AN ASSESSMENT OF CHEMICAL RIPENING OF SUGARCANE IN SOUTH AFRICA AND SWAZILAND

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Abstract

Details are given of the chemicals that have been tested in South Africa and Swaziland and the methods used to test them in the field. Ethrel and Polaris consistently improved cane quality and sugar yield, and the best response was obtained with young, actively growing, irrigated sugarcane. Ethrel was more effective than Polaris at an equivalent rate of application. Varieties differed in their response to chemical ripeners.

Introduction

There has long been an interest in the artificial improvement of cane quality because of the obvious advantages to be gained from a higher sucrose content and greater sugar recoverability early in the season. Testing chemicals for artificial ripening of sugarcane started in South Africa in 1968. Since then a number of chemicals, some of which have shown promise elsewhere, have been tested in a series of small and large-scale field experiments. From this work it has been established that at present Ethrel (2 chloroethane phosphonic acid) is the best chemical ripener for South African conditions (Rostron, 1973[2] and 1974)[3]. It is likely that an application to register its use on sugarcane will be made shortly. A second product, Polaris (N,N-bis phosphonomethylglycine), which is already in commercial use in some countries, has also shown promise, but greater amounts have to be applied in order to achieve a ripening effect similar to that of Ethrel.

The object of this paper is to review briefly the work that has been done in South Africa during the past six years and to assess the potential value of artificial ripeners to the sugar industry.

Methods used in screening chemicals

Chemicals that have shown some ripening activity are tested initially in small-scale field experiments. The sugarcane is sprayed over the leaf canopy with a pressure-operated, hand-carried sprayer, fitted with an extended lance and a T piece which allows two rows to be sprayed simultaneously. Treatments are replicated sufficiently to permit an accurate statistical assessment of the results. If the experiment is to be harvested, the gross plot is usually between 90 and 100 m^2 (40 m^2 net) in size. If quality assessment only is required then the net plot size is 20 m^2.

Random samples comprising up to 20 cane stalks are taken from each plot at the time of spraying and at various intervals of time between 2 and 18 weeks after spraying. These samples are completely chaffed, sub-sampled and disintegrated to permit the analysis of the whole stalk for sucrose and moisture contents by standard methods.

Promising results were obtained with Ethrel and Polaris in initial small-scale experiments and several field-scale experiments were therefore conducted on miller-cum-planter estates. In these trials, the chemicals were applied to large (0,3-0,6 ha), adequately replicated blocks of sugarcane. Application of the ripeners was made by aeroplane in 25-50 litres of water/ha sprayed through micronair jets or by means of a fixed boom and nozzles. Plots were sampled as in the small-scale experiments, and the sugarcane in these large experiments was harvested between 10 and 12 weeks after spraying. The weight of cane from each plot was recorded and the crusher juice was analyzed by standard methods at the Ubombo sugar mill.

It is of interest to note that results obtained in small scale experiments on sugarcane at Chaka's Kraal were similar to those obtained in small scale experiments at Pongola and in the large scale experiments in Swaziland. It was also encouraging to find that assessments of the response to the chemicals based on 20-stalk samples per plot were similar to those obtained from mill harvest data (Table 1).

TABLE 1

Comparison of sample and harvest data: percentage increase in mass of estimated recoverable sugar from variety NCo 376 sprayed with Ethrel and Polaris

Site			Rate chemical (kg a.i./ha)	Sample % increase	Harvest % increase
Ubombo Ranches	March	1972	Polaris 3,8	10	15
Noodsberg Sugar Co.	March	1972	Polaris 4,9	—3	—5
Ubombo Ranches	Dec.	1972	Polaris 3,8	2	1
Ubombo Ranches	March	1973	Ethrel 1,2	12	8
			Polaris 4,5	8	6
Ubombo Ranches	March	1974	Ethrel 1,0	12	16
			Polaris 4,0	13	14

