PERFORMANCE OF VARIETIES N14 AND NCO376 IN THE SOUTH-EAST LOWVELD OF ZIMBABWE

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Abstract

Varieties NCo376 and N14 are the most widely grown varieties in Zimbabwe and are used as control varieties in the selection programme. The success of NCo376 was due to its high yield potential throughout the year and its ability to maintain good yields, even in advanced ratoons. A study was done to compare the performances of N14 and NCo376 in the South-East Lowveld of Zimbabwe, using data from 1985 to 2003. A significant decline in the area planted to NCo376 took place in 1985 with the release of N14, and again in 1996 when ZN varieties began to be released. A stability analysis showed that yields of N14 responded better to favourable growing conditions than those of NCo376, although NCo376 accumulated sucrose better under favourable conditions. Of the two varieties, N14 produced much higher cane, ERC % cane and sugar yields than NCo376 in early to mid-season harvested cane. Both varieties had high ratooning ability, with N14 having a distinct advantage from the plant crop to the third ratoon. Variety N14 produced superior cane and sugar yields from 1985 to 2003.

Keywords: varieties, N14, NCo376, stability, harvest month, ratooning

Introduction

The main objective of a sugarcane breeding programme should be to provide varieties that will increase the profits (or reduce losses) of growers and millers over long periods of time. High production of sugar per unit area is the most important character, being the character most closely correlated with economic value, under normal conditions (Skinner *et al*., 1987).

Varieties NCo376 and N14 are the major varieties grown in Zimbabwe. Variety NCo376 was released for commercial planting in the South-East Lowveld of Zimbabwe in the early 1960s, and N14 was released in 1985. Before the release of N14, more than 99% of the industry cane area was planted to NCo376. In the short to medium term, varieties NCo376 and N14 are likely to remain the major varieties grown in the South-East Lowveld of Zimbabwe. Variety NCo376 has been widely grown in southern Africa, and has been a major variety in South Africa, Swaziland, Mozambique, Malawi and Zambia (Nuss, 2001). It became the most dominant variety in South Africa in only 25 years, and maintained that position for 40 years (Hewitt *et al.*, 2000).

Variety NCo376

The parents of NCo376 are Co421 (female) and Co312 (male) (Anon, 2002a). The cross was made at the Coimbatore Research Station in India, and the resulting seed was planted at the South African Sugar Association Experiment Station (SASEX) in KwaZulu-Natal. NCo376 was one of the varieties selected for commercial propagation, and was released in South Africa in 1955 (Anon, 2002a). It was imported into the South-East Lowveld of Zimbabwe in the 1960s and released for commercial production. Despite the disadvantages of high smut

susceptibility, relatively poor sucrose content and heavy flowering, NCo376 remained the most dominant variety in Zimbabwe for years (Anon, 1977, 1979, 1981; James, 1975). Many other varieties were subsequently released but, with the exception of N14, none proved comparable to NCo376 in terms of sustained production over a full cycle of ratoon crops.

Variety trial results have shown that the success of NCo376 relative to other promising varieties is due primarily to its high yield potential throughout the year, and to its ability to maintain good yields throughout the ratoon cycle. Low sucrose is adequately balanced by high cane yields, and loss of yield through smut is minimal if the recommended rouging policies are adopted (Anon, 1977). A review of the results of all variety trials conducted up to the end of 1979 revealed that most of the varieties recommended as alternatives to NCo376 were released prematurely, with smut resistance taking precedence over yield performance as the criterion for commercial production. Under commercial field conditions these varieties subsequently showed common weaknesses such as lower sugar yields than NCo376 and poor ratooning ability, and they all failed to gain popularity because they were not competitive in economic terms (Anon, 1979).

Variety NCo376 has been used as the control (standard variety against which other test varieties are compared) in the Zimbabwe Sugar Association Experiment Station (ZSAES) selection programme since 1976. Nuss (2001) described NCo376 as a scientific 'model', and in South Africa it has been used as a control for over 50 years.

Variety N14

The parents of N14 are N7 (female) and unknown males (Anon, 2002b). The parents of N14 were crossed at SASEX and seedlings selected by SASEX in the irrigated programme at Pongola. Variety N14 is still one of the most widely grown varieties in the Northern Irrigated region of South Africa (1personal communication). Variety N14 has been included as a second control since its release for commercial planting in 1985. At present, for the ZSAES to consider any promising variety for release, it should produce more sugar than N14.

