A NEW CHEMICAL (GLYPHOSATE) FOR KILLING SUGARCANE

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ABSTRACT

The results of eight experiments to evaluate the efficacy of glyphosate (N-(phosphonomethyl)glycine) for killing sugarcane are discussed. Factors that were considered include the time of application, growth stage of the crop, rate of application, spray volume and varietal susceptibility. Glyphosate applied to actively growing sugarcane with a leaf canopy height of approximately 30-60 cm consistently gave the best results. Varieties differed in their susceptibility to glyphosate but results indicate that under favourable conditions an application rate of 3,6 kg a.e. per hectare will kill most of the released sugarcane varieties of the South African sugarcane industry.

Introduction

Sugarcane growers today are being encouraged to plant only pure and disease-free seedcane as a foundation for a good sugarcane crop. The efforts that are put into procuring healthy seedcane can be lost, however, if the field to be planted contains diseased volunteer plants from the previous crop. It is important to eradicate the volunteers to obviate transmission of disease to the new crop.

The method of fallowing land for a season following harvest and plough-out, using continued cultivation or a cover crop to eliminate volunteers, has lost favour due to economic pressures to keep the land in production. The technique used currently in most areas within the South African sugar industry is to first plough the field in early winter so as to invert the cane stools, and this is then followed by repeated cross-cultivations with disc or tined implements to ensure desiccation of the old cane stools, the volunteers that subsequently germinate being generally dug out with a hand hoe. The elimination of volunteers with conventional land preparation equipment is extremely ineffectual and the cost of removing germinating volunteers by hand is very high so that a chemical which kills sugarcane would therefore be of value for eliminating the old crop. For such a chemical to be of value it would need to be quick-acting, have no soil residue which would harm the following crop, and be totally effective and reliable.

A number of workers have reported the efficacy of glyphosate (N-(phosphonomethyl)glycine) in killing various weed species and agricultural crops (Overton *et al*,[1] Worsham and Lewis,[2] Derting *et al*,[3] Connell and Derting,[4] Wiese,[5] Baird and Upchurch[6]).

Glyphosate is a broad spectrum, post-emergence herbicide that is well translocated to roots and tubers from sprayed foliage. It is inactivated in the soil and hence has no residual activity. The mode of action of glyphosate has been fully described by Jaworski.[7] This paper reports the results of six experiments which were established to observe the efficacy of glyphosate in killing sugarcane. Factors which were studied include crop growth stage, rates of application, spray volumes, varietal susceptibility and the effect of season.

Experimental

The Mon 2139 formulation of glyphosate which contains 360 grams per litre of acid equivalent of the isopropylamine salt of (N-(phosphonomethyl)glycine) and surfactant, was used in all experiments.

For experiments I, III and IV a gas-operated sprayer was used and for the remainder a lever-operated knapsack. In each case the spray nozzle was held directly above the sugarcane row ensuring full coverage of the foliage.

Ratings on the per cent kill of sugarcane are based on the E.W.R.C. 1–9 scoring system. A rating of 1 = no effect, and 9 = 100% kill.

Experiment I

The initial observation trial was established on the site of a discontinued variety trial to evaluate the efficacy of glyphosate for killing sugarcane with a single application in winter, in summer, and with a winter spray followed by a summer spray. Two rates of glyphosate were used at all times — 2 kg a.e. and 4,0 kg a.e. per hectare with a water volume of 380 l/ha.

The sugarcane when sprayed in winter (July) had 3–7 leaves unfurled and a leaf canopy height of 45–60 cm, having been harvested 2 months previously. Soil conditions were wet and air temperatures were cold (15°C) at the time of spraying and cool weather and poor growing conditions followed for 3 months.

At the time of the summer application (November) the crop had 8–10 leaves unfurled and an average leaf canopy height of 80 cm. Soil conditions were damp and air temperatures were warm (21,5°C) at the time of spraying and very good growing conditions prevailed in the month following treatment.

Results

The effects of glyphosate on the sugarcane became visible within 5 days of spray application with the proximal end of the lower leaves becoming chlorotic. Chlorosis then occurred on the remainder of the leaf surface and also became apparent on the remaining leaves. Gradually the distal end of the lower leaves became necrotic, and when this spread to all parts of the plant the cane stool died.

