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Value of cane trash in nitrogen nutrition of sugarcane

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Abstract

The significance of trash containing 0.3 to 0.5% N in the N nutrition of sugarcane (*Saccharum hybrid* sp.) was investigated in pot- and field experiments using ^{15}N-labelled trash. The data obtained from the pot study with 2 silty-clay loams (a Humic Nitosol and a Humic Acrisol) showed that surface-applied trash (10 tonnes/ha), although ground to pass a 1-mm sieve, contributed less than 10% of N removed by sugarcane. Uptake of trash N was most active during the initial 6 months of the experiment though at the end of the study period of 18 months less than 15% of trash N was altogether recovered by sugarcane.

In the absence of fertilizer N in a field study on the Humic Acrisol (C/N ratio 22), unground trash (5 tonnes. ha^{-1}) depressed soil N uptake by sugarcane by immobilizing available soil N. The field study moreover confirmed that the contribution of trash N in the supply of N to sugarcane is negligible. The value of trash would reside in its capacity to increase over the long term the organic matter level in the soils.

Introduction

Sugarcane (*Saccharum hybrid* sp.) produces an average of 10 tonnes trash ha^{-1} (Deville, 1979). A common management practice in Mauritius and elsewhere (Humbert, 1968) is to stack the trash as a surface mulch in the interrows of sugarcane. This trash contains 0.3 to 0.5% N in an initially unavailable state for plant uptake. However with the combination of high temperature and rainfall in the humid tropics favoring rapid decomposition of organic materials (Cornforth and Davis, 1968; Vallis, 1983) the trash is a source of N which may contribute significantly towards the N requirements of the subsequent crop. In sugarcane cultivation, the importance of knowing as accurately as possible the N needs of the crop is underlined by the fact that an excess of N is not only wasteful but also depresses the sucrose content of sugarcane (Humbert, 1968; Laksmikantham, 1974).

The present study using ^{15}N-labelled trash in a pot and in a field experiments, was therefore initiated to determine the significance of trash N mineralization in the N nutrition of sugarcane. The knowledge gained is expected to allow the dose of the increasingly expensive fertilizer N to be adjusted for the most profitable sugar yield.

Materials and methods

Pot experiment

The top 30-cm of 2 soils commonly occurring in Mauritius were used. They were, by FAO/UNESCO classification, a Humic Nitosol formed in an area (Réduit) receiving 1550 mm rain annually and a Humic Acrisol developed at Belle Rive under an average rainfall regime of 3700 mm/year. Though both soils are silty-clay loams they differ in organic matter content; thus while the Humic Nitosol has 3.4% organic matter, 0.17% N, and a C/N ratio 12, the corresponding values for the Humic Acrisol were 5.6%, 0.15% and 22, respectively.

After packing 4.5 kg air dry soil in polyvinyl chloride columns (30 cm high × 15 cm diameter), one-eye sugarcane cuttings of variety M 13/56, germinated on moist sawdust, were planted. Adequate amounts of Si (500 kg $CaSiO_3$/ha in Humic Acrisol only), P (600 kg triplesuperphosphate/ha) and K (475 kg KCl/ha) were also applied. Each soil was then subjected to the following 3 treatments replicated 9 times:

(i) ^{15}N-labelled $(NH_4)_2SO_4$ only,
(ii) ^{15}N-labelled $(NH_4)_2SO_4$ with the equivalent of 10 tonnes unlabelled trash/ha, and
(iii) Unlabelled $(NH_4)_2SO_4$ with the equivalent of 10 tonnes ^{15}N-labelled trash/ha.

In all treatments $(NH_4)_2SO_4$ supplied the equivalent of 100 kg N ha^{-1}. The ^{15}N-labelled $(NH_4)_2SO_4$ contained 2.79% atom excess ^{15}N. On the other hand, the ^{15}N-labelled trash, obtained from a field experiment where sugarcane had been fertilized with $(NH_4)_2SO_4$ labelled with 17.6% atom excess ^{15}N, was enriched with 3.09% atom excess ^{15}N. The trash which had 0.39% N and a C/N ratio of 128 was ground to pass a 1-mm sieve before being surface-banded together with the $(NH_4)_2SO_4$. On account of the different rainfall regimes under which they were formed the 2 soils did not receive the same water treatments during the study period of 18 months. Thus the Humic Nitosol was subjected to the average rainfall prevailing at Réduit from 1976 to 1980 while the Humic Acrisol received the average moisture regime of Belle Rive for the same period (Fig. 1).

Six and 18 months after fertilization the sugarcane in each column was trimmed at the soil surface, dried at 90°C for dry matter yield and total N determinations. At the end of the 18-month period, the columns were also destroyed for soil sampling. In so doing the roots were carefully removed by hand, washed and included with the aboveground plant materials. Total N in soils were determined using the method of Bremner (1965) and the $^{15}N/^{14}N$ ratio of soil and plant samples was measured on a NO1–5 emission spectro-photometer. Organic matter, the cation-and anion-exchange capacities (CEC and AEC) of the soils were determined as described by Metson (1956) and Gillman (1979), respectively.

