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SHORT COMMUNICATION

MINERAL NITROGEN CONTENTS IN CANE-CROPPED VERTISOLS OF SUDAN AND GUADELOUPE AS INFLUENCED BY UREA APPLICATION MANAGEMENT

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Abstract

To obtain high yields in sugarcane, there must be adequate mineral nitrogen (N) in the rooting zone of the crop. The effects of two methods of urea application management on soil mineral N levels in ratoon cane at two sites were measured and compared. Both experiment sites were on vertisols and received different irrigation practice. In Sudan (site S) cane is grown under furrow irrigation, and urea is broadcast and then buried on the rows by hilling up. In Guadeloupe (site G) cane is grown rainfed with complementary drip irrigation, and urea is broadcast on and near the cane rows.

Site G results showed that, one week after urea application, all applied N was recovered in the topsoil. At site S, however, only 70% N was recovered. The results also revealed that at site S, where yield was higher, the amount of mineral N in the topsoil was at a higher level than the pre-application amount for a far longer period than at site G.

Of the application methods tested, the best commercial practice to extend the time that mineral N is at an adequate level in the rooting zone, and thus enhancing cane yield, appears to be hilling-up of the cane rows after broadcasting the urea.

Keywords: sugarcane, nitrogen, urea, fertiliser, hilling-up, broadcasting, vertisol, irrigation

Introduction

Sugarcane, as all high yielding C4 crops, requires a consistent supply of nitrogen (N) from tillering to full canopy stage (Fauconnier, 1991). For a yield level of 100 tonnes cane per ha, the recommended rate of N to be applied per ton of harvested ratoon cane has been variously determined as 2 kg by Calcino (1992) and Osman (1998), 1.5 kg by Fauconnier (1991) and Meyer *et al*. (2007), and only 1.2 kg by Fillols *et al.* (2007).

Urea is the source most often used to satisfy the N requirement of the cane crop. However, N losses, mainly by volatilisation when urea is broadcast, can be as high as 15-40% on the soils of Australia (Denmead *et al*., 1990), and 30-40% on the vertisols of Guadeloupe (Courtaillac *et al*., 1998). N losses by urea volatilisation can, however, be reduced by burying the N application in the soil (Calcino, 1992).

Although a number of investigations have dealt with mineral N losses in sugarcane production, few studies have considered the mineral N content within the rooting zone during crop growth, despite this N pool being of critical importance for the satisfaction of crop requirements.

The objective of this short communication is to demonstrate the impacts of two urea management practices on the mineral N pool in the soil during the growth of ratoon cane on two similar vertisols.

Materials and Methods

Location, soil, variety, treatment and irrigation

This short communication is based on studies conducted in commercial cane fields in two countries: Sudan (East Africa) and Guadeloupe (Lesser Antilles). In Sudan (site S) the study was conducted in fields of the Kenana Sugar Company, and in Guadeloupe (site G) on the lands of the Gardel sugar mill.

At both sites the soils are Eutric Vertisol. The major difference between the soils at the two sites is their total N content, being 0.097% for 0-30 cm at site S, and 0.179% at site G. At both sites, more than 80% of the cane roots were found in the top 30 cm of the soil.

The soil mineral N study at site S was conducted in two fields under variety Co6806, being respectively in ratoon 7 (R7) and in R12. The climate being hot and aridic, with ±400 mm mean annual rainfall (MAR), furrow irrigation is applied. At site G the study was conducted in a field under variety Co6415 in R6. With the climate at site G being tropical insular, with ±1 000 mm MAR, heterogeneous in and between the years, complementary irrigation is applied by drip irrigation on each cane row using a system that avoids over-irrigation.

At site S, 220 kg N/ha, equivalent to 130 mg N/kg soil between 0-30 cm depth, is broadcast as urea one month after harvesting the previous crop and is buried on the cane rows by ‘furrowing’ several centimeters deep in the interrows. At site G, urea is broadcast on and near the cane rows soon after harvest at a rate of 150 kg N/ha, equivalent to 100 mg N/kg soil between 0-30 cm depth.

Measurement of mineral N and cane yield

Soil sampling for mineral N determination was carried out by auger near and under the cane rows. Measurements of the N-NH_4 and N-NO_3 content of compound auger samples were done according to the Berthelot method (Fallavier and Egoumenides, 1975). At site G sampling was carried out on days 0, 7, 13, 21, 25 and 38 after urea application (DAUA) at depths of 0-10 and 0-30 cm, while at site S sampling continued until 180 days after urea application and was carried out at depths of 0-15 and 30-45 cm.

At site S, cane yields were recorded for the area of the commercial fields (about 50 ha). At site G, yield analysis was based on a 5x6 = 30 m linear harvested area with a row spacing of 1.6 m.

