SHORT COMMUNICATION

NITROGEN RESPONSES AND NITROGEN USE EFFICIENCY OF FOUR SUGARCANE VARIETIES IN MPUMALANGA

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Abstract

Nitrogen recommendations for sugarcane are currently based largely on responses of variety NCo376 in the various bioclimatic regions of the industry, together with an estimate of the nitrogen (N) mineralisation potential of the soil. However, previous studies suggest that commercial varieties differ in their N use efficiency, thus indicating a need for variety-specific N recommendations (Meyer *et al*., 2007). A nitrogen response trial using varieties N19 and N32 was conducted at the Komati Research Station in Mpumalanga during the period 2001 to 2007. In 2007, a similar trial was established on the Komati farm using varieties N25 and N36. Nitrogen was applied at three rates: zero N, 50% and 100% of the Fertiliser Advisory Service (FAS) recommendation.

In the first experiment, N19 was found to be less responsive to N than N32, with there being a relatively diminished response in the case of N19 from the second to the highest N level. In contrast, in most trial years, N32 responded continuously to N up to the highest application level. These patterns of response were supported by data from N balance measurements: N32 required more N to achieve maximum sucrose yield, whereas for N19, N losses increased markedly at the highest N rate. Preliminary data from the second experiment (plant and 1st ratoon crops) suggest that N36 is more responsive to N than N25.

In these trials, yields from the zero N treatments were remarkably high, ranging from 80 to 145 tons cane/ha), and indications are that this was attributable to high N amounts mineralised from the former virgin soil and, to some extent, to high N levels in the irrigation water. Both these effects would account for the generally low responses to N fertilisation in the trials, and demonstrate the importance of accounting for all possible N sources as part of the N balance.

Keywords: nitrogen, fertiliser, varieties, responses to N, N losses, N sources, N mineralisation

Introduction

Varietial differences in N use have been demonstrated by a number of authors (e.g. Gasho *et al*., 1986; Stevenson *et al*., 1992, Robinson *et al*., 2007). In South Africa, previous work by Schumann *et al*. (1998) indicates that varieties differ in N use efficiency, and therefore have different N requirements. In particular varieties NCo376, N12 and N14 were shown to exhibit markedly different responses to N in pot trials. In order to quantify these differences for some commercial varieties under irrigated field conditions, a field trial was established in 2001 as a plant crop on a virgin site at the South African Sugarcane Research Institute (SASRI) farm at

Komati in Mpumalanga, using the varieties N19 and N32. In 2007 a trial of the same design was established on a previously cultivated site on the farm using varieties N25 and N36.

Materials and Methods

The soil at the 2007 trial site was classified as a shallow Shortlands form (±500 mm depth), containing 30% clay and 2.1% soil organic carbon. Average annual temperature (2000-2009) is 23.0°C and average annual rainfall over the same period was 569.71 mm. Nitrogen was applied at three rates: zero N, 50% and 100% of the Fertiliser Advisory Service (FAS) recommendation (plant crop = 40-80 kg N/ha, 1st ratoon = 50-100 kg N/ha, 2nd ratoon = 60-120 kg N/ha, 3rd, 4th and 5th ratoons = 70-140 kg N/ha as LAN). All treatments were replicated five times in a randomised block design. Both trials were drip irrigated and scheduled according to the My Canesim model (Singels, 2007). In addition to measurements of yield (stalk yield, sucrose) and soil parameters (complete nutrient analyses), measurements of above-ground biomass were carried out for N19 and N32 prior to harvest in 2005 and 2007, and for N25 and N36 in 2008 and 2009, with 7-10 stalks respectively per plot being separated into stalks, trash, tops and green leaves. All partitioned samples were analysed for their nutrient content (N, P and K) to calculate a nutrient balance.

Results and Discussion

The results for N19 and N32 from the first two years (2002 and 2003, plant crop and 1st ratoon) were apparently influenced by the above average soil mineral N release under the virgin site conditions. The plant crop was harvested at the age of eight months due to severe lodging, and no quality parameters were determined. Also in the 1st ratoon, both varieties showed no response to applied N, due to the high N mineralisation from the virgin soil, as previously demonstrated by Wood (1965). For the present site conditions this was confirmed by an incubation experiment involving virgin soil, which mineralised 120 kg N/ha, 40 kg N/ha more than the cultivated soil from the same site.

