A COMBINATION OF TEBUTHIURON AND DIURON FOR WEED CONTROL IN SOUTH AFRICAN SUGARCANE

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Abstract

A combination of tebuthiuron (25%) and diuron (50%) called Bimate* was evaluated for pre-emergence and post-emergence weed control. An early post-emergence application was the best treatment. No phytotoxicity to either plant or ratoon cane was recorded when the recommended rates of 4,0 kg of Bimate per ha were used on soil containing 8 to 30% clay, and 5,0 kg of Bimate per ha on soil containing 30 to 50% clay. There was no detrimental effect of the herbicide on sucrose content of the cane and residues of tebuthiuron and diuron were less than 0,1 mg/kg in the cane juice at all levels of chemicals tested. Stalk counts and height measurements showed an improvement over those obtained in the untreated control plots. The uses of this combination under various conditions are discussed.

Introduction

Tebuthiuron was initially developed as an industrial herbicide (Walker, Jones and Shaw[1], Eaton, Cebalo, Rainey, Sieck and Todd[2]). Development work indicated that, at rates lower than those used industrially, tebuthiuron could control weeds in sugarcane (Schwer[3], Pafford[5]). In 1975 development trials with tebuthiuron commenced in South Africa where it was evaluated as a pre-emergence treatment. At the same time the S.A. Sugar Association Experiment Station evaluated the compound (Iggo[5]) at high levels and found good weed control and signs of phytotoxicity to sugarcane. Initially, field results were variable and it was decided to evaluate tebuthiuron in combination with other compounds. The combination with diuron performed well under most conditions for pre-emergence and early post-emergence weed control and was not phytotoxic to plant and ratoon cane at the recommended rates. The combination that is now registered for use in sugarcane in South Africa is tebuthiuron 25% and diuron 50% marketed as Bimate 75 wp, previously coded EL-6003[6]. The chemical characteristics and toxicology of tebuthiuron were described by Schwer[3].

Materials and Methods

Replicated field trials were conducted throughout the sugarcane growing area of South Africa on soils ranging from 4 to 53% clay content and 0,31 to 7,01% organic matter content during the 1976/77, 1977/78 and 1978/79 growing seasons. The design of the trials was randomised blocks which were usually replicated four times. Plots consisted of at least three rows which were 10 m long. Untreated control plots as well as standard treatments of metribuzin/diuron and hexazinone/diuron were included in all trials. Trials were conducted on plant and burnt ratoon cane before and after the emergence of weeds. Post-emergence trials were done when broadleaved weeds were smaller than the six leaf stage and grasses had not yet tillered. Plant cane was generally at the one to two unfurled leaf stage and ratoon cane 100 to 200 mm high.

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Cultivars on which tebuthiuron/diuron was evaluated were NCo 293, NCo 310, NCo 376, N55/805, N53/216, N8 and CB36/14.

Treatments were evaluated for weed control efficacy at 30-day intervals until the canopy had fully developed, using the Barrett Horsfall method (0 = no control, 10 = 100% control) and expressing the results as a percentage of the weeds controlled in comparison with the untreated areas.

Stalk height measurements were taken on twelve randomly selected stalks per plot and measured from ground level to the uppermost visible node. Stalk counts were made on the centre row of each plot excluding 1 m at both ends of the plot. Damage to cane was rated at 30 day intervals for crop stunting and chlorosis. All treatments were applied with a carbon dioxide precision sprayer usually with a floodjet nozzle spraying a 1 m swath. Volume rates varied from 180 to 470 litres/ha. Dosage rates of Bimate ranged from 2,0 to 10,0 kg/ha, that is 0,5 to 2,5 kg of tebuthiuron/ha and 1,0 to 5,0 kg of diuron/ha. Agricura G49 or Cittowett surfactant at 0,2% was added to the spray solution for post-emergence applications. Samples comprising 5 to 10 cane stalks taken at random from each treatment in each replicate were taken six to eleven months after treatment for tebuthiuron and diuron residues and sucrose determinations. The juice was expressed and the sample submitted for analysis. Residue determinations were done by the SA Bureau of Standards and the sucrose determinations by the SA Sugar Association Experiment Station.

