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

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Implications

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

Background and objectives

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

Key results and discussion

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

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

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

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

^{a} = (n-1); ^{b} = (n-2)

How work was carried out?

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

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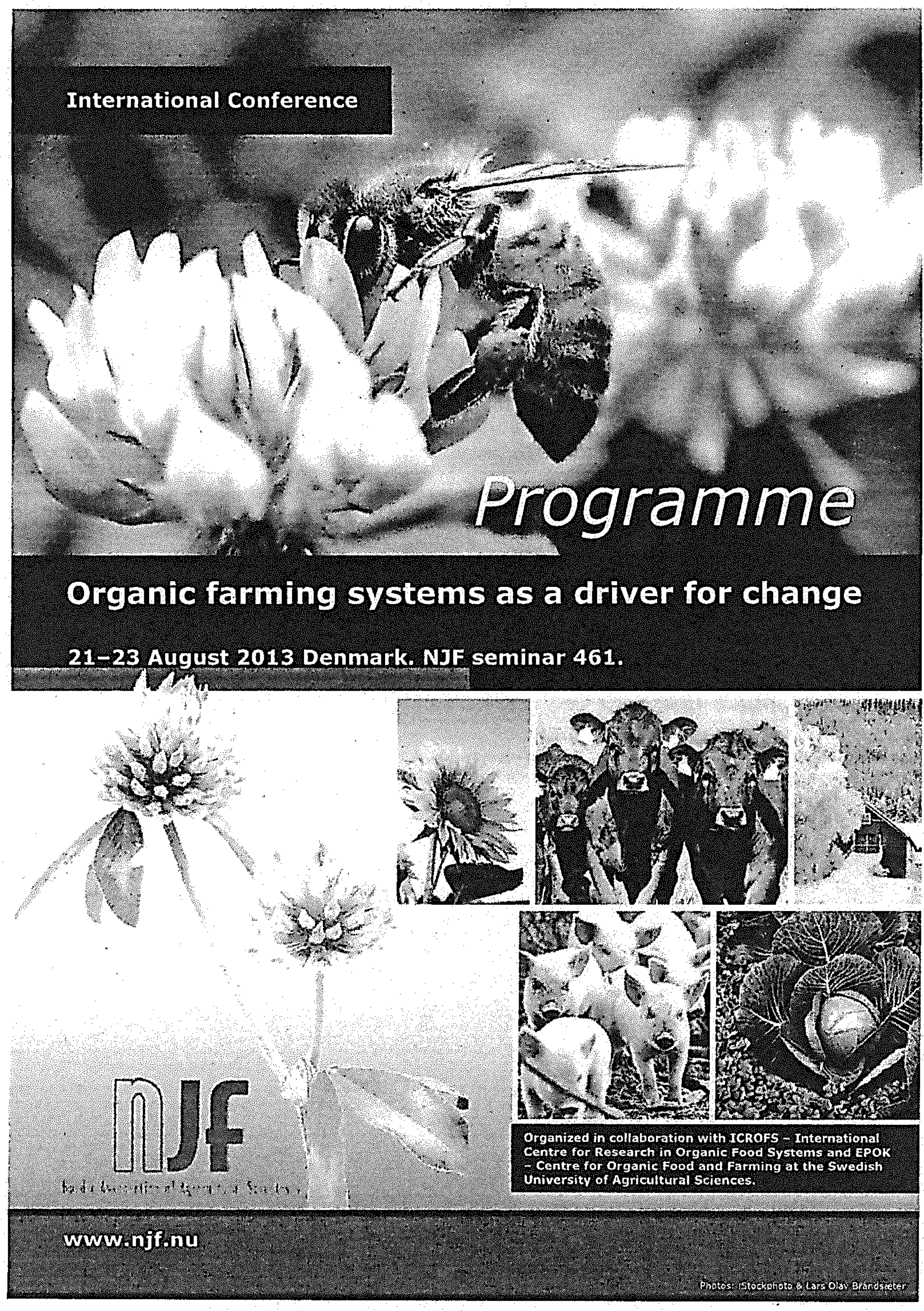

Magdalena Oluu: Vortrag, PPT auf eprints & Tagungsband

Organic farming systems as a driver for change

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

Target groups

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

Four tracks

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

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

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

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

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

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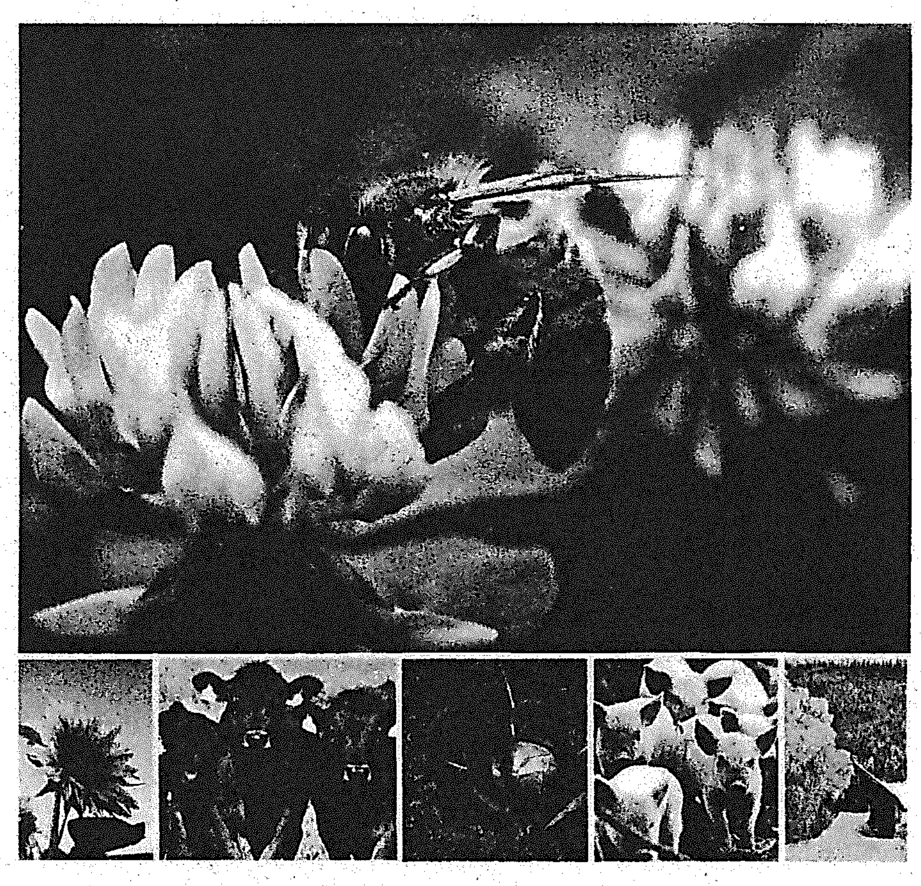

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