RESPONSE OF DIFFERENT SUGARCANE VARIETIES TO GREATER THAN NORMAL APPLICATIONS OF NITROGEN

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Abstract

In addition to normal fertiliser applications, nitrogen was applied at intervals during the growth cycle of three cane varieties. Its effect on yield and quality and the uptake of nutrients was determined. In general the treatments resulted in increased uptake of nutrients and increased yield, but decreased quality. However, with an imported variety, bred in exceptionally fertile conditions, the increased fertilisation resulted in a considerable increase in yield, with little decline in quality.

Introduction

Two physiological factors which probably limit yield of sugarcane are exceptionally slow early growth, hence slow expansion of leaf area, which results in much radiation falling on bare ground at the beginning of the growth period (Allison and Haslam, 1982), and low leaf nutrient content (particularly nitrogen) towards the end of the life cycle (Meyer, 1981, Haslam and Allison, 1985), which may limit rate of photosynthesis.

Most of the nutrients accumulated by the above-ground parts of the plant are taken up during the first six months in a crop harvested at 12 months (Haslam and Allison, 1985, Thompson, 1988). Fertiliser is normally all applied at or shortly after the beginning of the growth period. Hence it is not clear whether nutrients are taken up slowly after the first few months of growth because they are in short supply in the soil, or because the 'requirement' of the plant decreases with time.

Current recommended fertiliser practices in South Africa are based on extensive trial work with major cane varieties. If considerably greater than recommended amounts of nitrogen are applied cane yield may sometimes increase, but quality will most probably be unacceptable, and sugar yield is unlikely to increase much and may even fall.

The results reported here are from a preliminary study to assess the scope for increasing yield potential by breeding in conditions of increased fertility. Yield and quality of two locally bred varieties (NCo376 and N14) and a foreign variety, bred in a region with exceptionally fertile soil (CP66/1043), were measured with both standard and increased fertilisation.

Procedure

Trial 1:

Use was made of a plot of first ratoon sugarcane, variety NCo376, at Pongola, to conduct a preliminary observation trial.

The plot, which had been harvested in September 1988, and had received a standard application of fertiliser (120 kg N, 120 kg K/ha), was divided into three parts, each with 12 rows spaced at 1,4 m and 5 m in length. Part 1 received no further fertiliser (control); part 2 received six applications of 55 kg N/ha, 11 kg P/ha and 55 kg K/ha monthly between two and seven months after the start of growth, the nutrients being applied to the soil; part 3 also received these quantities of fertiliser applied to the soil on the first three occasions, and then 14 weekly foliar applications of approximately 300 l/ha of 1,0% N, 0,1% P and 1,3% K solution, together with a spreader, until seven-and-a-half months after the start of growth. The foliar application treatment was included in case fertiliser applied late in the growth period would be taken up more readily by leaves than through roots.

At nine months of age the above-ground plant material was harvested from four 1 metre lengths of row in rows 3, 5, 7 and 9 in each of the three parts into which the original plot had been divided, making 12 samples altogether. Each sample was measured for weight and milling quality of cane, and of dry weight and N, P and K content of green leaf, trash (withered leaf) and stalk.

Trial 2:

Plots of varieties N14 and CP66/1043 were established in four replicates at Pongola in October 1990. The plots consisted of 12 rows, 8 m in length, spaced at 1,4 m. Standard fertiliser (80 kg N, 30 kg P, 200 kg K/ha) was applied to the whole of each plot. Half of each plot (6 rows) also received 150 kg N/ha at 3 and 12 weeks, and 100 kg N/ha at 22 and 30 weeks after planting. The trial was fully irrigated, the normal practice at Pongola.

Leaf samples for nutrient analyses were collected on four occasions, including one at harvest, 10 months after planting, when nutrient contents of stalks were also determined; net plot size was 4 rows x 6 m per half-plot.

Trial 3:

A trial, similar in design to that at Pongola, was established at Shakaskraal in December 1990, but here the varieties were NCo376 and CP66/1043. Whole plots received a standard application of fertiliser (140 kg N, 140 kg K/ha); half of each plot also had approximately 40 tons of filtercake (containing about 200 kg N/ha) incorporated in the soil immediately before planting; these half-plots also received 150 kg N/ha at 18 weeks and 80 kg N/ha at 34 weeks after planting.

Leaf samples for nutrient analysis were collected on three occasions during the growth period; and at harvest, at 12 months, nutrient contents of leaves and stalks were determined. The trial was not irrigated; total rainfall during the life of the crop was 1 058 mm, and some water stress must have occurred.

