RESULTS OF SCREENING PRE-EMERGENCE HERBICIDES FOR SUGARCANE

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Abstract

Results are reported of three pre-emergence herbicide screening trials designed to evaluate weed control efficacy, and one trial in which the phytotoxic effects of selected pre-emergence herbicides on sugarcane were studied. Eleven coded compounds, used alone or in combination with other herbicides, were evaluated for their pre-emergence weed control efficacy, and their activity was compared with that of pre-emergence herbicides currently recommended by the South African Sugarcane Association Experiment Station. Of the herbicides evaluated CGA 17020, CGA 24705, EL 103, DPX 3674 and MBR 2851 showed sufficient activity on weeds to warrant inclusion in the initial phytotoxicity trial which was conducted in trays. Used at twice the recommended rate, CGA 24705, EL 103, DPX 3674 and MBR 8251 all exhibited phytotoxic effects on plant cane of variety NCo 376.

Introduction

Weeds have their greatest detrimental effect on the ultimate yield of sugarcane during the early stages of the crop development (Pearson[1]), and for this reason pre-emergence herbicides can play a valuable role in controlling weeds at this critical growth stage. Under certain conditions it is feasible, with some of the newly developed herbicides, to control weeds adequately by means of a single spray application at the time of planting or soon after harvesting.

Weeds emerging in the cane row probably constitute the greatest weed problem, as it is these weeds which are the most difficult to control by cultivation. Furthermore, full cover post-emergence herbicide applications are of limited value if the sugarcane leaf foliage is offering protection to the underlying weeds. Pre-emergence herbicides can be used very successfully to keep the cane row weed-free until the crop is well established. The need for subsequent weed control is then usually restricted to the interrow where it can be obtained by means of cultivation or directed interrow applications of post-emergence herbicides.

Both 2, 4-D and MCPA have been widely used in the South African sugarcane industry in past years as pre-emergence herbicides, and in most cases have provided acceptable control of broadleaf weeds and a number of annual grasses. However, with their constant use a number of semi-tolerant or tolerant weed species are becoming dominant. Such weeds include *Panicum maximum*, *Digitaria* spp., *Cyperus rotundus*, *C. esculentus* and a number of broadleaf weeds. Because of these 2, 4-D and MCPA-tolerant weeds, and the demand for more persistent pre-emergence herbicides, there is a constant need for new herbicides developed by agricultural chemical companies to be evaluated locally. In recent years two new pre-emergence herbicides, alachlor and metribuzin, have been introduced to the South African sugarcane industry, and their efficacy has been reported on by Richardson[2,3] and Hebblethwaite.[4]

This paper is a report on the findings from four pre-emergence screening experiments. Experiments I, II and II were designed to evaluate the weed control efficacy of a number of new herbicides under different soil and climatic conditions. Five promising herbicides were selected from these three experiments to be included in Experiment IV which was established to test for phytotoxic effects on plant cane.

Experimental

Experiments I and III were carried out on fallow land in the absence of sugarcane, whilst Experiment II was established in a field of variety NCo 376 plant cane. To test for phytotoxicity in Experiment IV, 6 single-eye setts of variety NCo 376 were planted in trays and the various selected treatments were applied.

The physical characteristics of the soils from the four experiment sites are presented in Table 1. The table also includes, for Experiments I, II and III, the rainfall recorded 0-14 and 15-28 days after herbicide application, and the moisture content of the top 5 cm of soil at the time of spraying.

TABLE 1

Description of the soils, soil moisture contents and rainfall recorded at the sites of the four experiments

Experiment No. and location	Physical characteristics of the soil			Moisture content in top 5 cm at time of spraying	Rainfall following spraying	
	% Clay	% Sand	% Silt		0-14 days	15-28 days
I Shakas Kraal	5,0	89,0	5,0	6,2%	67,0	55,3
II Mt Edgecombe	44,0	22,0	34,0	6,9%	97,0	234,1
III Shakas Kraal	19,0	11,0	69,0	11,2%	4,9	46,0
IV Mt Edgecombe	34,0	54,1	11,0	—	—	—

The experiment designs were random blocks, with treatments replicated four times in Experiments I, II and III and six times in Experiment IV.

