EFFECTS OF FUSILADE SUPER ON THE GROWTH AND YIELDS OF THE SUGARCANE VARIETY NCo376

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Abstract

An experiment was conducted to verify the results from a preliminary study of the responses to Fusilade Super when applied to drought stressed cane. Irrigation was suspended at different times before harvesting to induce stress ranging from nil to severe. Stress was monitored through leaf water potential readings, measurements of plant extension rates and soil moisture levels which were estimated by a profit and loss account. Fusilade Super was applied to the cane 98 days before harvesting and whole stalk samples were taken twice after spraying to monitor the effects on sucrose content and stalk mass. One undisturbed row in each plot was harvested to determine plot yields 98 days after the ripener was applied. Cane tops which were left in plots after harvesting were analysed to determine the effect of topping on the responses to treatments. The results confirmed that the greatest benefit from applying Fusilade Super was from well irrigated, unstressed cane and that responses were substantially lower in stressed cane. The effects of topping on the responses to treatments are discussed. No residual effects from Fusilade Super were detected in the succeeding crop at the age of 12 months, regardless of whether or not the cane had been stressed at the time of spraying.

Introduction

Fusilade Super disrupts cane growth and causes the sucrose content of stalks to increase. This altered growth may cause losses in cane yield if the spray to harvest interval is long. Preliminary investigation (Donaldson and van Staden, 1992) showed little effect of Fusilade Super on stalk mass and cane yields. This was so, despite a long interval between spraying and harvesting, and the chemical having been applied to well irrigated and stressed cane. A possible reason for this may have been the relatively large tops that broke off when samples were being prepared for analysis and severe topping of well grown cane at the time of harvesting. The expected decreases in cane mass due to moisture stress and the possible effects of Fusilade Super could therefore have been masked. An alternative method of assessing the effects of these treatments on stalk mass and sucrose content was therefore necessary.

In addition to estimating soil moisture levels through a profit and loss account, the reaction of the plants to changing soil moisture levels by factors other than sucrose content and cane yields, was also measured. These were leaf water potentials, plant extension rate and senescence of leaves, which are useful indicators of developing drought stress.

It was also decided to impose more severe stress than that developed during the preliminary experiment (Donaldson and van Staden, 1992) to assess the residual effects of Fusilade Super when applied to drought stressed cane.

Treatments and Methods

After the first ratoon crop was harvested on 26 July 1989, the site was irrigated with overhead sprinklers during August and September. The physical characteristics of the Hutton sandy clay soil at the site, with a total available moisture capacity (TAM) of 464 mm (Thompson, 1976), have been reported by Donaldson and van Staden (1992). The site was fertilised with a top-dressing of 635 kg/ha 1.0.1 (36). Smut infected stalks were removed on four occasions up to the end of February.

After overhead irrigation was suspended in September, perforain pipes were used to irrigate individual plots. W1 plots were irrigated regularly up to July to produce conditions free of drought stress. Irrigation to W2 plots was suspended after March to induce moderate stress. W3 plots were irrigated on 22 June and 14 July to relieve stress which had developed from suspending irrigation in September. W4 plots received no irrigation after September. A profit and loss account of the moisture gained by the soil from rainfall and irrigation and that lost through evapotranspiration (Et) was computed for the entire period of the crop. An arbitrary amount of 200 mm of moisture was credited to the profit and loss account on 1 October when the crop was 66 days old. The ratio between Et and evaporation (Eo) from an open class A pan (Et:Eo) was assumed to be 0,7 for the first 30 days after 1 October and 0,85 for a further 30 days until the time that the cane foliage formed a complete canopy at the end of November. After this, calculations to estimate soil moisture levels were the same as those used for the plant crop (Donaldson and van Staden, 1992). After W3 plots had been irrigated to relieve stress, the Et of W3 cane was again assumed to be equal to Eo (Inman-Bamber, 1986). The treatments, which were replicated seven times in a random block design, were re-randomised for this experiment.

The rate at which trimmed spindle leaves were extending (plant extension rate or PER) and leaf water potentials (LWP) were measured on various dates with a Scholander pressure chamber as described by Inman-Bamber (1986).

