THE INFLUENCE OF TRASH ON NITROGEN MINERALISATION—IMMOBILIZATION RELATIONSHIPS IN SUGAR BELT SOILS*

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I. LABORATORY INVESTIGATION OF NITROGEN TURNOVER

Introduction

Biological immobilization and mineralisation of nitrogen in the soil can be regarded as opposing processes. The former is the transformation by microbial action of inorganic or mineral N into an organic form and thereby rendered unavailable to the plant, while the latter is the conversion of the immobilized N to the plant available inorganic forms by microbial decomposition. Winsor[14] points out that from the biological nature of these two processes it is obvious that both must occur simultaneously, since the formation of organic nitrogenous compounds by micro-organisms is an essential feature of their growth, these compounds in turn being decomposed on the death of the organisms concerned. The cycling of products in the above manner is referred to as nitrogen turnover and takes place continuously in all soils.

Many workers have shown that the effect of adding carbonaceous materials such as straw[2, 5, 6, 7, 8, 9], sawdust[1, 6] and other plant residues[10, 11, 12] to the soil, is to lower the inorganic N content, the C/N ratio of the added material largely governing the degree by which it is reduced. Waksman[13] in 1924, showed that organic materials containing N in excess of 2.0—2.5 per cent, decomposed with immediate release of NH_4-N, whereas residues of lower N content generally caused assimilation of any inorganic N present by soil organisms. Jansson[8] and others[2, 4] have shown that nitrogen tied-up in this way is eventually released as mineral N at a characteristic turning point, i.e. when nett immobilization changes into nett mineralisation.

In view of these findings it was decided to investigate the rate of nitrogen turnover in Sugar Belt soils, many of which are heavily trashed, in order to obtain some assessment of the importance of this process. Incorporation of trash into the topsoil, generally of high C/N ratio, which inevitably occurs under field conditions, may lock up considerable quantities of available N, often at a time when plant requirement is greatest. Under these conditions additional fertilizer N would probably be necessary to counteract this effect and assist in the turnover process. An experiment was therefore undertaken to establish immobilization rates and subsequent release of nitrogen, following the addition of trash and fertilizer N to a representative group of Sugar Belt Soils.

Procedure

800 g. air dry samples of seven soils series, analytical data for which is presented in Table I, were subject to the following treatments:

1. Control — no fertilizer or trash.
2. 80 mg. N as $(NH_4)_2SO_4$ — 100 ppm. (200 lb. N/acre).
3. 1 per cent trash — 10 tons/acre equivalent.
4. 80 mg. N as $(NH_4)_2SO_4$ + 1 per cent trash.

TABLE I

Soil Analytical Data — Nitrogen Turnover Experiment

Soil Group	Series	% Texture				Textural Group	pH	% Org. C	% N	C/N Ratio
		C.S.	F.S.	S	C					
Recent sand	Clansthal	41	48	3	8	Sand	6.15	0.79	0.07	11.3
T.M.S. (ord.)	Cartref	69	19	3	9	Loamy sand	5.50	0.65	0.04	16.3
Dwyka tillite	Waldene	19	47	13	18	Sandy loam	5.80	1.70	0.08	21.3
Granite	Glenrosa	51	18	9	20	Sandy clay loam	5.90	2.26	0.10	22.6
T.M.S. (mistbelt)	Inanda	32	18	11	37	Sandy clay	5 15	5.50	0.20	27.5
Alluvium	—	12	27	20	34	Clay loam	6.20	2.47	0.17	14.5
Dolerite (red)	Shortlands	8	18	11	59	Clay	6.90	2.32	0.14	16.6

C.S. = Coarse sand. F.S. = Fine sand. S = Silt. C = Clay.

* This work will form part of a thesis to be submitted to the University of Natal, Soil Science Department, for the Ph.D. degree.

TABLE II

Changes in soil inorganic nitrogen during laboratory incubation (means of duplicate samples in ppm.)

T.M.S. (mistbelt) — INANDA — Period of Incubation (days)

Treatment	N fraction	0	5	8	13	20	27	41	55	69
1 Control (Nil)	NH_4-N	—	—	—	—	—	—	—	—	—
	NO_3-N	26	29	30	36	35	36	41	42	48
	Total	26	29	30	36	35	36	41	42	48
2 100 ppm. N as $(NH_4)_2SO_4$	NH_4-N	93	78	74	65	35	14	—	—	—
	NO_3-N	26	35	41	50	79	99	112	119	122
	Total	119	113	115	115	114	113	112	119	122
3 1% trash	NH_4-N	—	—	—	—	—	—	—	—	—
	NO_3-N	26	1	—	—	—	—	—	—	—
	Total	26	1	—	—	—	—	—	—	—
4 100 ppm. N +1% trash	NH_4-N	89	17	3	1	—	—	—	—	—
	NO_3-N	26	33	38	48	51	56	64	71	78
	Total	115	50	**41**	49	51	56	64	71	78

RECENT SAND (red) — CLANSTHAL — Period of Incubation (days)

