RECENT DEVELOPMENTS FOR THE CONTROL OF *CYPERUS* SPECIES IN THE SOUTH AFRICAN SUGAR INDUSTRY

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Abstract

The common nutsedge species, *Cyperus esculentus* and *Cyperus rotundus,* continue to be a problem despite the availability of a range of herbicides capable of controlling these weeds. Recent tests included the herbicides Canopy (chlorimuron-ethyl 107 g a.i./ kg + metribuzin 643 g a.i./kg), Servian (halosulfuron 750 g a.i./kg), Katana (flazasulfuron 100 or 250 g a.i./kg) and sulfentrazone (750 g a.i./kg). Numerous trials have been conducted to determine the influence of climate and soil conditions on the potential of these products to control these weeds effectively. Encouraging results show that it is now possible to control or significantly suppress both species at all stages of development. Both Canopy and sulfentrazone can provide impressive pre-emergence control of *Cyperus* species. The length of control from post-emergence applications of Katana or Servian is superior to that of MSMA (mono-sodium methane arsenate 720 g a.i./L) although repeated applications of these new products are necessary. Length of control can be extended with sulfentrazone due to the product's soil residual activity. Indications are that these products can dramatically reduce viable *Cyperus esculentus* tuber populations, which, with continual use, could help alleviate the problem. Preliminary investigations suggest that certain adjuvants are able to enhance the activity of these products more than the currently recommended additives. There were no phytotoxic effects from applying Servian and Canopy to young sugarcane, thus confirming their safe use with the crop. Katana and sulfentrazone can be damaging when applied to the crop foliage.

Keywords: *Cyperus* spp., weed control, herbicides

Introduction

Either one or both *Cyperus* species are encountered in all regions of the South African sugar industry. *Cyperus esculentus* (yellow nutsedge) is common both on the coastal belt and in the midlands, while *Cyperus rotundus* (red or purple nutsedge) is prevalent in the warmer coastal regions and the lowveld. In certain localities, such as river floodplains, nutsedge populations have become so extensive that few other weed species are able to compete. Similar trends elsewhere could be attributed to the widespread use of herbicides that effectively control broadleaf and grass weed competitors. The relative tolerance of *C.rotundus* to conventional herbicides, coupled with its ability to produce allelopathic exudants (Holm *et al.,* 1977), has resulted in the suppression of other weeds and homogeneous stands of this species in certain areas. Experiments have shown that sugarcane yields can be significantly reduced by infestations of *C. rotundus,* with plant crops being particularly susceptible (Turner, 1984). Until recently, standard recommendations for the control of *C. rotundus* included products such as EPTC (thiocarbamate 720 g a.i/L) and Butisan S (metazachlor 500 g a.i/L) applied pre-emergence, and MSMA (mono-sodium methane arsenate 720 g a.i./L) applied as repeated applications for post-emergence control. Other products of the phenoxy, acetanalide and triazine herbicide groups are also capable of controlling *C. esculentus.* However, these treatments seldom provide adequate control of *C. rotundus* and there has been a need for more reliable herbicides. Commercial companies have recognised this need and have consequently developed a range of new products. The majority of these compounds are of the sulfonylurea group, which are effective on sedges.

Water dispersible granule (WG) formulations of Servian (halosulfuron 750 g a.i/kg), Katana (flazasulfuron 250 g a.i/kg), Canopy (chlorimuron-ethyl 107 g a.i./kg + metribuzin 643 g a.i./kg) and a triazol sulfentrazone (750g a.i/kg) have undergone or are approaching registration for use in cane fields in South Africa. Servian and Katana are intended for post-emergence control, whereas Canopy is more effective as a pre-emergence treatment. Sulfentrazone is able to control sedges at both the pre and post-emergence stages of development. The Agronomy Department of the South African Sugar Association Experiment Station was involved in assessing these products in field tests to determine weed control efficacy and cane phytotoxicity levels.

