Understanding soil nitrogen supply: organic matter quality and quantity

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ABSTRACT

The soil organic matter (SOM) contents of organic and conventionally farmed soils were compared. Whilst the quantity of SOM was found to be similar with both systems, the quality of SOM differed in respect of higher amounts of N released by the organic soils under anaerobic incubation. This indicated a greater potential rate of mineralization and suggested that the inherent fertility of the organic soils had been improved.

INTRODUCTION

Successful organic crop production depends on building-up soil fertility to a level which can sustain the supply of nutrients required for healthy plant growth. In contrast, conventional agriculture relies on fertilizers to replenish any short-fall in nutrients by attempting to synchronise the amount and timing with plant demand. Nitrogen (N) is often a limiting nutrient in organic rotations, so the rate N is released by mineralization can be considered as one (important) measure of inherent soil fertility. In a preliminary survey, soils were collected from 29 mixed, arable and stockless enterprises in autumn'99 from fields that were conventionally managed and receiving fertilizer, or organically managed. The organic fields were sampled either after 2-3 years of grass/clover designed to build-up fertility (high fertility), or at the fertility-depleted stage, i.e. after 2 or 3 crops had been grown (low fertility). Using anaerobic incubation, the potential N mineralization (PMN) was obtained from the net release of plant-available N from the SOM. Initial results suggested that, particularly with mixed farming systems, mineralization was greater in the high than after the low fertility phase and conventional management was intermediate, demonstrating that organic soils are not necessarily always more 'fertile' (Shepherd et al., 2000).

MATERIALS AND METHODS

In spring 2000, four of these farms were selected to examine soil fertility in more detail. Soils were sampled from Farm W, on a fine loam over clay (stagnogley) in Warwickshire; from Farm N, on a silty clay loam (fluvisol) in Norfolk; from Farm O, on a clay soil (calcareous peolsol) in Oxfordshire and from Farm G, on a silt loam/sandy silt loam (calcareous brown earth) in Gloucestershire. The soils were air dried, ground (2 mm) and PMN and SOM separation were used to investigate properties of soil quality. The free light fraction (LF) was separated by suspending soil in sodium iodide solution, soluble organic C by hot water extraction and total soil C and N contents were also determined.

Results

In all four farms, PMN in the high fertility organic phase was at least 20% higher than conventional soils ($p<0.05$). The soils in the low fertility phase tended to be intermediate. There were no consistent trends in soil total C (av. 2.2%), N (av. 0.3%), or C:N ratio (av. 8.4) in any of the farms. Rates of N turnover (% total soil N mineralized by PMN) ranged from 2 and 8%; maximum values were found in the organic soils of all four farms. In Farms O and N, rates were lower under conventional management ($p<0.05$). Soluble (hot water) organic C was similar in soils from three farms; it was highest ($p<0.05$) in the high fertility soil in Farm N and none of the fertilized soils exceeded values obtained in the organic soils in any of these farms. The LF was on average, 10% (by mass) of the total SOM and there were no differences between organic and conventionally managed soils. The C:N ratio of LF was similar in three farms (av. 18.2), the exception was Farm W, where the LF in the conventional soil had a higher C:N ($p<0.05$). Overall, the proportion of N held in the LF represented only about half of that released by PMN.

DISCUSSION

That there were no consistent differences in soil total C, or N between the different farming systems was perhaps not surprising. Total SOM content depends on many factors, including long-term balances of C inputs/outputs. There is no clear evidence in the literature of consistent differences in total C, or N between conventional and organically farmed soils. The more labile SOM contributes to N dynamics, as well as other soil properties such as structure, and it is this fraction that warrants more attention. Rates of N turnover were within the published range (1-10% of total soil N). Since none of the conventional soils had a higher N turnover than the organic soils, it suggests that the supply of N may be maintained by higher rates of mineralization, at least in the high fertility phase. This may reflect differences in the quantity, or quality of labile sources of SOM, but does not indicate the source involved. In this study, analysis of the LF showed that it could not account for all N released by PMN. Biological degradation (PMN) of SOM and physically harsh extractions (hot water) may be more effective in accessing other protected forms of SOM than were recovered in the LF. Future work will, therefore look at other components of labile SOM, including the 'protected' intra-aggregate LF and silt-clay complexes and examine the extent to which microbial activity may differ in these systems.

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