SHORT COMMUNICATION

Nitrogen uptake by ryegrass from organic wastes applied to a sandy loam soil

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Abstract

Sandy-textured Mediterranean soils are invariably depleted in organic matter and supply only small amounts of N to crops. To compensate for these deficiencies, we tested the N supply from six organic wastes applied to a Cambic Arenosol in pots growing ryegrass. The results showed that the behaviour of the wastes in supplying N to a ryegrass crop grown in this soil can be predicted by observing their performance in laboratory aerobic incubations. The N made available during these incubations fitted well to a one-pool kinetic model.

Keywords: Nitrogen mineralization, organic wastes, ryegrass, sandy loam texture

Introduction

Soil conservation implies not only the application of sound management practices to prevent the loss of good land, but also the efficient recycling of organic materials produced by different activities. These are manures and by-products from industry and municipal wastes. Such wastes cannot only be recycled as a source of plant nutrients, but can also enhance future crop production by improving soil quality (Vagstad *et al.*, 2001; Douglas *et al.*, 2003). By adding organic wastes to the soil, total nitrogen (N), organic matter, microbial population, enzyme activity, moisture retention, pH buffering capacity and crop yields can be increased (Cordovil, 2004).

Nitrogen is often a limiting factor in the growth of many forage species such as ryegrass. Moreover, crops grown on coarser textured soils may require more N fertilizer because lesser amounts will be mineralized from the relatively small organic matter content.

The objective of the present study was to evaluate results previously obtained in laboratory aerobic incubation experiments (Cordovil *et al.*, 2005) by assessing N mineralization of six wastes from different sources (animal, industrial and urban) using N uptake by ryegrass plants as a measure of

their net mineralization and determining how far the supply of organic N in sandy soils may contribute to plant available N for ryegrass.

Materials and methods

Six organic wastes previously dried and sieved were mixed separately with loamy sand soil (Cambic Arenosol) with 0.34 g kg⁻¹ total Kjeldahl-N and 5.9 g kg⁻¹ OM: composted solid municipal waste, secondary pulp mill sludge, horn meal, poultry manure, dried solid phase from pig slurry and composted pig manure. The wastes were characterized by OM and Kjeldahl-N contents and the C/N ratio (Table 1) (Cordovil *et al.*, 2005). Ryegrass (*Lolium perenne* L. cv. Billion) was grown for nearly 6 months, in Kick-Brauchmann pots under controlled environment conditions, and cut five times.

Two rates of the wastes, corresponding to 80 and 160 kg total N ha⁻¹, were tested. Half of the pots received the equivalent to 120 kg mineral N ha⁻¹. The remaining pots received only waste as N supply. The control treatment received the same mineral N fertilization and no organic amendment. Pots were weighed and watered every 2 days to maintain soil at 60% field capacity. Plant herbage was harvested and analysed for N content. Data was statistically analysed and correlated with previous incubation results (Cordovil *et al.*, 2005).

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Table 1 Chemical characteristics of the six organic wastes under study

	Composted solid municipal waste	Secondary sludge	Horn meal	Poultry manure	Solid phase from pig slurry	Composted pig manure
N _{kj} (g kg ⁻¹)	17.8	42.4	116.7	35.5	17.4	21.7
OM (g kg ⁻¹)	482	875	845	766	714	812
C/N	15.7	12.7	4.2	12.5	23.8	21.7

N_{kj}, kjeldahl nitrogen; OM, organic matter; C/N, C-to-N ratio.