Methods

Weed control efficacy trials were conducted in fallow fields, and sugarcane phytotoxicity trials were conducted on cane growing in trays as well as on plant and ratoon field crops. The trials covered a wide variety of soil, geographic and seasonal conditions.

The weed control and field phytotoxicity trials were sprayed by knapsack using a floodjet type nozzle (either APM (green) or Lurmark AN 4.0), and a Spraying Systems 8003E fanjet was used in the traysite trials. The traysite trials were conducted using variety NCo376 grown in drip irrigated trays (270 x 330 mm) containing both sandy and clay soils. Field phytotoxicity trials were established on plant or ratoon NCo376 and N14, with post-emergence treatments applied when the bend of the uppermost leaf reached approximately 500 mm. Three L/ha of Sencor (metribuzin 480 g a.i/L) + 2 L/ha of diuron (diuron

800 g a.i/L) were used as the standard in all cane phytotoxicity trials. Cane from the phytotoxicity trials was cut by hand, weighed and sampled for quality evaluation. Weed efficacy trial sites were prepared by rotavating or discing to reduce apical dominance and promote germination. Pre-emergence treatments were applied soon after carrying out the physical operation, while post-emergence treatments were applied at the early flowering stage. Spraying was followed by periodic visual ratings to assess percentage control compared with untreated strips around each plot. In certain trials, soil core samples (210 x 210 x 280 mm deep) were taken to determine treatment effects on *Cyperus* tuber development and their influence on germination viability. Composite samples were prepared from each treatment (eight cores). Plant material was sorted from soil in a semi-automated water separator, and the tubers were then separated, counted and planted in a weed free medium in trays to determine the tuber germination percentage for each treatment.

All four products were included in at least one tray site trial. Servian + Complement (adjuvant) was included in a further two field phytotoxicity trials and seven weed control efficacy trials where a standard (50 g product/ha) and double rate were tested. The 100 g a.i/kg wettable powder (WP) formulation of Katana was tested at rates of up to 300 g a.i/ha in three field phytotoxicity trials. WP or WG formulations of Katana were used in nine weed control efficacy trials where the rates ranged from 25 to 200 g a.i/ha. Sulfentrazone 75 WG at rates of up to 3,20 kg product/ha was included in three field phytotoxicity trials, only one of which has been harvested. The product was also used at rates ranging from 0,6 to 1,2 kg product/ha in two post-emergence and nine pre-emergence weed control efficacy trials. Canopy was omitted from this series of field phytotoxicity trials as registration was granted on past results obtained for Classic (chlorimuron-ethyl 250 g a.i/kg) + Sencor (metribuzin 480 g a.i/L). Canopy was applied in seven weed control efficacy trials where it was used as the standard treatment. Although some of the new products have been tested in mixtures with other herbicides, only results for single product treatments are reported in this paper.

Results

Phytotoxicity

Servian

Servian + Complement proved exceptionally safe when applied to the foliage of cane grown in trays. The standard Servian rate of 50 g product/ha produced fresh mass yields that were 167 and 88% greater than the Sencor + diuron standard for sandy and clay soils respectively ([1]unpublished data). This observation was supported by post-emergence field trials (Table 1) where Servian produced low levels of cane phytotoxicity compared with an unsprayed control.

Katana

Only high rates of Katana applied to cane in sandy soils proved significantly phytotoxic in tray trials ([2]unpublished data). Table 2 shows the results for post-emergence Katana treatments in the three field phytotoxicity trials where rates in excess of that intended for registration were tested. Yield losses reached statistical significance only in Trial 2 on N14 grown under irrigation. However, none of the Katana rates tested produced yields that were statistically different to that of the Sencor + diuron standard.

Sulfentrazone

Only one of the three sulfentrazone field phytotoxicity trials has been harvested to date. Results for this trial on an irrigated plant crop of N14 are shown in Table 3, where cane and sucrose yields for all three rates were reduced significantly (P=0,05) compared with the unsprayed control. However, each of the sulfentrazone rates outyielded the Sencor + diuron standard.