For the screening trials an unsprayed control area surounded each sprayed plot to assist in evaluating the efficacy of weed control in each treatment. Visual ratings of weed control efficacy were made at regular intervals. The ratings were based on a 1-9 scoring system, a score of 1 representing 100% control, 4 just commercially acceptable, 5 just commercially unacceptable, and 9 no effect whatsoever. For evaluation purposes grass and broadleaf weed species have been grouped together, but where relevant, observations pertaining to individual species have been recorded.

Technical details of the herbicides used are given in Appendix I.

Experiment I

The experiment was established at Shakas Kraal on the Natal Coast during October 1973 under conditions favourable for pre-emergence weed control. Sixty-seven millimetres of rain were recorded in the 14 days following herbicide application. Weeds which were dominant in the control areas included *Cyperus esculentus*, *Eleusine indica*, *Digitaria adscendens*, *Commelina benghalensis* and *Nicandra physalodes*.

Alachlor + atrazine, metribuzin, 2, 4-D amine, MCPA and diuron were applied at rates currently recommended by the South African Sugar Association Experiment Station (Anon[5]). Two rates of application were used for each of the new coded compounds. The lower rate used was that recommended by the manufacturers for a sandy loam, and the higher rate was either double the lower rate or the rate recommended for soils with a higher clay or organic matter content.

Results

The mean visual ratings recorded 36, 56 and 77 days after herbicide application are presented in Table 2.

TABLE 2

Mean visual ratings 36, 56 and 77 days after spray application in Experiment I

Treatment		Days after application								
Herbicides	Rate per hectare kg a.i. or a.e.	*C. esculentus*			Grasses			Broadleaf		
		36	56	77	36	56	77	36	56	77
alachlor + atrazine	1,92+1,0	3	5	7	1	1	4	2	2	4
metribuzin . . .	1,75	4	5	7	2	2	3	1	1	2
2, 4-D amine. . .	2,9	7	9	9	4	7	7	5	7	7
MCPA . . .	2,8	6	8	8	2	3	6	4	4	4
diuron	3,2	5	6	7	2	2	4	3	3	5
U27267 + atrazine .	2,0+1,0	5	6	6	2	1	2	5	5	7
DPX 2851 . . .	2,4	3	2	2	1	1	1	1	1	1
DPX 2851 . . .	4,8	2	2	2	1	2	2	1	1	1
EL 103	0,8	5	7	8	2	3	6	3	4	5
EL 103	1,2	6	7	7	2	2	5	3	2	5
SN 40624 . . .	1,0	5	7	8	5	5	7	7	8	8
SN 40624 . . .	2,0	6	7	7	5	7	7	5	6	7
LS 691299 . . .	1,0	6	8	8	3	7	8	6	7	8
LS 691299 . . .	3,0	7	9	9	3	5	6	3	3	6
AC 92553 . . .	0,75	6	8	9	2	5	7	8	9	9
AC 92553 . . .	1,5	6	7	8	2	2	5	7	8	8
MBR 8251 . . .	2,25	2	3	3	1	2	4	2	3	6
MBR 8251 . . .	4,5	1	1	2	1	1	2	1	2	3
CGA 17020+atrazine	1,0+1,0	3	4	6	1	1	4	1	2	5
CGA 17020+atrazine	1,5+1,0	3	4	6	1	1	4	1	2	4
CGA 17020+atrazine	2,0+1,0	2	3	6	1	1	3	1	2	3
CGA 17020+29696	2,0+1,0	2	3	5	1	1	1	1	1	1
DPX 3674 . . .	1,25	2	2	3	1	1	1	1	1	1
DPX 3674 . . .	2,5	3	2	2	1	1	1	1	1	1

