DIFFERENCES IN MAJOR LEAF NUTRIENT CONCENTRATIONS BETWEEN COMMERCIAL SUGARCANE VARIETIES IN SWAZILAND

DWF BUTLER

Swaziland Sugar Association, PO Box 367, Simunye, Swaziland

Abstract

Foliar analyses are used in the Swaziland sugar industry to monitor nutrient uptake in the young crop and to ensure that the prescribed fertiliser strategy is satisfactory. Current fertiliser recommendations are based on norms developed for variety NCo376, reflecting the widespread cultivation of this variety in the industry. Separate P and K leaf thresholds are used for variety N14.

Concentrations of N, P and K in the third fully unfurled leaves of NCo376 were compared with those of varieties N14, N19, N23, N24 and N25 in a series of replicated field trials in Swaziland. Foliar levels of K were higher in all of the newer varieties than in NCo376, while levels of N and P were lower. Most varietal differences were small and insignificant, with the exception of leaf nitrogen in N19, leaf phosphorus in N14, and leaf potassium in N14, N23 and N25. Levels of P and K were lower in N14 than in NCo376, supporting the current use of lower leaf thresholds. The results indicate that leaf K thresholds specific to N23 and N25 will be necessary when these varieties become popular. Correction factors to adjust threshold values developed for NCo376 have been proposed for varieties N19, N23 and N25 as an interim measure.

Keywords: leaf analysis, nutrient thresholds, *Saccharum* spp., varieties

Introduction

Leaf sampling is used in Swaziland to check the nutrient status of the crop, thereby monitoring fertiliser recommendations based on soil analysis. Although leaf nutrient concentrations vary considerably among different varieties grown under the same conditions (Gosnell and Long, 1971; Hellmann, 1975; Meyer, 1975; Inman-Bamber, 1984), thresholds used in Swaziland are based on those derived by the Experiment Station of the South African Sugar Association (SASEX) for variety NCo376. Separate thresholds are recommended for variety N14 for phosphorus and potassium (Wood, 1989; Donaldson *et al.*, 1990). The reason for this is that NCo376 has been the predominant sugar cane variety grown in Swaziland for some time, and N14 comprised over 30% of the industry in the early 1990's (Rostron *et al.*, 1999).

The proportion of N14 has since declined because of its agronomic limitations under Swaziland conditions, while the industry's heavy reliance on NCo376 has necessitated the introduction of newer varieties which share its reliable yield performance but are not as susceptible to sugar cane smut disease (*Ustilago scitaminea*). New varieties imported to Swaziland are tested in a series of replicated field trials, located to represent potential combinations of soil type and season of harvest as fully as possible. The primary objective of these experiments is to evaluate the yield performance of the new varieties against that of ripened NCo376. From results of these experiments, varieties N19, N23 and N25 have been identified as promising alternatives to NCo376 (Rostron *et al.*, 1999). A decline in seed cane requirements from 57% to 42% by area for NCo376 and an increase from 26% to 47% for varieties N19, N23 and N25 between 1997 and 2000 demonstrates the increasing demand for these newer varieties.

With the increasing popularity of new varieties, it may be appropriate to review leaf nutrient thresholds in order to ensure that all varieties are fertilised adequately. Leaf nutrient concentrations have been monitored in all Swaziland variety trials since their establishment. In this paper, the resulting database has been used to examine trends in the deviation of leaf nutrient contents of new varieties from the reference variety, NCo376, under common environmental and nutritional conditions. The extent and direction of differences should provide a reliable indication of the need for variety-specific leaf thresholds, and should permit derivation of correction factors for existing thresholds.

Procedure

Thirty three variety trials were established on a number of sites in the irrigated lowveld of Swaziland between 1984 and 1999. All trials were randomised blocks with between 24 and 60 plots and were continued for a plant crop and up to five ratoons. Each trial comprised between three and five varieties, which always included NCo376 as a standard. N14 was planted as a second standard in all trials established before 1989 and in one trial established in 1996. Varieties were replicated between six and 20 times, depending on the design of the trial.

