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N released from organic amendments is affected by soil management history

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Abstract

A ryegrass bioassay was conducted to investigate the effect of soil management history on nitrogen mineralisation from composted manure and pelleted poultry manure. Soils were used from 2 field experiments comparing conventional and organic/low input management systems. When composted manure was added, soils which had received high rates of composted FYM under biodynamic management released a greater amount of nitrogen for plant uptake than those with a history of mineral or fresh manure fertilisation, suggesting that biological preconditioning may result in greater efficiency of composted FYM as a nitrogen source for plants. "Native" N mineralisation was found to be related to total soil N content.

Introduction

Soil biological properties in organic and conventional production systems are frequently compared (Carpenter-Boggs et al., 2000; Fließbach and Mäder, 1997; Mader et al., 2002; Werner and Dindal, 1990). In general, organic production systems increase indices of soil microbial biomass and activity, while within organic systems, biodynamic practices are sometimes favourably compared to standard organic practices (Mader et al., 2002). However, it is not clear whether these differences in soil biological activity parameters, result in differences in soil function. One of the key functions of the soil biological community relating to crop growth in organic systems is the mineralisation of nitrogen from added amendments. In these systems, all N must be supplied to the crop from soil reserves, biological fixation, and/or from approved plant or manure-based fertiliser inputs. This experiment was designed to investigate the relative potential of soils with different management histories to release plant-available N from added organic amendments.

Materials and methods

Soils were from the DOK long-term field experiment near Therwil in Switzerland which was established in 1978 (Mäder et al., 2002), and the Nafferton Farming Systems Comparison (NFSC) experiments established in 2001 (Leifert et al., 2007). Soils from the DOK trial were collected in March 2004 and included the manure based systems BIODYN, BIOORG and CONFYM receiving manure at rates corresponding to 0.7 and 1.4 livestock units (LU), a conventional mineral fertiliser based system (CONMIN) and an unfertilised control (NOFERT) (for details see Fließbach et al. 2007). The NFSC soils used in this study were sampled in March 2005 following a potato crop in 2004, and included samples from soils which were previously managed to (a) organic

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farming standards (OP-OF), (b) British "Farm assured" conventional management practice (CP-CF), and (c) two "low-input" management systems: CP-OF which used a conventional crop protection system based on chemosynthetic pesticides, but organic fertility management practices based on legumes and manure inputs, and OP-CF in which crop protection was to organic farming standards, but fertility management was based on mineral fertiliser regimes recommended for conventional farming systems. Soils were sieved (10 mm mesh) and stored at 4°C until use in the bioassay.

A pot trial was set up to estimate the inherent N mineralisation potential of the soils, and also to estimate the capacity of each soil to release N from added organic amendments. A total of 300 g soil (dry basis) was placed in each pot. Mineralisation from two different amendments is reported here: composted manure, which was 2.1%N (3% NH_4^+-N+NO_3^--N) and 22.9%C, and pelleted poultry manure, which was 4.4%N (14% NH_4^+-N+NO_3^--N) and 38.6%C. An additional non-amended treatment was included. Amendments were applied to the pots at a rate equivalent to 170 kg N ha^{-1} based on the total N content of the material. Italian ryegrass was planted and the pots were maintained in a glasshouse at field capacity throughout the bioassay. Ryegrass was harvested at 2, 4, 8 and 12 weeks after planting by cutting (0.5 cm above the soil surface) and removing all shoot tissue. Total above-ground N uptake by the ryegrass (N_{up}) was determined based on the harvested tissue N content and the dry matter yield of each harvest. The mineral N content of the soil in each pot was determined at experimental setup (N_{mini}) and after the final harvest (N_{minf}).,. Net N mineralisation during the bioassay was estimated as:

$N_{min} = N_{minf} + N_{up} - N_{mini}$, expressed as mg N pot^{-1}

The inherent N mineralisation potential of each soil was assumed to be equivalent to the N_{min} values calculated for the non-amended treatments. Net N release from the organic amendments (N_{rel}) was calculated by subtracting the N_{min} value for the non-amended treatments from the N_{min} value for each amendment. Data was analyzed using a general linear model in MINITAB® Release 14.20. Means were compared using Tukey's HSD test.

Results

For the NFSC soils there was no significant treatment effect on inherent N mineralisation potential (N_{min}) with an average value of 15.7 mg N pot^{-1}. The average N_{min} value for the DOK soils was 10.1 mg N pot^{-1}. The soil with a history of high inputs of conventionally stored FYM (CONFYM 1.4) had a significantly higher N_{min} value (12.7 mg N pot^{-1}) while soil which had received the lower rate of conventionally stored FYM (CONFYM 0.7) resulted in significantly lower inherent N mineralisation potential (8.7 mg N pot^{-1}).

