

GROWTH STIMULATION FROM ETHREL AND THE EFFECTS OF GIBBERELIC ACID WHEN APPLIED TO SUGARCANE

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Abstract

Ethrel (48%) at 1,5 litres product per hectare was applied during a period of active summer growth, to different varieties of sugarcane in the coastal and midlands regions. The treated cane was about one year old and was considered mature at the time of spraying (i.e. juice purity was over 80 per cent). Results showed that Ethrel stimulated growth on varieties NCo293, N55/805 and NCo310 by causing additional elongation of the upper internodes which were still elongating at the time of spraying. This stimulation in growth resulted in an increase in stalk mass and a concurrent reduction in sucrose per cent cane. NCo376, currently the most widely grown variety in South Africa, did not respond to treatment with Ethrel. These results further emphasize the importance of maturity testing of cane in the rainfed regions before applying Ethrel as a chemical ripener. Pro-Gibb Plus, a 10 per cent formulation of gibberellic acid (GA_3), was applied between January and September usually as a double application of 690g product per hectare on each occasion. Trials were conducted in each of the three main ecological regions. Results showed that growth was stimulated only on variety NCo293 which received the first application of Pro-Gibb Plus in January. The remainder of the trials were carried out on variety NCo376 which did not respond during the cooler winter months between April and September, even when irrigation water was applied. The effects of Ethrel and gibberellic acid (GA_3) are compared and the possibilities of these plant growth regulators are discussed.

Introduction

Ethrel is registered in South Africa as a chemical ripener for application early in the milling season to sugarcane which is immature (juice purity 75 per cent or less). The main effects of applying Ethrel to sugarcane as a ripener are to increase sucrose per cent cane and juice purity without producing a noticeable effect on stalk mass (Rostron⁹; Sweet¹¹; Clowes³). However, growth stimulation has also been reported on certain varieties (Rostron⁹; Clowes³).

Gibberellic acid (GA_3) is applied commercially to sugarcane in Hawaii to promote growth (Moore⁵) and some varieties are more responsive than others (Moore and Buren⁶). Andel and Verkerke¹ have shown both similarities and differences between gibberellic acid and Ethrel when applied to vegetative tillers of some gramineae. The growth of internodes of vegetative tillers was increased by both Ethrel and GA_3 due to increased cell length; however, GA_3 also increased cell number. When the two chemicals were applied together there was an additive effect on cell length, but a decrease in cell numbers. The stimulation of growth by using growth regulators may be complementary to the use of ripeners as Sowers¹⁰ found that the additive effects of GA_3 and Polaris in Hawaii exceeded the individual increases in sugar yield caused by the two chemicals separately. This prospect may be improved once a glyphosate becomes registered because good ripening responses due to treatment with this chemical have been obtained whenever actively growing cane has been sprayed (Clowes³).

This paper presents results obtained from applying Ethrel to mature sugarcane (juice purity over 80 per cent) of different varieties growing in the coastal or midlands ecological regions. Cane in these regions is usually too mature early in the season for a ripening response to be obtained from treatment with the registered chemical ripeners, Ethrel and Embark. Pro-Gibb Plus was applied, mainly during the ripening period, to variety NCo376 growing in each of the three main ecological regions (coastal, midlands and northern irrigated). In addition, Pro-Gibb Plus was applied in January to NCo293 growing in the midlands region.

Materials and Methods

The trials with Ethrel were carried out during the spring and summer months under rainfed conditions, except for Trial 6 (NCo376) which was irrigated. All of the trials with Pro-Gibb Plus except one were established in the winter months in all three of the main ecological regions. The trials in the midlands were rainfed whereas trials in the other two regions were irrigated.

Ethrel and Pro-Gibb Plus were applied to four replications of small plots in randomized block trials. Two rows of cane were sprayed simultaneously using an extended lance attached to a carbon dioxide pressurized sprayer. Two Spraying Systems TK1,0 floodjets were positioned on a horizontal boom immediately above each cane row. The nozzles delivered approximately 70 litres of spray solution per hectare at a pressure of 200 kPa when moving at a pace between 1,1 to 1,4 metres per second, depending on the row spacing, which varied between 1,2 and 1,5 metres. Ethrel (48%) was applied at 1,5 litres per hectare (approx. 0,75 a.i. per ha) while Pro-Gibb Plus was applied at 690g (69g GA_3) per hectare as a single or double application when weather conditions were considered to be favourable for spraying. The net plots, which varied between 20 and 48 m² in size, were separated by two or three guard rows.