Table 1. Numbers of trials, crops and samples taken for each variety.

Variety	Trials	Crops	Sampling occasions	No. of samples
N14	8	15	18	224
N19	11	26	30	359
N23	9	30	30	501
N24	7	23	23	373
N25	8	28	28	463
NCo376	23	64	69	1038

Results from crops in which NCo376 was deficient in either N, P or K were excluded from this study. Trials conducted on base-saturated soils and results from crops that may have been affected by moisture stress at the time of sampling were also excluded. Over 2,900 leaf samples were taken from 64 crops in 23 trials between November 1988 and February 2000 (Table 1).

All experiments were fully irrigated by either overhead sprinkler or surface drip irrigation systems. Rows were spaced 1.5m apart and fertiliser application was based on the results of soil samples taken after harvest, using norms derived for NCo376. Fertiliser application rates and timing were the same for all varieties in any one trial crop. Gross plot size ranged from 76.5m^2 to 135m^2 and net plot size from 39m^2 to 72m^2.

Leaf samples were taken from 40 primary stalks in each plot during the morning on one or two occasions between three and six months after planting or harvest. The third fully unfurled leaf was selected for sampling from each primary stalk. The central 300mm of each leaf was separated from the top and bottom portions and the mid ribs removed immediately after sampling. The laminae were dried and sent to the Mhlume Sugar Company Laboratory for determination of leaf nitrogen, phosphorus and potassium content.

NCo376 was the only variety against which others were compared, and only data from the same trials were used when these comparisons were made. Leaf analyses for N14 were included in this study to test for agreement of the results with current thresholds. The standard error of the analytical determination of all three elements was calculated for 24 samples analysed at the Mhlume Sugar Company Laboratory during 1999 (Mkhweli, [1] personal communication). These standard errors were compared with those for variety comparisons to indicate which varietal differences were likely to be meaningful.

The data from the trials reported in this paper also provided an opportunity to determine the physiological age-leaf nutrient content relationship for each variety. Crop physiological age was calculated for each sampling occasion and expressed as thermal time (degree days) with a base temperature of 11.5^{0}C. Thermal time was calculated from the date of the previous harvest for ratoon crops, and from the estimated date of germination for plant crops. Crops planted between October and March were estimated to take 21 days to germinate; equivalent figures were 28 days for April and September planting and 35 days for May and August planting (McGlinchey, [2] personal communication). Crop physiological age was plotted against leaf nitrogen concentration for each sampling occasion in order to test the age-nitrogen relationship for each variety (after Schumann and Meyer, 1999).

Results and Discussion

Mean leaf nutrient differences

Mean nitrogen and phosphorus concentrations were higher in NCo376 than in all the other varieties, while mean levels of potassium were lower, with the exception of N14. Differences were generally small and not statistically significant, although low standard errors showed that they were consistent (Table 2). Deviations in nutrient levels were larger than the standard error of their analytical determination in N19 (nitrogen), N14 (phosphorus and potassium) and N23 and N25 (potassium) (Figure 1), indicating that these differences are large enough to consider the development of separate leaf thresholds. Measures to account for smaller differences would be impractical because of the natural variation in the analytical methods used.

Table 2. Mean differences in leaf nutrient concentration between each variety and NCo376.