Results

1. *Pre-emergence Trials*

   (a) Broadleaf weeds: Control of the more common broadleaf weeds encountered in sugarcane, such as *Acalypha eckloni, Ageratum conyzoides, Amaranthus* spp., *Argemone mexicana, Bidens* spp., *Chenopodium* spp., *Commelina bengalensis, Galinsoga parviflora, Gnaphalium pensylvanicum, Portulaca oleracea, Richardia brasilensis, Siegesbeckia orientalis, Solanum* spp and *Tagetes minuta* was good to excellent at dosage rates of 4,0 to 5,0 kg Bimate/ha.

   (b) Grass Weeds: The efficacy of Bimate against grass weeds before emergence was variable. In the majority of trials the major grass weeds encountered were well controlled. In some trials, certain grasses, notably *Panicum maximum,* was not adequately controlled at 3,0 kg Bimate/ha but good control was obtained with 4,0 to 5,0 kg Bimate/ha. Table 1 illustrates the level of control achieved with Bimate on three common species of grass.

   (c) *Cyperus esculentus:* Bimate had little effect on *C. esculentus* as a pre-emergence treatment (see Table 2). Higher rates were more effective than lower rates but were not commercially acceptable. There were indications that a reasonable level of control could be achieved on light soils but this was not so in soils with a high clay content.

TABLE 1
The Efficacy of Bimate on the Percent Control of Grasses in Pre-emergence Situations

Species		*Panicum maximum*				*Panicum laevifolium*			*Digitaria sanguinalis*				
Trial Number		ZA 76.020	ZA 77.102	ZA 77.106	ZA 78.103	ZA 77.101	ZA 77.105	ZA 77.106	ZA 76.020	ZA 77.101	ZA 77.103	ZA 77.104	ZA 77.105
Clay %		21	53	9	24	9	32	9	21	9	5	40	32
Days after application		58	64	63	57	62	62	98	58	91	61	61	62
Bimate kg/ha	3,0	46,6	45,0	95,0	—	88,7	100,0	100,0	100,0	98,7	98,7	90,0	100,0
	4,0	93,3	45,0	90,0	72,5	98,7	100,0	100,0	100,0	98,7	98,7	96,9	98,7
	5,0	—	100,0	92,5	100,0	100,0	100,0	100,0	—	100,0	99,4	99,4	100,0
	8,0	—	—	100,0	100,0	97,5	100,0	100,0	—	100,0	—	91,9	100,0

TABLE 2
The Efficacy of Bimate on the percent control of *C. esculentus* in Pre-emergence Situations

Species		*Cyperus esculentus*					
Trial Number		ZA 76.020	ZA 77.101	ZA 77.102	ZA 77.104	ZA 77.107	ZA 78.103
Clay %		21	9	53	40	4	24
Days after application		58	62	64	61	98	57
Bimate kg/ha	3,0	10,0	20,0	10,0	20,0	85,0	—
	4,0	20,0	10,0	0,0	22,5	80,0	66,2
	5,0	—	40,0	10,0	53,3	73,7	63,7
	8,0	—	58,7	—	71,9	—	—

TABLE 3
The Efficacy of Bimate on the Percent Control of Some Grasses in Post-emergence Situations

Species		*Panicum maximum*			*Panicum laevifolium*			*Digitaria sanguinalis*			
Trial Number		ZA 78.103	ZA 78.105	ZA 78.111	ZA 78.107	ZA 78.108	ZA 78.111	ZA 78.103	ZA 78.107	ZA 78.108	ZA 78.111
Clay %		24	6	23	9	9	23	24	9	9	23
Days after application		57	60	65	57	59	65	57	57	59	65
Bimate Kg/ha	4,0	100,0	90,0	97,5	95,0	97,5	100,0	100,0	97,5	100,0	97,5
	5,0	100,0	90,0	100,0	100,0	99,4	100,0	100,0	100,0	100,0	99,4
	6,0	100,0	—	—	—	—	—	100,0	—	—	—
	10,0	—	—	100,0	100,0	100,0	100,0	—	100,0	100,0	100,0

