leaching. In the second group of rotations (Table 2) different catch crop options added to rotation 2 are tested with the same objectives. As a simple index of sustainability used to compare the rotations the ratio of nitrogen lost by leaching to nitrogen harvested with the crops are calculated for each rotation.

In general, the model seems to have overestimated nitrogen fixation in the clover grass ley somewhat. Therefore, harvested nitrogen and nitrogen lost by leaching are presumably too high as well. However, the pattern of loss and response to different management practices seem meaningful, and can be used to understand the typical effects of changes in rotation or catch crop use.

Results

In rotation 1, the nitrogen losses are high, and for each kg of N harvested from the fields, 1.45 kg N is lost by leaching (Table 1).

Tab. 1: Four different rotation options simulated with the EU-rotate model. Using rotation 1 as a 'standard rotation', changes where made in the other rotations trying to improve their sustainability in terms of N efficiency. Simulated values of harvested N, N lost by leaching and the ratio between the two are shown.

	Rotation 1	Rotation 2	Rotation 3	Rotation 4
Year 1	Barley with undersown clovergrass	Barley with undersown clovergrass	Barley with undersown clovergrass	-
Year 2	Green manure, winter wheat from September	Green manure	Green manure	Barley with undersown clovergrass
Year 3	Winter wheat	Spring wheat	White cabbage	Spring wheat
Year 4	Early potatoes	Early potatoes	Early potatoes	Early potatoes
Year 5	Carrots	Carrots	Carrots	Carrots
Harvested N (kg N/ha/year)	74	72	101	87
Leached N (kg N/ha/year)	107	101	73	69
Lost N to harvested N ratio	1.45	1.40	0.72	0.79

The losses were especially high after year 2 when green manure was ploughed under to establish winter wheat (Figure 1). An obvious solution could be to allow the green manure to grow until winter, and then grow spring wheat instead (rotation 2); we have experimental data showing good results with this. However, the simulations indicate that this only improves the system slightly. So much N is released after green manure incorporation that the spring wheat cannot use it. The nitrogen is left in the soil available for leaching after year 3 instead.

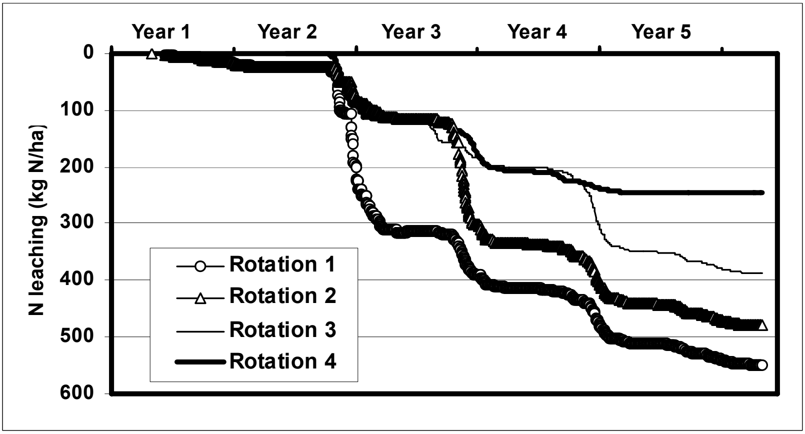

Figure 1: Nitrogen leaching during five-year rotations (see Table 1). In rotation 2, the winter wheat from rotation 1 is replaced by spring wheat to avoid early plough down of green manure, in rotation 3, spring wheat is replaced by cabbage to increase crop N removal, and in rotation 4 the green manure period is reduced by one year to reduce total N input.

Adding a more N demanding crop as cabbage instead of spring wheat (rotation 3) reduces losses more, and only 0.72 kg N is then lost per kg N harvested. The main leaching now occurs one year later after year 4, as the N rich residues of cabbage adds more to the leaching loss in year 4 than the N poor wheat residues. Another option is to reduce N input to improve the N balance. In this case, the green manure period was reduced with one year (rotation 4). This reduces the N surplus and the leaching loss very much, and shortens the rotation with one year. Thereby, the ratio of N lost to N harvested is improved to 0.79, almost as in rotation 3.