Canopy

No field phytotoxicity trials were carried out with Canopy. The product was tested pre-emergence on cane grown in trays where different rates were applied for both sandy and clay soil conditions. Results are given in Table 4. Fresh mass yield losses with Canopy were statistically significant for both rates applied to cane grown in a sandy soil (8% clay). This may have been due to high pH levels (±7,8), as alkaline conditions can cause increased phytotoxicity from chlorimuron-ethyl (Thomson, 1993).

Post-emergence weed control with MSMA, Servian, Katana and sulfentrazone

Three post-emergence weed control efficacy trials on *Cyperus* species compared the new products with a standard MSMA treatment (Table 5). Repeated MSMA applications are common practice for post-emergence control of *Cyperus* species, but can cause serious crop injury and significant yield reductions if not directed away from the cane foliage. Both Servian and Katana outperformed MSMA in all three trials, even where the latter was the only treatment applied as a repeated spray (Table 5, Trial 2).

Treatment effects on tuber numbers and germination viability for both *Cyperus* species were assessed approximately six months after the first spraying in Trial 3. Results in Table 6 suggest that *C. rotundus* tuber populations were unaffected by treatments although fewer tubers were recorded from the MSMA plots. Germination tests are currently in progress and a full season is required to separate the non-viable from dormant tubers. *C. esculentus* tuber populations in the trial were too low for conclusions to be reached.

Adjuvants for sulfonylureas

Van Biljon *et al.* (1996) demonstrated the importance of adjuvants to optimise Servian performance, and the necessity of including adjuvants with other sulfonylureas is well documented. One trial was established to determine whether differences in weed control efficacy exist between a range of products. Figure 1 shows how the performance of Servian at 0,05 kg/ha is modified on mixed *Cyperus* species populations with certain

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Table 1
Post-emergence treatment effects of Servian (halosulfuron) on cane yield, sucrose % cane and sucrose yield, expressed as a percentage of the unsprayed control (NS = statistically non-significant).

	Treatment	Rate (product kg or L/ha)	Cane yield	Sucrose % cane	Sucrose yield
Trial 1 Plant cane	Servian + Complement Servian + Complement	0,05 + 0,50 0,10 + 0,50	105 95	103 98	108 91
			NS	NS	NS
Trial 2 4th ratoon	Servian + Complement Servian + Complement	0,05 + 0,50 0,10 + 0,50	109 112	95 99	105 111
			NS	NS	NS

Table 2
Post-emergence treatment effects of Katana (flazasulfuron) on cane yield, sucrose % cane and sucrose yield, expressed as a percentage of the unsprayed control (NS = statistically non-significant, *P = 0,05).

	Treatment	Rate (grams a.i./ha)	Cane yield	Sucrose % cane	Sucrose yield
Trial 1 Plant cane	Katana (WP)	100 150 300	94 91 87	102 91 87	97 82 77
			NS	NS	NS
Trial 2 1st ratoon	Katana (WP)	100 150 300	96 95 90*	97 99 99	92* 96 88*
			*	NS	*
Trial 3 1st ratoon	Katana (WP)	100 150 200 300	95 93 97 99	103 85 104 87	96 78 100 85
			NS	NS	NS

Table 3
Post-emergence treatment effects of sulfentrazone on cane yield, sucrose % cane and sucrose yield, expressed as a percentage of the unsprayed control (*P = 0,05).

	Treatment	Rate (product kg/ha)	Cane yield	Sucrose % cane	Sucrose yield
Trial 1 Plant cane	Sulfentrazone 75 WG	1,20	94*	93*	88*
		1,60	93*	97*	90*
		3,20	90*	90*	81*
			*	*	*

adjuvants. Products that did not increase efficacy beyond that attained by Complement (commercial standard), were Agrowett at 0,25% by volume, Tronic at 0,50 L/ha and Pulse at 0,20% by volume.