Discussion

Both alachlor + atrazine and metribuzin gave good control of grasses but metribuzin was more effective on broadleaf weeds. The efficacy of alachlor + atrazine and metribuzin on the Cyperaceae has previously been reported by Richardson[2,3] and Hebblethwaite,[4] and in this experiment both treatments gave acceptable control of *C. esculentus* for a period of six weeks. The more effective and longer control of broadleaf weeds and grasses by MCPA compared with 2, 4-D amine may be attributed in part to the lower water solubility of MCPA (Anon[6]). Richardson[3] reported that the herbicide U27267 was particularly weak on *Commelina benghalensis* and in this experiment, even with the addition of atrazine, the species was notably tolerant to the herbicide.

Of the eight new compounds four gave very effective weed control at both the low and the high rates of application. These were CGA 17020 + atrazine (or CGA 29696), DPX 2851, DPX 3674 and MBR 8251. DPX 3674 was outstanding in its complete control of grasses, broadleaf weeds and its very effective control of *C. esculentus*. *C. esculentus* was also well controlled by the other three products but control with the CGA 17020 combinations held for a period of approximately 60 days. The control of *C. esculentus* by MBR 8251 has previously been reported by Gentner.[7] However, MBR 8251 was ineffective in controlling broadleaf weeds. EL 103 gave a reasonable control of grasses and broadleaf weeds but had very little effect on *C. esculentus*. SN 40624, LS 691299 and AC 92553 gave unacceptable control of all weed species.

Experiment II

The experiment was established on Saccharine section of Hulett's Natal Estates near Mt. Edgecombe in January 1974. The treatments were applied the day after the site had been planted with variety NCo 376. Alachlor + atrazine and metribuzin at the recommended rates were again used as the standard treatments for comparison. The herbicides which had provided effective weed control in Experiment I were included at two rates of application. The occurrence of weeds was variable throughout the experiment site but the following species were dominant: *Rottboellia exaltata, Panicum glabrescens, Echinochloa colonum, Commelina benghalensis, Hibiscus trionum* and *Acalypha ecklonii.*

Results

The mean visual ratings of weed control efficacy recorded 50 and 70 days after herbicide application are presented in Table 3.

TABLE 3

Mean visual ratings 50 and 70 days after spray application in Experiment II

Treatment		Days after spraying			
Herbicide	Rate per ha. kg. a.i.	Grasses		Broadleaf weeds	
		50	70	50	70
alachlor + atrazine . .	1,92+1,0	3,0	3,75	5,5	6,75
metribuzin	1,75	3,0	4,5	3,5	4,75
CGA 17020 + atrazine .	1,5+1,0	2,75	4,0	4,0	5,25
CGA 17020 + atrazine .	2,0+1,0	2,25	2,25	4,25	4,5
MBR 8251	2,25	2,0	3,0	5,25	6,25
MBR 8251	4,5	1,0	2,5	3,75	4,5
DPX 3674	1,25	1,0	1,0	1,0	1,25
DPX 3674	2,5	1,0	1,0	1,0	1,25
DPX 2851	2,4	3,5	3,25	3,5	4,25
DPX 2851	4,8	2,25	2,25	2,0	3,75
EL 103	0,8	3,75	4,5	5,5	6,25
EL 103	1,6	4,75	5,75	5,25	6,25

Discussion

All treatments, with the exception of EL 103, gave commercially acceptable control of grasses for a period of 70 days. Confirming the results of Experiment I, DPX 3674 at both rates gave complete control of grasses and virtually complete control of broadleaf weeds. Although the population of *R. exaltata* was low within the experiment area, the only herbicides to give complete control were DPX 2851 and DPX 3674. Only DPX 2851 and DPX 3674 gave commercially acceptable control of broadleaf weeds for a period of 70 days. MBR 8251 was notably weak on *A. ecklonii* and *H. trionum*. Unusually short term broadleaf weed control was achieved with alachlor + atrazine, which was probably due to the high clay content of the soil. The weed control efficacy of atrazine is reduced by a high clay content of soils (Anon[8]). The conclusion of the experiment (i.e. 70 days after spraying), observations were made on the effects of the herbicides on sugarcane growth. The only treatment to cause any visual sign of phytotoxicity was DPX 2851 at 4,8 kg a.i. per hectare. The visual symptoms were leaf chlorosis and slight stunting of cane growth.

