Soil Fertility and Biodiversity effects from Organic Amendments in Organic Farming

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Key words: soil biology, soil microbial biomass, soil quality, manure, compost

Abstract

After a completed rotation of seven years, soils of the Manure as a Chance (MAC) trial were analysed for the effect of organic amendments on soil physical, chemical and biological properties. Yields suggest significant differences due to different organic amendments after seven years. In treatments receiving farm yard manure and bio waste compost yields increased over time. Soil properties indicate changes in soil carbon, nitrogen mineralization en plant feeding nematodes due to different organic amendments. No significant changes in microbial and fungal biomass were found.

Introduction

Organic farming strives for a balance between a reasonable good yield, a high produce quality and a limited environmental impact. Inputs include plant residues and plant based composts, animals manures from various origin and stages of decomposition and additional fertilizers like rock dust (Anonymous, 2005). Soil fertility and especially soil biological fertility is promoted within organic farming for reasons of nutrient cycling, structure improvement or biodiversity (von Fragstein, 2006). Very little research has been done to facilitate farmers to make choices between available amendments and improve soil fertility within the legal framework of organic farming. In this study we evaluate the effects of eight (out of thirteen) different organic amendments applied within the legal framework of organic farming in the Netherlands. Effects on crop and soil fertility are evaluated in terms of yield and in terms of physical, chemical and soil biological properties.

Materials and methods

Starting in 1999, the fertilisation trial Manure As a Chance (MAC) in Lelystad, The Netherlands (5° 30' East, 52° 32' North), examines the effects of thirteen different organic amendments on crop yield. In 2006, after one rotation was completed and amendments had been applied for seven years, effects of eight selected amendments on soil fertility and crop yield were compared. Only data from 2006 are used in this paper. The on site farm experiment was set up as a randomised complete block with four replications and 7m x 9m plot size. The soil was characterized as a sandy calcareous marine deposit (1.6% organic matter, 9% clay, pH-KCL 7.6). Mean annual precipitation is 780 mm. Except for fertilisation, all other elements of cultivation are the same in all treatments and follow normal organic farming practices. The intensive vegetable rotation, common in Dutch organic farming systems, includes red cabbage, potatoes, beet, carrot, parsnip, broccoli, pumpkin and cauliflower in 2006. The legal framework limited the manure or compost additions: 1)The manure or compost

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addition is limited by a maximum of 100 kg N ha^{-1} $year^{-1}$. 2)The manure or compost addition is limited by a mean net legal maximum of 80 kg P_2O_5 ha^{-1} $year^{-1}$. 3). The compost addition is limited by a legal maximum of 6000 kg dry matter ha^{-1} $year^{-1}$.

Tab. 1: Selected treatments of the organic amendment experiment MAC and average application of active nitrogen, P_2O_5 and organic matter in kg.ha^{-1} $year^{-1}$.

Level	Amendment	Active nitrogen*	P_2O_5*	Dry matter*	OM*
1	Deep stable manure (FYM)	67	66		4930
1	Cattle slurry (CS)	67	35		1530
1	Mineral fertiliser (MIN)	67	43		0
1	Biowaste and slurry (GFT+CS)	67	69		2910
2	Chicken manure (CM)	47	80		1680
2	Plant compost 1 (NC)	24	80		7870
3	Biowaste compost (GFT)	9	57	6000	1490
3	Plant compost 2 (GC)	8	48	6000	1770

* amendments are applied two years in three.

Yield of cauliflower was assessed in 4 rows per plot, 5 plants per row. Soil samples (0-10 cm depth) per plot were taken in November 2006 and analyzed for their total N, total C, organic C and POM-C contents. For physical characterization the pH in water, bulk density and earthworm pores according to Koopmans and Brands (1993) were determined. Microbial and fungal biomass, N mineralization, nematodes and basal respiration were determined according to Mulder et al. (2005). Data were analyzed by analysis of variance (ANOVA). Significant effects were separated by the least significant difference (LSD) at P = 0,05.