Stability analysis

One of the most frequently used stability measures is based on a regression model first proposed by Yates and Cochran (1939). It was developed to describe the adaptation of individual varieties to changing environment by Finlay and Wilkinson (1963) and was again proposed by Eberhardt and Russell (1966). The stability statistic in this instance is the slope of the linear regression of the yield of the variety on the mean yield of genotypes in that environment. The mean yield of all genotypes serves as an index of the overall yield potential in that environment. With this statistic, a genotype that has a slope of one is the most stable. Finlay and Wilkinson (1963) pointed out that the slope provides an indication of regions of adaptability and stability. Genotypes that have a slope significantly greater than one are specifically adapted to high yielding environments. On the other hand, genotypes with a slope of less than one are insensitive to change in the environment and are therefore better adapted to low yielding environments (Petersen, 1994).

The objective of this paper is to describe the performance of varieties N14 and NCo376 in the South-East Lowveld of Zimbabwe using data collected from 1985 to 2003.

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Materials and methods

Climate of the South-East Lowveld of Zimbabwe

The ZSAES is located 430 m above sea level at a latitude of 21º 01' S and longitude 28º 38' E (Anon, 1998). The South-East Lowveld of Zimbabwe is characterised by hot, dry weather with high Class A pan evaporation. The winter period from May to September has very little rainfall. The summer months (September to March) are characterised by higher air temperatures, higher Class A pan evaporation and erratic rainfall. The sugarcane crop is irrigated, with furrow irrigation being dominant throughout the industry and used on over 85% of the area (2personal communication). The remainder of the sugarcane growing area is irrigated using dragline, centre pivot and drip irrigation systems.

Experiment details

The data was derived from Variety Observation Trials (VOTs), Advanced Variety Trials (AVTs) and Pre-Release Variety Trials (PRVTs). The AVTs and VOTs were planted at ZSAES, with the VOTs being harvested in the plant and first ratoon, and the AVTs being harvested in the plant, first, second and third ratoon crops. The PRVTs were planted at ZSAES, Hippo Valley, Triangle and Mkwasine Estates. The ZSAES and Mkwasine sites represented sandy clay loam soils, Hippo Valley represented clay loam soils, and the Triangle site represented sandy loam soils. Most of the PRVTs were harvested in the plant, first, second and third ratoon crops, with a few crops being harvested up to the eighth ratoon. The crops were harvested in the months of April to November from 1985 to 2003.

The crops were planted using two three-eyed cane setts laid side by side in the bottom of the furrow, spaced 1,5 m apart. The cane setts were covered with 100 mm of soil, and water was applied in the furrows immediately after planting.

Single superphosphate fertiliser was applied in the furrow before planting at a rate of 100 kg P_2O_5/ha in the plant crop, and 60 kg P_2O_5/ha as a maintenance dressing in the ratoon crops. Potassium was applied as muriate of potash at 60 kg K_2O/ha, four weeks after emergence or cutting for plant and ratoon crops. Nitrogen was applied as ammonium nitrate. In the plant crop, 140 kg N/ha was applied in the furrow, with 60 kg N/ha being applied four weeks after emergence and 80 kg N/ha being applied eight weeks after emergence. In the ratoon crop, a split application of 90 kg N/ha was made at four weeks and again at eight weeks after cutting.

Hand weeding was done as frequently as required to control weeds. Smut rouging and inspection for other diseases was done once every month until harvest, or until lodging prevented access to plots. Irrigation was scheduled using evaporation data from a United States Weather Bureau Class A pan. Water was applied at 50% depletion of total available water (TAM).

Measurements

At harvest all millable stalks in each plot were cut using cane knives and weighed using a Martin Decker load cell. The number of millable stalks in each plot was counted. A 24-stalk sample was collected after burning but before harvest, for cane quality analysis. Stalk diameters and lengths were measured from the 24-stalk sample. Lodging and flowering were estimated visually at harvest. Smut whips were counted and rouged each month until harvest or until lodging prevented access to plots. The number of stools infected with leaf scald was recorded every month until harvest or until lodging prevented access to plots.

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A sample of 20 stalks per variety were collected from several trials and tested for ratoon stunting disease (RSD). The RSD bacterium was diagnosed using a phase contrast microscope.

Data analysis

Data was analysed using the MSTAT version 4, Lotus 123 and Microsoft Excel computer programs. For stability of yield and sucrose content, the values of N14 and NCo376 were plotted against site mean. The site mean was taken as a measure of environmental yield and sucrose content potential (Petersen, 1994). The data was analysed for times of harvest, ratooning and years of harvest. A total of 521 crops were included in the analysis.