Experiment III

The experiment was established at Shakas Kraal during October 1974. At the time of spraying, the soil moisture content was 11,2% in the top 5 cm (see Table 1), but the soil was very dry between 5 and 30 cm deep. During the first 14 days following herbicide application only 5 mm of rainfall was recorded, but 46 mm fell between the 15th and 28th days after treatment.

Alachlor + atrazine, metribuzin, 2, 4-D and MCPA were again included as standard treatments for comparative purposes. Evidence had become available (Gonggrijp and Wessels[9]) that indicated that DPX 3674, used at rates above 1,25 kg a.i. per hectare, could be phytotoxic to plant cane when applied pre-emergence on some soils. DPX 3674 was therefore used at rates of 0,25 and 0,5 kg a.i. per hectare in this experiment to determine whether effective pre-emergence weed control could be achieved at these lower rates of application.

Weed species germinating in the control areas included *Cyperus rotundus*, *Amaranthus spinosus*, *Nicandra physalodes*, *Portulacca oleracea*, *Datura stramonium*, *Lepidium didymus* and *Cleome monophylla*.

Results

There was rapid germination of *C. rotundus* from the outset of the experiment. No herbicide showed any control of this weed until after the first significant fall of rain (41 mm) which was recorded 23 days after herbicide application. It was only following the rain that broadleaf weeds germinated in quantity. The mean visual ratings of weed control efficacy recorded 29, 43, 63 and 84 days after herbicide application are presented in Table 4.

TABLE 4

Mean visual ratings 29, 43, 63 and 84 days after spray application in Experiment III

Treatment		Days after application							
		Cyperus rotundus				Broadleaf weeds			
Herbicides	Rate per ha. kg. a.i. or a.e.	29	43	63	84	29	43	63	84
metribuzin	1,75	9,0	8,3	8,3	8,0	5,5	1,0	1,5	1,5
alachlor+atrazine	1,92+1,0	9,0	9,0	9,0	8,8	2,3	1,8	3,5	3,3
2,4-D amine	2,9	9,0	9,0	9,0	9,0	2,5	4,0	6,8	7,3
MCPA	2,8	9,0	8,5	8,8	9,0	3,3	3,0	5,5	6,0
CGA 24705+ atrazine	2,0+1,0	9,0	8,0	8,5	8,8	1,3	1,8	4,0	4,0
CGA 24705+ atrazine	3,0+1,5	9,0	8,5	8,8	8,5	2,8	1,0	1,8	2,0
CGA 17020 atrazine	1,5+0,75	9,0	7,5	8,0	8,8	2,5	1,3	2,8	2,5
CGA 17020+ atrazine	2,0+1,0	9,0	7,3	8,0	8,5	1,0	1,3	2,0	2,3
alachlor+atrazine	3,36+1,0	9,0	8,8	8,8	8,8	2,3	1,3	2,3	2,0
alachlor	4,32	9,0	8,0	8,5	8,0	1,3	1,8	2,8	3,3
MBR 8251	2,0	9,0	5,5	5,8	6,8	6,0	5,0	6,5	7,3
MBR 8251	3,0	9,0	4,3	4,8	4,8	6,3	5,5	6,5	8,5
DPX 3674	0,25	9,0	8,8	8,5	8,8	7,5	2,0	3,3	3,0
DPX 3674	0,5	9,0	7,3	6,8	7,3	7,0	1,0	1,8	2,0
WL 63611	1,0	9,0	9,0	9,0	9,0	8,5	5,0	6,8	8,0
WL 63611	2,0	9,0	9,0	9,0	9,0	6,8	3,8	6,5	5,8
metribuzin+diuron	1,4+1,6	9,0	8,3	7,5	8,0	5,8	1,3	1,3	2,0
EL 103	1,5	9,0	7,8	7,8	8,3	5,5	2,0	3,8	3,3
EL 103	3,0	9,0	6,5	5,3	5,8	5,8	1,0	1,0	1,0
2, 4-D lithium	2,9	9,0	8,0	8,8	9,0	2,8	4,5	7,3	7,5