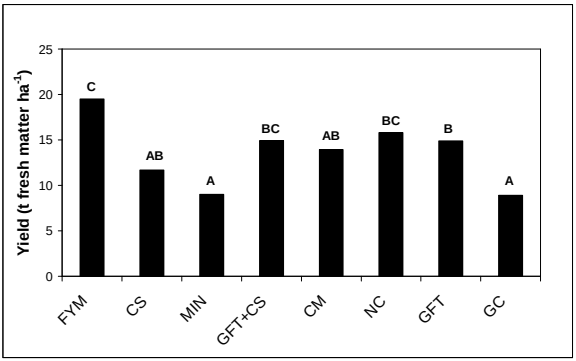

Figure 1: Yields of cauliflower in the MAC trial in 2006 (p<0.001).

Results

After seven years the use of FYM resulted in the highest yields (Fig.1). The GFT and GFT+CS treatments showed similar yields indicating that a higher nitrogen availability in the GFT+CS treatment did not result in higher yields. The results confirm a trend observed in the past seven years in which yields in the MIN treatment diminished, yields in the CS and CM treatments remained at the same level and yields in the FYM and GFT treatments increased if compared to averages of all treatments. Soil physical, chemical and biological properties were affected by the amendments. NC resulted in the highest C-total content, CM in the lowest (Fig.2). Nitrogen mineralization was relatively low in all treatments. Significantly lower values were found in MIN and GFT (Fig 2.).

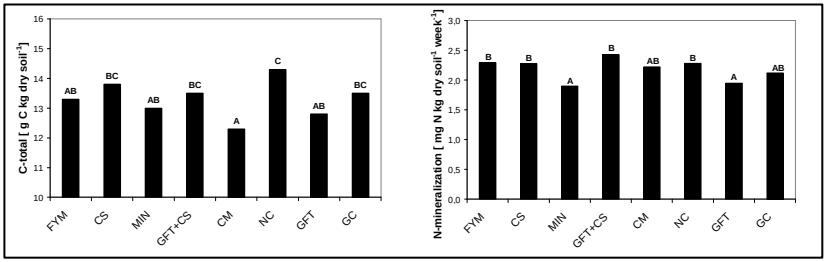

Figure 2: Total soil carbon and potential anaerobic nitrogen mineralization in soils of the MAC trial with different organic amendments (significant at P<0.05).

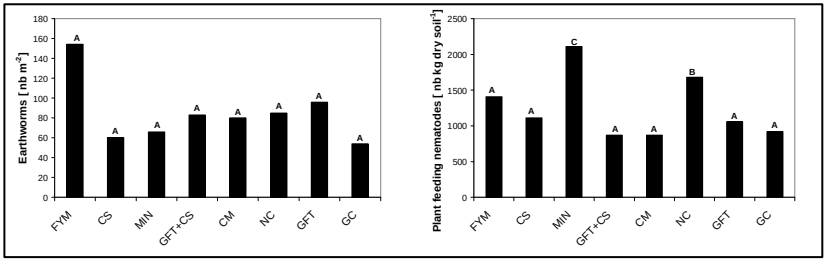

Figure 3: Number of earthworms and plant feeding nematodes in soils of the MAC trial with different organic amendments (significant at P<0.05).

No significant effects were found on the biomass of bacteria, fungi and earthworms (Fig. 3). However, earthworm pores, counted at 20 cm depth were significantly higher in the FYM as compared to the other treatments (data not shown). Amendments mainly had an effect on the number of plant feeding nematodes with MIN and NC resulting in the highest numbers (Fig 3.).

Discussion

The results show that organic amendments affect yields and soil fertility properties within a time frame of seven years. The lasting effect of FYM and the GFT+CS treatment in terms of yields and mineralization is especially pronounced and confirms earlier findings (Koopmans and Zanen, 2007). Soil mineralization and nematode population are among the soil properties that are most easily affected by fertilizer choice. However, fertilizer choice and crop production may interfere, resulting in a change of soil biodiversity through for instance root production.

Conclusions

The study shows that organic amendments used within the legal framework of organic farming may impact soil fertility and biodiversity indicators within seven years. Further research is required to understand the biological mechanisms behind this. The findings help to gain insight into the relationships between soil management, soil biodiversity and soil support services like soil fertility to optimise yields, mineral-use-efficiencies and soil structure formation in organic farming.

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