Results and discussion

Proportion of varieties

The proportion of land planted to NCo376 decreased significantly after 1985 and 1996 (Figure 1). The decreases coincided with the release of N14 in 1985 and the introduction of ZN varieties in 1996. After 1997, there was a steep increase in the area of N14 after it was shown that although it was more susceptible to drought than NCo376 (in 1992), N14 was more tolerant to smut and its yield potential was much higher than that of NCo376. Planting of ZN varieties increased to more than 13,5% of the total area by 2003. The increase in the area planted to N14 and the ZN varieties resulted in the decrease of NCo376 to below 50%.

Means of all crops

From a mean of 521 crops, N14 produced 11,3 tons/ha (8%) more cane than NCo376, and 2,1 tons/ha (12%) more sugar. It also had 0,42 units (3%) higher ERC % cane than NCo376 (Figure 2).

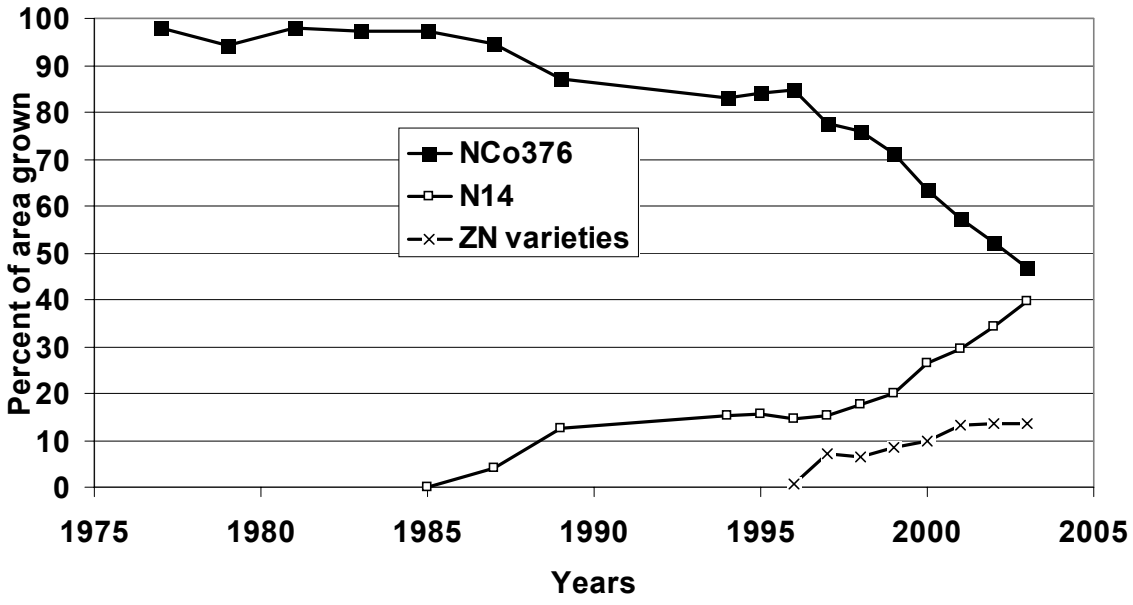

Figure 1. Proportion of land area planted to N14, NCo376 and ZN varieties in the south-east lowveld of Zimbabwe (1975 to 2003).

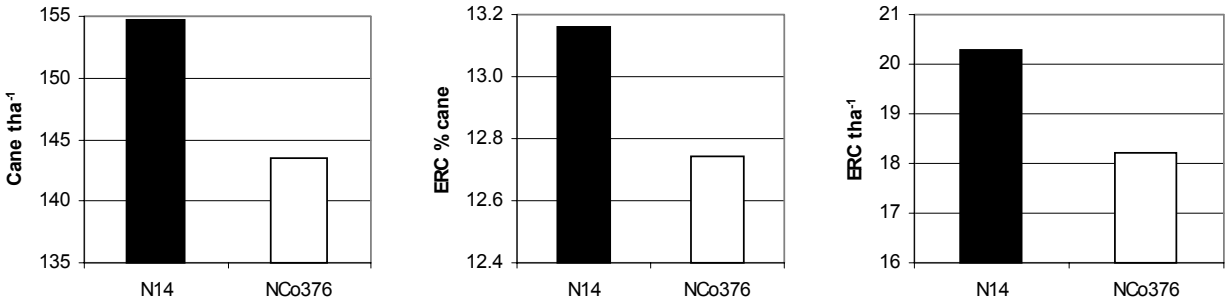

Figure 2. Cane (t/ha), ERC % cane and ERC (t/ha) of N14 and NCO376 (mean of 521 crops).