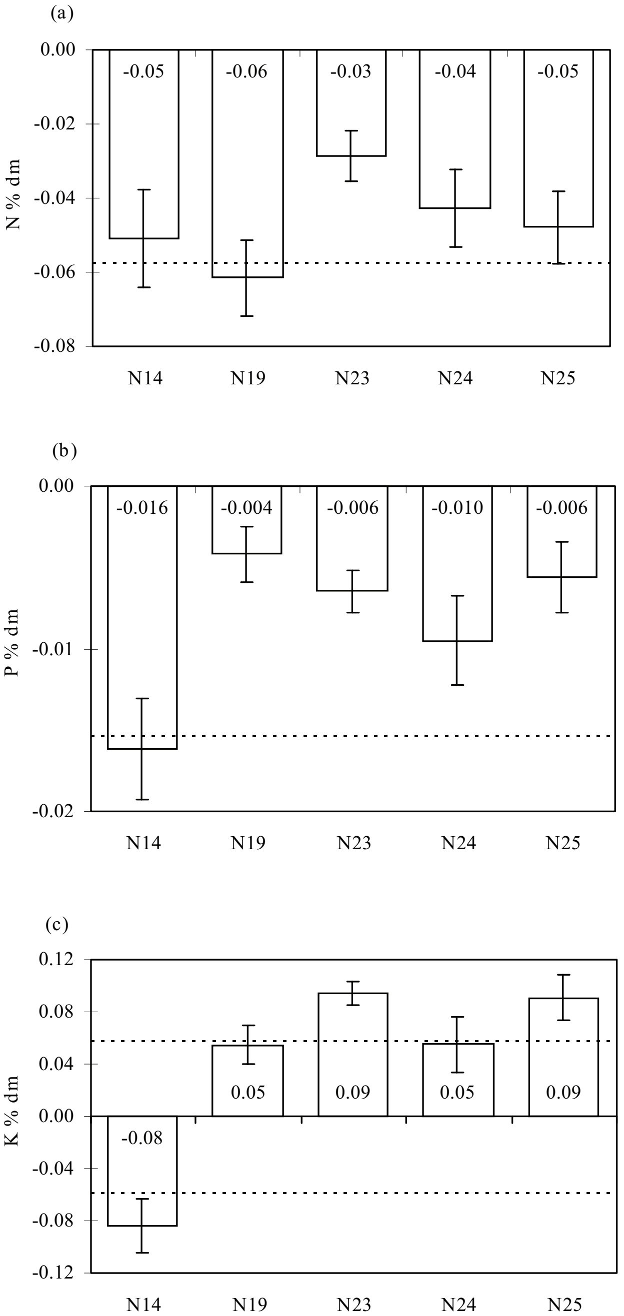
Variety	% dm	NCo376 % dm	Mean difference	se	Significance*
Nitrogen	N % dm	NCo376 N % dm			
N14	1.90	1.95	-0.05	0.011	6 (33)
N19	1.90	1.96	-0.06	0.010	14 (47)
N23	2.00	2.03	-0.03	0.007	7 (23)
N24	1.96	2.00	-0.04	0.010	4 (17)
N25	1.92	1.97	-0.05	0.010	9 (32)
Phosphorus	P % dm	NCo376 P % dm			
N14	0.21	0.22	-0.016	0.003	12 (67)
N19	0.23	0.23	-0.004	0.002	8 (27)
N23	0.24	0.25	-0.006	0.001	9 (30)
N24	0.23	0.24	-0.010	0.003	11 (48)
N25	0.23	0.23	-0.006	0.002	9 (32)
Potassium	K % dm	NCo376 K % dm			
N14	1.15	1.24	-0.08	0.020	5 (28)
N19	1.32	1.26	0.05	0.015	11 (37)
N23	1.32	1.23	0.09	0.010	16 (53)
N24	1.33	1.27	0.05	0.021	7 (30)
N25	1.33	1.24	0.09	0.018	14 (50)

*Significance indicates the number of sampling occasions on which nutrient content differed significantly between varieties and NCo376 (P=0.05). Percent of sampling occasions in brackets.

The leaf nitrogen content of N19 was equal to or lower than that of NCo376 on the majority of sampling occasions (Figure 2), while the leaf potassium content of both N23 and N25 was higher (Figure 3). Differences were more consistent for N23 than for N25. The use of NCo376 leaf thresholds for varieties with naturally high nutrient contents could lead to nutrient deficiencies being overlooked, whilst in varieties with lower contents it could lead to deficiencies being incorrectly diagnosed.