Weed control efficacy from Servian on the two *Cyperus* species was improved significantly where the organosilicone adjuvant Break Thru replaced Complement at a rate of one litre product per hectare. In addition, Break Thru accelerated the reaction to Servian and severe chlorosis appeared only a few days after spraying. Organosilicone surfactants such as Break Thru are regarded as super wetters and are capable of causing stomatal flooding, greatly improving product uptake (product label). Reverseal 10 (0,25% by volume) improved Servian efficacy to a level between that attained by Break Thru and Complement, whereas control was unacceptable when the herbicide was used alone (Figure 1).

Table 4
Pre-emergence treatment effects of Canopy (chlorimuron-ethyl + metribuzin) on fresh mass yield, expressed as a percentage of the unsprayed control, for sandy and clay soil conditions (NS = statistically non-significant, *P = 0,05).

Treatment (458)	Rate (product kg/ha)	Fresh mass
Sandy soil Canopy Canopy	 0,80 1,60	 38* 59*
		*
Clay soil Canopy Canopy	 1,00 2,00	 116 101
		NS

Table 5
Post-emergence effects of four herbicide treatments on *Cyperus* species, expressed as percentage control compared with unsprayed sections (DAT = days after first application).

	Treatment	Rate (product kg or L/ha)	% control		
			C. rotundus		Mixed *Cyperus* species
			40 DAT	44 DAT	108 DAT
Trial 1	MSMA	6,0	0		
	Servian + Complement	0,05 + 0,5	87		
	Katana (WG) + Frigate	0,40 + 1,0	88		
	Sulfentrazone + Rev 10	1,2 + 0,36	87		
Trial 2	MSMA*	4,0 (x2)		0	
	Servian + Complement	0,05 + 0,5		75	
	Katana (WP) + Armoblen	1,5 + 0,3		83	
Trial 3	MSMA	4,0 (x2)			40
	Servian + Complement	0,05 + 0,5 (x2)			97
	Katana (WG) + Tronic	0,40 + 0,75 (x2)			88
	Sulfentrazone + Surfactant	1,2 + 0,15 (x2)			83

Note: MSMA in Trial 2 and all treatments in Trial 3 applied as split applications.

Table 6
Post-emergence effects of four herbicide treatments on number of tubers and percentage germination, six months after the initial spray in Trial 3 (CYPES = *Cyperus esculentus*, CYPRO = *Cyperus rotundus*).

Treatment	Rate (product kg or L/ha)	Number of tubers/sample (0,1 m^3)		Number of tubers/ha (10^6)	
		CYPES	CYPRO	CYPES	CYPRO
Control	-	3	421	0,1	12,0
MSMA	4,0 (x2)	4	320	0,1	9,1
Servian + Complement	0,05 + 0,5 (x2)	0	540	0	15,4
Katana (WG) + Tronic	0,40 + 0,75 (x2)	0	668	0	19,1
Sulfentrazone + Surfactant	1,2 + 0,15 (x2)	0	500	0	14,3

Pre-emergence weed control with Canopy and sulfentrazone

Initial pre-emergence trials with Canopy showed the product to be highly effective in controlling *C. rotundus* ([3]unpublished data). Trials sprayed under optimal conditions proved that Canopy has important residual effects and the potential to significantly reduce viable tuber numbers in the following season. This is illustrated in Figure 2, where a dramatic reduction in *C. rotundus* population occurred after spraying Canopy onto sandy soils of high pH the previous season.

However, results depend on soil moisture, as reduced efficacy can occur where applications are made onto dry soils that remain so for a period after spraying. This does not appear to be critical in light soils (±8% clay), where Canopy generally controlled *C. rotundus* irrespective of moisture status (Figure 3a). Canopy applied under dry conditions to heavier soils inevitably failed to provide adequate long term control (see B and C, Figure 3b).