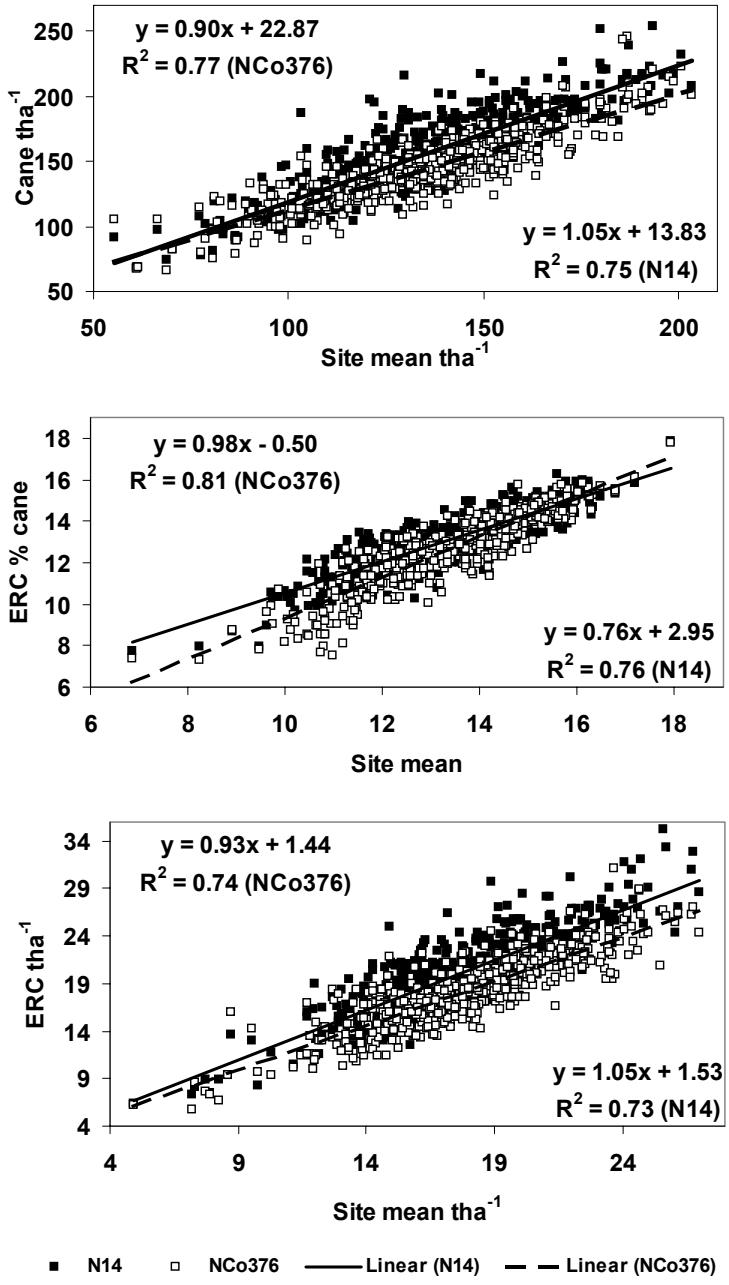

Figure 3. Stability of cane t/ha, ERC % cane and ERC t/ha of N14 plotted against NCO376.

Stability graphs for cane (t/ha), ERC % cane and ERC (t/ha)

The stability graphs showed that NCo376 had more stable cane and sugar yields than N14 (Figure 3). This means that, under more favourable growing conditions, N14 would yield much higher cane and sugar yields than NCo376, while under unfavourable conditions NCo376 could yield better. Variety N14 also showed higher cane and sugar yields than NCo376, particularly in high yield potential environments. Variety N14 had more stable ERC % cane than NCo376 and was likely to produce greater ERC % cane at less favourable sucrose accumulation conditions than NCo376. This explains N14's poor response to low rates of ripeners in Zimbabwe. NCo376 responds well to ripeners in the South-East Lowveld of Zimbabwe ([2]personal communication).

Month of harvest

Variety N14 produced higher cane and sugar yields than NCo376 throughout the year. However, N14 had the greatest cane and sugar yield advantages over NCo376 in April (17 and 29%), May (11 and 19%), June and November (8%). Variety N14 had greater ERC % cane than NCo376 in early harvested crops (April 11%, May 7%), but produced similar or marginally less sucrose content than NCo376 in crops harvested in August, September, October and November (Figures 4, 5 and 6). The best time for harvesting N14 would thus be early to mid-season (April, May, June and July) and at the end of the cutting season in November, when it excelled in sugar yield.