Treatment	N fraction	0	5	8	13	20	27	41	55	69
1 Control (Nil)	NH_4-N	4	11	4	—	—	2	—	—	—
	NO_3-N	12	24	36	43	45	48	66	77	83
	Total	16	25	40	43	45	50	66	77	83
2 100 ppm. N as $(NH_4)_2SO_4$	NH_4-N	88	105	96	73	62	53	5	—	—
	NO_3-N	14	25	41	64	77	85	140	146	150
	Total	102	130	137	137	139	138	145	146	150
3 1% trash	NH_4-N	4	—	—	—	—	—	—	—	—
	NO_3-N	10	—	—	—	—	—	—	—	—
	Total	14	—	—	—	—	—	—	—	—
4 100 ppm. N +1% trash	NH_4-N	90	49	34	18	16	13	—	—	—
	NO_3-N	14	15	21	37	45	52	82	97	102
	Total	104	64	55	**55**	61	65	82	97	102

T.M.S. (ordinary) — CARTREF — Period of Incubation (days)

Treatment	N fraction	0	5	8	13	20	27	41	55	69
1 Control (Nil)	NH_4-N	10	11	11	4	1	1	—	—	—
	NO_3-N	5	8	10	20	24	27	32	29	33
	Total	15	19	21	24	25	28	32	29	33
2 100 ppm. N as $(NH_4)_2SO_4$	NH_4-N	105	102	105	100	96	80	58	41	39
	NO_3-N	5	7	14	21	24	39	56	73	80
	Total	110	109	119	121	120	119	114	114	119
3 1% trash	NH_4-N	8	—	—	—	—	—	—	—	—
	NO_3-N	6	1	—	—	—	—	—	—	—
	Total	14	1	—	—	—	—	—	—	—
4 100 ppm. N +1% trash	NH_4-N	107	57	46	46	37	24	11	1	1
	NO_3-N	7	5	6	9	10	13	33	51	61
	Total	114	62	52	55	47	**37**	44	52	62

GRANITE — GLENROSA — Period of Incubation (days)

Treatment	N fraction	0	5	8	13	20	27	41	55	69
1 Control (Nil)	NH_4-N	6	20	20	16	6	—	—	—	—
	NO_3-N	4	6	12	22	31	39	43	50	57
	Total	10	26	32	38	37	39	43	50	57
2 100 ppm. N as $(NH_4)_2SO_4$	NH_4-N	99	113	116	108	109	98	83	70	67
	NO_3-N	2	6	8	13	20	35	52	67	73
	Total	101	119	124	121	129	133	135	137	140
3 1% trash	NH_4-N	7	—	—	—	—	—	—	—	—
	NO_3-N	2	—	—	—	—	—	—	—	—
	Total	9	—	—	—	—	—	—	—	—
4 100 ppm. N +1% trash	NH_4-N	102	60	58	57	41	33	21	17	7
	NO_3-N	3	—	1	2	4	8	21	35	53
	Total	105	60	59	59	45	**41**	42	52	60

DOLERITE (red) — SHORTLANDS — Period of Incubation (days)

Treatment	N fraction	0	5	8	13	20	27	41	55	69
1 Control (Nil)	NH_4-N	8	13	7	—	—	—	—	—	—
	NO_3-N	9	20	30	38	39	42	47	50	59
	Total	17	33	37	38	39	42	47	50	59
2 100 ppm. N as $(NH_4)_2SO_4$	NH_4-N	94	100	94	65	47	33	2	—	—
	NO_3-N	11	21	34	57	80	92	124	129	132
	Total	105	121	128	122	127	125	126	129	132
3 1% trash	NH_4-N	8	1	—	—	—	—	—	—	—
	NO_3-N	9	2	2	—	—	—	—	—	—
	Total	17	3	2	—	—	—	—	—	—
4 100 ppm. N +1% trash	NH_4-N	94	72	28	—	—	—	—	—	—
	NO_3-N	7	23	27	37	36	39	38	43	54
	Total	101	95	55	37	36	39	**38**	43	54

DWYKA TILLITE — WALDENE — Period of Incubation (days)

Treatment	N fraction	0	5	8	13	20	27	41	55	69
1 Control (Nil)	NH_4-N	3	11	7	—	—	—	—	—	—
	NO_3-N	1	5	13	24	25	28	31	39	42
	Total	4	16	20	24	25	28	31	39	42
2 100 ppm. N as $(NH_4)_2SO_4$	NH_4-N	97	99	94	72	38	19	7	5	4
	NO_3-N	1	8	16	40	74	90	104	109	110
	Total	98	107	110	112	112	109	111	114	114
3 1% trash	NH_4-N	4	—	—	—	—	—	—	—	—
	NO_3-N	—	—	—	—	—	—	—	—	—
	Total	4	—	—	—	—	—	—	—	—
4 100 ppm. N +1% trash	NH_4-N	94	37	28	12	—	—	—	—	—
	NO_3-N	1	1	4	17	26	19	16	20	22
	Total	95	38	32	29	26	19	**16**	20	22