Chemicals tested

There were 10 small scale experiments and 6 large experiments in which a total of 15 different chemicals were tested. Ethrel was tested in 9 experiments and Polaris in 11 experiments. The other Chemicals were each tested in only one or two experiments. Chemicals that showed some ripening activity were Pesco 1815 (a mixture of 15% 2-methyl-4-chlorophenoxyacetic acid and 4,8% 2,3,6-trichlorobenzoic acid), DA5 (composition unknown), Hyamine 1622 (Di-isobutylphenoxyethyoxyethyldimethylbenzyl ammonium chloride), PP 757 (composition unknown), and Sustar 2S (N-4-methyl-3-1,1,1-trifluoromethyl sulphonyl amino phenyl acetamide). The development DA 5 and Hyamine 1622 has been suspended by the companies concerned with their manufacture, Pesco 1815 is not a suitable product because of the danger of undesirable residues, and PP 757 and Sustar 2S are still being tested. Chemicals that have shown no ripening activity under local conditions are Cycocel (2-Chloroethyltrimethylammonium chloride), Tordon (4-amino-3, 5, 6-trichloropicolinic acid), Paraquat (1,1 dimethyl-4,4 bipyridilium), Hydrothol (Mono N,N dimethylalkylamine salt of 3,6-endoxohexahydrophtholic acid) and CGA 11610 (composition unknown).

Results

(*a*) *Stage of maturity and time of year*

The response of sugarcane to chemical ripeners in South Africa and Swaziland appears to be dependent on the stage of maturity of the crop at the time of spraying, which may be assessed in terms of juice purity (Figure 1). When sugarcane was young (6-10 months old) and growing actively at the time

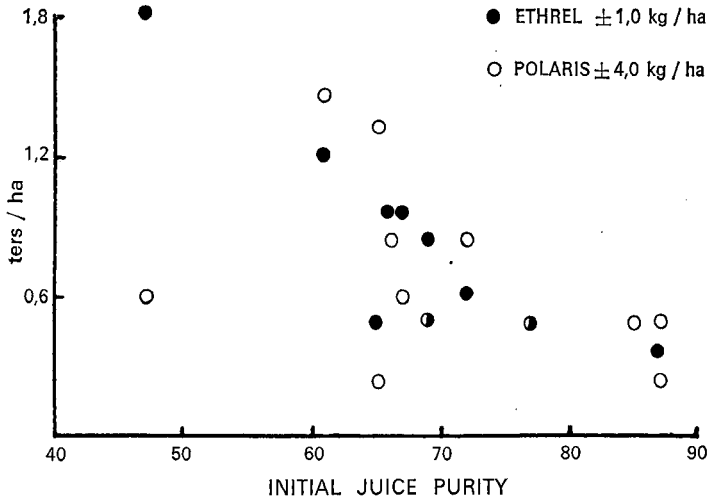

FIGURE 1 The relationship between the juice purity of whole stalks of variety NCo 376 at the time of spraying with Ethrel and Polaris and the average increase in sugar yield between 6 and 12 weeks after spraying in all experiments.

of spraying, the response to treatment was high, e.g. sucrose yield increases of 0,5 to 1,4 t/ha or sugar yield increases of 0,7 to 2,2 ters/ha (Table 3). When the cane was older (18 months) fairly mature, and growing slowly when sprayed, either in the Natal midlands at the beginning of the milling season, or at Mount Edgecombe and in Swaziland at the end of the milling season, the response to treatment with a chemical ripener was lower. (Figure 1). When harvest was delayed until 12 weeks after spraying in the Midlands trial and until 13,5 weeks at Mount Edgecombe, the yield of cane from untreated plots exceeded those from treated plots (Table 2), and estimated sugar yield (ters/ha) was reduced following treatment despite improvements in sucrose per cent cane fresh mass (S%c) and juice purity. Typical responses obtained in Swaziland under conditions favouring a good response to treatment are presented in Table 3.

Although Polaris reduced cane yields under some circumstances (Table 2) there is no evidence of a reduction in cane yield under conditions that favour good chemical ripening. Ethrel did not reduce cane fresh or dry mass yield appreciably in any of the experiments in which it was tested.