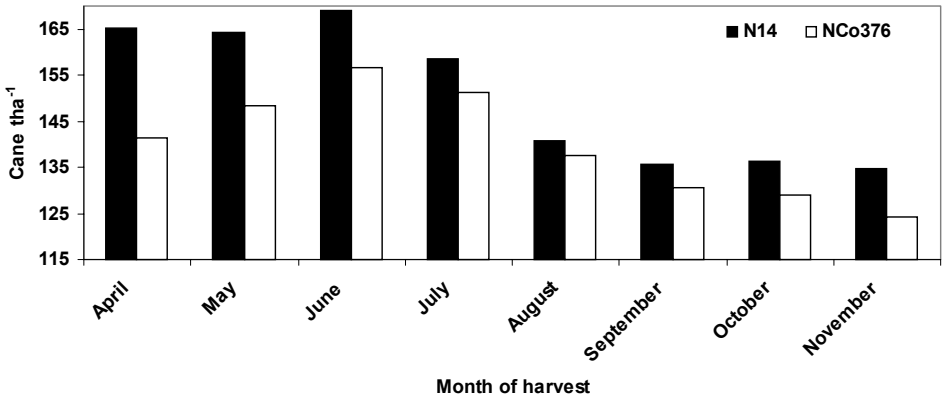

Figure 4. Cane yield (t/ha) of varieties N14 and NCo376 harvested from April to November.

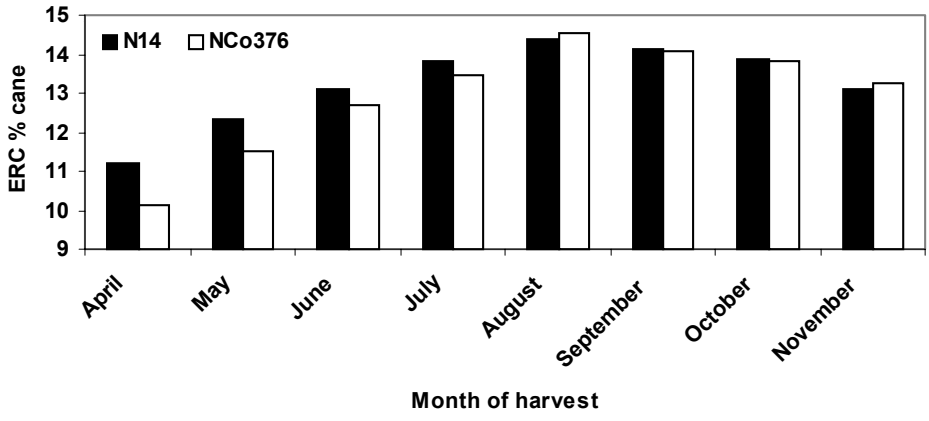

Figure 5. ERC % cane of varieties N14 and NCo376 harvested from April to November.

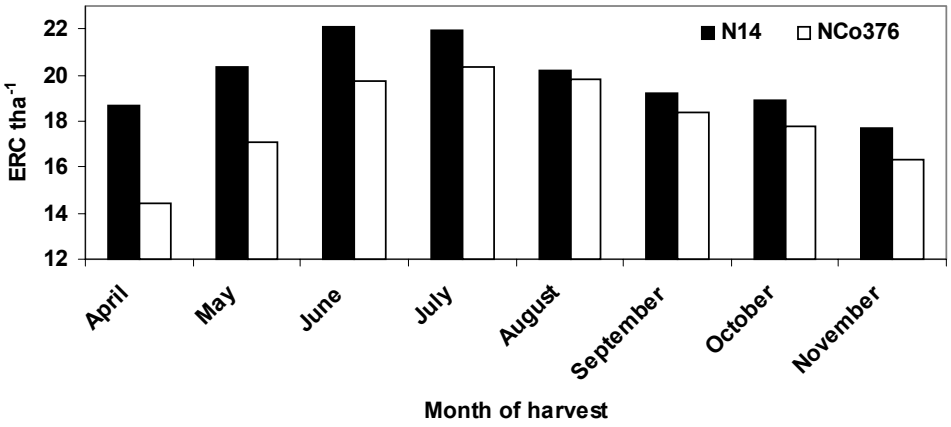

Figure 6. ERC (t/ha) of varieties N14 and NCo376 harvested from April to November.

Ratoon cycles

From the plant crop to the third ratoon, N14 produced more cane, ERC % cane and sugar than NCo376 (Figures 7, 8 and 9). Beyond the third ratoon, the ERC % cane of N14 was consistently less than that of NCo376, and its sugar yield fluctuated. In older ratoons, however, it produced higher cane and sugar yields than NCo376.