The cane that had been sprayed in winter at rates of 4 kg a.e./ha slowly developed healthy shoots after the initial growth setback, eventually being practically indistinguishable from the unsprayed cane. Glyphosate applied at 2 kg a.e./ha in winter was totally ineffectual.

Summer applications of 4 kg a.e./ha severely affected the cane and at one stage 95% of stools were estimated to be dead. However, after 2 months a few green shoots developed from parts of the stools and these then tillered and developed normally. The low application rate of 2 kg a.e./ha was again unsatisfactory.

Where the cane had been sprayed in both winter and summer at the 4 kg a.e./ha rates, the stools were the most severely affected of all treatments, but recovery did occur but to a lesser extent than the summer-only applications.

Observations indicated a varietal difference in susceptibility to glyphosate.

Experiment II

A former nematicide trial which included sugarcane varieties N 55/805 and N 50/211 was used to observe he efficacy of glyphosate at different rates of application. The treatments were applied in November when the ratooning cane had a leaf canopy height of 80 cm with approximately 8 leaves unfurled per shoot. A total of 40 metres of cane row was sprayed at each herbicide rate.

The following rates were applied:

1 Control

2 glyphosate at 0,8 kg a.e. per hectare

3 glyphosate at 1,6 kg a.e. per hectare

4 glyphosate at 3,2 kg a.e. per hectare

5 glyphosate at 4,8 kg a.e. per hectare

An application volume of 450 l/ha was used for all rates.

Results

Four weeks after treatment leaf chlorosis had developed on all the treated rows of sugarcane and this ranged from severe (4,8 kg a.e.) to slight (0,8 kg a.e.). Although the trial was sprayed in very calm wind conditions, there was evidence of leaf chlorosis on the adjacent unsprayed lines.

Six months after treatment a 100% kill had been achieved at the 4,8 kg a.e. rates and only a few green shoots were present in the rows sprayed at the 3,2 kg a.e. rate. The sugarcane sprayed with 0,8 and 1,6 kg a.e./ha showed severe stunting but the new tillers that had developed were healthy. At the two lower spray rates it appeared from the rate of regrowth that the variety N 50/211 was more susceptible to glyphosate than was variety N 55/805.

Experiment III

This experiment was also established with sugarcane varieties N 50/211 and N 55/805 to determine the optimum rate of glyphosate for the post-emergence killing of ratoon sugarcane, but treatments were applied in May, compared to the November applications of Experiment II. The cane at time of spraying (May) had an average leaf canopy height of 75 cm. Glyphosate was applied at 2,2, 2,9, 3,6, 4,2 and 5,0 kg a.e. per hectare with a common water volume of 867 l/ha. Treatments were replicated 4 times.

Results

The mean visual rating for both varieties, for the degree of control obtained at 6 weeks and 24 weeks after spray application are presented in Table I.

TABLE I

Mean visual ratings at 6 and 24 weeks after spray application in Experiment III

Treatment	Weeks after application	
	6 weeks	24 weeks
Control	1	1
Glyphosate 2,2 kg a.e. per ha ..	4,5	8,0
Glyphosate 2,9 kg a.e. per ha ..	6,0	8,5
Glyphosate 3,6 kg a.e. per ha ..	7,0	9,0
Glyphosate 4,2 kg a.e. per ha ..	8,5	9,0
Glyphosate 5,0 kg a.e. per ha ..	9,0	9,0

Supporting the results of Experiment II, early ratings indicated a quicker and more effective kill of variety N 50/211 than of variety N 55/805 at all rates of application, but 24 weeks after spray application a varietal difference was not apparent at rates of 3,6 kg a.e./ha and greater. At the two lower rates, however, variety N 50/211 appeared to be more susceptible than variety N 55/805.

Experiment IV

An experiment was designed to determine the optimum stage of growth at which to spray ratooning sugarcane with glyphosate. The trial area was divided into 4 blocks, the harvesting of which was done at 10-day intervals in order to obtain ratoon cane at variable growth stages, when the whole trial was sprayed on 24th May. The age of the crop and the height of the leaf canopy for the respective blocks are shown in Table II.