Discussion

Dean and Parker[10] have reported control of *C. rotundus* with pre-emergence applications of MBR 8251 at 2,28 kg a.i. per hectare, and in this experiment it was the only herbicide to provide commercially acceptable control of the weed. At 3,0 kg a.i. per hectare acceptable control was achieved for a period of 84 days. Treatment with EL 103 at 3,0 kg a.i. per hectare was approaching acceptable control after 84 days and the only other herbicide which gave any indication of control was DPX 3674 at 0,5 kg a.i. per hectare.

Despite the fact that there was only 5 mm of rain in the 14 days following herbicide application, the standard treatments with alachlor + atrazine, 2, 4-D and MCPA still provided control of broadleaf weeds for a period longer than is normally expected of such products under local conditions. This would indicate that lack of soil moisture following the application of the herbicides may not necessarily be a limiting factor in respect of persistence of weed control.

From Table 4 it can be seen that the broadleaf weeds were controlled in two different ways by the herbicides. Metribuzin, DPX 3674, metribuzin + diuron and EL 103 controlled the weeds after they had emerged, but the remaining herbicides tended to inhibit germination of weed seeds. This confirms that the previously mentioned herbicides are active when applied pre- or post-emergence (Anon,[11] Gonggrijp and Wessels[9]).

Eighty-four days after herbicide application, 2, 4-D amine, MCPA, MBR 8251, WL 63611 and 2, 4-D lithium were the only treatments no longer giving commercially acceptable control of broadleaf weeds. Confirming the results of Experiment I, MCPA was slightly more effective than was 2, 4-D amine. MBR 8251 was notably weak on *Cleome monophylla*, *D. stramonium* and *L. didymus*.

Experiment IV

From the results of the three weed control experiments it was evident that CGA 17020, CGA 24705, EL 103, DPX 3674 and MBR 8251 were providing sufficient herbicidal activity to warrant studies being made on their phytotoxic effects on sugarcane.

The trial was established in December using 45 cm × 20 cm × 20 cm trays full of soil into which six one-eyed setts of sugarcane variety NCo 376 were planted. Immediately after planting the setts at a depth of 5 cm, herbicides were applied at 2 times the rate recommended by the manufacturers for a sandy clay soil. Alachlor + atrazine, at 2 times the recommended rate, was included for comparative purposes. The trays were irrigated daily with a perfo-rainer system and an amount of nutrient solution was applied to each tray at regular intervals. Visual observations on the phytotoxic effects of treatments were made during development of the crop and, eleven weeks after planting, the above-ground portions of the plants were cut and weighed.

Results

Only the DPX 3674 and MBR 8251-treated cane showed any visible phytotoxic effects. The sugarcane sprayed with DPX 3674 developed a very chlorotic appearance which eventuated in the leaf tips becoming necrotic and the plants stunted. MBR 8251 caused a slight initial stunting of growth and a bunched appearance of the individual plants. Leaf colour was darker green compared with those in other treatments.

The trial was harvested at a time when it was considered that the herbicides were having their greatest effect on growth and it is considered likely that had the time of harvesting been delayed, then treatment differences would have been reduced. The harvest data are presented in Table 5.