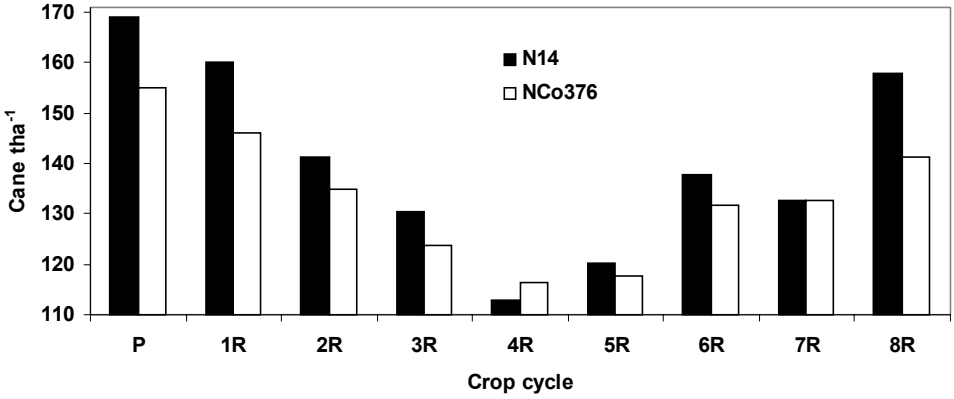

Figure 7. Yields of cane (t/ha) of varieties N14 and NCo376 from the plant crop to the eighth ratoon.

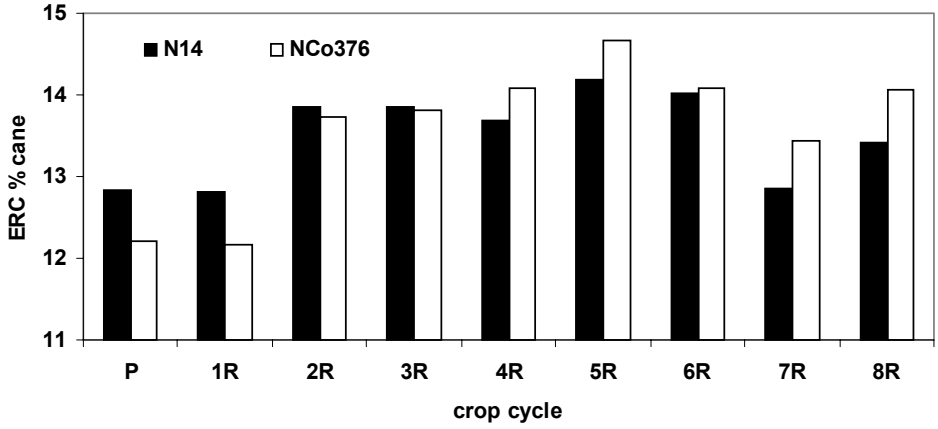

Figure 8. Yields of ERC % cane of varieties N14 and NCo376 from the plant crop to the eighth ratoon.

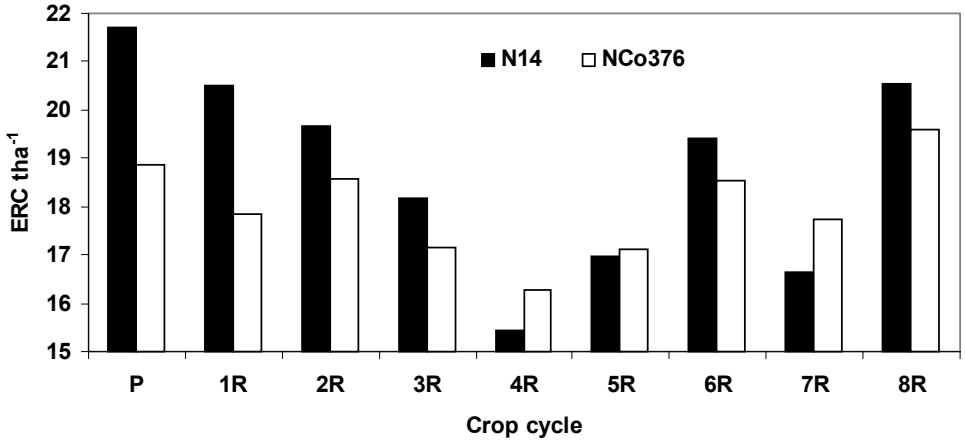

Figure 9. Yields of ERC (t/ha) of varieties N14 and NCo376 from the plant crop to the eighth ratoon.

Year to year variation

Variety N14 consistently produced higher cane and sugar yields than NCo376 from 1985 to 2003 (Figures 10 and 12). The ERC % cane of N14 was generally greater than that of NCo376 throughout the same period (Figure 11).