On 18 April, the net rows of half the number of plots were sprayed with 330 ml per hectare of Fusilade Super, using a hand-held boom with two TK 1,0 floodjet nozzles.

One hundred stalks were marked in two net rows of each W1 and W4 plot before Fusilade Super was applied. The marking and sectioning technique (Donaldson, 1992) which was used, produced five sections of each stalk that were in relatively similar positions for sprayed and unsprayed stalks, so that they could be compared at different intervals after spraying the ripener. Section one = top 200 mm + new growth, section two = second 200 mm, section three = third 200 mm, section five = the basal 1 000 mm and section four = the remaining mid section. On 6 June and 10 July (data not shown for this date), 24 marked stalks were harvested from each plot, sectioned and weighed. The sections were shredded and the juice that was extracted was analysed in the conventional way.

Standard 16-stalk samples were taken from all plots at intervals after spraying. Data from these samples are presented elsewhere (Donaldson, 1992) and are referred to briefly in the discussion.

On 25 July the cane in the fourth net row of each plot was harvested and weighed. A sample of 40 stalk tops was taken from each plot after the cane had been harvested. The tops were weighed and analysed so that an assessment of the effect that topping may have had on treatments, could be made. No attempt was made to remove the leaf sheaths which clung to the stalk tops after burning.

The number of stalks in the fourth net row were counted, on five occasions from January until the time of harvesting on 25 July, and converted to stalk population per hectare. At the time of harvesting the flowers which had emerged in the fourth net row of each plot were counted.

The residual effects of treatments on growth of the next ratoon, which was irrigated by overhead sprinklers, were monitored by measuring stalk heights and counting stalk numbers. At 12 months of age the cane was harvested and weighed in the same manner as that described for the previous crop.

Results and Discussion

Climatological and soil factors

Between April and July, when minimum temperatures were declining, the production of stalk dry mass was favoured above the production of wet mass in well irrigated cane (Figures 1 and 2).

The estimated soil moisture of W4 plots on 21 April showed that approximately 330 mm or 70% of the TAM of 464 mm had been depleted (Figure 3). At this time the TAM in W1 plots was estimated to be depleted by about 57%. The moisture balance shows that moisture levels were maintained above 50% of TAM in the W1 plots until June. Any

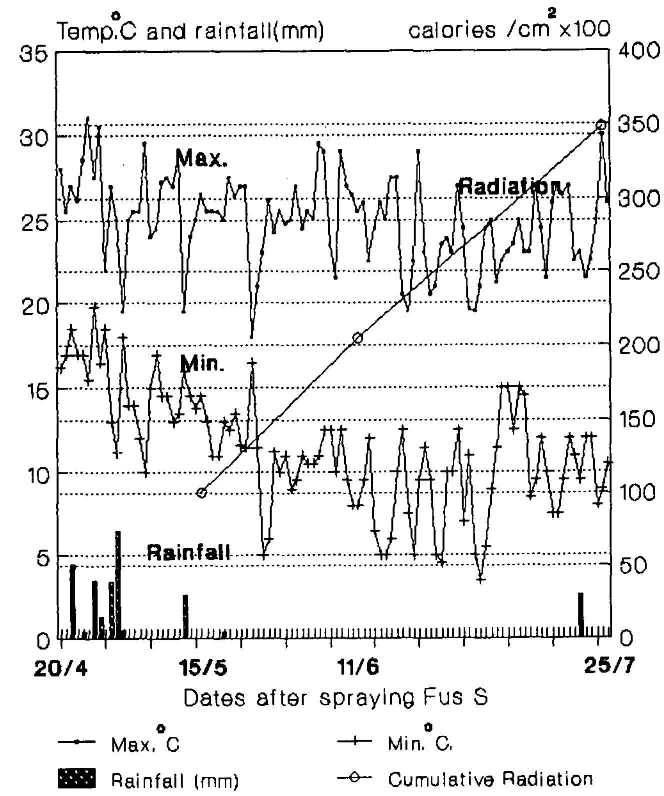

FIGURE 1 Minimum and maximum temperatures, rainfall and cumulative radiation between 20 April and 25 July.