As it may be difficult to synchronize the N release from green manure or organic fertilizers with the demand of the cash crops, the system may be improved by adding autumn catch crops. They can retain N in the system during winter and release it for later crops. In the spring wheat system (rotation 2), adding a catch crop after wheat (rotation 5, Table 2), strongly reduced leaching. Again, some of the leaching came later, in the autumn of year 4 rather than in year 3 (Figure 2), but overall losses were reduced and total N harvested with the crops were increased with 10-15%. All together, the ratio of N lost to N harvested was reduced to 1.02 when a ryegrass catch crop was grown and to 0.92 when a deep rooted fodder radish catch crop was grown.

Tab. 2: Different use of catch crop in the rotation simulated with the EU-rotate model. Based on rotation 2 (Table 1), simulations were made to test the possibilities for optimizing rotation sustainability in terms of N efficiency by growing catch crops. Simulated values of harvested N, N lost by leaching and the ratio between the two are shown.

	Rotation 2	Rotation 5	Rotation 6	Rotation 7	Rotation 8
Year 1	Barley with undersown clovergrass	Barley with undersown clovergrass	Barley with undersown clovergrass	Barley with undersown clovergrass	Barley with undersown clovergrass
Year 2	Green manure	Green manure	Green manure	Green manure	Green manure
Year 3	Spring wheat	S. wheat + f. radish catch crop	S. wheat + ryegrass catch crop	S. wheat + f. radish catch crop	S. wheat + f. radish catch crop
Year 4	Early potatoes	Early potatoes	Early potatoes	Early potat. + rye catch crop	Late potatoes
Year 5	Carrots	Carrots	Carrots	Carrots	Carrots
Harvested N (kg N/ha/year)	72	83	79	91	93
Leached N (kg N/ha/year)	101	76	81	58	64
Lost N to harvested N ratio	1.40	0.92	1.02	0.63	0.69

In a next step, it was attempted to reduce the N losses in year 4 after potatoes. In one attempt the N demand was increased by switching from early to late potatoes (rotation 8), alternatively, an extra catch crop was added after potato harvest (rotation 7). Both options reduced N lost to N harvested ratio effectively to only 0.69 or 0.63.

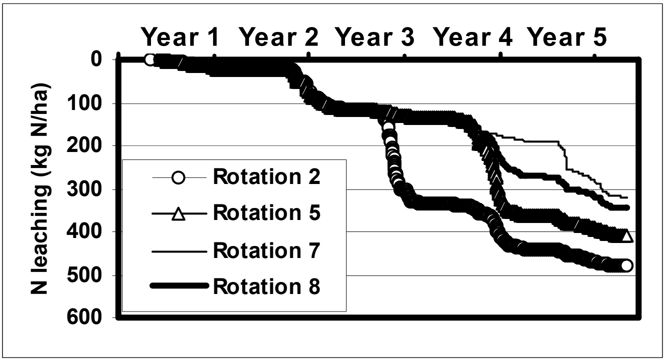

Figure 2: Nitrogen leaching using different catch crop options (see Table 2). In rotation 5 a fodder radish catch crop is grown after spring wheat, in rotation 7 a catch crop is also grown after potaoes in year 4. In rotation 8 early potatoes are replaced by late potatoes to increase crop N demand and use more of the N effect of the catch crop in year 3.

Discussion

Together, these simulations indicate several possibilities for improving system performance, by matching N supply and N demand better, in amount, timing and placement. Changing the time of N release, as when the green manure is incorporated during winter rather than during early autumn to establish winter wheat, can have big effects too (Francis, 1995). But a major improvement is only seen if there is a demand for the N at the later time when it is now released. That is why it was much better when white cabbage rather than spring wheat was grown after the green manure.

The results show that using catch crops to make a more optimal timing of N availability in a rotation can be a strong tool to improve N use efficiency in organic crop rotations. In the present examples, delaying the N release during the early stages of the rotation after green manure had limited effect unless very N demanding crops were grown, as at this stage N availability was in general high compared to crop N demand. At the later stages, as exemplified by the second catch crop grown after potatoes, a delay in N availability may have a very good effect on total N use efficiency, as at this stage of the rotation the main crops are generally N limited, and can use the N when it is released at a later time.

The need to synchronize N availability exactly to crop N demand depends also on crop rooting depth. In these simulations this has only been indicated by the comparison of the deep rooted fodder radish catch crop to the more shallow rooted ryegrass. However, experimental results have shown that when growing deep rooted crops, N that was 'lost' some time earlier may still to a great extent be used by the crops, but when growing shallow rooted crops it is important than N is only released in the soil shortly before the crop needs to use it (Thorup-Kristensen, 2006). Therefore, shallow rooted crops should only be grown in the parts of the rotation where optimal timing of N availability can be made, whereas, when this is not possible, deep rooted crops or catch crops should be grown to recover nitrogen leached to deeper soil layers.