TABLE 4
The Efficacy of Bimate on the Percentage Control of *Cyperus esculentus* in Post-emergence Situations

Species		*Cyperus esculentus*			
Trial Number		ZA 78.103	ZA 78.105	ZA 78.106	ZA 78.107
Clay %		24	6	15	9
Days after application		57	60	56	57
Bimate kg/ha	4,0	81,2	96,9	76,2	50,0
	5,0	90,7	92,5	97,5	65,0
	6,0	93,9	—	—	—
	10,0	—	—	—	92,5

2. *Post-emergence Trials*

(a) Broadleaf Weeds: Bimate plus a surfactant killed the majority of broadleaf weeds. The long residual action of tebuthiuron was apparent in all trials. Weeds that were not completely controlled included *Physalis viscosa* and *Boussingoultia basselloides*. It was generally found that 4,0 kg of Bimate/ha was effective against broadleaf weeds and little or no improvement in performance could be achieved by increasing the dosage rate.

(b) Grass Weeds: Bimate plus a surfactant killed nearly all grass weeds in the pre-tillering stage. Grasses in the post-tillering stage were generally severely scorched but the larger plants recovered. Grasses in the replicated trials were treated in the pre-tillering stage and good to excellent control was achieved. The data in Table 3 illustrates the efficacy of post-emergence treatments on grasses in the pre-tillering stage.

(c) *Cyperus esculentus:* Control of *C. esculentus* with Bimate plus a surfactant as a post-emergence treatment was considerably superior to that obtained when it was used before emergence. Control of established *C. esculentus* was good and there was an improvement in efficacy when dosage levels were increased. Re-growth of *C. esculentus* occurred after treatment with Bimate, but the plants were seldom healthy and gradually died back (See Table 4).

Crop Injury

In all 14 trials visual assessments of crop stunting, chlorosis and thinning were made. In only four of the trials were any injurious effects recorded and these were low levels of stunting at the higher dosage rates (See Table 5).

Tebuthiuron and diuron residues in the crop

Samples of juice expressed from cane taken from both pre-emergence and post-emergence plots were submitted for residue determinations. The results indicated that there was less than 0,1 mg/kg of both compounds in all the samples tested. The highest dosage rate evaluated was 8,0 kg Bimate/ha. (The lowest limit of detection of both chemicals was 0,1 mg/kg and the percentage recovery of tebuthiuron was 87% and diuron 88,5%).

Sucrose analyses

Composite samples of cane treated with Bimate indicated that there was no effect on the sucrose and ers contents nor on juice purity (see Table 6).

Other Observations

Stalk height measurements and stalk counts were made and both were found to be greater for treated plots than for the controls but the differences were not statistically significant at the 5% level of the Duncan Multiple Range Test. (See Tables 7 and 8).

Discussion

In the initial stages Bimate was used solely as a pre-emergence treatment. It gave good results especially on broadleaf weeds and most grass weeds. However, control of *C. esculentus* was unacceptable. Some grasses were not controlled and it was thought that they may have germinated but not emerged, and therefore were able to become established before this slow-leaching herbicide reached the root zone.