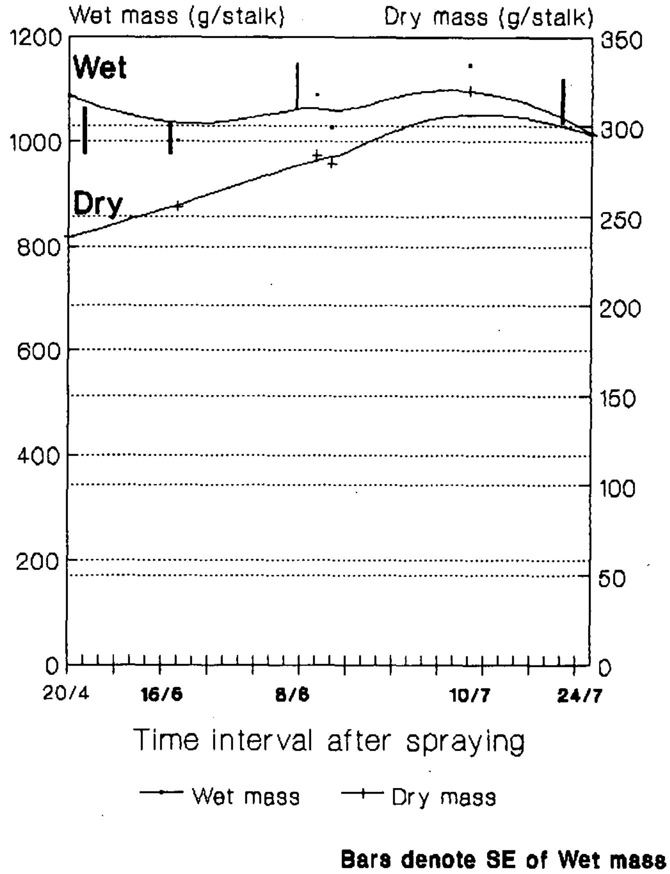

FIGURE 2 Accumulation of wet mass and dry mass of unstressed stalks after 20 April.

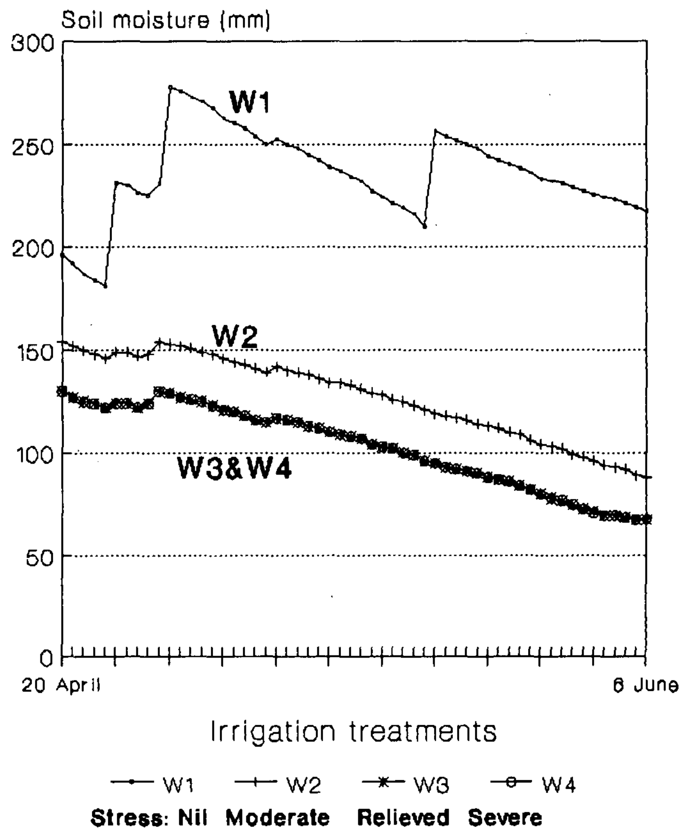

FIGURE 3 Soil moisture differences between irrigation treatments from 20 April to 8 June estimated by profit and loss account.

error that arose from the arbitrary assumption of the soil holding 200 mm at the onset of the experiment was probably nullified when the soil profile was filled by 344 mm of rainfall between 28 November and 4 December 1989, when the crop was four months old. The soil moisture values shown in Figure 3 are estimates and may not be accurate indications of the actual moisture content.