Conclusions

Model simulated effects of different rotations and management options do not present real data, and they should be interpreted with care. However, using simulation models, much more options can be tested than in field experiments. When used in combination with real field trials, model simulations can be a very strong tool to extend the results and conclusions we can draw from the experiments, and analyze how rotations can be improved (Schoop, 1998). Models can also analyze aspects of the field experiments which are not always measured, e.g. nitrogen leaching loss. Using simulation models therefore seem a strong approach to evaluate N effects in organic farming, both effects on yield and on leaching loss to the environment.

Model simulations will be employed in WP 7.1 of the QLIF project to analyze environmental effects of the cropping practices tested in some of the QLIF field experiments. Other approaches will be employed to test other aspects of system sustainability.

Acknowledgments

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Comparing energy use and greenhouse gas emissions in organic and conventional farming systems in the Netherlands

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Key words: energy use, GHG emissions, organic farming, farming systems.

Abstract

Results are presented of a model study comparing energy use and greenhouse gas emissions in organic and conventional farming systems in the Netherlands. Calculations have been performed for model farms, designed on the basis of current organic and conventional farming practices. Energy use and greenhouse gas emissions per hectare on organic farms are lower than on conventional farms, particularly in dairy farming. Energy use and greenhouse gas emissions per Mg of milk in organic dairy farming is about 80 and 90%, respectively of that in conventional dairy farming. Energy use and greenhouse gas emission per Mg product in organic crop production is 5-40 and 7-17%, respectively higher than in conventional systems. The wide ranges found in crop production reflect large differences among individual crops.

Introduction

In various studies it has been shown that in organic agriculture fossil energy use is lower than in conventional agriculture, both per ha and per unit product (e.g. Grönroos *et al.* 2006 and Cormack, 2000). Studies comparing greenhouse gas (GHG) emissions in conventional and organic agriculture are lacking. Dutch agriculture is characterized by relatively intensive land use, in both organic and conventional farming. The question thus is whether in Dutch farming practice energy use and GHG emissions are different in organic and conventional farming systems. In this paper results are presented of a model study on energy use and GHG emissions in current Dutch organic and conventional farming practice, covering dairy farming and arable and vegetable cropping.

Materials and methods

In the Netherlands, most farms, whether organic or conventional, are specialised farms, producing either milk, arable crops or vegetable crops. To cover the dairy farming sector, eight organic and six conventional specialised model dairy farms were defined, evenly distributed over sand and clay soils. Feed crops cultivated include grass and maize on the conventional farms and grass/clover mixtures and maize on the organic farms. Farms were classified as 'intensive', 'average' or 'extensive' on the basis of milk production per ha feed crops, covering the range in intensities found in practice. The definition of the model farms is such that the organic dairy farms are less intensive and use less concentrates and more grazing than the conventional farms, reflecting current practice. To cover the arable and vegetable farming sectors, four

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model farms were defined: one organic and one conventional arable farm on clay soil (both growing potato, sugar beet, wheat, carrot, onion and pea) and one organic and one conventional vegetable farm on sandy soil (leek, bean, carrot, strawberry, head lettuce and Chinese cabbage). Rotations in the two pairs of farms were similar, but not entirely equal. Fertilizer doses on the organic farms were defined lower than on the conventional farms, due to lower crop yields and corresponding nutrient requirements. Nutrient management on the organic farms is based on cattle slurry and solid cattle manure. On the conventional farms, pig slurry and mineral fertilizer is used.

Energy use and GHG emissions for all model farms have been quantified based on identical parameters and emission factors, using the model DairyWise (Schils *et al.* 2006 and Schils *et al.* 2005) for the dairy farms, and an extended version of the BEA Model (Mombarg *et al.* 2004 and Schoorlemmer and Krikke 1997) for the arable and vegetable farms. Both models account for direct and indirect energy use and GHG emissions and assume no net accumulation or depletion of soil C stocks. Emissions of CO2, CH4 and N2O are expressed in terms of their 100-year global warming potentials (CO2 equivalents).