ALLUVIUM — Period of Incubation (days)

Treatment	N fraction	0	5	8	13	20	27	41	55	69
1 Control (Nil)	NH_4-N	5	13	5	1	1	—	—	—	—
	NO_3-N	13	25	36	42	49	54	57	62	69
	Total	18	38	41	43	50	54	57	62	69
2 100 ppm. N as $(NH_4)_2SO_4$	NH_4-N	78	84	67	42	17	2	—	—	—
	NO_3-N	13	27	43	69	97	116	120	128	132
	Total	91	111	110	111	114	118	120	128	132
3 1% trash	NH_4-N	5	—	—	—	—	—	—	—	—
	NO_3-N	13	—	—	—	—	—	—	—	—
	Total	18	—	—	—	—	—	—	—	—
4 100 ppm. N +1% trash	NH_4-N	86	17	3	—	—	—	—	—	—
	NO_3-N	12	9	10	13	15	14	13	17	22
	Total	98	26	13	13	15	14	**13**	17	22

N.B.—Bold figures indicate mineral N content of soil when the turning point was reached.

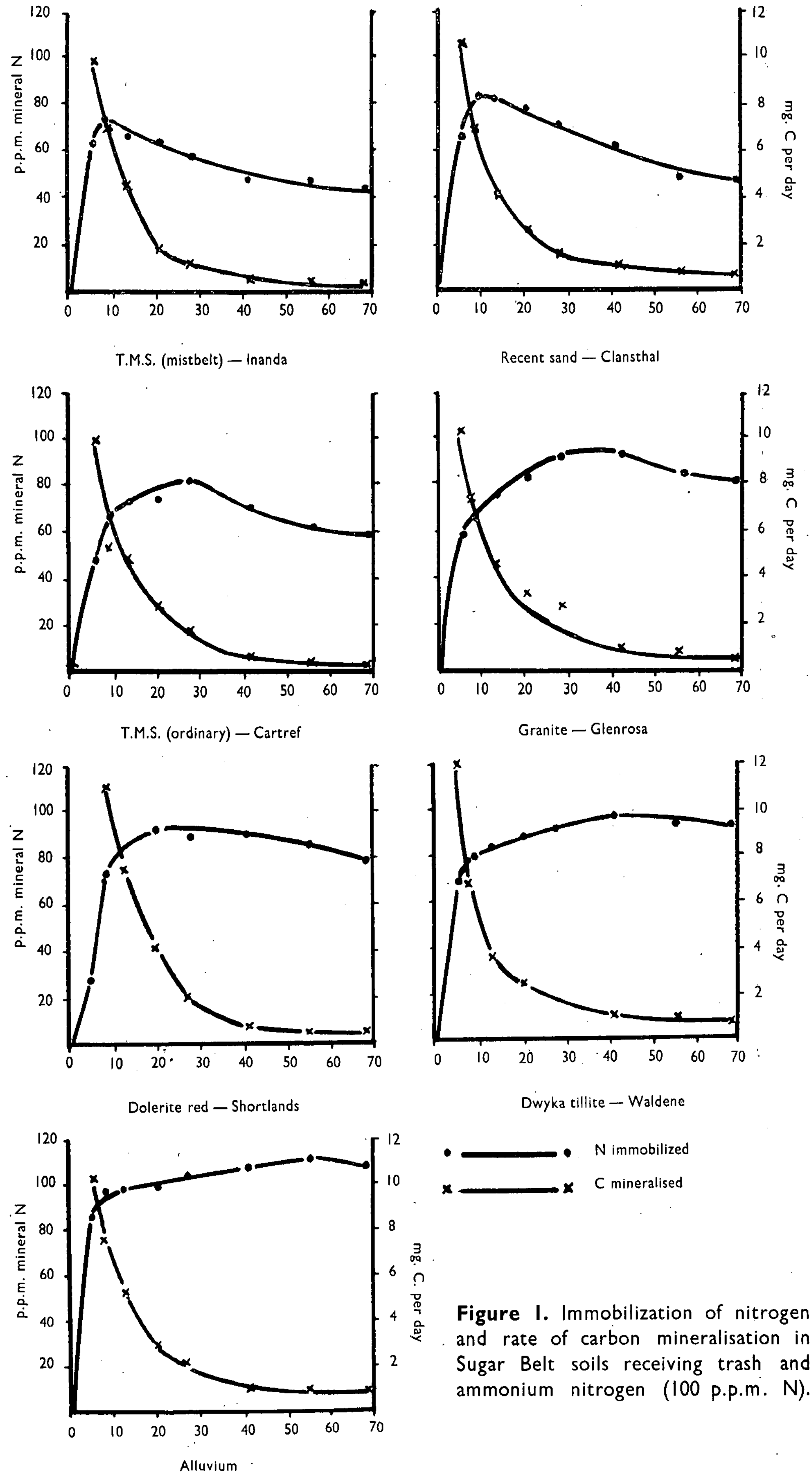

Figure 1. Immobilization of nitrogen and rate of carbon mineralisation in Sugar Belt soils receiving trash and ammonium nitrogen (100 p.p.m. N).