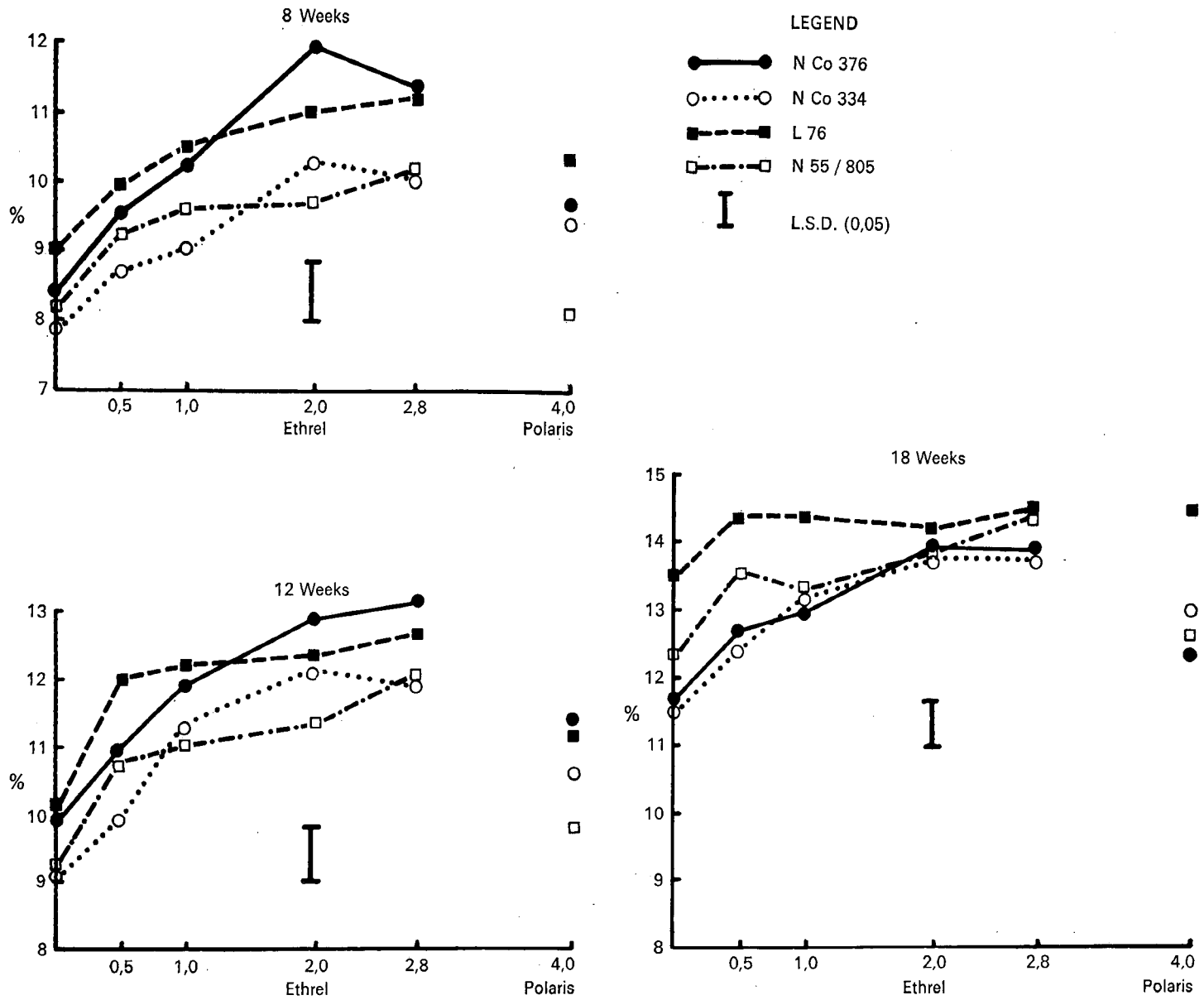

FIGURE 2 The effect of Ethrel and Polaris on the sucrose per cent cane of four varieties at different times after spraying at six months of age.