From the 2nd ratoon, there was a significant response to increasing N fertilisation. Figure 1 shows the average yield responses of the 2nd to 5th ratoons. Comparing sucrose yields at the highest N level, both varieties produced similar yields. On average, the four ratoons showed only a slight, non-significant advantage of 0.7 t sucrose/ha for N19 (LSD 5% = 1.5 t sucrose/ha).

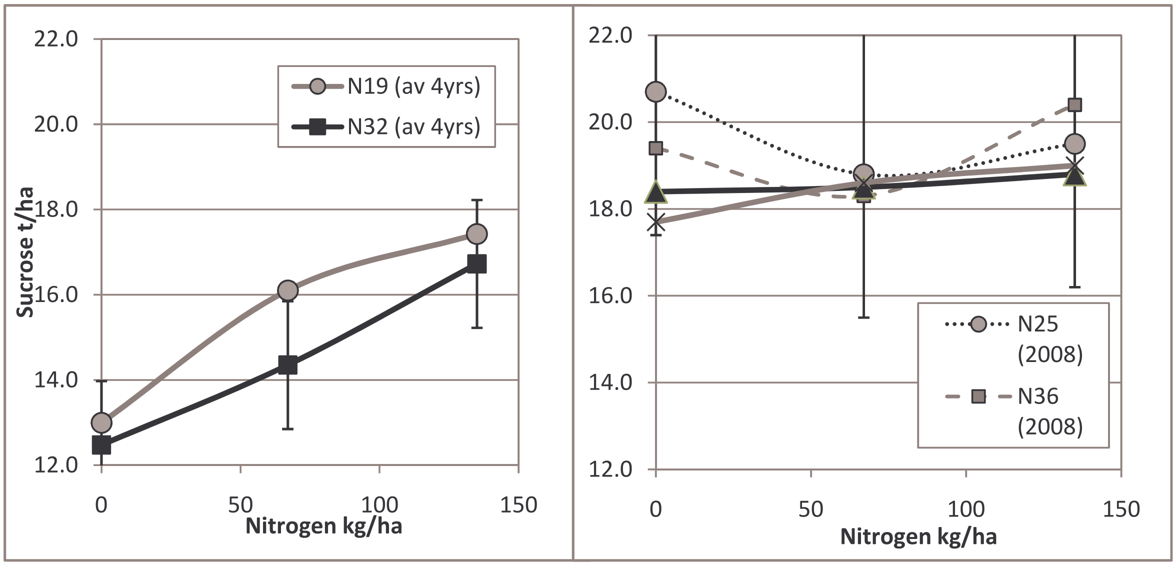

Figure 1. Yield responses (sucrose t/ha) to nitrogen of sugarcane varieties N19 and N32 (average of 2nd to 5th ratoons) and N25 and N36 plant crop and 1st ratoon.

However, N19 showed a higher yield response with less N. The yield response at this intermediate N level was 3.1 t sucrose/ha, which is equal to a relative yield increase of 24%. The yield increase for N32 at this medium level was 1.9 t sucrose/ha, which is a relative yield increase of 15%. At the highest N level, the yield response for both varieties amounted to about 33%. Variety N32 exhibits a continuous almost linear response to applied N, suggesting that the current FAS recommendation is insufficient for yield optimisation.

For N25 and N36, the experiment was started on a previously cropped field that had been under fallow for 14 months. Compared to the previous experiment, less N mineralisation from soil and a yield response to N in the earlier ratoons was expected. However, no response could be detected in the plant crop or in the 1st ratoon (Figure 1), which is probably the effect of the fallow period. The result from the 1st ratoon crop was influenced by lodging, in particular in N25. The stalk yield for N25 increased only up to the first N level (+7.1 t/ha), whereas for N36 a yield increase of 9.8 t/ha at the highest N level was measured. However, due to the lodging, the polarity and purity declined with increasing N, which again was more distinct in N25. Thus the sucrose yields show only a small, non-significant response of 0.4 t/ha for N25 and 1.3 t/ha for N36 (LSD 5% = 3.3 t/ha).

