NITROGEN AVAILABILITY IN SOILS AS INFLUENCED BY ORGANIC FERTILIZERS HAVING DIFFERENT C/N RATIOS

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Abstract

Three soils representing the Fernwood, Cartref and Inanda series were treated either with fresh or decomposed filtercake, poultry litter or poultry manure having different C/N ratios in order to examine their effects on N availability. Over a period of four weeks, rates of N immobilization and mineralization were determined for the various treatments under incubated conditions in the laboratory. Simultaneously in the glasshouse the recovery of N by sorghum under the same fertilizer treatments was determined in a pot experiment. The total inorganic N present in the different soil treatments after four weeks incubation was closely correlated with uptake of N by sorghum from all three soils. Plant uptake of N was depressed on all soils following the addition of fresh filtercake having high C/N ratios. The reduction in the amount of N taken up was least severe on the Inanda series soil, which showed a much greater capacity to mineralize N than either of the other soils. Immobilization effects were less obvious when the C/N ratio of the organic fertilizers was less than 20:1 than when it was greater than 20:1, but release of N was only substantial in the different soils after treatment with poultry manure, being equivalent to that obtained when 50-100 kg inorganic fertilizer N per hectare was applied to the soil. It is apparent that most organic fertilizers, even when the C/N ratio is favourable for N mineralization, are unlikely to contribute substantially on many soils to the N nutrition of sugarcane at an early stage of crop development.

Introduction

In a recent survey of the composition of filtercake taken from all mills in the South African and Swaziland sugar industries it was found that the C/N ratio of fresh filtercake was generally greater than 25:1 (Wood[5]). Alexander[1] said that filtercake would tend to immobilize some or all of the N available to the crop if applied to the soil in this condition. Harmsen and Kolenbrander[2] state that the C/N ratio of decomposing organic residues must be below 20 to 25:1 for appreciable net mineralization of N to occur. Moberly and Meyer[3] have shown that N availability is a function of both the C/N ratio of filtercake and the soil type to which it is applied.

Every year substantial amounts of filtercake (FC) and other organic fertilizers such as poultry litter (PL) and poultry manure (PM) which have widely differing C/N ratios, are used on various soil types throughout the sugar industry, and some allowance is made for their N content when drawing up fertilizer recommendations. The work now reported was done to study the effects of the addition of various organic fertilizers, having different C/N ratios, on the availability of N when added to several sugar belt soils, both in the laboratory and the glasshouse.

Procedure

Laboratory

Rates of N immobilization and mineralization were determined on three soils representing the Fernwood, Cartref and Inanda series. Bulk air-dry samples of the three soils, analytical data for which are given in Table 1, were subjected to the following fertilizer treatments :

1. Control — no inorganic fertilizer N or organic fertilizer added.
2. 50 kg N/ha (as NH_4NO_3).
3. 100 kg N/ha (as NH_4NO_3).
4. 150 kg N/ha (as NH_4NO_3).
5. Fresh FC (C/N ratio 40) — at a rate equivalent to 40 tons/ha.
6. Fresh FC (C/N ratio 40) — at a rate equivalent to 80 tons/ha.
7. Fresh FC (C/N ratio 29) — at a rate equivalent to 40 tons/ha.
8. Fresh FC (C/N ratio 29) — at a rate equivalent to 80 tons/ha.
9. Decomposed FC (C/N ratio 16) — at a rate equivalent to 40 tons/ha.
10. Decomposed FC (C/N ratio 16) — at a rate equivalent to 80 tons/ha.
11. Fresh PL (C/N ratio 19) — at a rate equivalent to 15 tons/ha.
12. Fresh PM (C/N ratio 13) — at a rate equivalent to 15 tons/ha.

When calculating amounts of fertilizer to apply it was assumed that one hectare of soil to a depth of 150 mm has a mass of 2,25 x 10^6 kilograms.

TABLE 1
Analytical data for soils and organic fertilizers

Soil series	pH	%C	%N	C/N ratio
Fernwood sand	5,2	0,15	0,01	15,0
Cartref loamy sand ..	5,6	0,57	0,05	11,4
Inanda clay loam ..	5,3	2,52	0,17	14,8
Organic fertilizer				
Fresh filtercake		36,0	0,90	40,0
Fresh filtercake		44,2	1,51	29,3
Old filtercake		24,6	1,47	16,7
Poultry litter		35,5	1,83	19,4
Poultry manure		35,2	2,63	13,4

The organic fertilizers (see Table 1) were incorporated into the soils before the bulk samples were moistened to 40 per cent of their water-holding capacity either with water or the appropriate solution of fertilizer N. The soils were incubated at 30°C, and after periods of 0, 3, 7, 14 and 28 days, duplicate samples equivalent to 25g air dry soil were withdrawn from all treatments and analysed for mineral N (ammonium + nitrate N) content. The soils were aerated throughout the incubation period.