There were also significant differences in the net release of N from the two different amendment types. In the NFSC soils, amendment with pelleted poultry manure resulted in an average N_{rel} value (after subtraction of non-amended controls) of 10.0 mg N pot^{-1} which was significantly higher than the average N_{rel} value for compost, of 5.9 mg pot^{-1}. The management history of the soils from the NFSC experiment had no effect on the N release potential from either amendment type.

For the DOK soils, pelleted poultry manure also resulted in higher net N release on average (5.3 mg N pot^{-1}) compared to compost (1.7 mg N pot^{-1}). There were no statistically significant differences in net N release from pelleted poultry manure among the different soil management treatments in the DOK trial; however, the

BIODYN 1.4 treatment resulted in the highest net N release numerically, while the NOFERT treatment was the lowest (data not shown). There were significant differences among the DOK soil management treatments in the net N release from composted manure (Fig. 1). The NOFERT and BIODYN 1.4 treatments had the highest net N release. BIOORG 1.4 and BIODYN 0.7 resulted in negative estimates of net N release, indicating a net immobilisation of N from these amendments in these soils.

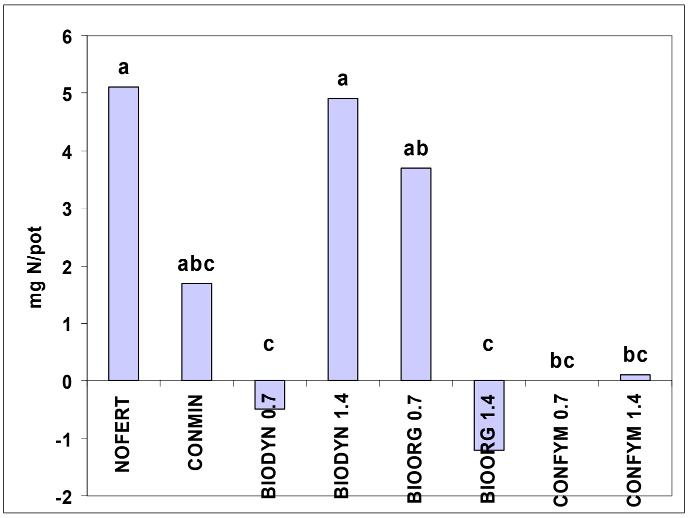

Figure 1: N released from an equal amount of composted manure, DOK soils

Discussion

The NFSC soils had an inherent N mineralisation potential that was 50% higher than the DOK soils on average. This reflects the differences in total N contents between the two soils (NFSC 2.5 g N kg^{-1}; DOK 1.5 g N kg^{-1}). Total N has been correlated with N mineralised from soils using the anaerobic incubation method (Fox and Piekielek, 1984), although it does not always correlate with crop uptake of N in the field, due to the variety of environmental factors that also control N availability to the crop.

The NFSC soils also resulted in higher net N release from both of the added amendments on average when compared to the DOK soils; however, some of the DOK treatments (e.g. BIODYN 1.4) resulted in net N release values similar to the average values for the NFSC soils. The different management practices had been applied for much longer in the DOK trial compared to the NFSC experiment, resulting in the development of distinct soil microbial communities depending on fertility management (Hartmann et al., 2006). Fließbach and Mäder (1997) found higher microbial biomass, and biomass C as a percentage of total C, in BIODYN treatments, but fewer differences in microbial community function, as measured using Biology GN microplates. Our results indicate that there are differences in microbial community function among the soils of the DOK trial, as shown by the differences in the potential to release N from added amendments, depending on previous management history. It is difficult to explain, however, why the 1.4 LU rate of compost application in the BIODYN treatment resulted in enhanced net N release from added compost compared to the 0.7 LU rate, whereas the opposite was true for the BIOORG treatments. Further experiments are needed to explain how management-related effects including: differences in biomass size and activity, pre-conditioning of the biomass to different amendment types, and treatment-related differences in microbial community function, could be altering mineralisation of N from added amendments, .

Conclusions

This study has shown that soil management practices can impact on the release of N from added organic amendments. Further research is required to understand the biological mechanisms controlling net N release from these sources. These findings can then be used to develop soil management practices to optimise the utilisation of N from organic amendments.

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