The trash was carefully mixed with the soils beforehand after which they were moistened to 30 per cent of their water holding capacity, either with a solution of $(NH_4)_2SO_4$ or water, an additional 3 ml. of water being supplied for each gram of trash, and incubated in jars at 30° C. After periods of 0, 5, 8, 13, 20, 27, 41, 55 and 69 days, the jars were shaken, and duplicate samples ≡ 25 g. air dry soil were withdrawn from all treatments and analysed for NH_4 - N and NO_3 - N. The soils were aerated daily throughout.

In addition, after the initial moistening, duplicate samples from each jar ≡ 50 g. air dry soil, were taken and put into macrorespirometers[17] at 30° C., in order that C mineralisation could be followed in all treatments throughout the experiment. Daily output of CO_2 was measured and related to that absorbed by 2 N NaOH after 35 and 69 days.

The trash used was a finely ground composite sample prepared from the dead basal leaves and sheaths of a large number of cane plants. It contained 42.6 per cent C and 0.28 per cent N, giving a C/N ratio of 152.

Results and Discussion

Treatment effects on the type and amount of inorganic N present in the various soils throughout the incubation period are given in Table II. Figure 1 presents graphically the degree of N immobilization occurring following the addition of trash plus $(NH_4)_2SO_4$ to the different soils before the turning point is reached, and the release of mineral N into the system that follows. Data for C mineralisation rates during the 69-day period is also superimposed. The main effects of the various treatments are now discussed.

Control. All treatments showed a nett mineralisation of N occurring throughout the incubation period and varying only with the potential of any particular soil to mineralise N. In most soils any NH_4 - N was rapidly nitrified shortly after incubation commenced.

Addition of $(NH_4)_2SO_4$. A variable amount of ammonium fixation was apparent in all soils. Nitrification of the added NH_4 - N occurred at differing rates being incomplete in some cases even after 69 days. With an adequate supply of nitrogen, mineralisation was somewhat reduced in all soils.

Addition of trash. Rapid immobilization of the existing supplies of inorganic N took place in all soils from the commencement of incubation, and no nett mineralisation of N occurred in any soil during the 69 days. This condition still existed after 150 days in all but two of the soils, namely those of the Clansthal and Waldene series. In the former at 97 days, 59 ppm. NO_3-N was detected and this had risen to 97 ppm. at 150 days, while in the latter soil at this time only 29 ppm. NO_3-N was present.

Addition of $(NH_4)_2SO_4$ plus trash. As with the previous treatment marked N immobilization occurred in all soils due to the presence of trash, but the addition of NH_4-N provided a supply of N in excess of that required by the soil micro-organisms, so that after the initial flush of decomposition, considerable amounts still remained in the soil. Preferential absorption of NH_4-N rather than NO_3-N by the soil micro-organisms during immobilization, was observed in all soils. This has been noted by other workers[5, 9], but it has also been shown that NO_3-N is also immobilized to a considerable extent when this is the only form available to soil micro-organisms[5]. The data reveals that when immobilization had reached a maximum in each of the soils the mineral N content gradually started to increase, thus indicating that the turning point had been reached and that nett mineralisation was occurring. The time taken to reach the turning point in the various soils showed very marked differences ranging from between 8 to 41 days.

C Mineralisation during Incubation. In the absence of trash, all soils with or without added N only mineralised carbon slowly, and the difference between these treatments was not significant. As anticipated the addition of trash greatly increased C mineralisation in all soils, but initially microbial action was far greater where fertilizer N was also present, so that at the end of the incubation period, with the exception of the Clansthal sand, a larger percentage of trash carbon had been mineralised, than where N was absent. (See Table III). Analyses for inorganic N after 69 days, of the small samples continuously aerated in the macrorespirometers, showed close agreement with those obtained from the bulk samples incubated over the same period, thus indicating that the C mineralisation data had provided an accurate measure of biological activity within these larger samples.

TABLE III

Per Cent Trash Carbon Mineralised After 69-Day Incubation Period

Soil Group and Series	Trash only	Trash plus Fertilizer N
T.M.S. (mistbelt) — Inanda	27.0	30.1
Recent sand — Clansthal	46.7	39.1
T.M.S. (ord.) — Cartref	19.3	31.8
Granite — Glenrosa	24.5	39.8
Dolerite — Shortlands	32.5	42.0
Dwyka tillite — Waldene	27.0	41.3
Alluvium	38.9	42.3

The degree of trash decomposition at the turning point. The information presented in Table IV shows that the amount of trash carbon mineralised at the time of maximum N immobilization varies considerably within the range of Sugar Belt soils examined. It would appear that generally the more fertile soils of somewhat heavier texture are able to decompose larger amounts of trash, and are thus characterised at the turning point by low C/N ratios in the remaining organic material. The sandier soils of lower fertility decompose far less trash before the turning point is reached, leaving a residue with a higher C/N ratio. In this latter group of soils in the presence of N fertilizer, the cycling of N immobilized during nitrogen turnover is apparently quite rapid, and under these conditions cane should be able to utilize the mineral N released after comparatively short periods.

