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What will long-term experiments deliver? Key results of 12 experiments on different continents

J RAUPP & M OLTMANNS

Institute for Biodynamic Research, Brandschneise 5, D-64295 Darmstadt, Germany

Summary

Twelve long-term experiments have been used to describe the main management effects of organic farming systems. The experiments were mostly used to compare various types of organic and conventional cropping systems, or to study fertilisation effects. The multi-year perspective was particularly important to reveal that soil biological parameters developed better and crop yields declined less under poor growth conditions in the organic treatments. Improved co-operation of researchers involved in long-term experiments is now occurring and this will lead to more effective use of data.

Key words: Soil organic carbon, yield, farmyard manure, green manure, inorganic fertiliser, stockless farming

Introduction

Agronomic long-term experiments are a common research tool to study the performance of agricultural systems or cultivation techniques. As sustainability and long-lasting soil fertility are particular objectives of organic farming methods, such experiments have also been used to evaluate such methods or to compare their effects with those of other farming methods. Although organic farming is relatively young, there are a number of long-term organic experiments worldwide. A dozen of them have been compared, and selected results have been evaluated in order to determine the main findings and the best management treatments.

Materials and Methods

The evaluation presented here was based on 12 long-term organically managed field experiments, carried out mainly in Europe and North America. Short descriptions of the trials and the results were reported by Raupp *et al*. (2006), and are listed in Table 1. The parameters for soil and crop yield have been chosen, as they were the most useful measurements on which to base comparisons, apart from their specific research area.

Table 1. *General information on the evaluated long-term experiments, compiled in Raupp* et al. *(2006). The numbers in the 1st column are just to identify the trials in Table 2 and in the text*

No	Title	Authors	Institute	Since	Treatments
1	MASCOT, Mediterranean Arable Systems Comparison Trial	Bárberi & Mazzoncini	CIRAA, Univ. of Pisa, Sant'Anna School, Pisa, Italy	2001	system comparison: organic and conventional arable cropping systems
2	The Rodale Institute Farming Systems Trial	Hepperly *et al.*	The Rodale Institute, Kutztown, Pennsylvania, USA	1981	system comparison: manure-based organic, legume-based organic and conventional systems
3	Soil fertility with organic and biodynamic farmyard manure amendment	Köpke *et al*.	Institute of Organic Agriculture, Univ. Bonn , Germany	1993	4 treatments with solid manure application and different biodynamic preparations *vs* a control
4	The DOK experiment	Mäder *et al.*	Research Institute of Organic Agriculture (FiBL), Switzerland	1978	4 organic and conventional farming systems differing mainly in fertilisation and plant protection concept
5	Recycling of urban waste	Magid *et al*.	KVL, Dept. Agric. Sci., Copenhagen, Denmark	2002	'urban fertilisers', e.g. human urine, sewage sludge, household wastes and different FYM treatments
6	Long-term, large-scale systems research directed toward agricultural sustainability	Mueller *et al.*	NC State Univ., NC A&T State Univ., North Carolina, USA	1998	system comparison: conventional systems, cropping/animal husb. systems, organic system, forestry system, successional system
7	Variable Input Crop Management Systems (VICMS) trials	Porter *et al*.	Univ. Minnesota, Dept. of Agron. & Plant Genetics, Minnesota, USA	1989	2 crop rotation lengths and 4 management strategies (zero inputs, low-purchased inputs, high-purchased inputs, organic inputs)
8	The Danish organic crop rotation experiment for cereal production	Rasmussen *et al.*	DIAS - Danish Institute of Agric. Sci., Tjele, Denmark	1996	at 3 sites in Denmark; 3 factors: crop rotation (fraction of grass-clover green manure), catch crop, slurry
9	IBDF long-term fertilisation trial	Raupp & Oltmanns	IBDF, Institute for Biodynamic Research, Germany	1980	fertiliser types: comp. manure with / without biodynamic preparations, inorganic fertiliser, each at 3 rates
10	Mineral nutrition of peach trees with organic and inorganic fertilisers	Raviv *et al*.	Newe Ya'ar Research Center, Israel	1998	inorganic fertilisation, cattle manure compost + feather meal, compost + leguminous cover crops
11	Organic Farming Trial Gladbacherhof	Schmidt *et al.*	Univ. Giessen, Dept. of Organic Agriculture, Germany	1998	rotation: livestock forage, stockless mulch, stockless cash crop; tillage: plough, 2-layer plough and a combination of cultivator and rotary harrow
12	Long-term monitoring of management systems within organic farming	Surböck *et al.*	BOKU, Dept. of Organic Farming, Austria	2003	fertilization: green manure system, green manure plus communal compost, farmyard manure

Results and Discussion

Almost half of the projects were focussed either on a comparison of cropping (farming) systems (1, 2, 4, 6, 7) or on fertilisation issues (3, 5, 9, 10, 12) (Table 1). The two other trials dealt with crop rotation linked with either catch crop cultivation and slurry application (8) or with tillage treatments (11).