Results

Total energy use per ha on the dairy farms varies considerably (30-116 GJ) among the farms (Figure 1) and increases with increasing milk production per ha, as that is associated with stronger dependence on imports and higher animal densities. Energy use per ha averaged over all conventional dairy farms (75 GJ per ha) is almost twice as high as that of all organic farms (39 GJ per ha). Energy use per Mg of milk produced ranges from 3.6 to 4.5 GJ on the organic farms and from 4.3 to 5.5 GJ on the conventional farms (Figure 2). Similarly to energy use per ha, energy use per Mg of milk is positively correlated to milk production per ha. Average energy use per Mg of milk on the organic dairy farms is about 0.9 GJ lower than on the conventional farms, i.e. 19% of the average energy use on the conventional farms. On all dairy farms, indirect energy use is much higher than direct energy use (Figure 1). Concentrates contribute the largest share to total energy use (about 30%).

Similarly to dairy farming, energy use per hectare on the organic arable and vegetable farms is lower than on the corresponding conventional farms (Figure 1). The difference between the organic and conventional arable farms is larger than that between the two vegetable farms, associated with the energy needed for product drying and storage in arable farming. The actual value for this activity depends on yields: higher yields in conventional farming imply higher energy use per hectare. On the arable farms, electricity use for drying and storage of the products consumes about 45% of the total energy consumption and the use of diesel 30%. On both vegetable farms, the most important item is indirect energy associated with the purchase of planting material (35% of total energy consumption). In general, energy use per hectare is high for root crops and planted crops. On average, energy use per Mg product in plant production is higher on organic farms than on conventional farms. The difference between the organic and conventional arable farm is rather small (5%), but larger between the vegetable farms (39%). Energy use per Mg strongly varies among crops (Figure 2). Energy use in growing organic peas, sugar beet and beans is lower than in the corresponding conventional crops. For the other crops (some of which are depicted in Figure 2), energy use in organic crop production is higher than in conventional production. For example, organic carrots require twice as much energy as conventional carrots, mainly because of the energy needed for flaming weeds.

GHG emissions per ha on the dairy farms increase with increasing milk production per ha (Figure 1). GHG emissions per ha on the conventional dairy farms are 65% higher than on the organic model farms. Average N2O and CH4 emissions per Mg milk do not differ between the conventional and organic dairy farms (1.1 kg N2O en 25 kg CH4). The absence of any significant difference for N2O is the result of the higher grazing intensity and the more frequent ploughing of grassland on the organic model farms. Moreover, N2O emissions are relatively high on the two organic model farms with deep pit stables. CH4 emission per Mg of milk does not differ, because feed intake per Mg milk, the main determinant of CH4 emission in the DairyWise model, is practically the same. Unlike N2O and CH4, CO2 emissions per Mg of milk strongly differ. This is the consequence of the fact that in DairyWise this emission is calculated directly from energy use, that was 19% lower on the organic farms. Combining the emissions of all three GHGs in terms of CO2 equivalents per Mg milk (Figure 2), yields a difference of 8% between organic and conventional farms. On all dairy farms, CH4 is, with 40-50%, the largest contributor to total GHG emission (Figure 1).

GHG emissions per hectare on the organic arable and vegetable farms are lower than on the conventional farms (Figure 1). Roughly half of the emissions consists of CO2 associated with energy use, the other half consists of N2O. N2O emissions mainly originate from within the farm (use of fertilizers, incorporation of crop residues and nitrogen fixation). GHG emissions per Mg product are on average higher on the organic arable and vegetable farms than on the conventional farms. Similarly to energy use, the difference between the two arable farms is rather small (7%), but larger between the vegetable farms (17%). Again, differences among crops are large (Figure 2). For some organically grown crops emissions are lower than for conventional ones (sugar beet, pea, bean), for some others much higher (leek, carrot, wheat). In general, GHG emissions are high for leguminous crops and crops with high nutrient requirements.

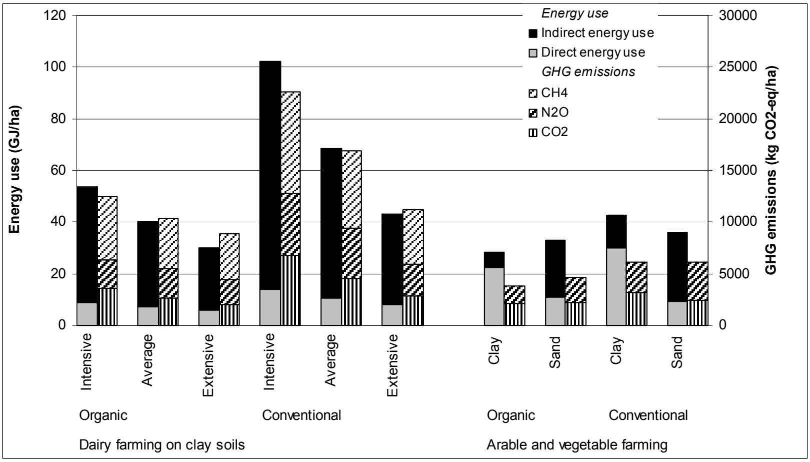

Figure 1: Energy use and GHG emissions per ha on organic and conventional model farms.