Leaf water potentials and plant extension rates as indicators of stress

Leaf water potential (LWP) measurements suggested that stress had developed in W4 plots by 28 March (Figure 4) and by 21 April had decreased to -1,5 MPa. This is an indication that the plants were severely stressed at the time that Fusilade Super was applied on 18 April. At such levels of LWP stomatal resistance rises rapidly and green leaf areas of the stalk are reduced (Inman-Bamber, 1986). Between April and July the LWP of W1 cane fluctuated between -0,3 and -0,5 MPa so that PER could have been restricted and stomatal resistance could have risen gradually. Although the LWP recorded in the W1 cane of this experiment was slightly lower than might be expected from a well watered crop, it may well be a feature of a maturing crop (Inman-Bamber, 1986). The LWP of W2 cane (about -1,0 MPa) suggests that the stress was moderate in comparison with little in W1 and severe in W4 cane. Since the irrigation treatments in W3 and W4 plots were similar until June, it would be a reasonable supposition that until then LWP of the cane from these two treatments were similar. PER of W1 cane were on average greater than those of W4 cane between 29 March and 17 April (Figure 5). PER of the unstressed cane (W1), although being well below potential at 2,3 mm/h, was more rapid than for other irrigation treatments (between 0,6 and 1,0 mm/h) on 2 to 3 April. Before 9 April the unstressed cane appeared to respond positively through increasing PER as temperatures rose. Whereas the increasing temperatures evoked a decrease of PER in stressed cane before 9 April, PER of unstressed cane increased during this time. After 9 April the PER of the stressed cane (W3 and W4) rose rapidly to be equal to, or exceed, that of the unstressed cane. Responses of stressed cane to the rainfall between 30 March and 6 April typify the effects that relieving stress has on PER. This was also evident after the late irrigation of W3 plots.

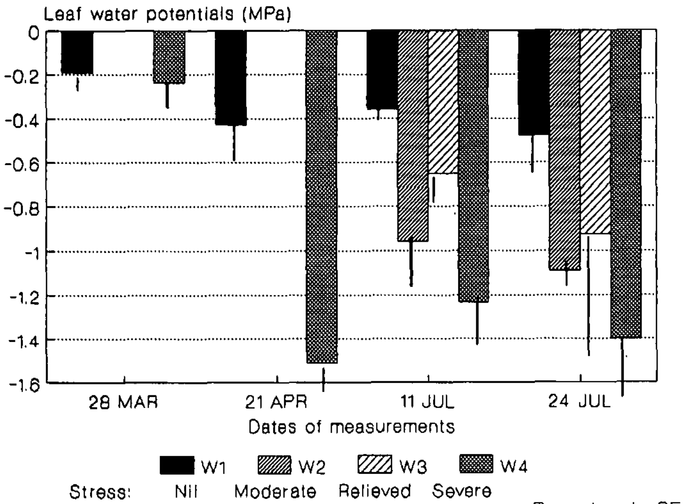

FIGURE 4 Leaf water potentials of cane subjected to four different irrigation treatments.