TABLE 2

The effect of Polaris on the yield and quality of Variety 376 sprayed in March 1972 in the Natal Midlands

Treatment (kg a.i./ha)	Cane Yield (tc/ha)	Sucrose %	Purity %	Sugar Yield (ters/ha)
Control	115	12,2	84,6	12,0
Polaris	104	12,8	86,1	11,4
% Change . . .	−9,6	+4,9	+1,8	−5,0
L.S.D. (0,05) . . .	7,1	0,6	2,3	0,8
(0,01) . . .	11,2	1,0	3,7	1,2
C of V (%). . . .	4,4	3,3	1,8	4,4

Data from Rostron (1973)

TABLE 3

Harvest data for variety NCo 376 in Swaziland, sprayed with Ethrel and Polaris between 8 and 12 weeks before harvest

Treatment (kg a.i./ha)	Ers %			Purity %			Ters/ha*		
	1972	1973	1974	1972	1973	1974	1972	1973	1974
Control . .	7,9	9,1	9,4	77,2	77,5	80,2	10,8	8,6	13,4
Ethrel 1,0-1,2 .	—	9,8	10,9	—	77,8	83,7	—	9,3	15,6
Polaris 3,8-4,5	9,2	9,8	10,7	82,0	78,1	83,0	12,6	9,3	15,3
Mean . . .	8,6	9,6	10,4	79,6	77,8	82,3	11,7	7,8	14,8
L.S.D. (0,5) .	0,7	1,3	0,4	3,3	N.S.	1,1	0,8	1,5	1,1
(0,01) .	1,1	—	0,6	5,2	—	1,6	1,3	—	1,6
C of V (%) .	6,1	10,7	3,2	3,0	—	1,0	5,1	12,8	6,1
% Response									
Ethrel . . .	—	8	16	—	0	4	—	8	16
Polaris 3,8-4,5	16	8	14	6	1	3	17	8	14

* There was no evidence of any effect of treatment on cane yield. Therefore, these yields are based on standard (control cane yields) of 1972 — 137 tc/ha, 1973 — 95 tc/ha, 1974 — 143 tc/ha.
Ers = Sucrose − 0,485 Non sucrose − 0,056 Fibre.

(b) *Varietal response*

Most ripening experiments have been conducted with variety NCo 376, which comprises some 60% of sugarcane grown in South Africa and Swaziland. In one experiment at the end of the milling season both Ethrel and Polaris stimulated the growth of variety N55/805 and slightly reduced cane quality. A small-scale experiment was therefore established at Pongola with varieties NCo 376, NCo 334, N55/805 and L76. Ethrel was applied at rates varying from 0,5 to 2,8 kg a.i./ha and were compared with Polaris applied at 4,0 kg a.i./ha. All varieties showed large and consistent increases in sucrose per cent cane fresh mass (S%c) and juice purity from four weeks after spraying in March, when the cane was only 6 months old. The effect on S%c is shown in Figure 2, from which it can be seen that varieties N55/805 and L76 did not respond as much as did varieties NCo 376 and NCo 334 at the higher rates of Ethrel application. In June, 12 weeks after spraying, when the crops were only 9 months of age, the juice purity of NCo 376 increased from 77,0% in control plots to 83,9% and 85,9% by applying Ethrel at 1,0 and 2,0 kg a.i./ha respectively, whilst sucrose % cane increased from 9,9% to 11,9% and 12,9%. Similar improvements in quality were also recorded in the other varieties.

None of the treatments had any effect on cane fresh or dry mass so that yields of sucrose and ters/ha were increased appreciably (Table 4). There was little additional response of varieties N55/805 and L76 to treatment with more than 0,5 kg a.i./ha, but NCo 376 responded increasingly to treatments up to 2,0 kg a.i./ha, and NCo 334 appeared to continue to respond to treatments up to 2,8 kg a.i./ha. Polaris at 4,0 kg a.i./ha was equivalent to Ethrel at 0,5 to 1,0 kg a.i./ha in its effects on all varieties.