Glasshouse

After weighing 1 200g amounts of the three different soils into pots, replicates of each soil type received inorganic fertilizer N or organic fertilizer at rates equivalent to those used in the laboratory experiment (see treatments 2-12 above).

FIGURE 1 The effect of organic fertilizers having different C/N ratios on crop growth on a Fernwood sand.

Two replicates of each soil type were left untreated to serve as control plots. After the appropriate organic fertilizers had been mixed with the soil, all pots were seeded with forage sorghum (babala). The soils were then moistened to 60 per cent of their water holding capacity using a standard P and K nutrient solution, with or without inorganic fertilizer N, according to treatment. All pots were restored to 60 per cent of the water holding capacity by daily watering.

From the outset large differences in growth were observed between the plants subjected to the various organic fertilizer treatments (see Figure 1). After four weeks both replicates of each treatment from the three different soils were harvested. The above ground parts of the plants were oven dried, weighed and ground prior to analysis for N content.

TABLE 2
Yield and N uptake of sorghum after four weeks growth under various fertilizer treatments

Treatment				Soil series					
				Fernwood		Cartref		Inanda	
No.	Fert N kg/ha	Org Fert tons/ha	C/N ratio	*Dry mass g	*N uptake mg	Dry mass g	N uptake mg	Dry mass g	N uptake mg
1	nil	nil	—	1,73	13,2	2,76	20,0	8,60	81,3
2	50	nil	—	3,74	29,3	5,28	28,5	9,55	115,1
3	100	nil	—	5,23	43,6	7,12	59,0	9,29	131,4
4	150	nil	—	6,35	64,8	8,11	80,2	9,97	131,7
5	nil	40 FC	40	0,49	4,3	0,45	4,4	6,49	76,9
6	nil	80 FC	40	0,40	2,9	0,43	3,0	6,00	61,7
7	nil	40 FC	29	0,87	9,5	0,88	8,6	6,43	59,9
8	nil	80 FC	29	0,78	9,4	0,45	5,3	5,47	56,4
9	nil	40 FC	16	2,22	15,4	3,31	20,9	8,42	97,0
10	nil	80 FC	16	2,91	19,9	4,24	27,4	8,25	103,8
11	nil	15 PL	19	2,80	17,5	2,83	18,2	7,67	87,0
12	nil	15 PM	13	5,17	40,3	5,74	43,7	11,92	112,1

*means of two replicates

TABLE 3
N mineralized under various fertilizer treatments

No.	Treatment			ppm N mineralized after 28 days		
	Fertilizer N kg/ha	Organic fertilizer tons/ha	C/N ratio	Fernwood sand	Cartref loamy sand	Inanda clay loam
1	nil	nil	—	22	24	63
2	50	nil	—	19	38	33
3	100	nil	—	18	39	51
4	150	nil	—	8	34	93
5	nil	40 tons FC	40	5	7	83
6	nil	80 tons FC	40	0	7	38
7	nil	40 tons FC	29	7	22	47
8	nil	80 tons FC	29	5	15	56
9	nil	40 tons FC	16	14	22	49
10	nil	80 tons FC	16	16	31	61
11	nil	15 tons PL	19	4	16	75
12	nil	15 tons PM	13	35	44	91