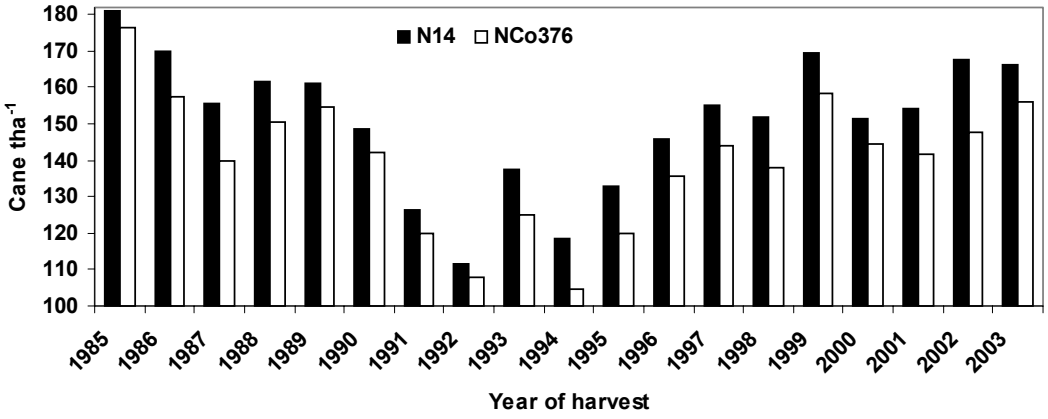

Figure 10. Yields of cane (t/ha) of varieties N14 and NCo376 from 1985 to 2003.

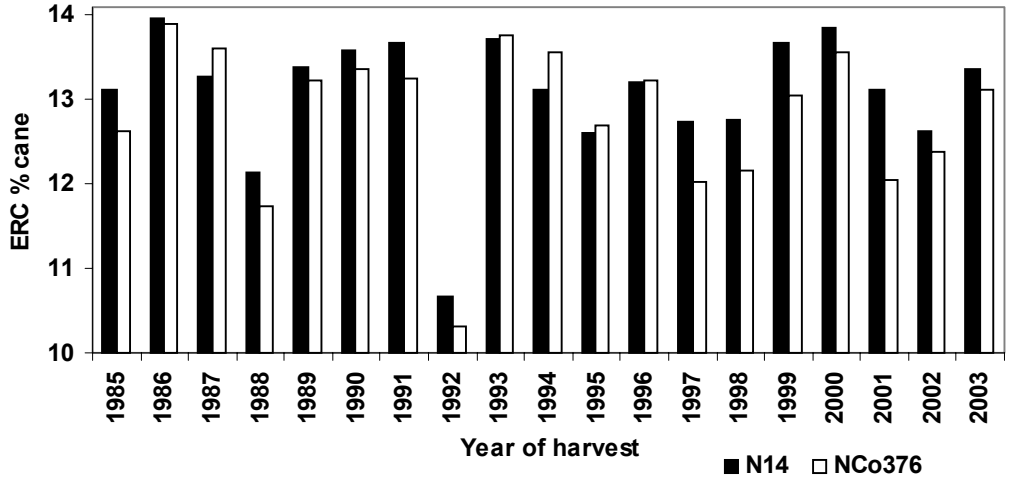

Figure 11. Yields of ERC % cane of varieties N14 and NCo376 from 1985 to 2003.

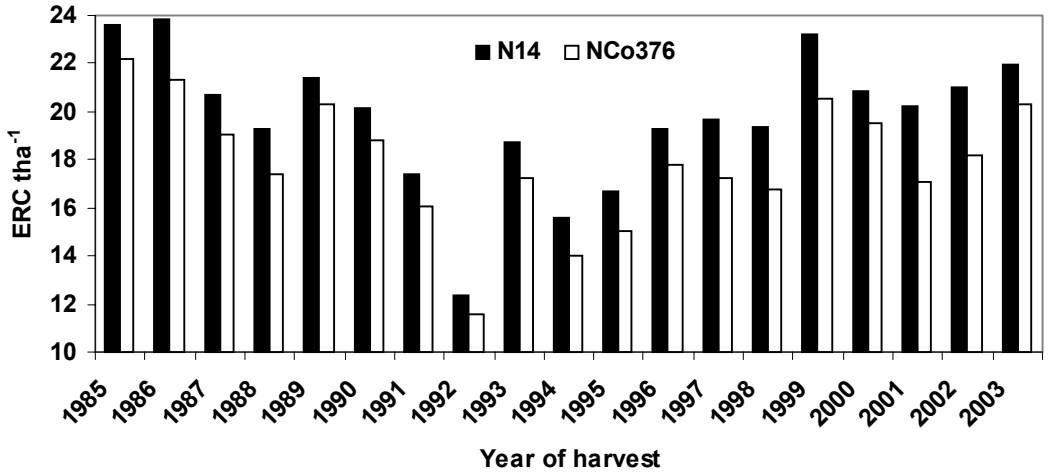

Figure 12. Yields of ERC (t/ha) of varieties N14 and NCo376 from 1985 to 2003.