Data analysis

As sampling depths for the topsoil were different at the two sites, the original data for sites S and G were transformed such that comparison of the 0-30 cm depth level between the two sites was possible.

Cane yields from the two fields at site S were similar in the year of the field study, as were the soil mineral N contents, therefore the mean value of the mineral N data obtained from the two fields was used for comparisons between sites S and G.

Results and Discussion

Soil mineral N levels in the 0-30 cm layer recorded at both sites are shown in Table 1. Data collected after the urea application (DAUA) revealed a large increase in total mineral N at site G, mainly in the N-NH_4 form, and a somewhat smaller increase at site S. However, at site S the soil mineral N increase extended over a much longer period than at site G.

The large initial increase in total mineral N and N-NH_4 at site G, as compared to site S, may be attributed to the fact that controlled drip irrigation on the cane rows occurs at site G, and that the level of organic matter at site G is almost twice that at site S. These two factors at site G (as compared to site S) may assist in preventing N losses by volatilisation and leaching, and favour the transformation of urea (mainly to N-NH_4) in the first few days after urea application (Xi and Zhou, 2003; James, 1993; Bery *et al*., 1978). This would explain why, soon after urea application, at site G all the fertiliser N apparently contributed to the large increase in total mineral N in the top 30 cm of soil, an increase (60-10 mg N/kg x 3 dm = 150 mg N, see Table 1) that was even higher than the amount N applied (100 mg N for 30 cm of soil) due to urea. At site S the increase was less, only 95 mg N ((=(32-2)x3)), to compare with the equivalent of 130 mg N applied.

After the peak in mineral N following the urea application, its level decreased markedly between 21 and 28 DAUA at site G. In part this is probably due its incorporation in soil biomass and in the soil organic matter, the N need of cane being low in the first stage of crop growth.

Irrigation being scheduled at weekly intervals at site S and applied in long furrows (more than 500 m) may explain why the maximum increase in soil mineral N was less than the amount of urea applied.

Considering (i) that the N uptake by cane is preferably done in the NO_3^- form, (ii) the N requirements of a cane crop with a 12-month cycle has to be satisfied during the first five months (Humbert, 1968), and, (iii) that N-NO_3 was above 5 mg N/kg soil until at least 90 DAUA at site S, but only about 25 days at site G, explain the higher cane stalk yield obtained at site S (94 tc/ha) than at site G (85 tc/ha)

Conclusions

The level of mineral N, particularly N-NO_3 in the topsoil, due to urea application, was more favourable for plant growth at site S than at site G. This, and the higher cane yield obtained at site S compared to site G, suggests that the N management system used in Sudan is superior to that used in Guadeloupe.

Surprisingly, all the urea applied in the system used at site G was transformed within a few days to mineral N, mainly N-NH_4, in the top 30 cm of the soil, the main level explored by the rooting system. However, there appeared to be a significant reduction in mineral N within a few days following the N mineral peak, particularly for N-NH_4. This may explain the lower cane yield obtained at site G, as well as the fact that at site G the soil organic matter (SOM) and total mineral N content in the top 30 cm of soil was almost twice that at site S. These data suggest the need to take into account the SOM content of a vertisol when formulating recommendations for urea fertilisation.

Site S appears to be subject to loss of mineral N, derived from applied urea, by superficial drainage and denitrification. These effects reduce the efficiency of the fertiliser, and indicate the need for improved irrigation strategies as a means of improving N urea utilisation by the cane crop.

Table 1. Changes in mineral N content in the top 30 cm of soil after urea application to ratoon cane in Guadeloupe and Sudan.

DAUA*	N-NO_3 (mg/kg)	N-NH_4 (mg/kg)	N-min total (mg/kg)	NO_3 as % of N-min total	N-min increase (mg/kg)
Guadeloupe					
0	2.3	7.0	10.0	24	–
7	7.0	53.0	60.0	12	51.0
13	8.0	50.0	58.0	14	48.0
21	25.0	30.0	55.0	45	45.0
28	1.7	17.0	18.0	9	9.0
35	1.7	13.0	15.0	11	5.0
Sudan					
0	0.4	1.9	2.3	16	–
7	16.0	14.0	31.0	53	28.0
14	11.0	23.0	34.0	32	32.0
30	10.0	20.0	30.0	34	28.0
60	9.0	19.0	28.0	33	26.0
90	6.0	3.6	10.0	64	7.7
120	2.0	0.8	2.9	71	0.6
150	1.9	0.7	2.6	73	0.3
180	1.9	0.7	2.6	73	0.3

*DAUA = days after urea application

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