TABLE 5

Harvest results of the sugarcane phytotoxicity trial established in trays: Experiment IV

Treatment	Rate kg. ai/ha	Mean no. of setts germinated	Mass of plant material in grams
Control	—	4,2	89
CGA 24705+atrazine	6,0+3,0	3,8	72
CGA 17020+atrazine	4,0+2,0	4,8	88
MBR 8251 . . .	7,0	3,7	74
EL 103	3,0	3,5	73
DPX 3674 . . .	3,0	4,3	56
alachlor+atrazine .	3,84+3,0	4,3	87
Mean	—	4,1	77
L.S.D. (P< 0,05) .	—	1,5	16

Discussion

The number of setts which germinated in each treatment was not affected by herbicide treatments at a level which was statistically significant, but the variability within treatments was high. DPX 3674 caused severe stunting of sugarcane growth which was also reflected in the mass of harvested plant material. CGA 24705 + atrazine, MBR 8251, EL 103 and DPX 3674 all substantially reduced the mass of harvested plant material, which stresses the need for these herbicides to be re-evaluated for phytotoxicity to sugarcane under field conditions to determine whether the effects persist until the normal age of harvest. The standard treatment, alachlor + atrazine did not affect plant growth detrimentally.

Conclusions

The currently recommended pre-emergence herbicides alachlor + atrazine, metribuzin, 2, 4-D and MCPA gave consistent results. CGA 17020 + atrazine provided excellent control of *Cyperus esculentus* and the control of grasses and broadleaf weeds was comparable with that given by metribuzin and alachlor + atrazine. DPX 3674 at higher rates was outstanding in the control of *C. esculentus*, grasses and broadleaf weeds.

MBR 8251 was the only herbicide evaluated to give commercially acceptable control of both *C. esculentus* and *C. rotundus*. Grasses were also well controlled but a number of broadleaf weeds appear to be tolerant to this chemical, indicating that the addition of a pre-emergence herbicide active on broadleaf weeds may be required.

Of the herbicides evaluated in this initial phytotoxicity trial, it was evident that CGA 24705 + atrazine, MBR 8251, EL 103 and DPX 3674 can have a detrimental effect on plant cane when applied pre-emergence at double the recommended rates of application.

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Appendix

Details of herbicides used in the four experiments

Herbicide used	Trade Name	Manufacturer	Formulation
alachlor	Lasso e.c.	Monsanto	48% *ℓ*
atrazine	Gesaprim 80	Ciba Geigy	80% w.p.
2, 4-D dimethylamine salt	Fernimine 7	Triomf	72% a.e. *ℓ*
diuron	Karmex	du Pont	80% w.p.
MCPA potassium salt	Fernimine 4	Triomf	48% a.e. *ℓ*
metribuzin . . .	Sencor	Bayer	70% w.p.
2, 4-D lithium salt	2, 4-D Lithate	Guth	92% a.e. w.s.p.
MBR 8251 . . .	Destun	3M	50% w.p.
DPX 3674 . . .	Velpar	du Pont	90% w.s.p.
CGA 24705/atrazine	—	Ciba-Geigy	50% *ℓ*
AC 92553 . . .	—	Cyanamid	33% *ℓ*
CGA 17020 . . .	—	Ciba-Geigy	40% *ℓ*
CGA 29696 . . .	—	Ciba-Geigy	80% w.p.
DPX 2851† . . .	—	du Pont	80% w.p.
EL 103	—	Elanco	80% w.p.
LS 691299 . . .	—	Pepro	50% w.p.
SN 40624	—	Schering	80% w.p.
U 27267	—	Upjohn	75% w.p.
WL 63611. . . .	—	Shell	50% w.p.

† DPX 2851 has been withdrawn by the manufacturers; a.e. = acid equivalent; *ℓ* = liquid; w.p. = wettable powder; w.s.p. = water soluble powder.