Soil acidity has been shown to influence the degree of decomposition[8, 15], as it affects the scale of microbiological activity in a particular soil. This probably accounts for the low turnover occurring in the mistbelt soil (Inanda series), which is known to contain large amounts of undecomposed material inert to microbial attack which accumulates under moist, acid field conditions[16].

Trash decomposition in the Recent sand (Clansthal series). The comparatively rapid cycling in this soil of N immobilized when trash was added in the absence of fertilizer N was noted earlier. On closer examination it was found that this was associated with the greatest percentage trash decomposition (46.7), occurring during the incubation period, in any of the soils, even where N was added in the presence of trash. This points to an extremely high degree of microbiological activity in these coastal sands and helps to explain the rapid disappearance of trash from them under field conditions. The additional N released by this rapid breakdown process may also partially explain the somewhat indifferent response given by cane to high applications of fertilizer N on this relatively infertile soil.

II. The Effect of Trash on Nitrogen uptake by Sugarcane

Introduction

Part I of this paper showed that immobilization of available N occurs when trash, which has a low N content, is incorporated with the soil. It also demonstrated that the addition of fertilizer N to soils containing trash helps to overcome the depression of available N and hastens the process of decomposition. Although immobilization does not result in a direct loss of N from the soil it is obviously able to compete with plant uptake, and in the case of young cane which apparently requires most of its N during the first few months of growth[3], competition of this type could seriously affect N uptake on certain soils, and if severe ultimately influence yield.

In order to investigate this aspect of cane nutrition the following greenhouse experiment was undertaken.

Procedure

1,500 g. air dry samples of two soil series (Cartref and Clansthal sands) and 1,200 g. samples of a third (Shortlands clay), representing between them a quarter of the acreage of the Industry, were weighed into polystyrene pots, and six replicates of each treated as follows:

TABLE IV

Degree of Trash Decomposition at the Turning Point

Soil Group and Series	Textural Group	pH	Days Incubation	Per cent Trash C Mineralised	C/N Ratio of Trash Residue
T.M.S. (mistbelt)—Inanda	Sandy clay	5.15	8	16.7	34.8
Recent sand—Clansthal	Sand	6.15	13	22.3	30.1
T.M.S. (ord.)—Cartref	Loamy sand	5.50	27	27.9	27.9
Granite — Glenrosa	Sandy clay loam	5.90	27	32.2	24.1
Dolerite — Shortlands	Clay	6.90	41	38.4	22.6
Dwyka tillite — Waldene	Sandy loam	5.80	41	35.0	22.5
Alluvium	Clay loam	6.20	41	36.7	20.0

TABLE V

The Effect of Trash on N Uptake by Sugarcane Grown on Three Different Soils†

Treatment	Control	0.5% Trash	*150 mg. N as $(NH_4)_2SO_4$	$(NH_4)_2SO_4$ + 0.5% Trash	*150 mg. N as Urea	Urea + 0.5% Trash
T.M.S. (ord.) — Cartref series						
	TOPS					
Yield g.	7.5	2.7	14.2	15.2	14.4	13.7
N content mg./g.	5.6	5.8	9.6	7.0	8.1	5.8
N in tops mg.	42.0	15.7	136.3	106.4	116.6	79.5
	ROOTS					
Yield g.	4.0	1.1	9.1	10.0	9.0	8.6
N content mg./g.	4.2	4.7	5.7	4.1	6.3	4.2
N in roots mg.	16.8	5.2	51.9	41.0	56.7	36.1
Total plant recovery mg. N	**58.8**	**20.9**	**188.2**	**147.4**	**173.3**	**115.6**
% Nett Recovery of fert. N	—	—	86.3	84.3	76.3	63.1
Recent sand — Clansthal series						
	TOPS					
Yield g.	8.7	2.7	12.5	17.3	13.5	15.5
N content mg./g.	6.1	9.0	11.6	6.7	10.7	6.7
N in tops mg.	53.1	24.3	145.0	115.9	144.5	103.9
	ROOTS					
Yield g.	4.5	1.7	6.9	8.9	7.3	8.1
N content mg./g.	5.7	5.7	7.0	5.3	6.5	5.7
N in roots mg.	25.7	9.7	48.3	47.2	47.5	46.2
Total plant recovery mg. N	**78.8**	**34.0**	**193.3**	**163.1**	**192.0**	**150.1**
% Nett Recovery of fert. N	—	—	76.3	86.1	75.5	77.4
Dolerite (red) — Shortlands series						
	TOPS					
Yield g.	13.7	6.3	16.5	15.1	13.9	15.2
N content mg./g.	6.3	7.5	8.8	7.3	10.3	7.0
N in tops mg.	86.3	47.3	145.2	110.2	143.2	106.4
	ROOTS					
Yield g.	4.6	1.9	7.0	4.9	5.5	5.5
N content mg./g.	5.0	5.6	6.5	5.6	7.3	4.6
N in roots mg.	23.0	10.6	45.5	27.4	40.2	25.3
Total plant recovery mg. N	**109.3**	**57.9**	**190.7**	**137.6**	**183.4**	**131.7**
% Nett Recovery of fert. N	—	—	67.8	66.4	61.8	61.5

* 120 mg. N only applied to the Dolerite as 1,200 g. soil used per pot.

