Changes in sugar content of Australian sugarcane cultivars after application of chemical ripeners

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Abstract

An experiment in the Burdekin region of northern Queensland examined the responsiveness of a number of sugarcane cultivars to four ripener treatments: Ethrel (ethephon) plus Fusilade (Ethrel/Fusilade), Fusilade (fluazifop) alone, Verdict (haloxyfop) and glyphosate. Eight weeks after application, glyphosate and Ethrel/Fusilade significantly increased mean CCS by 1.2 and 0.75 units respectively. There was no significant response to Fusilade alone or Verdict. There was significant variety by ripener interactions for both glyphosate and Ethrel/Fusilade treatments indicating that some cultivars responded better than others did to both treatments. This study has shown that glyphosate and Ethrel/Fusilade can increase the sucrose content of many cultivars that can now be studied further on the basis of their responsiveness. The ability of these chemicals to enhance sugar quality in immature crops with low CCS suggests that the profitability associated with early season harvesting can be significantly improved.

Key words

Sugarcane, chemical ripening, glyphosate, fluazifop, ethephon.

INTRODUCTION

Ripening of sugarcane is a process whereby fresh weight sucrose content increases in the stalk. This process occurs naturally when crops have accumulated adequate stem biomass and when climatic conditions favour a slowing of stem elongation. Inducing mild water stress can also cause ripening (13). Since the 1940's there has been worldwide experimentation on using chemicals to artificially increase sucrose content. The chemicals found to be successful are known as ripeners.

Ripeners are an integral part of farm management in many overseas countries. Ethrel, Fusilade Super (fluazifop) and Gallant Super (haloxyfop) are registered for use in South Africa, Guyana and Swaziland. Glyphosate is used in Hawaii, Mauritius, Florida and Louisiana and Moddus (trinexapac-ethyl) is used extensively in Brazil.

The Australian industry has previously examined ripeners including Ethrel, glyphosine and glyphosate and found varying responses (3, 8, 9 and 10). The reasons were poorly understood and further research was discontinued in the late 1970's. During this period harvest season lengths were shorter and confined to the period of the year when natural ripening conditions were adequate. Further research on Ethrel commenced in the 1980's and led to its registration as a ripener; however, it is not widely used in the industry today because of continuing reports of variable responses.

There is renewed interest in the Australian sugar industry in ripeners. Some mill areas are considering increasing the length of the harvest season to improve the utilisation of mill capital and to accommodate increased productivity. The concern with harvesting before the start of the current season is that the sucrose content of cane will be low. Low sucrose levels at harvest during the harvest season have reduced productivity in other mill areas. Ripeners have the potential to increase the sucrose content of cane prior to and during the current harvest season thus improving overall mill area profitability.

The response to ripeners is not well understood but is generally believed to be dependent on the state of the crop prior to and after application (6) and is influenced by variety (4, 7 and 12).

There are a large number of cultivars available to growers within the Australian sugar industry. However, there has been no recent experimentation in Australia that has examined the varietal differences in response to the chemicals commonly used as ripeners around the world. An experiment was established at Kalamia Estate, Ayr in North Queensland where 43 cultivars were examined for their response to different ripener treatments in the 2000-growing season. The objectives were to determine whether there was genetic variation in response to ripeners when applied under conditions considered favourable for a response (i.e. good growth and high rates of photosynthesis (6)). The second objective was to identify cultivars on the basis of responsiveness for use in future experimentation.

MATERIALS AND METHODS

The experiment was planted on 11 Aug. 1999 at Kalamia Estate, Ayr (19.32^{o}S, 147.25^{o}E). The 43 cultivars were randomly allocated to sub-plots (one row, 4m long with 1.5 m between rows) in five whole plots in each of the five replicate blocks. One of five ripener treatments was randomly imposed on one of the five whole plots within each replicate. The trial was then grown and fertilised according to local industry recommendations for commercial cane.