Various combinations were tested, but the efficacy particularly against *C. esculentus*, was not radically improved. It was therefore decided to test Bimate as a post-emergence treatment using a surfactant to increase the foliar activity of the diuron. This type of treatment improved the efficacy against *C. esculentus* dramatically and also gave good control

TABLE 5

The Percentage Stunting Caused by Bimate to Sugarcane

Trial Number		ZA 77.105		ZA 78.107	ZA 78.108	ZA 78.111
Cultivar		NCo 376		NCo 376	NCo 376	CB 36/14
Days after application		62	97	30	29	91
Bimate kg/ha	4,0	0,0	0,0	0,0	0,0	2,5
	8,0	2,5	0,0	—	—	—
	10,0	—	—	2,5	2,5	7,5

TABLE 6

The Effect of Bimate Sprayed Post-emergent on Sucrose Analysis

		Sucrose % Cane		ers % Cane		Purity	
Trial Number		ZA 78.105	ZA 78.106	ZA 78.105	ZA 78.106	ZA 78.105	ZA 78.106
Bimate kg/ha	4,0	13,6	11,2	9,41	7,71	81,7	80,3
	5,0	13,2	11,8	8,64	7,51	77,2	74,5
Control		12,2	11,8	8,40	8,54	80,8	84,8

of grasses and broadleaf weeds. Several more trials were planned to confirm the earlier findings and to determine the most economical rates for commercial use. The total control of *C. esculentus* in all situations was regarded to be an unattainable goal, but it was believed that a good knockdown and a measure of residual activity could be attained. Attention was therefore focused on achieving excellent control of grasses, especially *Panicum maximum*. Results have shown that the grass must be in the pre-tillering stage for good control to be achieved. Older grasses were severely burnt but were able to recover. In the field grasses of all ages occur in the weed population, and the timing of a herbicide application therefore becomes important. The spray should be applied early rather than late if the majority of the weeds are to be in the pre-tillering phase.

The size of broadleaf weeds was not as important although it was preferable to control them when younger than the six-leaf stage. It is advantageous to spray *C. esculentus* late because control with Bimate is achieved through knockdown rather than from residual action.

Climatic and soil moisture conditions were important. Spraying in misty conditions was not always satisfactory and it is thought that light rain and mist were sufficient to wash the chemical off the weed leaves. Best results were achieved when spraying after rain in sunny conditions. However, spraying in dry conditions, provided that rain fell within a few days, also produced good results.

It appears that leaching rate, particularly of the tebuthiuron, was an important factor. This may explain the indifferent results achieved with tebuthiuron alone in the early experiments and also the poor performance of Bimate during the early part of the season. An appreciable amount of rain is probably necessary to leach the chemical into the root zone of germinating weeds. Nevertheless, applications made under dry conditions, but where good rain follows within a few days, should be successful.

An application rate of 4,0 kg of Bimate/ha provided adequate control of most of the commonly occurring weed species on soils containing up to 30% clay. On soils with

TABLE 7
The Average Stalk Heights (m) of Sugarcane treated with Bimate

		Stalk Height									
Trial Number		ZA 76.020	ZA 77.103	ZA 77.104	ZA 77.105	ZA 77.106	ZA 77.107	ZA 78.105†	ZA 78.106†	Average	
Days after application		327	231	217	210	198	207	325	321	Pre-em	Post-em
C.V. %		9,3	7,0	5,5	4,6	16,6	6,0	9,7	9,7		
Bimate kg/ha	2,0	1,06a*		1,21ab	1,71a	1,31a				1,32	
	3,0	1,18a	2,08a	1,31a	1,74a	1,28a	1,72a			1,55	
	4,0	1,17a	2,18a	1,28a	1,75a	1,34a	1,75a	1,33a	0,87a	1,57	1,10
	5,0		2,26a	1,28a	1,73a	1,31a	1,73a	1,25a	0,95a	1,66	1,10
	6,0	1,20a								1,20	
	8,0			1,32a	1,78a	1,34a				1,48	
Control: Height in m		1,08a	2,21a	1,18b	1,76a	1,36a	1,74a	0,91b	0,94a	1,56	0,93

* Values followed by the same letter do not differ significantly at the 5% level of the Duncan multiple range test.
† Post-emergence treatments. (All others are pre-emergence).

