

Farmyard manure, plant based organic fertilisers, inorganic fertiliser - which sustains soil organic matter best?

By J RAUPP & M OLTMANN

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

Summary

Legume biomass or pulse meal may be considered as alternatives to farmyard manure (FYM) in organic farms with small scale animal husbandry or in stockless organic farms. From 1996 a field trial was established on a poor sandy soil to compare plant based organic fertilisers, FYM and inorganic fertilisers, each applied at 100 kg ha⁻¹ N. Additionally, FYM was tested at a higher rate of 170 kg ha⁻¹ N. Average soil organic carbon content in topsoil (C_{org}) of the last crop rotation period (2002-05) is compared to that in 1996. C_{org} remained at the same level of 0.78% only with FYM, while plant based and inorganic fertiliser decreased carbon contents to 0.74 and 0.72% C_{org}, respectively. The higher FYM rate increased C_{org} up to 0.84%. Based on these results, for soil organic matter maintenance, plant based organic fertilisers can not be recommended generally.

Key words: Soil organic carbon, faba bean meal, organic fertiliser, inorganic fertiliser, long-term experiment, biodynamic preparations

Introduction

In organic farms under low yielding site conditions (e.g. sandy soils, dry climate) the scale of animal husbandry is frequently restricted by the fact that the site conditions allow only for a limited area and yield of forage growing. Some of those farms are even stockless farms. The positive effects of farmyard manure (FYM) are not available (or only to a limited extent) on such farms. Plant based organic fertilisers, e.g. legume biomass or pulse meal, can be regarded as alternatives which have been studied until now mainly for their influence on nutrient supply to vegetable crops (Müller *et al.*, 2003; Rührer *et al.*, 2003). While the positive effects of FYM on soil life and fertility parameters have been shown by a number of investigations (Fließbach & Mäder, 2000; Jenkinson *et al.*, 1994; Raupp *et al.*, 2006), no comparable information was available for plant based organic fertilisers in order to evaluate their long-term effect on soil fertility.

Thus, in 1996 a field trial was started on a low yielding sandy soil under dry-warm climatic conditions to investigate the effects of both fertiliser types on crop yield and quality and on soil properties. In this paper, the organic carbon development in the first nine years of the experiment is reported.

Materials and Methods

The field experiment was located near Darmstadt (49°N, 8°E) on a sandy orthic luvisol. The annual mean air temperature was 9.5°C, and the annual mean precipitation was 590 mm. The experiment contained seven treatments (Table 1) arranged in a randomised block design with six replicates. The plant based organic fertilisers were Maltaflor® (a commercial organic fertiliser containing residues of barley malt and sugar beet processing) in 1997–2000, dried alfalfa meal in 2001–2002 and faba bean meal since 2004.

The crop rotation usually was legume, spring wheat, potatoes, winter rye. The legume crop remained unfertilised in all treatments. The fertilisers were applied before sowing or planting. Inorganic fertilisers were applied in early spring only to winter rye. In the biodynamic treatments the biodynamic (bd) manure preparations were added once to both organic fertilisers, and the field preparations were used three times at each stage of cultivations (Koepf, 1981). Cultivation techniques were the same in all treatments and corresponded to normal organic farming practices. Straw of the FYM plots was removed from the field (as FYM provided straw input), but remained on the field in the inorganic treatment. Irrigation was used normally on legumes, spring wheat and potatoes, but only in relatively small quantities (20–80 mm per year) because of technical reasons. Previous cropping on this field was according to organic farming practice, but at very low intensity.

In spring 1996, before treatment application, and in each year after harvest soil samples were taken from the topsoil (0–25 cm). Organic carbon (C_{org}) was determined as total C (Dumas) minus inorganic C (Scheibler). Where applicable, analyses of variance have been calculated with PLABSTAT (H.F. Utz, Univ. of Hohenheim, Germany). Least significant differences between means were calculated for a 5% probability.

Table 1. *Treatments and nitrogen amounts (kg ha⁻¹) applied with each fertiliser*

Treatment	kg ha ⁻¹ N	Acronym
Composted manure, normal rate	100	CM1
Composted manure + biodynamic preparations, normal rate	100	CMBD1
Plant based fertiliser, normal rate	100	PF
Plant based fertiliser + biodynamic preparations, normal rate	100	PFBD
Composted manure, high rate	170	CM2
Composted manure , + biodynamic preparations, high rate	170	CMBD2
Inorganic: calcium ammonium nitrate, super phosphate, potassium, magnesium	100	IN