Figure 2 shows the N uptake (in kg/ha) of the above-ground biomass with increasing N fertilisation. While for N32 the N uptake increased constantly with higher N fertilisation, the N uptake of N19 declined above the medium N level. The calculation of the N balance based on these values resulted in higher N losses[1] for N19 (48 kg N/ha at the highest N level) compared to N32 (23 kg N/ha at the highest N level). Similar trends, but less distinct, can be observed for N25 and N36, with the latter showing an increased N uptake up to the highest N level, while the N uptake for N25 declined slightly after the medium N level. However, these results are preliminary and might be influenced by the lodging.

[1] Losses = output (N uptake by the crop) minus input (N fertilisation + estimated soil N-mineralisation)

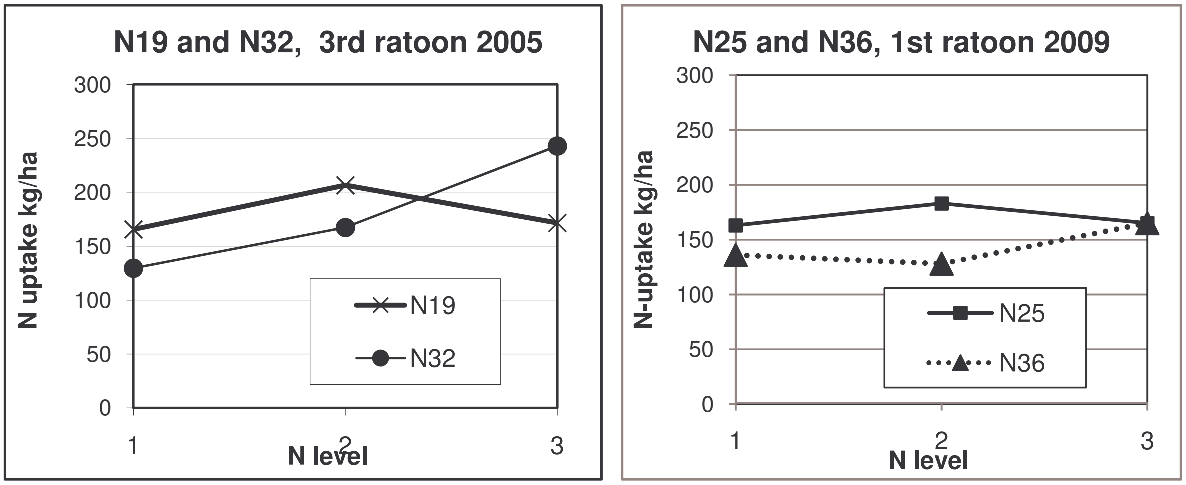

Figure 2. Nitrogen uptake (total shoot N) with increasing N levels (N19 and N32, 3rd ratoon 2005 and N25 and N36, 1st ratoon 2009).

The N uptake amounts from the zero N plots were surprisingly high, ranging in the first experiment from 85 to 166 kg N/ha. The mineralisation from soil according to its categorisation via NIR spectroscopy (Meyer *et al*., 1986) is between 60 and 80 kg/ha, and year, which was confirmed by an incubation trial. Other possible N sources, such as atmospheric N deposition and mineral N content in irrigation water are being investigated at present. First measurements show that the nitrate concentration in the dam water used for irrigation increases drastically in the dry winter period. Further measurements will be necessary to determine the amount over one full growing season.

Conclusions

It can be concluded from the findings above that FAS N fertiliser recommendations should be reduced for soils being cultivated for the first time. For the shallow Shortlands soil, the reduction could be about 30%, which was confirmed by results from N mineralisation during an incubation experiment.

Comparing varieties, N use efficiency is higher for N19 with high yields at low N levels, with little benefit from further N treatment. Variety N32, on the other hand, shows a yield benefit up to the highest N level, suggesting that the current FAS recommendation is insufficient for this variety. This confirms the necessity of variety-specific N recommendations.

The high N uptake from the plots without N fertilisation indicates that there is a need to check for all available N sources. This work will be expanded with another three experiments at three different sites with a total of 15 commercial varieties.

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