N14 leaf analyses

Differences in leaf phosphorus and nitrogen concentrations between N14 and NCo376 were slightly smaller than those reported by Inman-Bamber (1984) and Meyer ([3] personal communication). Deviations in leaf potassium concentration agreed with those reported by Inman-Bamber (1984) and Meyer (personal communication), but were smaller than those used by Donaldson *et al*. (1990) to derive lower K threshold values for N14. However, differences generally verified the current use of lower P and K threshold values for N14 and the same N threshold for both N14 and NCo376 (Schroeder *et al*., 1992; Anon, 1995), indicating that results were reliable.



------Standard error of analytical determination *

* Data provided by T.Mkhweli, Mhlume Sugar Company

Figure 1. Mean differences in leaf nutrient concentrations between varieties and NCo376, showing standard error of analytical determination. (a) Nitrogen, (b) Phosphorus and (c) Potassium. Vertical bars represent standard error of the mean for varieties.

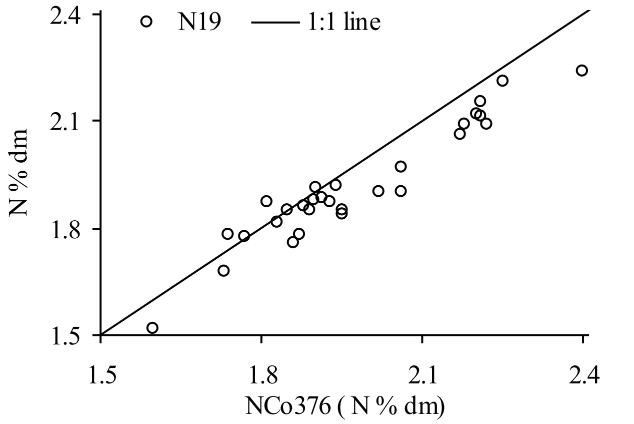


Figure 2. Comparison of leaf nitrogen concentration of N19 with leaf nitrogen concentration of NCo376 on 30 sampling occasions (N % dm).

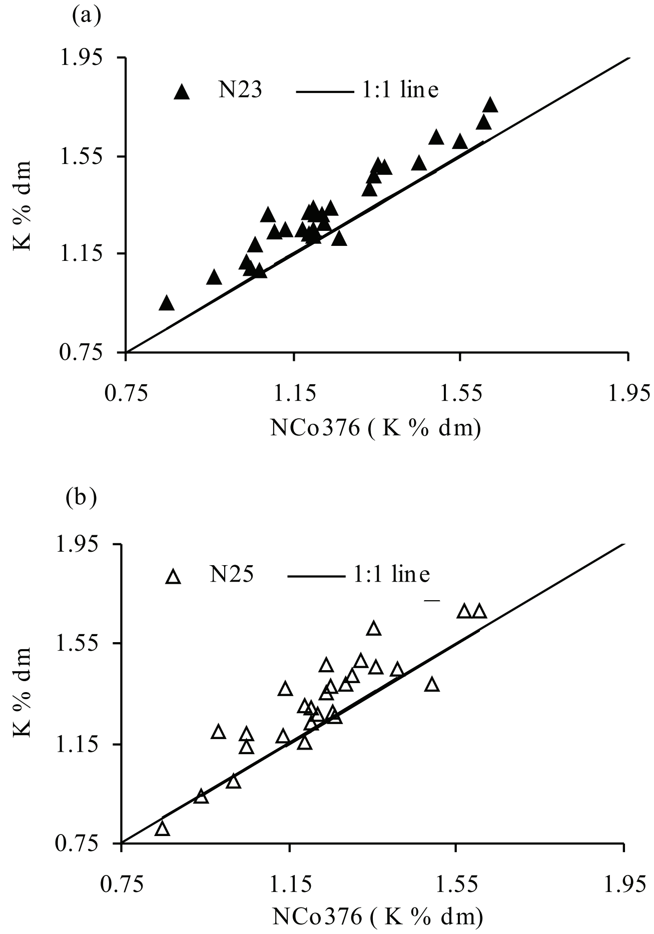


Figure 3. Comparison of leaf potassium concentration of varieties N23 and N25 with leaf potassium concentration of NCo376 (K % dm). (a) N23 on 30 sampling occasions and (b) N25 on 28 sampling occasions.