† All figures are the means of three replicates.

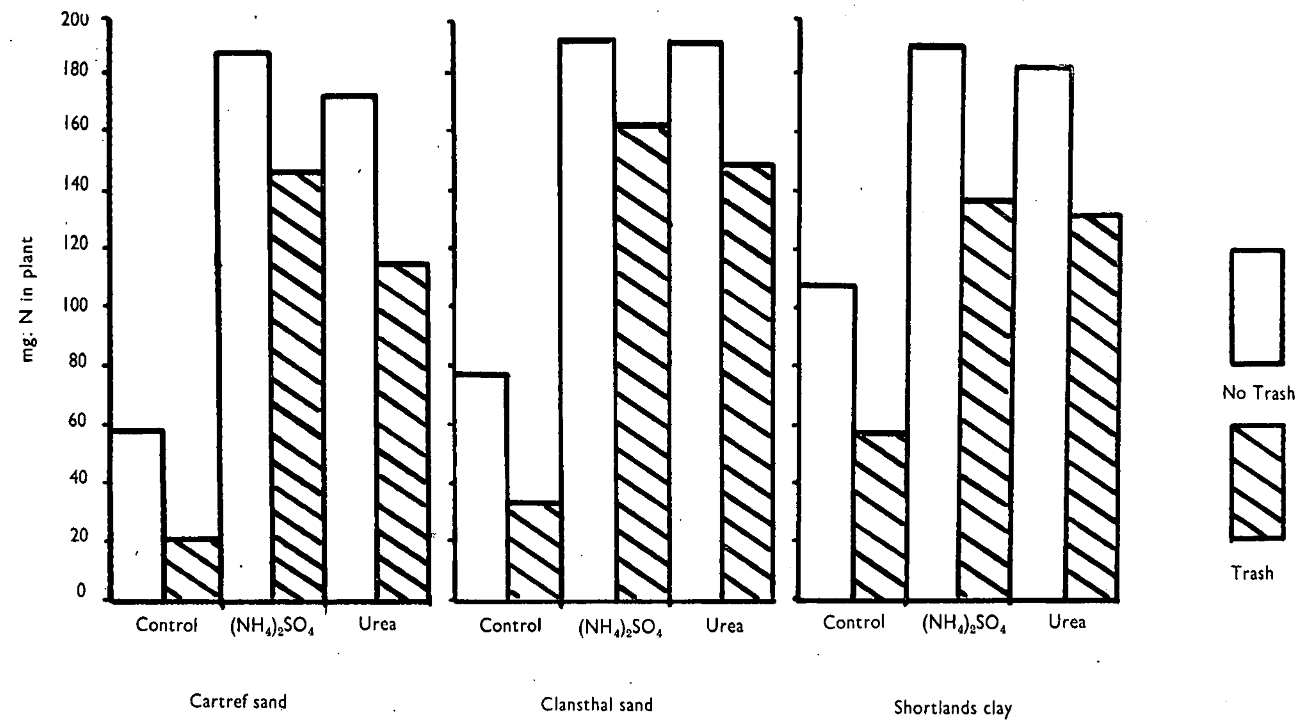

Figure 2. The effect of trash on total recovery of nitrogen by sugarcane from three soils after twelve weeks.

1. Control — no fertilizer or trash.
2. 0.5 per cent trash — 5 tons/acre equivalent.
3. 150 mg. N or *120 mg. N as $(NH_4)_2SO_4$ — 100 ppm. (200 lb. N/acre).
4. 150 mg. N or *120 mg. N as $(NH_4)_2SO_4$ + 0.5 per cent trash.
5. 150 mg. N or *120 mg. N as urea — 100 ppm. (200 lb./acre).
6. 150 mg. N or *120 mg. N as urea + 0.5 per cent trash.

* Shortlands clay only.

The trash was uniformly mixed with the soils beforehand, after which they were moistened to 50 per cent of their water holding capacity (W.H.C.) with a basic nutrient solution supplying 100 ppm. K and 80 ppm. P, plus where appropriate, $(NH_4)_2SO_4$ or urea. Solutions were applied down a perforated nylon tube, permanently situated in each pot, in an attempt to obtain even distribution of water and nutrients throughout the soil. All pots were sealed at the base to eliminate leaching losses.

The six replicates of each treatment were then split and half of them planted with previously germinated single-eyed cane setts, an inch in length and of approximately uniform weight. The remaining pots in each treatment were left unplanted.