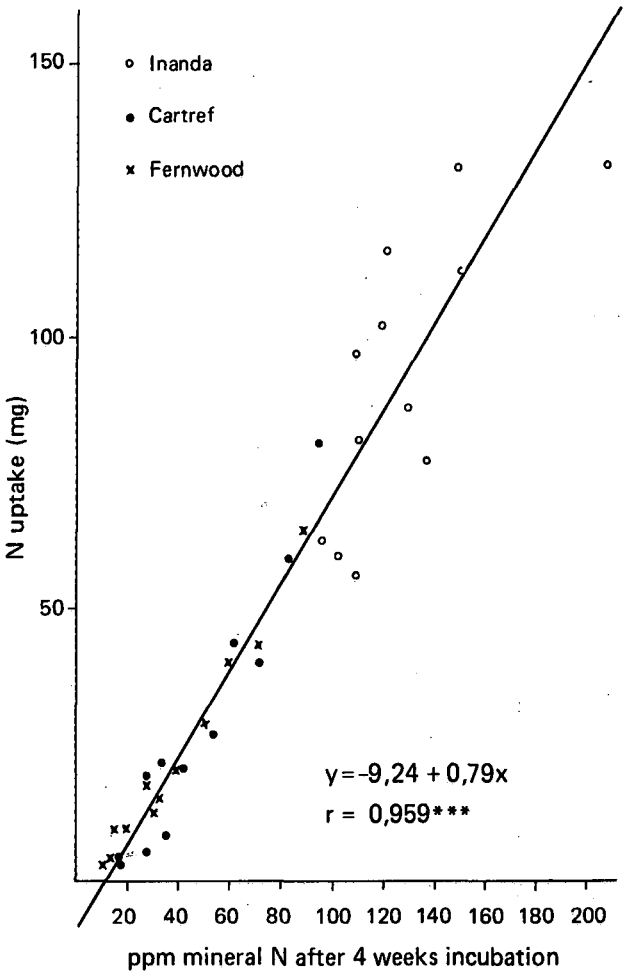

FIGURE 2 The relationship between total mineral N in the soil and N uptake by sorghum grown on three different soils receiving various fertilizer treatments.

Results and Discussion

Table 2 is a summary of data for yield and plant uptake of N after four weeks by sorghum grown under the various fertilizer treatments on the three different soils. Figure 2 shows that the total amount of mineral N present in the soil after four weeks incubation was closely correlated ($r = 0{,}959$) with uptake of N by the plants on all soils.

When compared with the control treatment to which no fertilizer was applied, the application of fresh filtercake with a C/N ratio of either 40 or 29:1 caused uptake of N to be depressed on all soils. The reduction in the amount of N taken up in these treatments was particularly marked on the sandier Fernwood and Cartref series soils. It was less severe on the Inanda series soil which, because of its humic nature, showed a much greater inherent capacity to mineralize N than either of the other two soils as shown in Table 3. The data in this table indicate that in the absence of the growing crop, there was a tendency for fertilizer N to suppress mineralization of soil N.

Where organic fertilizers with C/N ratios less than 20:1 were added to the soil, plant uptake of N generally increased, relative to that in the control treatments on all soils as the C/N ratio decreased (Table 2). Figure 3 shows that initially immobilization of soil N occurred to an extent on all three soils following the addition to the soil of organic fertilizers with a C/N ratio of more than 20:1. Though immobilization of N was not apparent when organic fertilizers with a C/N ratio of less than 20:1 were added to the soil, rate of N release was generally slow except when poultry manure was present (see Table 3).

Whilst laboratory and glasshouse conditions may exaggerate the effects observed, the results demonstrate clearly that the availability of N following the application of organic fertilizers to the soil is dependent on the C/N ratio of the material, and the type of soil to which they are applied. In a soil with a considerable potential to mineralize N such as that of the Inanda series, the immobilizing effects of high C/N ratio fertilizers are fairly mild. A substantial amount of N in the applied fertilizer becomes available for crop use within a relatively short period, because remineralization of N following immobilization occurs more quickly under these conditions (see Figure 3).

The N uptake data in Table 2 show that after four weeks a substantial release of N had occurred on all soils treated with poultry manure. This release was equivalent to that obtained when 50-100 kg fertilizer N per hectare was applied to the soil. When old filtercake and poultry litter with C/N ratios less than 20:1 were used, release of N was generally low on all soils, averaging about five per cent of the total N present in the fertilizer. An exception occurred when old filtercake was applied to the Inanda series soil when an average of 13 per cent of the total N was utilized during the first four weeks of crop growth.

From these results it is apparent that organic fertilizers, even when the C/N ratio is favourable for N mineralization, but with the exception of poultry manure, may not contribute greatly on many soils to the N nutrition of sugarcane at an early stage of crop development. This applies particularly to sandy soils and others which have a low capacity to mineralize N, and are therefore not able to buffer immobilizing effects satisfactorily. If inorganic fertilizer N were not applied to these soils, a significant delay after the application of the organic fertilizer would probably be experienced before net mineralization could be expected to supply any N to the plant. The need is apparent for inorganic fertilizer N to be added to organic fertilizer if severe immobolization effects are to be avoided, particularly when fresh filtercake is applied to the soil. Future glasshouse studies could be used to evaluate the effects of inorganic fertilizer N added to various organic fertilizers in increasing the rate of N release for crop use on different soils.