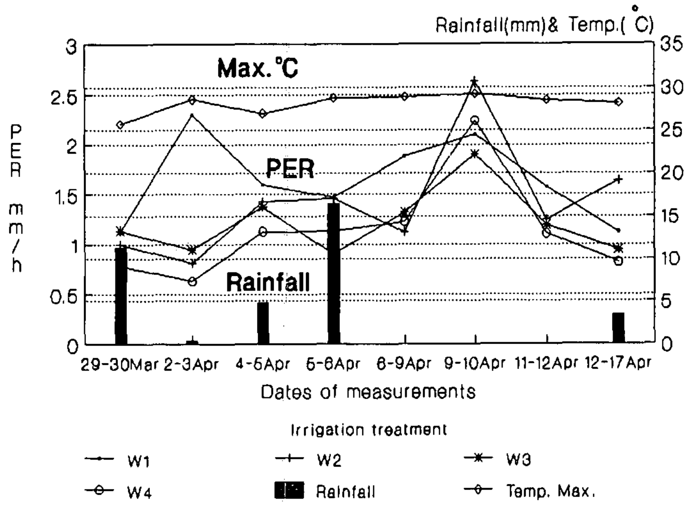

FIGURE 5 Plant extension rates (PER), rainfall and temperatures of cane subjected to four different irrigation treatments.

Changes in cane mass, sucrose content and sucrose yields

The greatest gain of sucrose mass was from the unstressed cane (W1) and moderately stressed cane (W2) 54 days after the ripener was applied (data not shown). The loss of responses in the standard samples after this time is attributed to natural ripening, the extensive lodging in rows that were being sampled and emergence of flowers (41% in unstressed cane not treated with ripener) (Nuss, 1989).

On 6 June (50 days after spraying) the small differences between sections of sprayed and unsprayed cane amounted to a reduction of 2% in the total stalk mass of unstressed cane, due to the application of Fusilade Super, and a mass gain of 2,6% in stressed cane (Table 1). By 10 July the wet mass of Fusilade Super treated cane was respectively, 7,4% less than and 16% greater than the unsprayed cane which had been unstressed and stressed (data not shown). These differences were mainly located in the mid and basal sections of stalks.

Table 1

Mass (g) of stalk sections from unstressed and stressed cane with (FS) and with (FS) and without (C) Fusilade Super treatment from samples taken on 6 June

	UNSTRESSED			STRESSED				
Stalk section	C	FS	FS-C	C	FS	FS-C	SED±	LSD 0,05
1	65	70	+ 5	60	57	− 3	5	10,5
2	60	68	+ 8	70	65	− 5	8	16,9
3	74	75	+ 1	75	79	+ 4	4	8,9
4	396	345	−51	226	246	+20	29	61,6
5	494	515	+21	510	518	+ 8	15	32,1
Total	1 089	1 073	−16	941	965	+24		

The improved sucrose contents of all sections above the base were substantial in the unstressed cane in response to the ripener (Table 2) and were evident only in the topmost section of the stressed stalks. Between 6 June and 10 July the sucrose content increased by about one unit in all treatments, so that responses in sucrose content on 10 July were similar to those recorded on 6 June.

Table 2

Sucrose content (pol % cane) of stalk sections from unstressed and stressed cane with (FS) and without (C) Fusilade Super treatment from samples taken on 6 June

	UNSTRESSED			STRESSED				
Stalk section	C	FS	FS-C	C	FS	FS-C	SED±	LSD (5%)
1	3,3	5,9	+2,6	4,9	6,1	+1,2	0,62	1,3
2	7,3	9,7	+2,4	9,7	9,7	0	0,44	1,3
3	8,3	10,2	+1,9	11,7	11,4	−0,3	0,42	1,3
4	10,6	12,0	+1,4	13,4	13,4	0	0,45	1,3
5	13,6	14,1	+0,5	16,1	15,7	−0,4	0,26	0,8
Total	11,2	12,4	+1,2	13,9	13,8	−0,1		

The gains of sucrose mass from applying Fusilade Super are presented in Figure 6 as the increased mass of sucrose per dry mass of each section, since the length (and mass) of the stalk sections were not equal. The data show that the responses, in terms of sucrose mass, were two to three times greater in the top 700 mm of the unstressed stalk than they were in the basal 1 000 mm. On 10 July there was a significant (P=0,05) gain of sucrose in base sections of unstressed stalks which had been sprayed with Fusilade Super. This sucrose increase was not evident on 6 June. Responses to Fusilade Super were not evident in standard samples taken after 6 June, while the significantly higher sucrose content of sectioned stalks, which were not stressed and had been sprayed, persisted to 10 July. This was probably because lodged and flowered stalks comprised the standard sample, whereas upright non-flowered stalks were selected for sectioning.