TABLE 8
The Average Number of Sugarcane Stalks per 10 m Sample Row Treated with Bimate

		Stalk Counts									
Trial Number		ZA 76.020	ZA 77.103	ZA 77.104	ZA 77.105	ZA 77.106	ZA 77.107	ZA 78.105†	ZA 78.106†	Average	
Days after application		183	231	217	210	198	207	325	326	Pre-em	Post-em
C.V. %		3,4	6,0	3,2	3,4	5,1	4,3	6,0	6,6		
Bimate kg/ha	2,0	155,57ab*		139,32bc	172,76a	134,16b				150,4	
	3,0	153,99ab	107,74ab	150,26abc	170,59a	133,02b	116,35ab			138,7	
	4,0	150,97ab	129,50a	147,18abc	164,76a	134,10b	124,97a	143,59a	118,40a	141,9	131,0
	5,0		120,58ab	148,73abc	180,12a	162,63a	125,36a	143,70a	116,70ab	147,5	130,2
	6,0	154,62ab								154,6	
	8,0			160,46a	176,91a	145,83ab				161,1	
Control: No. of Stalks		138,37b	114,29ab	137,02c	175,01a	139,37b	124,36a	96,17b	127,23a	138,1	111,7

* Values followed by the same letter do not differ significantly at the 5% level of the Duncan multiple range test.
† Post-emergence treatments. (All others pre-emergence).

a higher clay content the rate should be increased to 5,0 kg of Bimate/ha. Application of Bimate to plant cane on light soils should be avoided due to the possibility of crop damage. This could occur as a result of a heavy leaching rain soon after application and would be worse if the seed pieces were planted shallow. Bimate should not be applied to soils with an organic matter content in excess of 10% because tebuthiuron is inactivated by organic material.

Tebuthiuron has a half-life of approximately 12 months (Eaton, Rainey, Van der Schans and Frank[8]) and one would expect a build-up of this compound with repeated applications to the soil. Repeat applications in trials in South Africa and Brazil did not result in any phytotoxicity to sugarcane (Alves, Buss, Honda, Pompen, Silva and Van der Schans[7]). Bimate will perform well if applied to weeds at the correct stage of growth and it is important that the size of the grasses is used as the major criterion in this regard. Soil and climatic conditions should be conducive to moving the chemical into the root zone of the weeds. Under these conditions Bimate is capable of giving effective weed control for periods in excess of 12 weeks.

Acknowledgements

Grateful thanks is due to the growers who provided land and labour for the field trials and to the staff of the S.A.S.A. Experiment Station for their advice and the practical assistance in analysing soil and juice samples.

REFERENCES

1. Walker, J. C., Jones, M. L. and Shaw, J. E. (1973). Total Vegetation control with tebuthiuron — a new broad spectrum herbicide. Proc. North Cent. Weed Contr. Conf. **28**: 39.
2. Eaton, B. J., Cebalo, T., Rainey, D. P., Sieck, R. F. and Todd G. C. (1974). Tebuthiuron — a new broad spectrum herbicide. Abstr. Weed Sc. Sco. Amer., Abstr. 15.
3. Schwer, J. F. (1974). Characteristics and field performance of a new selective herbicide for weed control in sugarcane. *Proc.* 12th Br. Wed Contr. Conf. **2**: 847-850.
4. Pafford, J. L. and Hobbs, C. D. (1974). Tebuthiuron: a new herbicide for pre-emergence weed control in sugarcane. Abstr. Weed Sc. Soc. Amer., Abstr. 266.
5. Iggo, G. A. (1975). Results of screening pre-emergence herbicides for sugarcane. *SASTA Proc* **49**: 112-115.
6. Reg. number L.1857, Act 36 of 1947.
7. Alves, A., Buss, A., Honda, T., Pompeu, R. M. Silva, S. A. and Van der Schans, C. (1977). Effects of tebuthiuron, applied at full and half rates and re-applied at various rates, for weed control in sugarcane (*Saccharum officinarum L*). *ISSCT Proc XVI* 1123-1140.
8. Eaton, B. J., Rainey, D. P., Van der Schans, C., and Frank, R. (1977). Soil residues of tebuthiuron following single and repeat applications in sugarcane. *SASTA Proc XVI* 1049-1058.