TABLE II

Age and growth stage of the ratoon crop at the time of spray application in Experiment IV

Treatment	Harvest date	Age (days) at time of spraying	Average height of leaf canopy in cm
1	2 March	82	75
2	12 March	72	60
3	22 March	62	45
4	2 April	52	30

A common rate of glyphosate of 3,6 kg a.e./ha was applied but the water volume for each block was calibrated independently so as to apply sufficient diluent to reach the point of "run-off". The application volumes used were 867, 750, 683 and 633 litres per hectare respectively for the 82, 72, 62 and 52-day-old cane.

Results

The green shoot counts at 2 and 6 months after spraying are presented in Table III.

TABLE III

The number of green shoots per plot at 2 and 6 months after spray application in Experiment IV

Height of leaf canopy (cm)	At time of spraying	2 months after spraying	6 months after spraying
75	350	52	0
60	289	51	3
45	408	72	4
30	144	8	0

Although spraying at all growth stages eventually achieved a similar degree of kill it was the 30 cm, 45 cm and 60 cm high cane which suffered a quicker and more effective initial knockdown.

Experiment V

From earlier experiments it appeared that the optimum rate of glyphosate was fairly critical for the efficient killing of sugarcane. Hence a further trial was established on variety NCo 376 to compare rates of application, and in the case of two of the rates, high and low water volumes. Treatments were replicated four times in a randomized block design. Glyphosate was applied at 2,2, 2,9, 3,6 and 4,3 kg a.e./ha with a water volume of 700 l/ha, and 2,9 and 3,6 kg a.e./ha were applied with a water volume of 320 l/ha. Treatments were applied in October to ratooning sugarcane with a leaf canopy height of ± 55 cm.

Results

The mean visual ratings taken 3, 5 and 7 weeks after spray application are presented in Table IV.

TABLE IV

Mean visual ratings of the effects of different rates of glyphosate sprayed in different volumes of water on to ratooning variety NCo 376 in Experiment V

Treatment	Weeks after application		
	3 weeks	5 weeks	7 weeks
2,2 kg a.e. per ha/700 l	2,0	4,5	6,0
2,9 kg a.e. per ha/700 l	2,25	5,75	6,5
3,6 kg a.e. per ha/700 l	4,0	7,75	8,0
4,3 kg a.e. per ha/700 l	3,75	8,5	8,0
2,9 kg a.e. per ha/320 l	3,5	7,75	8,25
3,6 kg a.e. per ha/320 l	4,5	9,0	9,0

Seven weeks after treatment glyphosate applied at 3,6 kg a.e. per hectare in 320 litres of water was the only treatment to achieve a complete kill. Without exception, glyphosate when applied in the lower water volume achieved a greater degree of control than did the equivalent rates in the higher water volume.

Experiment VI

Results from Experiments I, II and III indicated a difference in varietal susceptibility to glyphosate. A further trial was established therefore to determine the susceptibility to glyphosate of many more released sugarcane varieties. The trial was established at Windy Hill on a ratoon crop of a discontinued variety trial which included the following varieties:

CB 36/14, N 55/805, N 6, NCo 382, NCo 376, NCo 293, CB 38/22, N 50/211, N 51/539, N 53/216 and N 51/168.

All varieties were sprayed with both 2,9 and 3,6 kg a.e. of glyphosate per hectare in a water volume of 425 litres per hectare. Varieties differed in their stages of growth at the time of spraying (November), but on average the cane had 5–6 leaves unfurled with an average canopy height of ± 40 cm. The trial was sprayed in overcast weather and a slight drizzle commenced 2 hours after applying the final treatment. In the 20 hours following spraying, 20,3 mm of rain was recorded.

Results

The mean ratings at 3 and 8 weeks after spray applications are presented in Table V with the varieties listed in order of decreasing susceptibility to 3,6 kg a.e. per hectare of glyphosate 8 weeks after treatment.