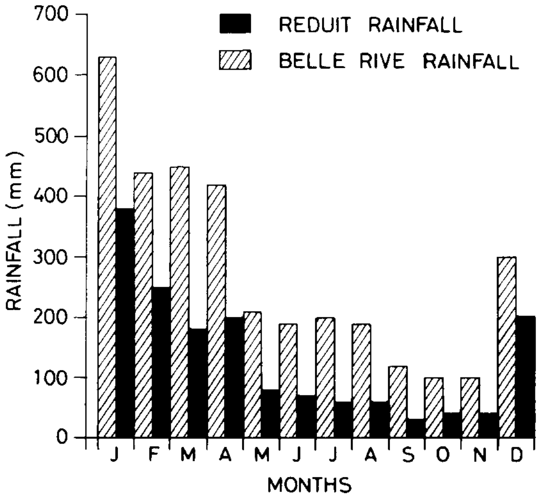

Fig. 1. Average (1976 to 1980) rainfall prevailing at Réduit and Belle Rive and applied to soils used in pot study.

Field experiment

Decomposition of crop residues low in N are often accelerated upon application of N fertilizers (Smith and Douglas, 1971). A field study was therefore designed to provide information on the effect of trash on soil-N availability and on the influence of fertilizer N on the mineralization of trash N. To attain these objectives, 8 small plots (300 cm long × 150 cm wide) were set up and enclosed with galvanized iron sheets (45 cm deep) in September 1981 in the Humic Acrisol at Belle Rive. In the middle of each plot a single row of sugarcane (variety M 574/62) was planted. The 8 plots then received the following 4 treatments replicated twice:

(i) Control (no trash, no N fertilizer), (ii) 5 tonnes trash/ha, (iii) 5 tonnes trash/ha + 225 kg N/ha, and (iv) 5 tonnes trash/ha + 450 kg N/ha.

Although, as reviewed by Heilman (1975), additions of non-N fertilizer salts such as KCl may trigger the release of N in soil, N was applied in the form of complete 17-8-25 fertilizer in order not to unbalance the NPK nutrition of sugarcane. The trash contained 3.64% atom excess ^{15}N and was not ground prior to surface-banding along the sugarcane rows. Twelve and 24 months after trash and N fertilizer application, sugarcane in each plot was harvested for dry matter yield and total N uptake determinations. The $^{15}N/^{14}N$ ratio in the sugarcane was measured on the NO1–5 emission spectrometer.

Results and discussion

Uptake of trash N by sugarcane

The data obtained from the pot experiment showed less than 10% N taken up by sugarcane to be derived from the trash (Table 1). This low contribution of trash to the N requirements of sugarcane is consistent with reports that crop residues had little influence on the N economy of the system (Myers, 1983; Azam *et al.*, 1985). The fact that trash played a less important role than soil in satisfying the N requirement of sugarcane cannot be ascribed to a poorer availability of trash N than of soil N. On the contrary, considering that the soil-N pool (≥ 3000 kg N/ha) by far exceeded trash N (39 kg N/ha) the latter had on the whole been relatively more available to sugarcane than soil N. The minor influence of trash N in the N nutrition of sugarcane, when compared to soil N, was related to the small size of its N pool.

However, as expected, the availability of trash N could not equal that of fertilizer N. Thus at the end of the 18-month pot study more than 45% fertilizer N as opposed to less than 10% of trash N had been utilized by sugarcane (Table 1). This value of trash-N utilization obtained in the pot experiment would in fact represent an upper limit of trash-N use by sugarcane because management of trash in the field does not involve any prior grinding to increase contact with the soil. Consequently under actual field conditions, it is to be expected that trash would not possess any significant value as a N source to sugarcane. In fact the results obtained from the field study showed that the ^{15}N enrichment of sugarcane receiving ^{15}N-labelled trash, with or without N fertilizer as 17-8-25, could not be differentiated from the ^{15}N natural abundance by the NO1–5 emission spectrophotometer. This indicates that even the high rate of N (450 kg N/ha) contained in the 17-8-25 fertilizer would not have any measurable influence on the extent of trash N release.

Uptake of trash N, similar to soil-and fertilizer-N uptake by sugarcane, occurred most actively during the initial 6 months in the pot experiment (Table 1). This is consistent with observations of N mineralization from crop residues noted elsewhere (Cochran *et al.*, 1980; Wagger *et al.*, 1985) and may be attributed to the rapid disappearance of the easily decomposable carbohydrates in trash (Herman *et al.*, 1977). Furthermore, the fact that only a minor fraction of trash N was recovered by sugarcane (Table 1) may be explained by the presence in trash of a great proportion of plant constituents such as lignin resistant to microbial degradation. In this context more than 73% of trash N was recovered in the soils at the end of the 18-month study period (Table 2).