Other characteristics

The fibre content of N14 was on average 4% less than that of NCo376. Variety N14 produced fewer stalks than NCo376, and was not prone to lodging. It did, however, flower more profusely than NCo376. Although N14 was more smut resistant than NCo376, it was more susceptible to RSD, with 17% more infected stalks than NCo376 (Table 1). Commercial surveys of the industry showed that N14 had 22% more infected stalks than NCo376 (3personal communication).

Table 1. Fibre % cane, % lodging, % flowering, and % smut, leaf scald and RSD for varieties N14 and NCo376.

Variety	Fibre % cane	Stalks/ha	% Lodging	% Flowering	Smut (% infected stalks)	Leaf scald (% infected stools)	RSD (% infected stalks)
N14	12,83	118100	16	28	0,34	0,04	97 (56[3])
NCo376	13,31	145 700	32	21	2,83	0,03	83 (46[3])

[3]personal communication

Advantages and disadvantages of N14 and NCo376

The advantages of N14 are high cane and sugar yields throughout the year, high ERC % cane in early harvested crops, high smut tolerance and an erect growth habit. Disadvantages are high susceptibility to RSD, prolific flowering and a tendency to have low ERC % cane in older ratoons.

The advantages of NCo376 are high cane and sugar yields throughout the year, good ratooning and good response to ripeners. Its disadvantages are low ERC % cane, particularly in early harvested unripened crops, high smut susceptibility, prolific flowering and severe lodging.

Conclusions

Varieties N14 and NCo376 are at present the major commercial varieties in Zimbabwe, and are likely to remain so in the short to medium term. It has taken over 20 years of selection

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work in the South-East Lowveld of Zimbabwe to produce varieties that can compete favourably with N14 and NCo376. Varieties N14 and NCo376 will remain useful as controls for the newly released ZN varieties. The major advantages of N14 and NCo376 are their high cane and sugar yields throughout the year, good ratooning and consistent yields over years. Despite their susceptibility to some diseases and prolific flowering, their advantages far outweigh their disadvantages. The high stability of ERC % cane of N14 makes it an ideal early cut variety, while its unstable cane yield is ideal for testing responses to good management and favourable growing conditions.

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REFERENCES

Anon (1977). Varieties. pp 7-8 In: Rhodesia Sugar Association Experiment Station Annual Report, 1976/77.

Anon (1979). Varieties. pp 11-12 In: Zimbabwe Sugar Association Experiment Station Annual Report, 1978/79.

Anon (1981). Varieties. pp 12-13 In: Zimbabwe Sugar Association Experiment Station Annual Report, 1980/81.

Anon (1998). Meteorological data. pp xiii-xvi In: Zimbabwe Sugar Association Experiment Station Research Report, 1996/98.

Anon (2002a). Variety NCo376. Information Sheet, South African Sugar Association Experiment Station, P/Bag X02, Mount Edgecombe, 4300, South Africa. *www.sugar.org.za\sasex\variety\index.html*

Anon (2002b). Variety N14. Information sheet, South African Sugar Association Experiment Station, P/Bag X02, Mount Edgecombe, 4300, South Africa. *www.sugar.org.za\sasex\variety\index.html*

Eberhardt SA and Russell WA (1966). Stability parameters for comparing varieties. *Crop Sci* 6: 36-40.

Finlay KW and Wilkinson GN (1963). The analysis of adaptation in a plant breeding programme. *J Agric Res* 14: 742-754.

Hewitt PH, Donovan PA and Carnegie AJM (2000). The South African Sugar Association Experiment Station at Mount Edgecombe – Milestones 1925 to 2000. *Proc S Afr Sug Technol Ass* 74: 8-11.

James GL (1975). The search for alternative varieties to NCo376 in Rhodesia. *Proc S Afr Sug Technol Ass* 49: 189-195.

Nuss KJ (2001). The contribution of variety NCo376 to sugar production in South Africa from 1955 to 2000 and its value as a parent in the breeding programme. *Proc S Afr Sug Technol Ass* 75: 54-59.

Petersen RG (1994). *Agricultural Field Experiments: Design and Analysis*. Marcel Dekker Inc, New York, Basel and Hong Kong. 408 pp.

Skinner JC, Hogarth DM and Wu KK (1987). Selection methods, criteria and indices. pp 409-453 In: DJ Heinz (Ed) *Sugarcane Improvement Through Breeding*. Elsevier Sci Pub, The Netherlands.

Yates F and Cochran WG (1939). The analysis of groups of experiments. *J Agric Sci* 28: 556-580.