Correction factors

Varietal correction factors based on the deviation in leaf nutrient levels from the standard can be used as an interim measure until specific thresholds can be determined from the results of replicated variety x nutrition trials which have been initiated recently in both Swaziland and South Africa (Anon, 1998). Gosnell and Long (1971) applied correction factors to NCo376 thresholds to account for significant differences in leaf nutrient concentrations between the standard and varieties NCo310 and CP 29-116. Samuels (1969) referred to correction factors used in Mauritius to bring individual varietal leaf concentrations in line with the mean of all varieties tested. In both cases, adjustments were small, with correction factors as low as +0.06 N % dm, +0.012 P % dm and -0.1 K % dm proposed by Gosnell and Long (1971).

Table 3. Proposed correction factors to adjust current NCo376 leaf thresholds to account for varietal differences in leaf nutrient concentrations.

Analyte	Correction factor (%)			
	N19	N23	N24	N25
N	97	-	-	-
P	-	-	-	-
K	-	108	-	107

Correction factors derived from the results reported here are given in Table 3, and are expressed as the per cent adjustment to apply to threshold values developed for NCo376. In line with the results for N14, correction factors have been derived only where differences in leaf nutrient content were greater than the standard deviation of their analytical determination.

The proposed correction factor for leaf nitrogen in N19 (Table 3) is arguably too small to justify an adjustment being made. The implications of high levels of leaf potassium in N23 and N25 are more important because of the dangers of incorrectly diagnosing nutrient sufficiency, and would justify future work to develop leaf K thresholds specific to these varieties. Such work would have to take into account seasonal variations in leaf K concentration noted by Donaldson *et al*. (1990) in NCo376 grown on heavy base-saturated soils.

Schumann and Meyer (1999) used the exponential relationship between crop physiological age and leaf nitrogen concentration in NCo376 to account for both month of cut and age at sampling when interpreting leaf nitrogen analyses. An exponential function best described this relationship in the results reported here, and accounted for 69% of the variation in both N19 and NCo376 (Figure 4). There were insufficient data to make similar comparisons in varieties N14, N23, N24 and N25.

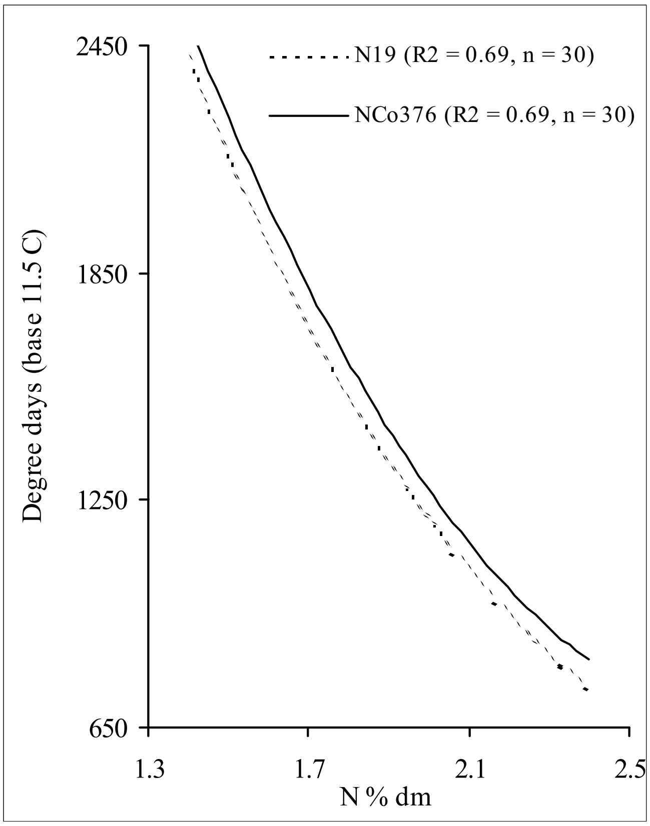


Figure 4. Relationship between physiological age (degree days) at sampling and leaf nitrogen content (N % dm) of varieties NCo376 and N19.