Samples comprising a total of 16 randomly selected stalks per plot were taken from two adjacent positions within each row at the time of spraying and at intervals thereafter. The trashed stalks were topped by hand at the natural breaking point. Each bundle of 16 stalks was fed through a disintegrator and sub-samples were analysed for juice quality and fibre content. The percentage of estimated recoverable sugar (ers % cane) was determined using the formula :

$$\text{Ers \%} = \text{sucrose \%} - 0,485 (\text{non sucrose \%}) - 0,056 (\text{fibre \%}).$$

On two occasions additional samples comprising 24 stalks per plot were taken from control and Ethrel-treated plots and each stalk was divided into the lower 0,75 m and the remainder, and the two parts then being processed and analysed separately.

Details of the six trials with Ethrel and Pro-Gibb Plus are shown in Tables 1 and 2 respectively.

Results

Ethrel visibly enhanced the elongation of the internodes which were lengthening at the top of the stalk at the time of

TABLE 1
Details of the six trials with Ethrel

Trial	Region	Variety	Month sprayed	Crop condition at spraying	
				Age	Juice purity %
1	Coastal	N55/805	October	10 m	89
2	Coastal	N55/805	October	11 m	91
3	Midlands	NCo293	October	15 m	87
4	Coastal	NCo310	January	14 m	92
5	Midlands	NCo293	January	16 m	92
6	Coastal	NCo376	January	12 m	90



FIGURE 1 Growth stimulation following the application of Ethrel.

application (see Figure 1) in all varieties treated except NCo376. The effects were noticeable three weeks after spraying and were usually still evident though not as pronounced 9 and 12 weeks after spraying.

The results in terms of sucrose per cent cane and stalk mass of cane in each trial on each sampling occasion are shown in Figure 2. These data support the visual observa-

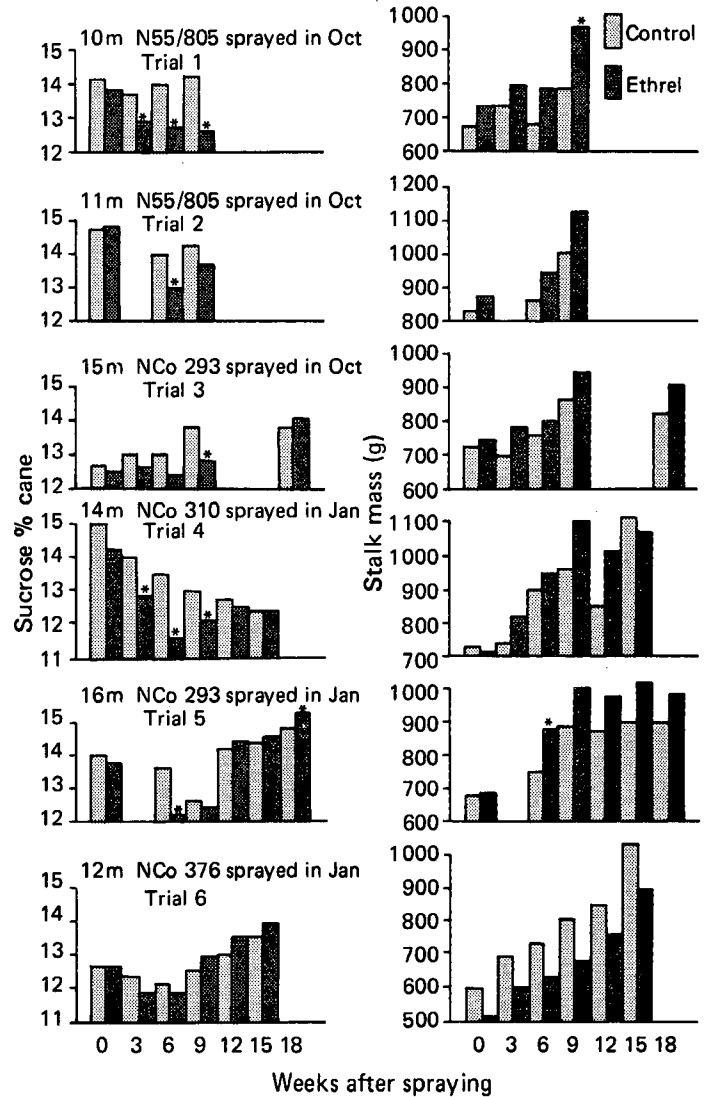


FIGURE 2 The effects of Ethrel on sucrose % cane and stalk mass. An asterisk indicates that the difference was significant (P=0,05).