Results and Discussion

Trial 1:

The significance of differences in the attributes measured in this (observation) trial cannot be tested because treatments were not replicated. Seemingly, the application of nutrients at intervals during the growth period, whether to the soil or to the leaves, resulted in an increase of almost 20% in cane yield (Table 1) and a somewhat smaller increase in the total dry matter produced (Table 2). Cane quality was, however, depressed by repeated application of nutrients, and yield of estimated recoverable sugar (ers) was not increased by extended fertilisation (Table 1). Such a result was expected, considering that the variety NCo376 is adapted to standard fertiliser practice, and that the crop had been harvested younger than normal under irrigation (9 rather than 12 months).

Table 1

Yield and quality with standard fertiliser or repeated applications of N, P and K applied either to the soil or the leaves (Trial 1, Pongola)

Treatment	Fertilizer applied kg/ha N	P	K	Cane t/ha	DM % cane	Brix % cane	Purity %	Pol % cane	ers t/ha
Standard	120	0	120	145	20,3	11,7	72	8,4	9,2
+ N P K soil	450	66	450	180	20,4	11,5	68	7,8	10,0
+ N P K leaves	325	37	340	169	19,6	11,1	66	7,3	8,6

Contents of P and K per cent of dry weight of the parts of the plant at harvest were similar, with and without the extended application of fertiliser (Table 2); small differences in the quantities of these nutrients in the parts of the plant largely reflected differences in dry weight. Apparently, however, substantially increased quantities of N were taken up by plants subjected to extended fertilisation. Most of this N found its way into the stem, though some reached or remained in the leaves. The resulting increased N content per cent of dry weight of the leaves could have resulted in increased photosynthetic efficiency (Ludlow *et al.*, 1991), and so been responsible for the apparently greater production of dry matter with extended fertilisation. The increased production of dry matter is unlikely to have been due to greater interception of light, because it seemed clear from observation (no measurements were made) that interception of light was about complete in all cases.

Table 2

Dry matter production and nutrient composition with standard and extra fertiliser applied to soil or leaves (Trial 1, Pongola)

		Dry weight t/ha	N %	N gm^{-2}	P %	P gm^{-2}	K %	K gm^{-2}
Standard	Trash	8,0	0,41	3,3	0,02	0,16	0,35	2,8
	Leaves	7,5	0,92	6,9	0,13	0,99	2,20	16,0
	Stem	29,4	0,29	8,6	0,06	1,76	1,31	38,6
	Total	44,9	0,42	18,8	0,06	2,91	1,28	57,4
+ N P K Soil	Trash	9,8	0,42	4,1	0,03	0,29	0,33	3,3
	Leaves	8,8	1,08	9,5	0,13	1,15	2,24	19,8
	Stem	36,7	0,51	18,6	0,05	1,94	1,18	43,5
	Total	55,3	0,58	32,2	0,06	3,38	1,20	66,6
+ N P K Leaves	Trash	10,3	0,40	5,8	0,03	0,34	0,40	4,1
	Leaves	7,2	1,09	7,9	0,14	0,98	2,21	16,4
	Stem	33,3	0,45	14,9	0,06	2,00	1,10	34,7
	Total	50,8	0,56	28,6	0,07	3,32	1,09	55,2

Trials 2 and 3:

Figure 1 shows both times and amounts of N applications to plots receiving extra fertiliser, and N contents of the third (diagnostic) leaf. At both sites leaf N content decreased with time, both with and without the application of N at intervals during the growth period. At Pongola the application of extra N increased leaf N content in both varieties, but by a considerably greater degree in CP66/1043 than in N14. So leaf N content of CP66/1043 was less than that of N14 with standard fertiliser, but similar to that of N14 with increased application of N. At Shakaskraal, except early in the life cycle with CP66/1043, extra fertilisation caused only comparatively small increases in leaf N content; and during the latter half of the life-cycle leaf N content was considerably less in CP66/1043 than in NCo376. With all the varieties at both sites, when extra N was applied, the total amount of N taken up increased markedly. Proportionally more of this was situated in the stem than in the leaves at harvest (Figure 2); roughly, the amount of N in the leaves was doubled and that in the stem trebled by extended N supply.