The relationship for N19 followed a similar pattern to that of NCo376, and reflected a reasonably constant difference in leaf nitrogen content at all physiological ages. The results indicate that the proposed correction factor for leaf N in N19 is appropriate for all months of harvesting and sampling.

Conclusions

- Mean concentrations of nitrogen and phosphorus in third leaves of varieties N19, N23, N24 and N25 were lower than those of variety NCo376. With the possible exception of nitrogen in N19, differences were not sufficient to warrant separate threshold values for each variety.
- Concentrations of phosphorus and potassium in third leaves of variety N14 were lower than those of variety NCo376, supporting the current use of lower critical values.
- Potassium content in the third leaf of varieties N19, N23, N24 and N25 was higher than that of NCo376. The largest differences were in varieties N23 and N25. New threshold values specific to these two varieties may be necessary to prevent the incorrect diagnosis of potassium requirements.
- As an interim measure, correction factors to adjust threshold values developed for NCo376 have been proposed to account for the low leaf nitrogen content of N19 and the high leaf potassium contents of N23 and N25.

Acknowledgements

J.H. Meyer of SASEX provided invaluable advice and encouragement and allowed me to refer to his unpublished data, for which I am extremely grateful. I also wish to thank T. Mkhweli of Mhlume Sugar Company for her kind cooperation, and H. Rostron of the Swaziland Sugar Association for assistance with the manuscript.

REFERENCES

Anon (1995). Fertiliser recommendations for Swaziland. Swaziland Sugar Association Extension Services. 8 pp.

Anon (1998). South African Sugar Association Experiment Station Annual Report 1997-1998, Mt Edgecombe, South Africa.

Donaldson, RA, Meyer, JH and Wood, RA (1990). Response to potassium by sugarcane grown on base saturated clay soils in the Eastern Transvaal lowveld. *Proc S Afr Sug Technol Ass* 64: 17-21.

Gosnell, JM and Long, AC (1971). Some factors affecting foliar analysis in sugarcane. *Proc S Afr Sug Technol Ass* 48: 217-232.

Hellmann, DB (1975). A comparison of sucrose patterns, yields and third leaf N % dry matter of sugarcane varieties grown in the Pongola area. *Proc S Afr Sug Technol Ass* 49: 196-201.

Inman-Bamber, NG (1984). The effects of nitrogenous fertiliser on sugarcane varieties and varietal differences in third leaf nutrient content. *Proc S Afr Sug Technol Ass* 58: 149-153.

Meyer, JH (1975). Advances in the interpretation of foliar analysis of sugarcane in the South African sugar industry. *Proc S Afr Sug Technol Ass* 49: 129-136.

Rostron, H, Butler, DWF, and Zwane, DM (1999). The performance of recently released South African sugarcane varieties in Swaziland. *Proc S Afr Sug Technol Ass* 73: 147-156.

Samuels, G (1969). Foliar diagnosis for sugarcane. Adams Press, Chicago. p 182-183.

Schroeder, BL, Wood, RA, and Meyer, JH (1992). Advances in leaf analysis techniques and interpretation in the South African sugar industry. *Proc int Soc Sug Cane Technol* 21: 123-135.

Schumann, AW and Meyer, JH (1999). Robust leaf N thresholds for foliar diagnosis based on exponential-Fourier functions. *Proc S Afr Sug Technol Ass* 73: 73-74.

Wood, RA (1989). Sugarcane nutrition and fertiliser use in South Africa. *Proc int Soc Sug Cane Technol* 20: 495-504.

1 Data provided by T Mkhweli, Agricultural Chemist, Mhlume Sugar Company. Three replicates were taken from each sample and analysed for the Agricultural Laboratory Association of Southern Africa (AgriLASA) control scheme during 1999.

2 Estimation of days to germinate in Swaziland lowveld used for CANESCHED irrigation scheduling software developed by M McGlinchey of Swaziland Sugar Association.

3 Unpublished data prepared for FAS Recommendations Committee (SASEX), provided by JH Meyer.