TABLE 2
Details of the four trials (7-10) with Pro-Gibb Plus

Trial	Region	Variety	Moisture regime	Spraying dates	Crop condition at spraying	
					Age	Juice purity %
7	Midlands	NCo293	Rainfed	25 Jan + 8 March	16 m	92
8	Midlands	NCo376	Rainfed	10 May + 4 June 4 June + 25 June 25 June + 17 July	8 m	67
					9 m	76
					10 m	79
9	Coastal	NCo376	Irrigated	26 April + 21 May 21 May + 11 June 28 June + 19 July 9 August + 12 Sept	8 m	88
					9 m	89
					10 m	92
					11 m	93
10	Northern Irrigated	NCo376	Irrigated	23 May 27 June + 24 July 24 July + 28 August	7 m	72
					8 m	79
					9 m	85

tions as stalk mass was increased by treating all varieties except NCo376 with Ethrel. Although this effect did not generally attain a level of statistical significance it was nevertheless consistent in varieties N55/805, NCo310 and NCo293, with no noticeable effect on NCo376. Sucrose per cent cane was significantly ($P = 0,05$) lower in the treated compared with the untreated cane between six and nine weeks after application in all trials where the growth rate was apparently increased. The decline in cane quality was generally apparent as early as three weeks after spraying. The growth responses occurred in October and January when the cane is normally actively growing and conditions for natural ripening are poor. A noticeable effect of the growth response in Trial 4 was an increased tendency for treated cane to lodge.

Although there were large changes in sucrose per cent cane and stalk mass (Figure 2) there was little change in the mass of ers except in one trial (Trial 5) where the application of Ethrel substantially increased the mass of ers from about nine weeks onwards (Table 3).

Results nine weeks after spraying from the two trials in which stalks were divided into the lower 0,75 m and the remainder for separate analysis are shown in Table 4. In both trials the effect of Ethrel was largely confined to the top portion of the stalk where there was a statistically significant ($P = 0,05$) increase in stalk mass, which resulted in an improvement ($P = 0,05$) in the mass of estimated recoverable sugar in one trial. In the other trial the effect nearly reached a level of statistical significance. Measurements of stalk height confirmed the differences as Ethrel increased stalk height by 14 and 7 per cent in Trials 1 and 5 respectively.

Besides stimulating the growth of elongating internodes, Ethrel reduced the size of the leaves which were being

formed. This effect was very marked nearly five months after spraying Trial 3 in October (see Figure 3) and resulted in a dramatic change in canopy architecture (Figure 4).

Pro-Gibb Plus did not have any effect on variety NCo376 (see Table 5). However, there was evidence of growth stimulation following treatment of variety NCo293 (Figure 5). The only visual effect following treatment of NCo376 was slight cracks on some of the elongating internodes, while on NCo293 internode elongation was apparent but there was no noticeable effect on the leaves.



FIGURE 3 A marked reduction in leaf size following the application of Ethrel.

TABLE 3
Percentage change from control in the mass of estimated recoverable sugar following the application of Ethrel

Trial No.	Weeks from spraying							
	0	3	6	9	12	15	18	22
1 . . .	+ 6	+ 1	+ 4	+ 5				
2 . . .	+ 5	—	+ 7	+ 6				
3 . . .	+ 2	+ 7	+ 1	0			+12*	
4 . . .	0	0	-13	+ 6	+18	- 4**		
5 . . .	0	—	+ 2	+10	+14	+15	+14	+ 9
6 . . .	-17	-20	-16	-13	- 8	-10		

* at 17 weeks.