Ripener treatments consisted of a control (unsprayed treatment), glyphosate (360 g/L glyphosate as the isopropylamine salt @ 1 L/ha), Fusilade (212 g/L fluazifop-P butyl @ 200 mL/ha), Verdict (130 g/L haloxyfop-R methyl ester @ 37 mL/ha) and a combination or “piggy-back” treatment. The combination treatment involved the application of Ethrel (480 g/L ethephon @ 1.5 L/ha) followed 4 weeks later by an application of Fusilade. The Ethrel application was applied on 8 March and all the other ripeners were applied 30 days later on the 7 April. The Fusilade and Verdict treatments included the non-ionic wetting agent Agral 60 at 350 mL/ha and 200 mL/ha of spray solution respectively. Spray solution was applied at 100 L/ha. Treatments were applied with a hand-held, LPG powered, spray boom in 3 m swaths.

Samples were collected for measurement of brix (total soluble solids) and pol (indirect measure of the sucrose concentration) on four occasions. The sampling procedure consisted of cutting two sound whole-stalks at ground level in each plot. These were fed through a small mill and the juice was analysed for brix and pol so an estimate of Commercial Cane Sugar (CCS) could be made. A fibre value of 13% was assumed and two CCS units were subtracted to approximate CCS measurement in a commercial sugarcane factory. The data was analysed and the results presented using units CCS. CCS gives an industry approximation of sucrose content. The sucrose content equals the CCS plus half the impurities percent cane (2).

Samples were collected from the control and Ethrel treatments on the 6 March and the 7 April, just prior to the application of the remaining ripener treatments. All treatments were sampled 4 and 8 weeks (on 8 May and 6 June) after the final ripener application.

The data were analysed for variance using the General Linear Model procedure in SAS (V6.12) using an analysis of variance model corresponding to a split plot in space and time (16). Data for each of the ripener treatments were analysed separately to determine the specific variety by ripener interactions.

RESULTS AND DISCUSSION

Main effects of ripeners

Averaged across all cultivars, the Ethrel/Fusilade and glyphosate treatments increased CCS over the control treatment (Table 1). Ethrel increased CCS by 0.8 units 4 weeks after application (Table 1). When Fusilade was added to the Ethrel plots, the combined treatment increased CCS over the control by 1.3 units on 8 May and 0.75 units on 6 June. Glyphosate increased CCS by 1.2 units 4 and 8 weeks after application. Fusilade alone and Verdict did not increase CCS at anytime during the experiment.

Table 1. CCS in each of the different ripener treatments compared with the control treatment at different dates. Values are the averages for 43 cultivars. ** denotes that the ripener treatment is significantly different (P<0.01) than control treatment.

Treatment	8/3/2000	7/4/2000	8/5/2000	6/6/2000
Control	0.50	3.95	7.60	10.47
Ethrel/Fusilade	0.61	4.71**	8.91**	11.22**
Fusilade			7.95	10.86
Glyphosate			8.73**	11.70**
Verdict			7.57	10.57

Effect of ripener treatments on different cultivars

There was a significant variety x ripener treatment interaction for Ethrel/Fusilade and glyphosate treatments, indicating that the cultivars differed in their response. The variety x treatment x date interaction for Ethrel/Fusilade was not significant (Table 2), indicating that the relative response of cultivars to that treatment did not differ significantly between sampling dates. However, there was a significant variety x treatment x date interaction for glyphosate (Table 2), indicating that the relative response of cultivars differed between sampling dates. This suggests that optimum treatment harvest interval for glyphosate may differ between cultivars.

CCS responses by the five most responsive and five least responsive cultivars to the Ethrel/Fusilade and glyphosate treatments are shown in Table 3. The responses of several other important cultivars are also indicated in this table. CCS increased by 2 to 3 units above the control in the most responsive cultivars.

Table 2. Mean squares for effects involving cultivars from analysis of variance of (i) the Ethrel/Fusilade and control treatment plots combined and (ii) the Glyphosate and control treatments combined. * & ** denote significance at P<0.05 and P<0.01 respectively. Degrees of freedom (d.f.) are given and where there are two numbers the first corresponds to the analysis for Ethrel/Fusilade (3 sampling times included in the analysis) and the second refers to that for Glyphosate (2 sample times).

Source of variation	d.f.	Ethrel/Fusilade	Glyphosate
Cultivar	42	12.29**	28.69**
Cultivar x treatment	42	2.67**	2.13**
Error 2	336	1.10	1.53
Variety x date	84/42	1.86**	1.22**

Variety x treatment x date	84/42	0.80 ns	1.16*
Error 4	694/353	0.69	0.74

Table 3. CCS response the Ethrel/Fusilade and glyphosate treatments at two different times. Response is defined as the CCS in plots where the ripener was applied minus CCS in the control plots. The five most responsive and five least responsive cultivars to each ripener are shown; and response of several other important cultivars is also indicated.