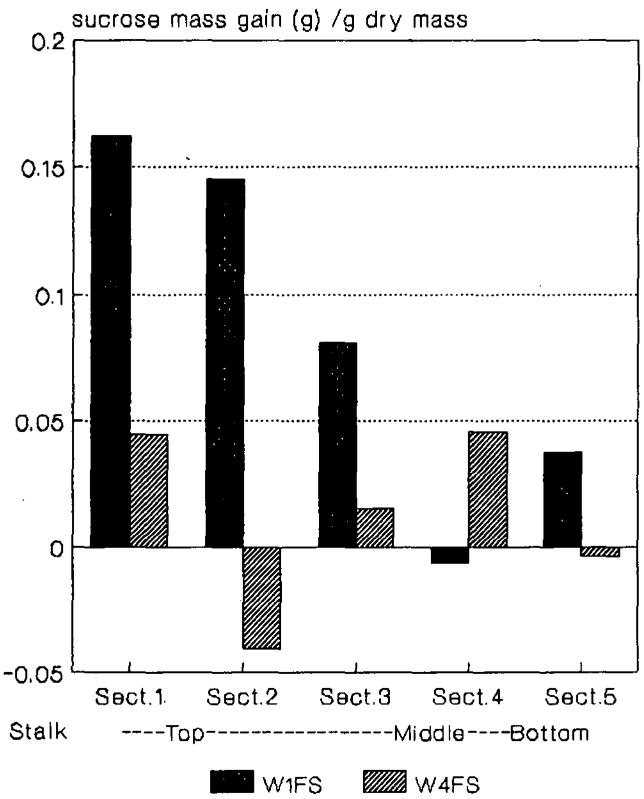

FIGURE 6 Gains of sucrose mass (g) per g dry mass of stalk sections in unstressed (W1) and stressed (W4) cane from treatment with Fusilade Super (FS) on 6 June.

Yield parameters at the time of harvesting

Stressed cane yielded 25% less cane wet mass than well irrigated cane (Table 3). The greater difference in cane mass from plot yields compared with that from the standard samples was probably due to the higher number of stalks in the irrigated plots which are not accounted for by sampling. Because of the substantial loss of potential cane growth in the stressed plots (W4), sucrose yields were on average 2,0 ± 1,28 tons per hectare less than in the well irrigated cane (W1) at the time of harvesting.

Table 3

Yields, sucrose content (ers % cane) and stalk numbers of NCo376 from four irrigation treatments (W) without (C) and with (FS) Fusilade Super harvested on 24 July

Treatments	Cane t/ha	Ers % cane	Ers t/ha	Stalk numbers/ha
W1C	140,8	11,8	16,6	153
W1FS	124,9	12,0	15,1	128
W2C	124,2	12,1	15,0	143
W2FS	127,5	11,5	14,6	121
W3C	123,3	13,3	16,3	169
W3FS	109,5	13,2	14,4	135
W4C	105,8	13,1	13,9	126
W4FS	98,9	13,8	13,7	136
MEAN	119,4	12,6	14,9	139
CV %	13,1	6,8	16,0	12,0
SE +	5,9	0,4	0,9	6,3
LSD 0,05	16,8	1,1	2,6	17,9
LSD 0,01	22,5	1,4	3,4	24,0
W1	132,8	11,9	15,8	140
W2	125,9	11,8	14,8	132
W3	116,4	13,3	15,4	152
W4	102,3	13,4	13,8	131
SE ±	4,2	0,3	0,6	4,5
LSD 0,05	11,9	0,8	1,8	6,3
LSD 0,01	15,9	1,1	2,4	12,7
Control	123,5	12,6	15,5	148
Fusilade S	115,2	12,6	14,4	130
SE ±	3,0	0,2	0,5	3,2
LSD 0,05	8,4	0,5	1,3	9,0
LSD 0,01	11,3	0,7	1,7	12,0

The effects of Fusilade Super on the wet mass of stalks comprising the standard sample taken from well irrigated plots on 24 July, were negligible (<2%), while the mass of sectioned stalks taken on 10 July reflected a reduction of 7% due to Fusilade Super. Cane yields of well irrigated cane were on average 11% lower where Fusilade Super had been applied at the time of harvesting.