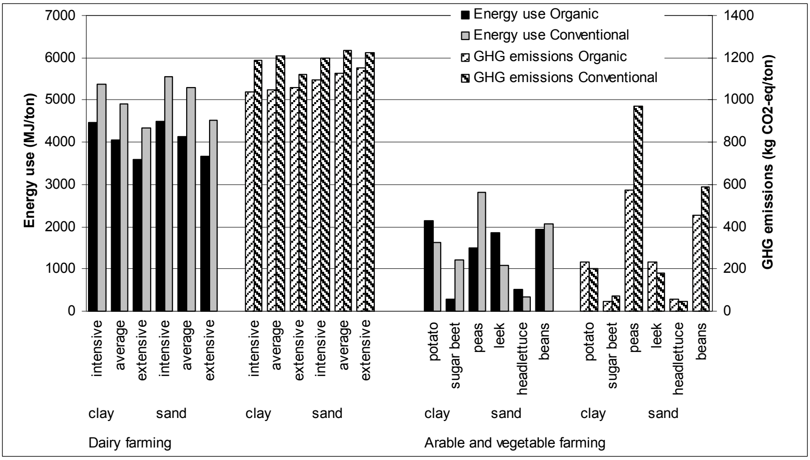

Figure 2: Energy use and GHG emissions per Mg of product on organic and conventional model farms.

Discussion

Energy use and GHG emissions calculated for stylized model farms can not be directly generalized to sector level. That would require careful weighing of the results of the model farms on the basis of their representativeness. As the dairy sector is relatively uniform, we did estimate the 'weights' for the dairy model farms. The results of the weighted averages did not differ from those reported above.

In the present study, energy requirements for imported organic manures were restricted to those for transport and application only. We hence assumed a 'zero energy' price for organic manures themselves. Consequently, energy use is lower for a crop fertilized mainly with organic fertilizers than for a crop fertilized mainly with mineral fertilizers. It is equally justified to assign a non-zero energy value to imported organic manures, for example on the basis of their fertilizer value. That would lead to higher energy use estimates, particularly for organic crops.

Conclusions

Energy use and GHG emissions per hectare on organic farms are lower than on conventional farms, particularly in dairy farming. Energy use and GHG emissions per Mg of milk in organic dairy farming are about 80 and 90%, respectively of that in conventional dairy farming. Energy use and greenhouse gas emissions per Mg of product in organic crop production are 5-40 and 7-17%, respectively higher than in conventional crop production. Based on these results, organic dairy farming performs 'better' and organic crop production 'worse' than their conventional counterparts.

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Available from the first author upon request.

Dissemination

International training and exchange – a useful instrument in knowledge and attitude dissemination.

van der Burgt, G.J.H.M.[1] and Wagenaar, J.P.[1]

Key words: development of organic agriculture, knowledge dissemination.

Abstract

Knowledge about organic agriculture is constantly changing and growing. Research related to organic agriculture at EU level nowadays plays an important role. Organic agriculture, being an integrated, holistic and multi-target approach, needs researchers who are trained to investigate poly-factorial and multi-level problems. For students and junior scientists, international seminars and exchange programs are necessary instruments to gain 'state of the art' knowledge and skills from senior scientists in the field of organic agriculture. The QLIF training programme under WP 7.4 provides training in the different aspects of ecological farming systems, but also offers an opportunity to discuss relevant and adequate research strategies and results. Within the EU sixth framework QLIF project, so far two seminars have been organized. Contents and impact of these seminars are discussed.