Table 1. Contribution of trash, fertilizer ammonium sulphate and soil to N uptake (kg N. ha^{-1}) by sugarcane 6 and 18 months after planting in pot

Soil and N sources	No trash applied		With 10 tonnes trash/ha	
	6 months	18 months	6 months	18 months
Humic Acrisol				
$(NH_4)_2SO_4$	56.8 ± 6.8	64.7 ± 7.5	48.7 ± 8.8	55.0 ± 7.9
Soil	17.2 ± 2.8	21.1 ± 2.8	19.1 ± 4.2	24.4 ± 4.0
Trash	–	–	4.0 ± 0.5	5.0 ± 0.6
Humic Nitosol				
$(NH_4)_2SO_4$	42.5 ± 5.0	47.2 ± 6.7	47.3 ± 5.1	54.5 ± 3.6
Soil	14.0 ± 1.9	23.1 ± 2.3	17.9 ± 2.8	28.3 ± 2.9
Trash	–	–	3.4 ± 0.5	6.3 ± 1.0

Influence of trash on fate of fertilizer N

Crop residues with C/N ratio wider than 20 are known to immobilize available N (Smith and Douglas, 1971; White, 1984). Consequently fertilizer N immobilized and therefore recovered in both soils was significantly larger in the presence of trash (C/N ratio 128) than in its absence (Table 2).

Table 2. Fate of fertilizer N and trash N at the end of an 18-month pot study with sugarcane

Soil and fate of N	Fertilizer N		Trash N
	Absence of trash	With 10 tonnes trash/ha	
Humic Acrisol			
% recovered by plant	64.7 ± 7.5	55.0 ± 7.9	10.6 ± 1.4
% in soil	13.4 ± 1.5	24.4 ± 4.0	83.8 ± 10.4
% unaccounted for	21.9 ± 5.9	20.6 ± 4.9	5.6 ± 5.8
Humic Nitosol			
% recovered by plant	47.2 ± 6.7	54.5 ± 3.6	13.3 ± 2.1
% in soil	21.5 ± 2.2	28.8 ± 2.9	73.1 ± 4.2
% unaccounted for	31.3 ± 8.4	16.7 ± 4.8	13.6 ± 6.8

As a result of enhanced immobilization of fertilizer N due to trash application, uptake of fertilizer N by sugarcane tended to be reduced in the Humic Acrisol (C/N ratio 22) though the reductions were within the limits of standard deviation (SD) observed. In the Humic Nitosol this negative influence of trash on fertilizer N uptake by sugarcane was not observed because by immobilizing fertilizer N, trash also reduced its losses (unaccounted-for fraction) from the system (Table 2). Thereafter with a C/N ratio of 12 which would favour mineralization processes (Cochran *et al.*, 1980), at least a fraction of the conserved fertilizer N in the Humic Nitosol was apparently released for uptake by sugarcane.

A significant reduction in the uptake of soil N by sugarcane due to trash application was also noted in the field study where in the absence of both trash and fertilizer N, 84.9 ± 5.5 kg N. ha^{-1} were removed by sugarcane from the Humic Acrisol over a study period of 2 years. Application of 5 tonnes trash. ha^{-1} with no added fertilizer N led to the uptake of only 69.8 ± 7.8 kgN. ha^{-1}. This field observation of negative priming effect is in agreement with findings of Parker (1962), for instance, who reported that corn grown in the presence of cornstalk residue but without fertilization contained less N than plants grown with no residue and no N fertilization.

Immobilization of available soil N by trash was not evident in the pot experiment. On the contrary, the latter study showed that more soil N was removed by sugarcane in the presence of trash than in its absence (Table 1). The increase in soil N uptake was however within the limits of the SD and occurred during the initial 6 months when decomposition of the easily degradable carbohydrates was taking place. The observed increases in soil-N uptake shown in Table 1, may be attributed to the participation of the released carbohydrate-N in a pool substitution process leading to an apparent added nitrogen interaction (Jenkinson *et al.*, 1985). In this context mineralized trash N could have taken the place of soil N in immobilization reactions occurring continuously in the soil thereby allowing more soil N to be recovered by the sugarcane.

Table 3. Influence of trash (10 tonnes/ha) on selected properties of the Humic Acrisol and Humic Nitosol at the end of 18-month pot experiment with sugarcane

Parameter	Humic Acrisol		Humic Nitosol	
	No trash	Trash	No trash	Trash
% N	0.14	0.16	0.18	0.19
% organic matter	5.5	6.7	3.2	3.8
C/N ratio	22.0	24.3	10.2	11.6
CEC (me/100 g)	4.1	4.2	4.4	4.9
AEC (me/100 g)	0.7	0.6	1.1	1.0

Conclusions

The present study showed that trash delivers a negligible amount of N to immediately following sugarcane crops. In the absence of fertilizer N, it may even depress the availability of native soil N. The positive value of trash lies in its capacity to minimize in some instances N losses from the soil and to increase organic matter level (Table 3) so that over the long term the physical conditions and the ability of the soils to retain nutrient cations are improved.

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