TABLE V

Mean visual ratings on the effects of spraying glyphosate at two rates on eleven sugarcane varieties in Experiment VI

Variety	Glyphosate 2,88 kg a.e./ha		Glyphosate 3,6 kg a.e./ha	
	3 weeks	8 weeks	3 weeks	8 weeks
N 50/211	5,0	6,0	6,25	7,5
N 51/168	5,75	7,0	6,0	7,25
NCo 382	5,25	4,75	6,5	7,0
CB 36/14	4,75	5,0	5,25	7,0
NCo 376	3,0	3,0	4,25	6,25
N 53/216	2,75	4,0	3,75	6,0
NCo 293	4,0	5,0	4,5	5,75
CB 38/22	4,0	3,0	5,25	5,25
N 51/539	3,75	4,75	4,0	5,0
N 55/805	2,5	2,25	4,75	4,5
N 6	3,25	3,0	3,25	4,5

Eight weeks after treatment none of the varieties had been killed completely with either rate of glyphosate but N 50/211 appeared to be one of the most susceptible, with N 55/805 one of the least susceptible varieties.

Discussion

The results from the experiments reported indicate that glyphosate has the ability to kill sugarcane. However, there appear to be a number of factors affecting the efficacy of the chemical.

Winter applications of glyphosate were not as effective as those applied in warm weather and with moist soil conditions, indicating greater efficacy during periods of active sugarcane growth. Active growth is presumably necessary for the effective translocation of the chemical.

The optimum stage of sugarcane growth at which spray application is most effective does not appear to be too critical, but a quicker and more effective kill will initially be achieved if glyphosate is applied to sugarcane having a leaf canopy height of between 30 and 60 cm. If taller cane is sprayed control will take longer to achieve. As glyphosate is translocated through the leaf surface, the crop must be allowed to develop sufficient leaf area so as to allow adequate absorption of the chemical. A minimum stage may be 4–5 leaves unfurled at a height of $\pm$ 30 cm.

When using a chemical of this nature to kill sugarcane volunteers it would be essential that the first application be successful, as all the benefits apart from expense would be lost if another application were necessary. Therefore applying the correct rate of glyphosate is very important. Results indicate that glyphosate applied at 3,6 kg a.e. per hectare will give a reliable kill of sugarcane providing other factors are favourable. At rates lower than 3,6 kg a.e. unacceptable results can be expected.

Although a complete kill of any one variety was not achieved in Experiment VI sufficient control was achieved to confirm earlier findings that sugarcane varieties differ in their susceptibility to glyphosate. Varieties N 6 and N 55/805 proved to be the most difficult to control but in earlier experiments (II, III and IV) sprayed under favourable climatic conditions, glyphosate applied at 3,6 kg a.e. per hectare gave acceptable control of N 55/805. It could be expected therefore that, given favourable conditions, the eleven varieties present in Experiment VI could be controlled with glyphosate applied at 3,6 kg a.e. per hectare.

Baird and Upchurch[6] found that when glyphosate was applied in spray volumes of between 112 and 337 litres per hectare, greater activity on *Sorghum halepense* was achieved than when similar rates of glyphosate were applied in spray volumes of 1 010 litres per hectare. This supports the findings of Experiment V where better control of sugarcane was achieved with spray volumes of 320 litres per hectare compared with 700 litres per hectare. For the commercial application of herbicides the use of lower spray volumes is of economical importance when considering the transportation of water.

The comparatively poor results obtained with glyphosate in Experiment VI indicate that rainfall following application reduces the efficacy of the chemical. Baird and Upchurch[6] found the occurrence of rainfall within eight hours after herbicide application reduces activity, with the most significant reduction occurring within four hours after application.

Conclusions

This series of experiments has indicated that sugarcane can be killed by glyphosate, but to be totally effective both crop growth and climatic conditions have to be favourable.

Further investigations are required to assess the ways in which glyphosate can be most advantageously used in the South African sugar industry. There is the potential for its use in chemical ploughing and minimum tillage which has important implications, particularly in the steep areas of the sugarbelt, and also for simple spot spraying of volunteer plants after the first ploughing.

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