The yield data shown in Table 3 are those from cane which was topped at harvesting. Table 4 gives the mean mass of tops that were left in the plots at harvesting, their sucrose contents and the mass of sucrose which could be recovered from them.

The estimated cane yield from the discarded tops would be equivalent to 16 t/ha, 13 t/ha, 13 t/ha and 9 t/ha and the total cane yields would be 149 t/ha, 139 t/ha, 129 t/ha and 111 t/ha for W1, W2, W3 and W4 cane, respectively. By including the yield from the tops the indications are that moderate and severe stress had reduced cane yields by 10

Table 4

Wet mass (g), sucrose content (pol % cane) and estimated recoverable sucrose (ers g/top) of discarded tops at harvesting from four irrigation treatments (W) with (FS) and without (C) Fusilade Super

Treatments	Wet mass (g)	pol % cane	Ers mass (g)
CW1	116	6,8	4,9
FSW1	113	8,0	6,4
CW2	86	7,0	3,2
FSW2	114	8,5	6,8
CW3	85	6,5	3,3
FSW3	79	6,9	3,6
CW4	72	7,7	3,5
FSW4	64	7,7	3,1
MEAN	91	7,4	4,4
CV %	21,5	14,7	40,0
SED ±	10,5	0,6	1,2
LSD P = 0,05	21,2	1,3	1,9
W1	114	7,4	5,7
W2	100	7,7	5,2
W3	82	6,7	3,5
W4	68	7,7	3,3
SED ±	7,4	0,4	0,7
LSD P = 0,05	14,9	0,8	1,4
C	90	7,0	3,8
FS	93	7,8	5,0
SED ±	5,2	0,3	0,5
LSD P = 0,05	10,6	0,6	1,0

and 38 tons per hectare respectively, which are greater than the reductions indicated by data from topped cane. The late irrigation applied to W3 cane increased cane yields by 21 tons per hectare and not by 17 tons per hectare as would be deduced from the cane yields of topped cane shown in Table 3. This reinforces the likelihood that the reason for similar cane yields of stressed and well irrigated cane in the experiment reported in the preliminary study (Donaldson and van Staden, 1992) was associated with differential topping.

Tops of well irrigated cane which had been sprayed with Fusilade Super contained significantly (P=0,05) more sucrose than untreated cane tops. Data from the sectioned stalks indicate that differences would have been substantially greater had the cane been harvested between 6 June and 10 July. There was little difference in the sucrose content of all tops from stressed (W3 and W4) cane at harvesting. These results provide further evidence that the sucrose yields from tops should be included when estimating the sucrose yield benefit from the application of Fusilade Super, particularly to well irrigated cane (Donaldson, 1989).

The yields at harvesting (Table 3) showed no adverse effects from having applied Fusilade Super to stressed cane. This could be of some significance, since it may indicate that the risk is low when using this chemical in areas which are not irrigated, and where stress may develop if no rain falls after spraying. There is good evidence that losses in cane and consequently sucrose yields may be suffered within a relatively short time, when Fusilade Super is applied to stressed cane which later reverts to rapid growth.

The benefit from applying Fusilade Super in this experiment was inversely proportional to the increased sucrose content which was induced by the stress that the plants endured before samples were taken. The observation that Fusilade Super had little effect on the wet mass of cane stalks was not surprising since stalks accumulated little wet mass during the first 50 days after the ripener was applied.

Residual effects

No residual effects of Fusilade Super were detected while the growth of the succeeding crop was monitored. After twelve months of growth, cane yields of Fusilade Super treated cane was no different from untreated cane, regardless of whether the chemical had been applied to unstressed or stressed cane in the previous crop (Donaldson, 1992).

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