

Soil fertility

A summary of research conducted under the German Federal Programme for Organic Agriculture and other forms of Sustainable Agriculture

BÖLN

Bundesprogramm Ökologischer Landbau
und andere Formen nachhaltiger
Landwirtschaft



Summary of research results of the German Federal Programme for Organic Farming (BÖLN), 2001-2011

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1. Introduction

The German Federal Programme for Organic Agriculture (BÖLN) was founded in 2001, with the goal of improving the conditions for organic farming and food industry in Germany, and to achieve the conditions for a balanced growth of supply and demand. The programme is funded by the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), and implemented and coordinated by the Federal Agency for Agriculture and Food (BLE) in Bonn. Since 2008, the programme is part of the German National Action Plan (2005-2014).

Since the beginning of 2011, the second evaluation of the programme (project ID 09OE027) is carried out by the international contractor group Organic Research Evaluations; consisting of the partners InterVal GmbH in Berlin, The Organic Research Centre, Elm Farm, United Kingdom and the University for Sustainable Development in Eberswalde, Germany.

The focus is on the programme of the BMELV to support research projects in organic farming, where more than 650 projects have been funded since 2002. The evaluation is in particular to clarify the extent to which research results helped to strengthen organic agriculture in Germany and expand its market share. The evaluation results, which are expected to be publically available in early 2013, shall also benefit a future optimisation of research funding.

The summaries of research results in eight focus topics (soil fertility, plant protection in arable and horticultural production, plant protection in apple production, nutrition of monogastrics, animal health of ruminants, food quality and processing, regional marketing and knowledge transfer) from the whole period of the programme since 2002. All projects can be identified with the individual project ID number, shown in brackets in the title; and following the link below, further information can be found on the German BÖLN website. Where available, links to the final-reports of individual projects on the Organic Eprints website are added. Further results of running projects of the BÖLN research programme are regularly published at www.bundesprogramm-oekolandbau.de.

2. Summary

Since 2002, the federal research programme for organic agriculture has supported research projects on soil fertility. Research projects at the beginning studied specific subject areas such as comparison of various mulch materials, nutrient mobilisation (especially phosphorus), humus balance and soil erosion. This addressed gaps especially in methods in organic practice, where data acquired from conventional agriculture are not applicable. From 2008, the research on soil fertility significantly increased and there was a special focus on interdisciplinary systems approaches. The joint research project on the management of soil fertility in organic farming, for example, examined a number of factors that interact in this field, such as tillage and soil compaction, fertilisers, green manures and cover crops, weed and disease pressure, crop species and yield levels, energy consumption and the use of machinery, but also cost-benefit analyses of promoting soil fertility and recommendations for farmers. Other projects addressing the need to increase soil fertility investigated the influence of agronomic management measures on soil quality, and of various aspects of reduced tillage; these projects continue the idea of the systems approach. In 2011 a status quo analysis of long-term field experiments in German-speaking countries was conducted, which included comparisons of systems employed to study the long-term impact of management measures on soil fertility, and to identify further research needs.

Important results from individual projects on soil fertility are presented below. Based on new data, recommendations are given on the use of different mulching materials and effects on soil moisture and nutrient content. Also results relevant for practitioners were derived from the revision of the method for estimating soil erosion, and concrete suggestions for new methods were made. Similar to the case of the method for estimating humus balance, this method could also be adapted for the conditions of organic farming in Germany. From on-going projects (started since 2008) important first results have been obtained. For example, the status quo analysis of long-term field experiments produced new findings on the long-term effects of different management systems, and new research gaps were identified.

3. The individual projects

Mulching materials (02OE565) 01-10-2002 to 31-12-2003 <http://orgprints.org/17201/>

Previously, studies on the influence of mulching were often carried out without reference to quantitative nutrient and water budgets and there were few comparative studies on the various mulching materials. This project attempted to address these gaps. In pot and field experiments, the influence of mulching on the water and nutrient balance of the soil, and further side effects of mulching materials were analysed. It was found that regardless of the mulch material, the content of plant-available water was increased compared with unmulched treatments (42 l/m² on average over 8 years). In grass mulch, a significantly higher N release was observed compared with the control (by 100 to 380 kg/ha, total effect over the years). N-immobilisation was observed (15 to 70 kg/ha) with wood chips, bark and straw as mulching materials. For compost, no N release was detected in the first 2 years, but there was a cumulative effect over the years of up to 90 kg/ha. This information allowed a direct implementation in practice through quantitative assessment of changes in plant-available nitrogen and water. Applicability of the results includes organic farming, horticulture and landscape gardening, especially with regard to more extensive approaches.