Introduction

Associated with a growing market for organic products in the EU is growing national and EU support for research and research training dedicated to organic farming systems. Also, there is a growing number of researchers who are, partly or fully, engaged in organic research. For early stage researchers (ESR) entering the area of organic farming R&D often realise that their previous research education/training has not provided them with sufficient knowledge and skills to address the challenges and problems in organic agriculture which is generally characterized as an integrated, holistic and/or multi-target approach with multi-level interrelationships within the system (Anonymous 2005). As a results training schemes are required to prepare ESR for handling multi-level research questions directly within the context of the agriculture system itself. The skills and knowledge base require can be taught and integrated with the existing research skill and knowledge base and attitudes of ESR new to research on organic/ecological farming systems.

The EU framework 6 'Quality Low Input Food' (QLIF) project has allocated a specific budget for activities related to training and exchange of junior scientists. In training courses, students and junior scientists are introduced by senior scientists to existing knowledge, research questions, research attitudes and research techniques which are appropriate for organic agriculture.

In the research dedicated to organic agriculture, three aspects on how research is carried out are of particular importance. First there is the awareness that what is done here and now, has its effects on later and elsewhere (Brundtland, 1987). Of course this is not typical for organic agriculture, but within the organic movement it is an explicit part of the approach. Secondly, ethics and values such as naturalness (Verhoog et al, 2002) and integrity (Verhoog, 2005) play an important role in the way organic agriculture is implemented. Thirdly, knowledge development directly focussed

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on farm practice should involve farmers in every phase, as is documented by Baars and De Vries (1999) and scientifically elaborated by De Vries (2004).

Table 1. Some characteristics of the seminars

	Soil quality	Animal rearing
Participants		
Number	26	25
Nationalities EU	7	6
Nationalities non-EU	2	2
Students	6	2
(junior) scientists	13	16
Speakers		
Number	10	8
Institutions	8	6
Nationalities	3	3
Content		
Lectures	7	8
Workshops	3	2
Farm visits	2	2

Seminars

So far, two three-day seminars have been organised, both coordinated by the Louis Bolk Instituut in Driebergen, the Netherlands. In February 2005 the first 1st QLIF-ESR training seminar was organised and focused on ‘soil quality management (Van der Burgt, 2005). In February 2006 the 2nd QLIF-ESR training seminar focused on ‘rearing of young farm animals’ (Wagenaar and Bestman, 2006). In February 2007 the third seminar will be held, entitled ‘Measuring food quality: concepts, methods and challenges’. (Van de Vijver et al, 2007). For some of the characteristics of the seminars, see Table 1. In the next paragraphs details of the seminars are presented and discussed

Soil quality

In the soil quality seminar, much attention was focused on direct soil observation. Soil structure, soil life and rooting pattern are important characteristics in agriculture and can easily be observed and, to a certain degree, quantified and validated. For such observations to give meaningful results close contact between the researcher and farmer is thought to be essential (Baars and De Vries, 1999). It is the farmer who has the knowledge of what has happened in the field in the past and why he decided to do what he has done so far. It is then desirable for both the farmer and researcher to assess/observe soil quality in situ and discuss results. It is the researcher who contributes methodological knowledge and eventually the measurements to quantify the observations.

An instrument presented to and elaborated by the participants was the nitrogen model NDICEA (Van der Burgt et al, 2006). The objective of his model is to give insight in the nitrogen dynamics of a farm requiring fertility inputs. Also, the model should be easy to use for farmers or extension workers so that results can be obtained on-farm’ at the kitchen table’. The NDICEA systems was used as an example of a scientifically validated instrument developed in close cooperation between researchers and farmers, to be used by farmers themselves as well as by farm advisory services.

The rearing of young farm animals

The way young farm animals are reared has a major impact on important characteristics in adult animals, such as health and production (Koene 2001). Especially in organic farming, which aims to provide livestock husbandry systems that deliver higher levels of animal welfare and health, sound young animal rearing practices should be advocated and promoted. In this seminar the concept and consequences of alternative ways of rearing farm animals were presented and discussed. Scientific results produced thus far within the QLIF project were combined with examples from other R&D programmes carried out in Germany, United Kingdom and The Netherlands. Potential conflicts between different objectives/themes of organic livestock principles such as behavioural freedom versus health were considered (Wagenaar and Bestman 2006).

Final remark

Scientific research for organic farming requires more than **(a)** what is taught in conventional farming focused University and college courses and **(b)** the often mono-factorial approaches used in conventional agriculture focused R&D. It requires additional integrated, multidisciplinary, holistic and/or poly-factorial research methodologies, farmer participatory approaches and often an adapted attitude towards the subject studied. Training and exchange programme for ESR are therefore essential to improve the link between research and knowledge transfer specialists and the expanding organic industry.