** treated cane was lodged.

TABLE 4
The effects of Ethrel on the lower 0,75 m of stalk and the remainder, nine weeks after spraying

Trial	Variety	Sprayed	Treatment	Lower 0,75 m				Remainder			
				Sucrose % cane	Juice purity %	Stalk mass	Mass ers g	Sucrose % cane	Juice purity %	Stalk mass	Mass ers g
1	N55/805	October	Control . . .	15,7	93,7	327	47	11,9	84,3	487	49
			Ethrel . . .	15,2	94,4	341	48	11,2	82,5	631	59
			CV % . . .	3,1	0,9	4,4	5,3	5,5	3,1	11,1	10,1
			LSD ($P = 0,05$)	0,8	1,3	24	4,5	1,1	4,2	91	8,6
5	NCo293	January	Control . . .	15,2	95,8	386	55	10,6	83,1	496	44
			Ethrel . . .	15,1	96,1	385	54	10,7	82,7	604	55
			CV % . . .	2,5	0,8	5,3	6,0	5,6	2,7	11,6	13,5
			LSD ($P = 0,05$)	0,6	1,2	30	5,0	1,0	3,6	87	10,4

TABLE 5
Results from trials with Pro-Gibb Plus (PGP) on variety NCo376

Trial	Treatment	Sucrose % cane						Stalk mass (g/stalk)									
		Weeks after the first application															
		0	3	6	9	13	17	0	3	6	9	13	17				
8	Control	8,0	10,1	10,8	11,9	12,7	12,6	291	380	355	345	392	412				
	PGP (May + Jun)	7,5*	10,0*	11,2	11,9	12,4	12,8	336*	402*	383	392	392	384				
	PGP (Jun + Jun)		10,7*	11,3*	12,0	12,6	12,9		375*	355*	341	411	416				
	PGP (Jun + Jul)			11,1*	12,0*	12,2	12,9			347*	389*	427	422				
	LSD (P = 0,05)	2,5	2,0	0,85	0,90	0,54	0,52	72	48	92	57	64	78				
Trial	Treatment	0	3	6	9	12	15	20	24	0	3	6	9	12	15	20	24
9	Control	12,2	12,9	13,7	13,3	13,5	13,3	14,8	15,2	498	567	531	575	533	531	672	605
	PGP (Apr + May)	12,4*	13,1*	13,4	13,1	13,3	13,4	14,8	15,2	489*	564*	487	536	525	572	616	619
	PGP (May + Jun)		13,7*	14,0*	13,2	13,6	13,6	14,9	15,4		575*	494*	591	564	548	606	572
	PGP (Jun + Jul)			13,8*	13,6*	13,3	14,6	14,8			611*	558	583	669	605		
	PGP (Aug + Sept)					13,9*	14,7*	14,7				584*	648*	578			
LSD (P = 0,05)	1,0	0,3	0,6	1,0	0,6	0,7	0,5	0,5	85	70	116	84	94	81	113	102	
Trial	Treatment	0	5	9	14	18	22	0	5	9	14	18	22				
10	Control	7,7	9,7	11,2	12,4	13,3	14,7	542	559	598	670	678	748				
	PGP (May)	8,0*	9,8	11,8	12,7	13,6	14,9	536*	569	636	684	703	755				
	LSD (P = 0,05)	—	0,4	0,5	1,3	0,9	0,7	—	93	49	71	129	107				
	Control		10,6	11,8	12,8	13,9	15,0		712	668	750	703	814				
	PGP (Jun + Jul)		10,1*	11,4*	12,4	13,6	14,6		685*	627*	764	734	848				
	PGP (Jul + Aug)			11,9*	12,8*	13,5	14,3			662*	760*	758	753				

* Dates of application



FIGURE 4 The change in canopy architecture following the application of Ethrel.

Discussion

The results (Figure 2) show that treatment with Ethrel stimulates growth of varieties NCo293, N55/805 and NCo310