Results

At the beginning of the experiment, there were no significant differences in organic carbon content amongst the plots of the different treatments. On average, the soil started at a level of 0.78% C_{org} . During the first trial years until 2000/01, the values of all treatments showed a tendency to decrease (Fig. 1). Starting in 2001 the treatments began to differ which obviously continued until

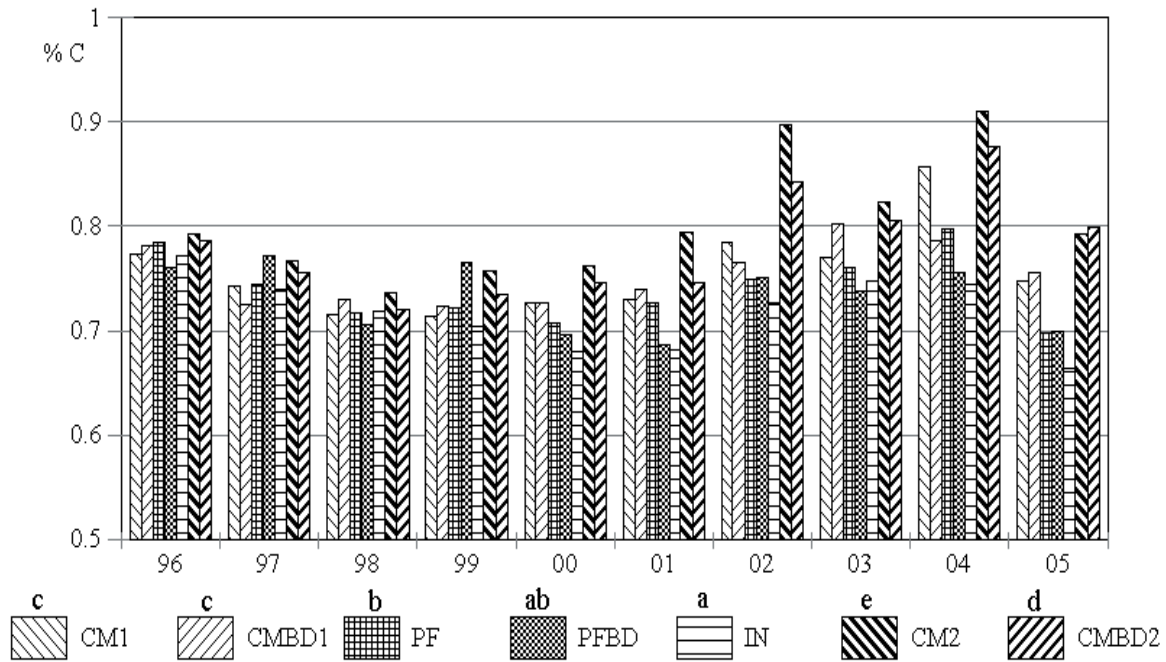


Fig. 1. Organic carbon content (%) in topsoil; see Table 1 for treatment acronyms; treatments with different letters are statistically different on average for the period 2002-05 ($P < 0.05$).

now. A new steady state seemed not yet achieved. Based on the average of the last crop rotation (2002–05) the lowest C_{org} contents were with inorganic fertiliser (0.72%) and plant based fertiliser (0.74%). With FYM the values were significantly higher (0.78 %; $P < 0.05$) and were the same as at the beginning of the trial. The increased rate of FYM gave the highest values, 0.84% on average. The only effect of the biodynamic preparations was a slight decrease of C_{org} with the high FYM rate.

Discussion

The results underline the significance of FYM in long-term maintenance of soil organic matter. Compared to inorganic fertilisation or to conventional systems, this finding is in line with a number of other experiments (e.g. Agbenin & Goladi, 1997; Hepperly *et al.*, 2006). From long-term trials in Northern Europe it was reported that the initial soil carbon content, carbon inputs and site conditions determined whether carbon stocks declined or increased (Kätterer & Andrén, 1999). The carbon input supplied by plant based fertilisers was obviously not enough (or not effective enough) to maintain soil organic matter content over years. This was probably not, or not primarily, a matter of the quantity of the organic carbon input. The reason may also be its quality (apart from C:N ratio which was the same in both treatments), as in another long-term trial on our site two FYM treatments with comparable amounts of carbon input developed a significantly different C_{org} content (Raupp, 2001). It was impossible, however, to describe quality in this context in more detail.

In addition to organic carbon, further soil biological parameters have to be studied in order to provide an overall view of the effectiveness of plant based fertilisers for accumulating carbon. For example the influence of straight household waste compost application for several years on some microbial parameters and on the macro fauna has been investigated (Pfozter, 1997). In this study, the effects of household waste compost and FYM were comparable.

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