Table 2 Ryegrass total dry matter production and plant N uptake

Treatments	Dry matter (g pot ⁻¹)	Uptake (mg pot ⁻¹)	Dry matter (g pot ⁻¹)	Uptake (mg pot ⁻¹)
Soil + N _{min} (control)	31.6	517.4		
	80 kg N waste ha ⁻¹ + N _{min}		160 kg N waste ha ⁻¹ + N _{min}	
Composted SMW	33.5* e	543.8* fg	37.0 cd	625.6 e
Secondary sludge	33.5* e	550.5* f	34.3 de	604.0 e
Horn meal	35.4 cd	621.3 e	36.0 cd	717.1 c
Poultry manure	36.2 c	659.0 d	42.1 a	826.1 a
Solid PS	35.7 cd	629.8 e	39.2 b	775.0 b
Composted PM	34.5 de	603.2 e	35.6 cd	694.2 c
	80 kg N waste ha ⁻¹		160 kg N waste ha ⁻¹	
Composted SMW	11.9 k	249.4 n	13.9 ij	296.4 m
Secondary sludge	11.6 k	251.0 n	14.0 i	309.0 lm
Horn meal	13.2 j	304.1 lm	16.4 g	411.6 i
Poultry manure	15.1 h	348.7 jk	19.7 f	515.0* g
Solid PS	13.8 ij	329.1 kl	16.5 g	451.1 h
Composted PM	12.9 j	306.1 kl	14.4 i	366.8 j

*Not significantly different from control (according to Dunnett test) ($P < 0.05$). Values of the same column followed by the same letter are not significantly different according to LSD test ($P < 0.05$). For key to wastes see Table 1. N_{min} = 120 kg ha⁻¹ fertilizer N.

Results and discussion

All treatments without the addition of mineral nitrogen fertilizer resulted in less plant growth, as well as less N uptake by the plants, when compared with that of the control (Table 2). Biomass production was well correlated with N uptake by ryegrass ($0.99 < r < 1.00$), reflecting growth being dependent on N supply to the crop. The greater production from N_{min} treatments was probably the result of a greater uptake of N and of other plant nutrients such as phosphorus and potassium, being stimulated by mineral N fertilizer application (Evers, 2002; Ehlers & Goss, 2003), together with a priming effect on mineralization. The priming effect is commonly observed with some organic wastes (Laura, 1975). Poultry manure gave the greatest dry matter production and uptake, followed by the dried solid phase from pig slurry and horn meal, which were not statistically different. The wastes that were less efficient in supporting plant nutrition were the composted municipal solid waste and pulp mill sludge, both with high proportions of recalcitrant N compounds (Cordovil *et al.*, 2005).

Figure 1 Relationship between the amount of potentially available N per pot, estimated by the Stanford and Smith model (Cordovil *et al.*, 2005), and N uptake by ryegrass (all the 12 treatments without mineral N application).

Results obtained were compared with those obtained in a laboratory aerobic incubation (Figure 1) (Cordovil *et al.*, 2005). Through the fitting of the Stanford & Smith's (1972) one-pool kinetic model, it was possible to predict the amounts of N mineralized from each waste tested (Table 3), which followed the sequence: composted solid municipal waste < pulp mill sludge < composted pig manure < solid

	Treat 80 (kg ha ⁻¹)	Treat 160 (kg ha ⁻¹)	% N _m ^a	% N _U ^b (OW)	% N _U ^b (OW + N _{min})
Composted SMW	16.9	33.9	21.3	19.3	12.2
Pulp mill sludge	19.3	38.6	25.2	20.5	11.6
Horn meal	25.7	51.3	32.5	36.4	30.9
Poultry manure	29.6	59.3	36.9	50.9	44.8
Solid PS	20.6	41.4	25.9	43.1	36.4
Composted PM	20.1	40.2	25.0	33.3	26.4

^a%N_m = [(Nm/total N applied) × 100]. ^bN_U = N uptake (% of total N applied). ^cN₀ = potentially mineralizable N. For key to wastes see Table 1.

phase from pig slurry < horn meal < poultry manure, as reported before by Cordovil *et al.* (2005).

Results obtained in the present study suggest that the behaviour of the six wastes tested in supplying N to ryegrass growing in a sandy soil can be predicted by observing their performance in aerobic incubations, because data from these incubations fitted well to Stanford & Smith's (1972) one-pool kinetic model.

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Table 3. Prediction of mineral N from organic waste mineralisation at the end of the experiment (% N_m), according to Stanford & Smith's (1972) model (except for solid PS to which N₀^c is considered), and N uptake as percentage of total N applied in each treatment (% N_U).