The third seminar on Measuring food quality: concepts, methods and challenges’ was held 12-14 February 2007, Driebergen, the Netherlands. QLIF will organise two further seminars in February 2008 and 2009. The 2008 seminar will again focus on soil quality, with emphasis on nitrogen dynamics and soil life. Further details can be obtained from the website http://www.qlif.org/forum/training/index.html or by e-mailing the author of this paper.

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million € (Niggli, 2006) per annum total. In comparison, the US spending on organic farming research is below 20 million € (Niggli, 2006) and countries such as Canada, Australia and Russia have far lower budgets. On the other hand, in Asian countries like India and South Korea, the funding for organic farming research has tremendously increased in recent years (Niggli, 2006).

Support for organic research in the EU Framework Programmes

Support for organic farming focused research has increased significantly in successive EU research funding frameworks, from approximately 5 million € under FP3 (AIR 4), 11 million € under FP4 (FAIR), 33 million € under FP 5 (QOL) and probably 35 million € under FP 6 (IFOAM EU, 2006b). This was in line with constantly increasing consumer demand for organic foods over the last 20 years, which has accelerated again over the last 2 years in many European countries.

The most active countries in organic farming research in Europe are Austria, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Sweden, Switzerland and UK. The national spending of these 11 countries on organic farming research amounted to 25 million € in the year 2000, 32 million € in 2001, 44 million € in 2002, 55 million in 2003, 50 million in 2004 and 41 million € in 2005 (calculations based on Lange *et al.*, 2006)

The latest survey of the European Commission on national public funding for organic food and farming research covering 2003 & 2004 showed that the funding differed greatly from country to country (EC, 2004).

Table 1- National public funding for organic food and farming research (2003-2004)

Level of investment in organic farming research	European Countries
Very high (more than 13 million €/year)	The Netherlands
High (10-7 million €/year)	Germany, Switzerland, Denmark, France
Medium (4-6 million€/year)	Sweden (6 million €), Italy (4 million €)
Low (1-3 million €/year)	Austria, Finland, Norway and UK
Very low (under 1 million €/year)	Spain and the rest of EU Countries

Source: Survey EU Commission years 2003-2004 (EC 2004)

Organic research priorities

There is no particular procedure to establish organic research priorities at European level. The IFOAM EU group – representing all European organic stakeholders – has intensively discussed the role of research activities for the future development of organic food and farming over the last 5 years, on the basis of a broad consultation process, and in its own 3-year workplan (IFOAM EU, 2006a), on research topics and priorities (IFOAM EU, 2005). A detailed list of proposals for relevant and innovative research topics has been produced after a broader internal consultation process.

The highest research priority, identified by all IFOAM EU Group members, was in the area of organic plant production, particularly techniques for improving soil health and plant health. Other areas deemed universally important were environment and biodiversity, and food processing to support innovation in SMEs.

Old Member States (EU-15) gave a relatively high priority to socio-economic aspects of organic farming, the investigation of organic farming and climate change, and improving animal husbandry systems with respect to animal welfare. The new EU Member States, on the other hand, gave higher priority to nutrient losses and recycling, the development of novel pesticides suited for organic farming, particular socio-economic aspects involving consumer attitudes and organic food markets.

The IFOAM EU Group especially highlighted a greater involvement of stakeholders at all stages of research programmes (IFOAM EU Group, 2004). The involvement of farmers and other actors in research enhances their trust in the findings, ensures that relevant research is conducted, ensures that new skills and techniques are learned and guarantees a rapid dissemination of results. Research budgets should include the costs of stakeholder participation. The IFOAM EU Group is involved in 3 EU Research Projects Consortium to support policies (ORGAP[1], Orwine[2] & Organic Revision[3]), has also developed some tools to integrate organic sector actors in research activities (Gonzálvez, 2006).

Organic research support under the 7th Framework Research Programme

In the 7th European Research Framework Programme (FP7), it was expected that Organic Food and Farming research would be strengthened. However, the latest list of topics for the 1st , 2nd and 3rd Calls indicate that the funding for organic farming will for the first time significantly decrease, probably even below the levels of funding that were made available under the 5th European Research Framework Programme FP.

Furthermore the current topics of the 7th RFP will make it very difficult to continue with a **'whole system'** approach**,** such as was successfully implemented in organic farming research projects under FP5 (e.g. Blight MOP) & FP6 (Integrated projects) These projects had also been highlighted by the European Commission as a positive example of innovative research.