Phosphate mobilisation (02OE424) 15-10-2002 to 31-12-2003 <http://orgprints.org/17240/>

To promote and stabilise soil fertility, soils are often limed, leading to a relatively high pH (usually about 6). However, this increase in soil pH reduces the chemical solubility of rock phosphates which are applied in organic agriculture. This project addressed this problem by examining the effect of alternative rotations using white lupine and field bean as phosphate-mobilising pre-crops. It was found that the P uptake of spinach following white lupine was higher than that following spring wheat (P removal 48% higher, 60% increase in yield). In pot experiments the application of new Thomas phosphate (CaHPO₄) resulted in a higher phosphate uptake by plants than rock phosphate. Including white lupine in the rotation caused no comparable increase in efficiency of the applied raw phosphate compared to the fertilising effect of CaHPO₄. Results obtained in the pot experiment could only be reproduced to a limited degree in the field trials. Based on the plant analysis the effects of pre-crops of spring wheat, white lupine and field bean on oilseed rape and spinach need to be interpreted with caution.

Humus balance (03OE084/1, 03OE084/2) 01-04-2005 to 30-04-2008 <http://orgprints.org/16447/>

Decreases of organic matter content below tolerable levels lead to a decline in soil fertility and yield potential. However, it is difficult to assess the humus status of arable soils to draw conclusions for optimising on-farm humus management. In particular, instruments for analysing humus levels have not yet been adapted to organic agriculture. The aim of the project was to investigate the system-specific characteristics and requirements of humus production under conditions of organic farming and to develop a humus balancing method to be used in organic agriculture. Differences between conventional and organic farming regarding the level and development of soil organic matter content were rarely consistent, both under on-farm conditions and in long-term field trials. Consequently, the need for a differentiated analysis of management systems became apparent. Also, humus production from straw and green manure was very non-uniform and dependent on site-specific factors and interactions. Differences in humus levels among farming systems could only be detected when these systems differed substantially with regard to crop rotation and/or fertilisation. Neither in practice trials nor in long-term field experiments were any quantitative impacts of tillage intensity on humus dynamics detected. The humus balancing method developed in this project (HUMOD) showed an acceptable accuracy of prediction. However, an improved assessment of humus production has yet to be developed. One advantage of the newly developed method is the possibility of reproducible determination of a humus production coefficient for crops in different cropping systems and taking environmental conditions into account. In contrast to the established humus balancing methods, the new model is applicable to new and complex farming systems, since the coefficients were calculated using a consistent mathematical model.

Soil erosion (06OE256) 15-11-2007 to 31-12-2009 <http://orgprints.org/18812/>

To estimate water erosion various models have been developed. However, the adaptation of the USA's 'Universal Soil Loss Equation' to German conditions does not consider the specific conditions in the production processes of organic agriculture, which can lead to inaccurate assessments of soil erosion. In this project, the possible effects of organic farming on the soil loss dynamics were studied to integrate the effects, in terms of algorithms or parameter values, into the German General Soil Loss Equation (ABAG). The analyses showed higher levels of organic matter, improved soil structure and higher diversity of soil organisms in organic agriculture. In addition, reduced soil erosion in organic agriculture was observed. The results showed that these effects are not linked to individual causes, but to complex mechanisms. Such complex effects cannot be integrated into the general soil loss equations without major modifications. Since many of these aspects have been integrated into the 'Revised Universal Soil Loss Equation' (RUSLE), a general model change was proposed. Therefore the RUSLE should be further developed and adapted as an "advanced ABAG" for use in organic farming.