For a period of 12 weeks all pots were weighed daily and maintained at 50 per cent W.H.C. by the addition of water down the tubes. At the end of this time all treatments were harvested. Tops were cut level with the sett, and after rapid air drying the roots were separated from the soil and washed. Both tops and roots were oven dried for 24 hours at 90° C. and then weighed, after which they were finely ground and stored prior to total N analysis. All soils were also rapidly dried and ground to pass a 1 mm. sieve before being analysed for mineral N.

Analytical details of the soils used are given in Table I.

Results and Discussion

Yield data and N uptake by cane under the different treatments for the three soils at the end of the 12-week growth period are summarised in Table V, while Figure 2 shows the effect of trash on plant recovery of N.

While yields were depressed significantly on all soils by the addition of trash to the control treatment, no significant yield differences were found where N was applied either as $(NH_4)_2SO_4$ or urea in the presence or absence of trash. Trash however significantly reduced total plant recovery of N on all treatments, although there were no significant differences in effects between control, $(NH_4)_2SO_4$, and urea. The difference in fertility status of the soils and its effect on crop available N is clearly seen in those histograms in Figure 2 showing total plant recovery of N for the control treatments in the absence or presence of trash.

Though it was not possible to assess accurately the nett recovery of fertilizer N by the plant as ^{15}N labelled fertilizers were not used, an estimate was made by subtracting the average N uptake of the unfertilized pots from the pots receiving fertilizer, but otherwise treated alike, and expressing this figure as a percentage of the fertilizer added. On this basis a somewhat variable recovery was obtained in the absence of trash, being least in the Shortlands soil (62-68 per cent) and greatest in the Cartref sand (up to 86 per cent). This suggests possible storage of N in the organic phase of the more fertile soil. These results showing massive uptake of N by cane within the first few weeks of growth confirm those of Bishop[3] and others[18]. The depressing effect of trash on percentage recovery, which might have been expected was not generally evident except where urea was added to trash in the Cartref soil. This implies fairly rapid N turnover and the utilization of much of the N released during this process.

Inorganic N status of the soils. At harvest insignificant quantities of mineral N remained in the soils from the cropped pots under all treatments, confirming the rapid uptake of N already shown. In the uncropped pots, however, much of the added fertilizer was recovered, and levels of NH_4-N and NO_3-N found after the various treatments in the three soils are given in Table VI.

Nett recoveries of N in the absence of trash ranged from 75-90 per cent, losses of N occurring due to volatilization, denitrification or other factors being kept at a reasonably low level by moistening the soils only to 50 per cent W.H.C. Recoveries reported elsewhere in a comparable investigation[5] were as low as 56 per cent on similar sandy soils. The data also shows the effect of trash in immobilizing part of the fertilizer N, though without the use of ^{15}N it was not possible to establish the size of the fraction held in the soil organic phase. Turnover would appear to be reduced in the absence of the growing plant.

TABLE VI

Mineral N Remaining in Uncropped Pots after 12 Weeks
(means of three replicates in ppm.)

Treatment	N Fraction	Soil Series		
		Cartref	Clansthal	Shortlands
Control	NH_4-N	—	1	1
	NO_3-N	5	18	93
	Min. N	5	19	94
0.5% trash	NH_4-N	1	1	2
	NO_3-N	2	13	52
	Min. N	3	14	54
$(NH_4)_2SO_4$ only	NH_4-N	55	3	1
	NO_3-N	57	89	168
	Min. N	112	92	169
$(NH_4)_2SO_4$	NH_4-N	24	1	2
+	NO_3-N	58	62	131
0.5% trash	Min. N	82	63	133
Urea only	NH_4-N	19	2	2
	NO_3-N	78	110	166
	Min. N	97	112	168
Urea	NH_4-N	2	1	1
+	NO_3-N	56	62	129
0.5% trash	Min. N	58	63	130

Conclusions

From the data reported in this paper it is clear that the presence of trash may influence to a greater or lesser extent the availability of N to the cane plant in all soils of the Sugar Belt. Where large quantities of undecomposed material are found in the soil at time of planting or are subsequently incorporated, these may provide considerable competition between soil micro-organisms and the developing plant for applied N, and fertilizer dressings on some of the less fertile soils might need to be increased to compensate for this.

When it is recalled that the N applied in the greenhouse experiment was at a high level (200 lb. N/acre), while the amount of trash added was comparatively small, (5 tons/acre) the chances of reductions in N uptake in the field are considerable. Average crop dressings range from 60-120 lbs. N/acre while up to 20 tons/acre of trash may be present. In these circumstances depression of N uptake due to trash could affect yield, especially if it is able to keep plant N supplies below the threshold value required for optimum growth. Much of course will depend on the fertility status of the soil concerned.