Most of the project topics listed in the 7th RFP focus on the development of methods that are only marginally applicable to organic farming systems and/or follow a very 'reductionist' - one problem-one potential solution **-** approach. In fact, only 4 projects in 3 calls on the provisional list have the word 'organic' in the title, one of which is focused on improving biodiversity impact assessment and the other on one type of innovation (breeding). Three of these four projects are more indirect support projects and do not directly help to practically develop organic food and farming systems.

In general, to boost the development of organic food and farming appropriate through innovative research, a different range of research projects is needed (IFOAM EU, 2006b): both <u>direct</u> (dealing with following topics: organic system development in production and processing; Specific market and consumer research; Specific policy support projects) and <u>indirect</u> (dealing with topics related to comparison projects, which are of interest mainly for the public society but do not contribute to system development like the contribution of organic farming to biodiversity, societal benefits of organic farming; or projects focussing on reduction in energy/fossil fuel use, environmental impact, food quality and safety through organic and low input

[1] Webpage http//;www.orgap.org

[2] Webpage: http//:www.orwine.org.

[3] Wepage: http//:www.organic-revision.org

agriculture. In the launched calls of the FP7, only indirect research projects have been approved.

The 5th and 6th FP clearly showed in several cases that research projects designed for high input agriculture cannot be adapted to the organic food and farming system approach, where many inputs or additives are not allowed. The knowledge and technology transfer to organic farmers and organic food processors is very limited, in these cases, while on the other hand knowledge transfer from specific organic food and farming projects to other farming systems can be very high, in particular regarding innovative and systems-oriented preventive strategies.

The organic farming research projects focussed on conversion problems under FP3 and FP4 and, more specially, the '*whole systems*' development R&D projects under FP5**,** allowed for the first time the development of interdisciplinary teams of researchers specialising in organic farming and also the integration a wide range of innovations to solve the main problem target by the project (Blight MOP and Worm cops). Under **FP6**, the first Integrated Project (QLIF) on organic farming was funded by the EC. This project has already provided a wide range of outputs both with respect to documenting specific food quality attributes in foods from organic (and other 'low input') systems and developing innovations that improve production efficiency and yields, nutritional sensory and processing quality of organic and 'low input' foods.

Organic research needs

Organic agriculture is highly knowledge-based, and exploits interactions in natural and semi-natural habitats and biological and ecological self-regulation. As many of these mechanisms are intuitively used by skilled organic farmers and are not yet widely explored by science, research activities in this field of agriculture and food production have a fast and high impact on technology progress and economic performance.

To resolve the lack of organic food and farming research relevant R&D in FP7, the IFOAM EU Group propose to remove the topics related to 'societal benefits of organic farming and the one related to 'Costs of different standard setting and certification systems for organic food and farming' and to give a high priority as it's is dealing with one of the main barriers of producers to convert to Organic Agriculture

In a long term , a significant number of research topics for organic agriculture need to be taken up for the development of the 3rd and 4th and subsequent calls under FP7, to compensate the small number of research topics for Organic Agriculture in the second and third calls (IFOAM EU Group, 2006c). Furthermore, a detailed gap analysis to identify the current and upcoming requirements of the organic food and farming industry should be carried out in collaboration with the organic research community around Europe.

Concluding remarks

There are several justified reasons for more specific research support for organic agriculture. There are also many experiences and results from past and on-going organic food and farming research projects, which also justify that the amount of money for the development of organic agriculture and food processing should at least be doubled compared with the 6th Framework Programme.

The latest known list of topics for the FP7 indicates that the funding for Organic Farming research will decrease, contradicting the economic potential , the and societal benefits, and also the scientific challenges of the food and farming approach which is counteracting several EU policy strategies.

The IFOAM EU Group research priorities, based on a broader stakeholder consultation, should be considered for immediate and long term improvements in the research topics and areas covered by FP7.

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For further info see www.qlif.org.

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It was convened in parallel with the 9th Scientific Conference on Organic Agriculture in German-speaking countries, entitled 'Between tradition and globalization', hosted by the University of Hohenheim.

The QLIF project aims to improve quality, ensure safety and reduce cost along the organic and low input food supply chains through research, dissemination and training activities. Its subprojects cover all aspects of organic and low input food and farming: Consumer studies, quality, crop & livestock production, processing and supply chains, environmental and socioeconomic aspects.