TABLE 4

The average sugar yield (Ters/ha)* of four varieties between 8 and 18 weeks after spraying with Ethrel and Polaris

Treatment (kg a.i./ha)	Variety			
	NCo 376	NCo 334	N55/805	L76
Control, untreated . .	9,6	6,8	8,3	10,1
Ethrel 0,5	10,8	8,3	10,0	11,8
Ethrel 1,0	11,8	9,6	10,5	12,0
Ethrel 2,0	12,2	9,6	9,9	11,4
Ethrel 2,8	12,0	10,0	11,1	12,1
Polaris 4,0	10,1	8,2	8,4	11,2
Mean.	11,1	8,8	9,4	11,4
For body of table				
L.S.D. (0,05) . . .	1,03			
(0,01) . . .	1,37			
C of V (%)	7,1			

* Based on mass per stalk and number of stalks per ha for each variety.

(c) *Rate of application of chemical*

The results presented in Figure 2 and in Table 4 confirmed those obtained in a similar small-scale, irrigated trial which was conducted at Chaka's Kraal with variety NCo 376 (Figure 3). There was a curvilinear response to treatment with increasing amounts of Ethrel and the optimum treatment appeared to be 1,0 kg a.i./ha, at least for the varieties NCo 376 and NCo 334. The extra response obtained by treating with 2,0 kg a.i./ha is unlikely to justify the additional expenditure incurred. Good responses to 1,0 kg a.i./ha Ethrel have also been obtained in field trials (Table 3), confirming the results of small scale trials. Variety L76, which has a lower population of thicker, taller stalks than the other three varieties, did not respond to treatment with more than 0,5 kg a.i./ha of Ethrel. The effect of Ethrel on N55/805 was not as marked as it was on varieties NCo 376 and NCo 334.

Polaris has been consistently less effective than Ethrel at an equivalent rate of application in all of the experiments in which they have been compared. The response of variety NCo 376 to treatment with Polaris up to 4,8 kg a.i./ha was found to be linear in one trial (Figure 3) and up to 5,2 kg a.i./ha in another.

(d) *Effects of moisture stress*

Good growth of the crop after treatment appears to be necessary for a response to be obtained. The first ripening effects of Ethrel and Polaris are usually detected about four