The data so far obtained has provided no information regarding the quantity of fertilizer N immobilized following an application, the fraction of this that is rapidly remineralised and absorbed by the plant, or the amount retained in the organic phase of the soil. Using ^{15}N labelled fertilizers it is hoped to establish more clearly the fate of fertilizer N when applied to a wide range of soils, and to accurately assess residual N effects and the importance of these in the N economy of cane.

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Summary

Incorporation of trash (10 tons/acre) into a wide range of Sugar Belt soils caused rapid immobilization of existing inorganic N supplies. Addition of $(NH_4)_2SO_4$ (200 lb. N/acre) with the trash, while stimulating decomposition provided an N surplus in all soils.

As maximum N immobilization was attained a turning point was reached in each of the soils when mineral N was once more released into the system. The time taken to reach the turning point varied from approximately 8-41 days, broadly depending on the fertility level, pH and texture of the soil.

Trash added to the Clansthal sand in the absence of fertilizer N resulted in a high degree of microbiological activity, which helps to explain its rapid disappearance from this soil under field conditions.

In a greenhouse experiment addition of trash at 5 tons/acre significantly reduced N uptake by cane on three different soils treated with $(NH_4)_2SO_4$ or urea, though no significant yield differences were found in the presence or absence of trash. Nett recovery of fertilizer N was variable ranging from 62-86 per cent in the cropped, and 75-90 per cent in the uncropped pots.

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Dr. Thompson: Mr. Wood and I disagree as to what is a small amount of trash. Ten tons of trash per acre would come from forty tons of cane, or if dry, sixty tons of cane. Nowadays probably only two or three tons of trash per acre is incorporated in the soil. During ratoons there is no incorporation, and action takes place at a mulch: soil interface. I would suggest that the raising of the C/N ratio and the immobilisation effect is therefore far less in field practice than would be found in these greenhouse trials.

Mr. R. A. Wood: My remarks were directed mainly towards nitrogen immobilisation occurring under plant cane. I have seen the topsoil in newly planted cane fields full of undecomposed plant material from the previously ploughed out cane crop.

Mr. Wilson: Even if a crop is burned there must be plenty of organic matter left in the form of stubble, roots etc.

Dr. Thompson: It would probably amount to about four tons and would occur everywhere, whether you practice trash conservation or not.

Mr. K. Alexander: Mr. Wood's paper will indicate to farmers that where they apply manures such as filter cake, which are high in carbon and low in nitrogen, immobilisation does occur and nitrogen will be needed to supplement the manure.

Dr. Matic: Referring to the previous paper on nitrification should not other factors such as temperature, soil moisture, etc. also be considered together with pH?

Mr. R. A. Wood: Of course they should, but it is impossible to examine several different parameters simultaneously in such work, and consequently optimum conditions must be provided for all the others to which you referred so that the effects of variable pH can be measured. I do not think that pH is any more important than any other factor controlling nitrification but it had to be examined in detail to provide an explanation for the set of results obtained.

Mr. Coignet: Is mechanical cultivation of ratoons justified in order to reduce immobilization of nitrogen?

Mr. R. A. Wood: Cultivation of this type through aeration and partial drying might stimulate nitrogen mineralisation and consequently reduce any immobilization effects.

Mr. Moberly: It has been said that the ammonium form of nitrogen is immobilised more easily than the nitrate form. If you are aware that your fields contain considerable organic material would it not be better to apply a fertiliser containing more nitrate than ammonium?

Mr. R. A. Wood: Although the ammonium nitrogen is preferentially utilised by the micro-organisms causing decomposition, the nitrate nitrogen will also be immobilised for this purpose once the ammonium form has been used up, so that little would be gained by applying more nitrate than ammonium fertiliser.

Mr. Landsberg: Is it not possible to find out in a field how much organic material is present and then calculate the amount of nitrogen required to satisfy the micro-organisms present?

Mr. R. A. Wood: Yes it would be possible if the average C/N ratio of the organic material were known together with the amount of nitrogen supplied by the soil during mineralisation.

Mr. Pearson: When green manure used to be used many years ago its rate of disappearance in the soil was extremely quick, so that it is quite possible that if there was any delay in planting after it was turned in there would be no response from the new crop.

Mr. R. A. Wood: This is quite possible as the green manure would have a high nitrogen content, and therefore on decomposition nitrogen would be immediately released into the soil, no immobilisation occurring.

Mr. du Toit. I agree with Dr. Thompson that there is very little incorporation of organic matter with ratoons. Before the days of the trash blanket there was mechanical cultivation in the line and it was difficult to get a response to nitrogen in ratoons. Plant cane crops benefit from nitrogen mineralisation resulting from ploughing and aeration and consequenty nitrogen responses are not as good in plant cane as in ratoons.

Trash does disappear quickly on the coastal sands but is that the cause of their lack of response to nitrogen, as there should be quick immobilisation?

Mr. R. A. Wood: Yes, there is rapid immobilisation but subsequent release of nitrogen is also far more rapid than in other soils even in the absence of added nitrogen. I think that nitrogen released in this way could be utilised fairly soon by plant cane so reducing the response to fertiliser nitrogen.