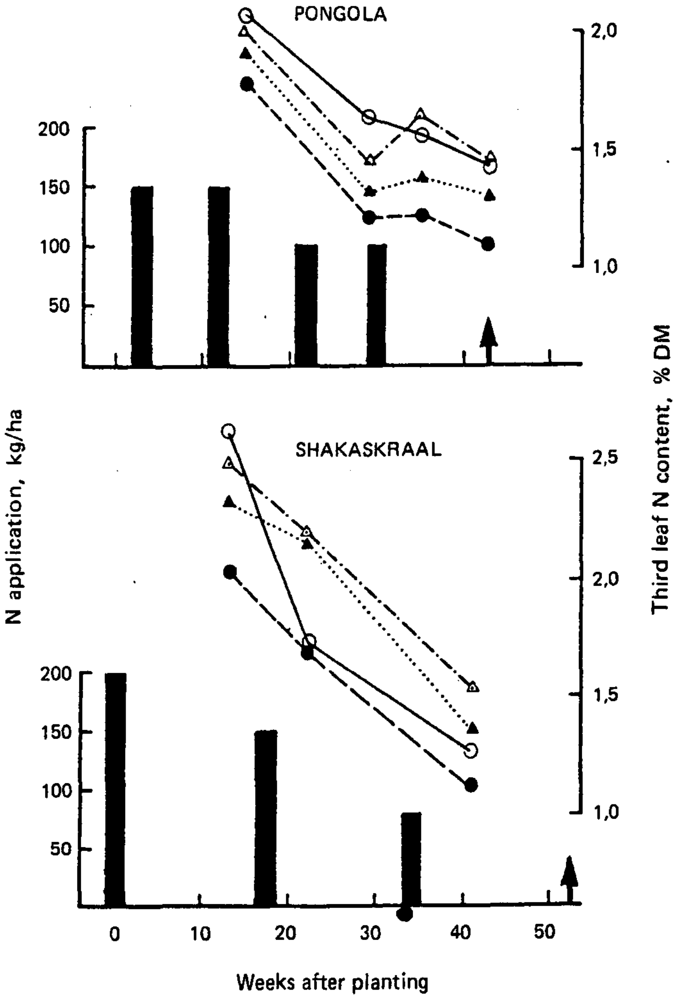

FIGURE 1 Applications of fertiliser (histograms) to plots receiving additional N, and leaf N content at intervals during growth at two sites.
○ ● CP66/1043; △ ▲ N14 at Pongola, NCo376 at Shakaskraal
Closed symbols = no additional N ↑ = time of harvest.

Extra fertilisation increased total dry matter yield at harvest, by 20 to 30% at Pongola, and from 50 to more than 60% at Shakaskraal (Table 3). The causes of these increases are uncertain. At Pongola the greater leaf N content during the latter half of the life cycle of plants receiving extra fertiliser (Figure 1) could have caused an increase in the rate of photosynthesis, though observation suggested (no measurements were made) that with CP66/1043 interception of light was also increased by extra N. At Shakaskraal extra fertilisation resulted in only modest increases in leaf N during most of the life cycle, and there the major cause of the substantial increase in dry matter with the application of extra fertiliser was probably increased interception of light by foliage; again, observation suggested that leaf area index (leaf area : land area ratio), particularly that of CP66/1043 was always too small to fully intercept solar radiation.

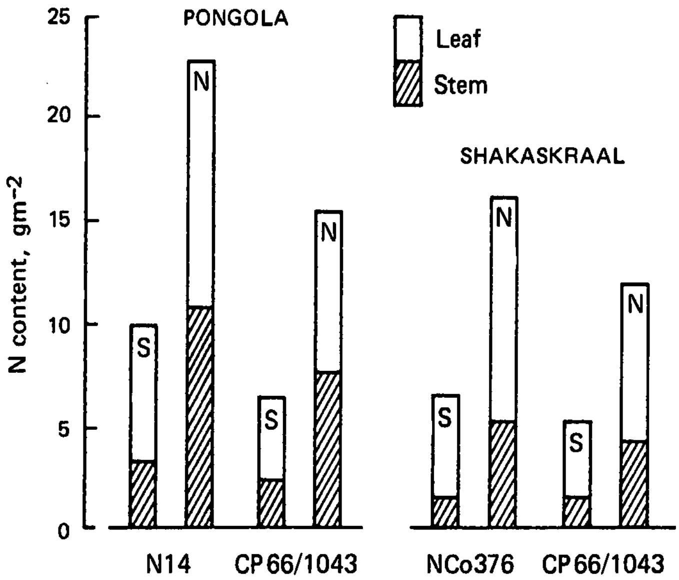

FIGURE 2 Amounts of N at harvest in green leaves and stems of varieties N14 and CP66/1043 at Pongola, and NCo376 and CP66/1043 at Shakaskraal.
S = standard fertiliser only; N = additional N applied at intervals during growth.

At Pongola the cane yield of N14 exceeded that of CP66/1043 by about 80% with both standard and increased fertilisation (Table 4). The dry matter content of the cane was, however, apparently less in N14, particularly when extra N had been applied. The soluble solids (brix) content of the dry matter was not much affected by the fertiliser regime, but seems to have been slightly greater in CP66/1043 than in N14. Purity (sucrose/soluble solids %) was greater in CP66/1043; it was appreciably depressed by extra fertilisation in N14, but hardly affected in CP66/1043. The outcome of these several effects was that the estimated recoverable sugar content of cane (ers % cane) was substantially greater in

Table 3

Dry matter yields (t/ha) of two varieties given either standard or extra fertiliser at intervals during the growth period, at Pongola and Shakaskraal (Trials 2 and 3 respectively)