	Ripener					
	Ethrel/Fusilade			glyphosate		
	Variety	8/5/00	6/6/00	Variety	8/5/00	6/6/00
Most	Q127	2.2	2.0	Tellus	2.1	3.0
responsive	Q173	1.8	2.3	Q135	2.0	3.0
cultivars	Q117	2.2	1.8	Q180	2.7	1.8
	MQ88-2047	2.7	1.3	Q113	1.7	2.7
	Q135	2.2	1.7	Q117	1.4	2.5
Least	Q152	0.9	0.0	Q138	-0.2	0.9
responsive	Q158	0.4	-0.5	Q186	0.7	-0.1
cultivars	Q163	-0.1	-0.2	Q163	0.4	0.2
	Q162	-0.2	-0.2	87A1413	0.6	-0.4
	Q136	-0.1	-1.1	Q179	0.5	-0.3
Other	Q96	1.7	0.6	Q96	1.7	1.6
important	Q120	0.9	0.0	MQ88-2047	0.6	0.2
cultivars	Tellus	1.6	1.4	Q127	1.8	1.7

l.s.d. ($p<0.05$)	1.7	1.7	1.9	1.9

Other studies have found significant differences in the response of cultivars to both Ethrel/Fusilade treatments and to glyphosate (4, 7, 5 and 12). Donaldson (5) found that some cultivars were responsive to Fusilade alone and that Ethrel in combination with Fusilade did not improve the response, whereas other cultivars had an increased response to the combination treatment. In our experiment, Fusilade did not increase CCS significantly and there was no treatment by variety interaction for Fusilade response, but there was variation in response by cultivars to the Ethrel/Fusilade combination. Roston (14) reported that Fusilade gave responses comparable to glyphosate when applied to South African cultivars although higher rates of Fusilade increased the response of some cultivars (15). A higher rate of Fusilade may be necessary for a response to occur in Australian cultivars in general.

Variation in the response of different cultivars to Ethrel/Fusilade combinations have been attributed to lodging, plants that were less lodged at application responded to the ripener treatment whereas those that were more lodged did not respond (5). However, none of the cultivars in our experiment were lodged at the time of application.

Our study also found no increase in CCS due to Verdict application. There is little published information on Verdict, which has recently been registered for use as an early season ripener in South Africa as Gallant Super (Donaldson per comm.). The active ingredient concentration of the formulation of Verdict that we used in this study was about four times higher than that of Gallant Super and uptake by the plant may have been difficult due to the low volume of chemical used. The use of an adjuvant or crop oil to facilitate the uptake of Verdict may improve the response at the low application rates used.

There was a significant interaction between ripener, variety and sampling date for glyphosate. Dusky et al., (7) also reported that response to glyphosate and the time between ripener application and achievement of maximum response differed between cultivars. They concluded that some cultivars needed different harvest intervals from ripener application than others. Alexander (1) hypothesised that sensitivity to glyphosine (a related precursor to glyphosate) in inter-specific hybrid cultivars of sugar cane is determined by the contribution of *S. officinarum* to that variety.

This study has shown that many Australian cultivars are responsive to Ethrel/Fusilade and glyphosate and that some are extremely responsive. We did not elicit responses to Fusilade alone and Verdict. Future work will concentrate on identifying the reasons behind varying responses and examining the effect of different rates of Fusilade and rates and formulations of Verdict.

CONCLUSION

Glyphosate and Ethrel in combination with Fusilade can significantly improve the CCS of early-harvested, Australian sugarcane cultivars. A number of important cultivars were identified as being responsive to one or both of these treatments, including Q117, Q127 and Q135. Our work shows there is potential to increase the CCS and hence productivity and profitability of immature sugarcane crops in the early part of the season. Further work is required to determine response criteria that will maximise the probability of positive responses to ripeners. This information will provide greater management options for growers to improve early season CCS. Further work will also focus on assessing the role of ripeners in improving late season CCS.

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