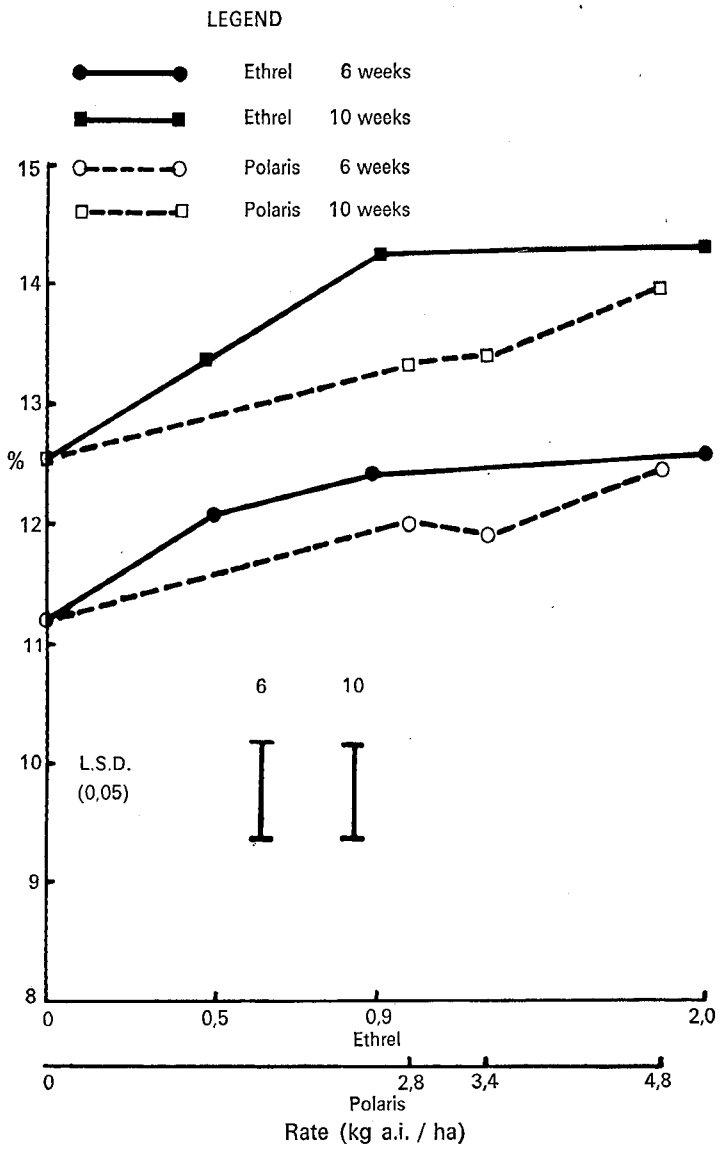

FIGURE 3 Comparison of the increase in sucrose per cent cane of variety NCo 376 following the application of different rates of Ethrel and Polaris.

weeks after spraying and these can be delayed by 2 to 4 weeks when there is moisture stress. Once a ripening response has been obtained, moisture stress no longer seems to be detrimental so that normal drying off procedures can be followed from four weeks after spraying. Conversely, excessive rainfall or irrigation up to harvest do not appear to affect the ripening effects of Ethrel and Polaris.

(*e*) *Time of harvest*

It is possible to harvest sugarcane that has been treated with Ethrel and Polaris over a considerable period of time without losing the beneficial effects of the chemicals (Figures 2 and 3). The optimum time for harvest would appear to be between 6 and 12 weeks after spraying, although under good ripening conditions (Figure 2) it may be possible to delay harvest for an even longer time. Fields that will be harvested over a period of at least 6 weeks can therefore be sprayed on one occasion.

Discussion

The results reviewed briefly in this paper show that both Ethrel and Polaris will ripen sugarcane under certain conditions in South Africa and Swaziland, improving cane quality and increasing yields of sucrose and recoverable sugar per hectare appreciably. Other promising chemicals are under test here and in Hawaii. Several chemicals were also reported to be worthy of further investigation (Nickell and Takahashi, 1973)[1]. It is probable, therefore, that the use of chemicals to increase sugar yields will gradually become a standard practice in many sugar producing countries. Possibly the only change in management practices that will be necessary, will be to harvest fields at ages, or at times of the year that are not favoured at present. The decision to use a ripener will depend on the costs of the chemical and its application compared with the average increase in income resulting from its use.

The major benefits of chemical ripening to the miller will be improved sucrose recovery at times of the year when cane quality is normally low. The marked increases in yields of estimated recoverable sugar shown in Table 4, from cane which would not normally be harvested at such a young age, or at such an immature stage of growth, indicate that it might eventually be possible to ripen sugarcane artificially during summer when the mills are normally closed. Further experimental work will be necessary to investigate the feasibility of this aspect of chemical ripening, but if it is possible, then a greater tonnage of cane could be milled without increasing milling capacity.

Experiments in South Africa and Swaziland have been concentrated in the early part of the milling season (May-June) because a few experiments conducted at the end of the season (December) gave only small improvements in yield and quality. It has since been established that an important factor determining the response to treatment with chemical ripeners, is the ability of the crop to grow after it has been sprayed, e.g. as in young cane which suffers no shortage of water or nutrients. Where very young, low-quality sugarcane has to be milled in December and January, chemical ripening should be successful. In Rhodesia, large and statistically significant increases in sugar yield have been obtained from sugarcane sprayed with 6 to 8 kg Polaris (85%)/ha two months prior to harvest in December (Haslam, personal communication).

It is envisaged that chemical ripeners will be used initially in the northern, irrigated areas of the South African Sugar Industry, particularly by the miller-cum-planter. However, chemical ripening could also be effective in rainfed areas whenever cane quality is low either because of continued rainy conditions, or because of the necessity to harvest relatively young sugarcane early and late in the milling season.

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