Note: The crops were burnt at harvest, so trash was not harvested

	Pongola				Shakaskraal			
	N14		CP66/1043		NCo376		CP66/1043	
	Std	+ N	Std	+ N	Std	+ N	Std	+ N
Stalk	37,1	44,8	23,7	29,7	14,4	21,0	12,3	20,1
Leaves	9,5	11,2	6,1	8,3	7,0	11,3	5,1	8,8
Total	46,6	56,0	29,8	38,0	21,4	32,3	17,4	28,9
SED (Total) DF = 9	3,3				2,4			

Table 4

Yield and quality of two varieties given standard nutrition, and either no further fertiliser or N fertiliser at intervals during the growth period of 10 months (Trial 2, Pongola)

Variety	Treatment	Fertiliser applied kg/ha			Cane t/ha	DM % cane	Brix % DM	Purity %	ERS	
		N	P	K					% Cane	t/ha
N14	Standard	80	30	200	142	26,3	54	88	11,0	15,6
	+ N	580	30	200	192	23,4	57	84	9,4	18,0
CP66/1043	Standard	80	30	200	80	29,8	57	94	14,8	11,8
	+ N	580	30	200	105	28,2	59	93	14,0	14,8
LSD (P = 0,05) for N-levels within varieties					16					1,8

Table 5

Yield and quality of two varieties given standard nutrition, and either no further fertiliser or filtercake at the time of planting and N fertiliser at intervals during the growth period of 12 months (Trial 3, Shakaskraal)

Variety	Treatment	Fertiliser applied kg/ha			Cane t/ha	DM % cane	Brix % DM	Purity %	ERS	
		N	P	K					% Cane	t/ha
NCo376	Standard	140	0	140	54	26,9	48	88	9,8	5,3
	+ N	570	150	190	80	26,4	46	85	8,7	7,1
CP66/1043	Standard	140	0	140	43	28,4	53	93	12,7	5,5
	+ N	570	150	190	72	27,7	52	91	11,5	8,4
LSD (P = 0,05) for N-levels within varieties					17					2,2

CP66/1043; moreover, whilst ers % cane was only slightly depressed by extra N in CP66/1043 it was depressed to a considerably greater extent in N14. N14 produced a considerably greater recoverable sugar yield than did CP66/1043, while the increase in recoverable sugar yield from extra fertilisation was 2,4 t/ha in N14, and 3,0 t/ha in CP66/1043. This small difference (0,6 t/ha) in response between the varieties was not statistically significant, but in relative terms extra N increased the recoverable sugar yield of N14 by 15% and that of CP66/1043 by 25%.

Commercially the quality of cane in N14 in this trial would not have been acceptable, particularly when extra N was applied. In contrast, the quality of cane in CP66/1043, which was hardly depressed by extra N, was well within the acceptable range.

In the much less favourable conditions at Shakaskraal (shallow soil and no irrigation) cane yield was moderately greater in NCo376 than in CP66/1043, and it was substantially increased by extra fertilisation in both varieties (Table 5). The dry matter content of cane was seemingly greater in CP66/1043, while it was little depressed by extra fertilisation in either variety. Brix % DM and purity were greater in CP66/1043, and were depressed to only a small extent by extra fertilisation in both varieties. Recoverable sugar content, which was depressed only slightly by extra fertilisation, was considerably greater in CP66/1043. Recoverable sugar yield was increased by 1,8 t/ha in NCo376 and by 2,9 t/ha in CP66/1043 as a result of extra fertilisation. The difference by which yield increased (1,1 t/ha) was not statistically significant, although in relative terms recoverable sugar yield increased by 34% in NCo376 and 53% in CP66/1043.

Conclusions

The results suggest that increasing and extending the supply of N to the crop could appreciably increase dry matter production. In favourable conditions, where the leaf area produced is large enough to intercept incoming radiation, this would seemingly be largely by increasing photosynthetic efficiency during the latter part of the growth period. In much poorer conditions there would perhaps also be some increase in photosynthetic efficiency but probably greater dry matter production would come mainly from increased interception of light. It is also apparent that with suitable genotypes cane quality can be maintained in the face of a substantially increased supply of N. Increased dry matter production could therefore be reflected in proportionally similar increases in sugar yield. On the other hand, in the varieties studied, the extended supply of N failed to completely arrest the decline with time of leaf N content. Photosynthetic efficiency during the latter part of the life cycle was therefore probably below the maximum possible despite a greatly increased supply of N to the crop. The increased uptake of N with increased N supply was 'inefficiently' distributed, with proportionally more of the extra N apportioned to the stem. To take full advantage of more liberal and extended N supply, genotypes will be required which 'forage' effectively for the N supplied and distribute it preponderantly to developing leaves, to provide the green leaf canopy with sufficient N to maintain photosynthetic efficiency throughout the life cycle.

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