The clear priority of the experiments listed in Table 1 was to analyse and understand systems as a specific set of agronomic factors. In nearly all of the trials (2, 4, 6, 7) the subject of organic vs. conventional farming was subdivided into several treatments for each system, varying with

Table 2. *Selected results of organic (compared to conventional) cropping systems or of organic (compared to inorganic) fertilisation, obtained in 12 long-term experiments with the symbols <, >, = expressing the difference between organic and inorganic fertilisation or in other trials between organic and conventional cropping systems; an empty field means: no data available for this parameter*

No.	Soil			Crop yield	Further results, special aspects
	C_{org}	C_{mic}	Other		
1				Durum, sunflower: < faba bean: > =	quality parameters of sunflower: > = and of sugar beet: > =
2	>			maize, 1st period: < maize, 2nd period: = soybean: =	maize crude protein: = maize yield in dry years: >
3				trial included no inorganic fertilisation or conventional cropping; biodynamic preparations had positive effects on some soil microbial parameters	
4	>	>	DHA: > qCO2: <	potato, w. wheat: < grass clover: < >	compared to the beginning C_{org} was stable in *organic* and decreased in *conventional*
5				trial did not include soil fertility parameters so far	
6					soil bulk density: <, total porosity: >, soil fungi: >; evaluation of soil microarthropods, PLFA >
7	>		minC: > POM-C: >	maize, soybean: <	basal respiration: >, mineralizable N: >
8				no treatments comparable to the other trials, interesting effects of rotation, mainly catch crops	
9	>	>	DHA: >	spring wheat: =, potato: < =, w. rye: <	POM light fraction: <, heavy fraction: >, soil amino acids: >, wheat yield in dry years: >
10	>		bulk d.: <	peach yield: =	stem growth of trees: = (after some years)
11			tendency of the stockless crop rotation: lower N input, decreasing soil N_t, lower N availability, more weeds; 2-layer tillage vs. deep ploughing: soil N_t higher in 0-12 cm; little or no effect by tillage: average cash crop yield, soil N_{min} in autumn and spring		
12			no effect of fertilization on soil chemical parameters, fungal biomass, N_{min}, nitrate leaching; crop yield in 2004: =, triticale yield in 2005: with FYM > with green manure; interesting effects of landscape structure		

Abbreviations: C_{org}: organic carbon, C_{mic}: microbial carbon, DHA: dehydrogenase activity, qCO_2: metabolic quotient, PLFA: phospholipid fatty acids, minC: mineralisable C, POM-C: particulate organic matter carbon, bulk d.: bulk density, N_{min}, mineral N, FYM: farmyard manure respect to input intensity, type of organic method or role of legume cultivation. Specific aspects of biodynamic farming (the preparations) were included in two experiments (3, 9). The role of animal husbandry in a farm - i.e. fertilisation treatments without farmyard manure, different options for using legumes in an organic system, testing conventional systems with/without animals - was considered in very many experiments (2, 4, 5, 6, 8, 9, 11, 12). This may be interpreted as an indication that farm structure is an important issue for all methods of agriculture. However, it also indicates that organic farming is likely to adopt conventional ways of farm specialisation.

Nutrient management was the other important area of experimentation underlining the fact that fertilisation is considered to be a central tool for soil and crop development in organic systems. In this field too, the treatments cover a wide spectrum of different organic materials, including partly on-farm components, and partly recycled wastes which may indicate that the concept of an organic farm is becoming more flexible.

In all fertililsation trials where comparisons were possible, (Table 2), the organic and inorganic treatments differed in soil biological properties with respect to organic carbon (2, 4, 7, 9, 10), microbial carbon (4, 9), dehydrogenase activity (4, 9) and particulate organic matter (7, 9). Furthermore, a higher level of (7) or equivalent (4) basal respiration, a lower bulk density (6, 10), a higher total porosity (6) and greater soil fungal abundance (6) was observed in the organic treatments. No difference in soil fungal biomass was determined in one of the younger trials (12). For future comparisons, it is proposed that a more harmonised set of parameters and methods will be used in order to enable a better and more comprehensive evaluation of trials and sites, and to identify parameters relevant to soil key functions. Further experiments will need to be included.

Yields of most crops were lower in organic treatments (1, 2, 4, 7, 9). No difference was observed with soybean (2), spring wheat (9), peach trees (10), and, if the biodynamic preparations were applied, with potatoes (9). The product quality of sunflower, sugar beet and maize, expressed by contents, was comparable or sometimes even better in the organic treatments (1, 2). When evaluating the yield data of a longer period of years and taking environmental (growth) conditions of the respective years into account, it was observed that under poor (dry) growth conditions organically cultivated maize (2) and manure fertilised spring wheat (9) yielded higher than the conventional or inorganic treatments, respectively. Obviously, the organic treatments were more efficient under restricted conditions. This phenomenon may be an important factor that contributes to the sustainability of organic systems. Determination of different yield potentials is only possible with multi-year data sets from experiments with constant treatments.

It is important to consider other advantages and disadvantages of long-term experiments when discussing the role that they can play in contributing to the development of farming systems. Such trials are relatively costly, as they make significant use of labour and equipment for many years. Strictly carried out, they are less flexible in integrating new treatments or reacting to new developments in agriculture or society. To reveal long-term effects sometimes a long period of thorough investigation is required; the researcher who sows does not always share in harvest.

The researchers whose trials are reported here and many other colleagues in additional countries are working to optimise the benefits of and to manage the problems associated with their experiments by means of an intensified exchange and a closer co-operation as members of the working group for long-term experiments under the roof of ISOFAR (International Society of Organic Agriculture Research; www.isofar.org/sections/wg-long-term-experiments.html).

Reference

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