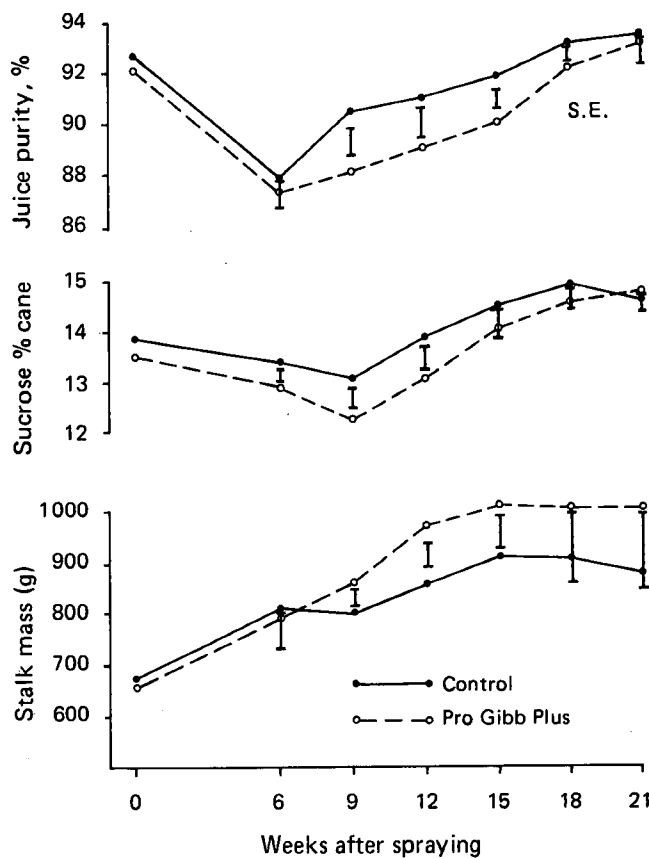


FIGURE 5 Changes in juice purity, sucrose % cane and stalk mass following the application of Pro Gibb Plus to NCo 293 in January and March (Trial 7).

but not variety NCo376, the variety grown most widely in South Africa. These results obtained with variety NCo376 support those of earlier work in the midlands region (Anon²).

However, George (unpublished) reported stem elongation which increased with increasing rates of gibberellic acid up to 800 g GA₃ per hectare when applied in March to irrigated eight-month old NCo376 growing at Komatipoort. The reasons for these differences may involve flower initiation (flower initiation occurred in 58% of the untreated cane at Komatipoort), concentration, or season. Initially, increased internode elongation following the application of Ethrel is associated with a concurrent decline in cane quality. However, from about 9 to 12 weeks after treatment, differences between cane quality of treated and untreated stalks were small in Trial 5 (see Figure 2) while differences in cane mass persisted. This resulted in increased sugar production following the application of Ethrel, which reached a peak about three months after application (Table 3).

Pro-Gibb Plus (GA₃) produced similar effects to Ethrel when applied in January and March to variety NCo293 (see Figure 5). Furthermore gibberellic acid was not effective when applied to variety NCo376 at various times during the winter period in each of the main ecological regions (Table 5). These results suggest that Ethrel and gibberellic acid may have similar effects at least on some varieties, thus confirming in part earlier evidence from treating gramineae (Andel and Verkerke¹).

The reduction in leaf canopy and change in leaf orientation following the application of Ethrel may be beneficial as it could possibly be used early in the life of the crop to reduce competition for light and consequently increase tiller survival. It is interesting to note the Pro-Gibb Plus did not produce this effect, which indicates that responses to these two growth regulators may also vary (see Andel and Verkerke¹). Current investigations are centred around applying Ethrel shortly after full canopy is reached. This is because the stalk population generally only stabilizes a few months after the development of full canopy. Also, it is undesirable to extend the time taken to reach full canopy by applying Ethrel earlier because of the likely resulting need for additional weed control. It is worth noting that mature NCo376, which did not respond to treatment with Ethrel within about four months of harvest, was subject to stalk elongation and a reduction in leaf size when treated before full canopy formation, while gibberellic acid tended to increase leaf length but reduce leaf thickness (unpublished data). The use of Ethrel to improve tillering (Takahashi¹²; Eastwood⁴) may not be beneficial on varieties like NCo376 which tiller vigorously, but it may benefit varieties like NCo293 and N8 which tend to regenerate poorly when cut in winter.

Morgan and Durham⁷, working with cotton, found that leaf abscission induced by ethylene was promoted by gibberellic acid. This would explain why similar responses may be obtained from both Ethrel (which releases ethylene) and GA₃. The results obtained indicate that cane growth may be stimulated artificially and that work with Ethrel and gibberellic acid should be continued, particularly in conjunction with glyphosates to ripen the additional growth.

These results further emphasize the need for maturity testing of cane growing in the midlands and coastal regions before applying Ethrel as a chemical ripener early in the milling season.

Conclusions

1. In addition to ripening immature sugarcane Ethrel may stimulate growth on varieties such as NCo293, N55/805 and NCo310 when the cane is mature and actively growing.
2. Gibberellic acid stimulated growth of variety NCo293 only when it was treated late in the growing season; results were similar to those obtained from Ethrel.
3. Variety NCo376 did not respond to either Ethrel when it was applied to mature sugarcane during the growing period, or to gibberellic acid when applied during the cooler winter months.
4. This preliminary work needs to be continued on younger cane and also in conjunction with a follow-up treatment with a glyphosate.
5. Higher rates of chemicals should be tried on variety NCo376.

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