Management of soil fertility (08OE004-9) 01-08-2008 to 31-12-2011

This interdisciplinary project studied organically managed cash-crop farms without or with little livestock with the aim of increasing soil fertility by different interacting strategies to achieve an increase in the value of organically grown food crops. A farm evaluation was conducted on 32 organic farms, collecting agronomic, economic and energy data. Furthermore, the project investigated effects of soil compaction and tillage on yield, N₂ fixation of legumes, soil water balance and the occurrence of plant diseases. The aim was to derive recommendations for site- and farm-specific optimal tillage intensity and for minimising mechanical impacts on the soil. The increase of assimilation and symbiotic N₂ fixation by legumes was explored and the effect of selective application of carbon-rich fertilisers on soil health was tested. Another focus was on the assessment of mixed cropping. Parameters measured in the project included yield stability, weed infestation, disease incidence and energy consumption for machinery use. Finally, part of the project studied key parameters of soil microbiology, with the aim of quantifying the cost-benefit ratios for measures to promote soil fertility by tillage and the use of legumes. The data were used to identify economically viable recommendations for farmers, taking into account environmental indicators. [The results of these studies have not yet been published, and the project was still running when the German version of this was written.]

Increase and utilisation of soil fertility (08OE020, 08OE147) 10-07-2008 to 30-11-2011

The background to this project is the compulsory use of 100% organic feed and the continuously increasing demand for protein sources for human consumption. Currently, protein demand is not covered from domestic production, and imported goods are often associated with certain risks (e.g. regarding GMO contamination of soybeans). Moreover, alternative tillage systems are urgently needed that use less energy input but do not result in disadvantages in terms of weed control, plant diseases, and crop yield and quality. The focus of this project is the improvement of nutrient supply to increase the N₂ fixation and productivity of grain legumes. Following an investigation of the plant root distribution the project determined how the nutrient supply of the plants (especially field bean and field pea) developed in rotations and how the nutrient supply can be optimised under these conditions. With this aim, permitted organic fertilisers are used. A key preliminary result is that the direct seeding of legumes, including beans, is possible under certain conditions. Furthermore it can be concluded that the relative importance of weed competition compared to the nutrient status and growth of grain legumes is significantly higher under direct seeding. The use of oat straw mulch to suppress weed flora in direct seeding of legumes is an effective approach; however, the final assessment of this approach with regard to different weed species is still pending. The relatively small differences in yield of beans after tillage compared to ploughing may be an advantage from a farm perspective.

Status quo analysis of long-term field experiments (10OE036) 15-12-2010 to 31-07-2011

<http://orgprints.org/19317/>

This project concerned the response of soils in different farming systems and measures to investigate (slower) changes over a longer period. Data for longer periods have previously been inadequately evaluated; there was a clear need for research. A status quo analysis was carried out for 43 long-term field trials. In addition, a questionnaire was sent to 91 key individuals to determine the research gaps. In the field trials, the main research topics were in the field of 'conventional vs. organic', and within organic systems 'with high and low livestock intensity', with eight and ten trials, respectively. In the area of production technology there were 14 tillage trials. According to the survey, the highest demand was seen for the topics 'humus production and humus balance' (4.5 on a scale of 1-5), 'biogas digestate', 'soil organisms' and 'root and mycorrhizal activity' (both 4.4). Other high- to very high-scoring areas were 'economic evaluation', 'cover crops' (both 4.3) and 'yield development' (4.2). The lowest demand was seen in the topics 'biodynamic preparations' (2.8), 'row spacing' (2.9) and 'system comparison: organic vs. conventional' (3.1). The benefits of this project lie in the uniqueness of the analysis because for the first time all long-term trials were recorded for the above topic. In addition, trials set up in the autumn of 2010 were recorded, in order to obtain a complete record for future years. Interested researchers, advisers and practitioners can now be informed about the number and topics of on-going and completed long-term trials and can contact researchers responsible for the trials.

Influence of farm management on the structure and function of the soil microflora (11OE001) 01-09-2011 to 31-08-2014

It is assumed that different land management systems affect soil microflora and soil quality. This project examines the impact of reduced tillage and the use of green manure on soil quality. Additional work refers to crop quality and yield, carbon storage, nutrient mobilisation and the reduction of greenhouse gas emissions. The aim of the project is to study how conservation tillage and the use of green manure influence the distribution and activity of soil organisms under different climatic and soil conditions.

Reduced tillage and green manures (11OE002) 01-09-2011 to 31-08-2014

Tillage is a key factor driving plant nutrient availability and crop productivity. Since nitrogen (N) is essential for crop yield and quality, the production process needs to be adapted to ensure N availability in reduced-tillage systems, especially in the light of competition from weeds and soil water balance. In particular, the effect of different times and intensities of residue incorporation of different green manures on the N and C dynamics in the soil will be investigated.