Moberly and Meyer[3] estimated that approximately 50 per cent and 20 per cent of the total N content of filtercake would become available to the plant crops of sugarcane in the midlands mistbelt (Inanda series) and 'other' soils respectively. Based on the results reported in this paper this is a reasonable assessment for decomposed filtercake, but where fresh filtercake is applied the recovery of N could well be lower. It should be remembered however that some of the 'other' soil category include series such as Dundee, Glendale, Mayo, Rydalvale and Shortlands, all of which have been shown to have a considerable potential to mineralize N (Wood[4]). It is considered likely that between 40 and 50 per cent of the total N content of decomposed filtercake applied to soils of these series would become available to the plant crop.

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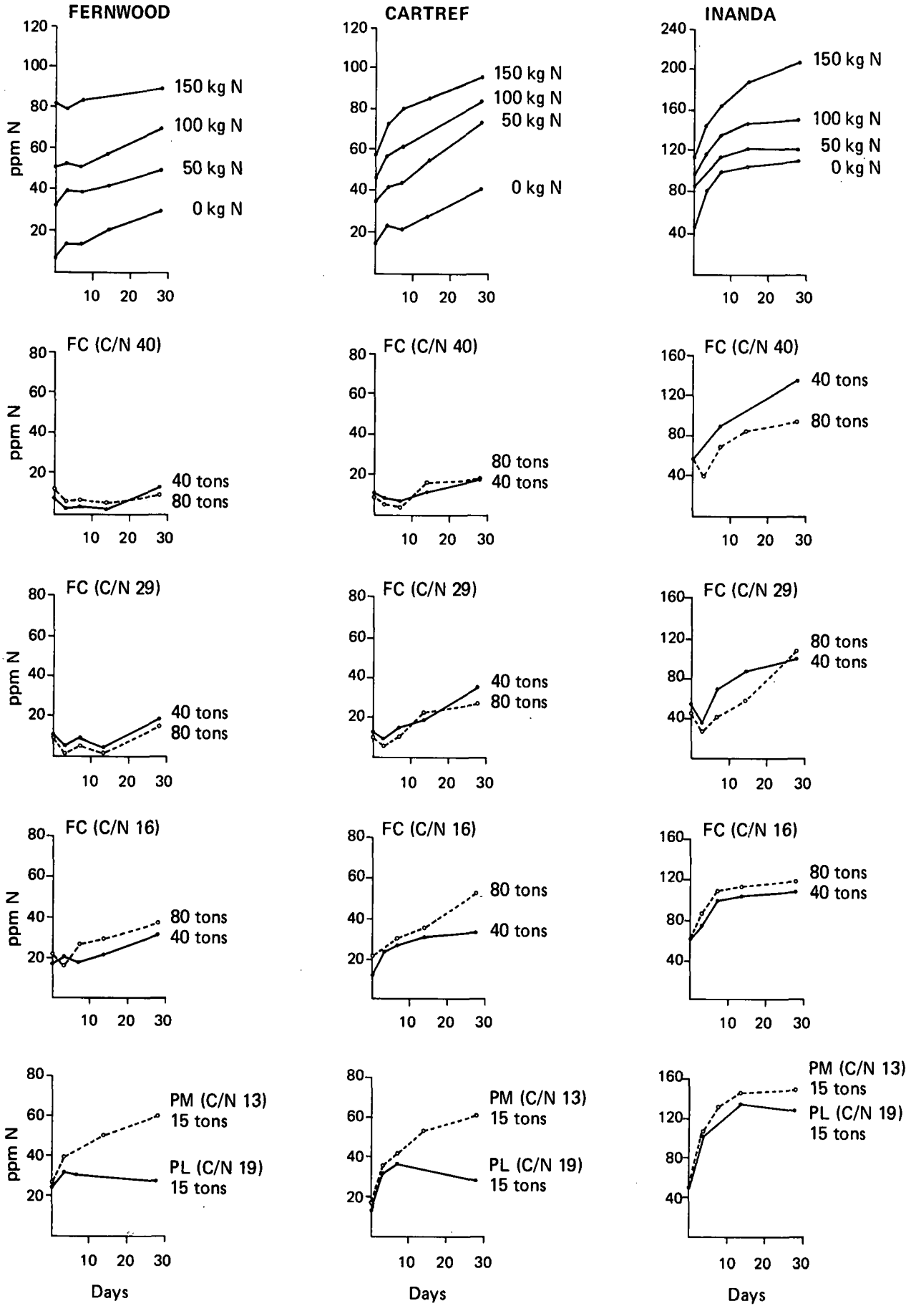

FIGURE 3 Changes in mineral N (ammonia + nitrate N) in three soils receiving organic fertilizers of different C/N ratios.