Sulfentrazone produced highly variable but generally unacceptable control of *C. rotundus* when applied under sandy soil conditions ([4]unpublished data). This situation was reversed on heavier clay soils where excellent control was achieved with sulfentrazone (Table 7). The action of this product is unique in that the target plant germinates normally and only displays necrosis once developed. The poor results for Canopy are not surprising, as the clay soil was dry at and after spraying.

Sulfentrazone is resistant to photodegradation (Thomson, 1993) and is thought therefore to have potential for early season application to provide weed control into spring and summer. The product was compared with Velpar + diuron on *C. esculentus* under different seasonal and soil moisture conditions in the KwaZulu-Natal midlands. Levels of pre-emergence control are shown in Figure 4, where all treatments except Velpar + diuron applied in June produced acceptable results.

Although pre-emergence efficacy from sulfentrazone culminated months after plant germination, the product generally produced excellent *C. esculentus* control irrespective of season and soil moisture status (Figure 4).

An investigation to determine product effects on *C. esculentus* tuber numbers and tuber germination potential, showed significant differences between treatments (Table 8). Sulfentrazone at 1,2 kg/ha reduced tuber numbers by 97, 83 and 78% for the June, July and August applications respectively. Figure 5 further illustrates the significant differences in tuber numbers between

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Table 7
Pre-emergence treatment effects of Canopy (chlorimuron-ethyl + metribuzin) and sulfentrazone on a mixed *Cyperus* stand at 14, 24, 38, 47 and 67 days after spraying.

Treatments	Rates (kg/ha)	% *Cyperus* species compared with control				
		Days after spraying				
		14	24	38	47	67
Canopy	1,0	2	4	4	3	0
Sulfentrazone	1,0	0	2	6	45	69
	1,2	0	4	11	69	80
	1,4	0	6	20	80	93

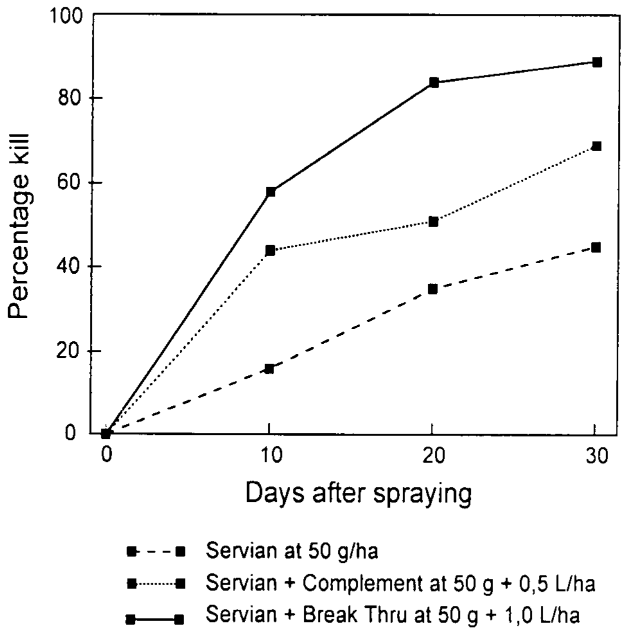

Figure 1. Effects of different adjuvants for *Cyperus* species control with Servian.

treatments, and suggests that substantial reductions in *C. esculentus* populations would occur should these products be used repeatedly. This supposition is supported by Manana *et al.* (1996) who found that regeneration of *C. esculentus* in subsequent years is a function of the previous year's population. Results from the germination viability tests (Table 8) show the number of germinated tubers per hectare that would have emerged and competed with the crop in the current season, the remainder being dead or in different stages of dormancy.

Discussion and Conclusions

Phytotoxicity

The recommended rate of Servian + Complement proved to be unusually safe on sugarcane and visual symptoms normally associated with herbicide damage were absent from treated cane

Table 8
Pre-emergence treatment effects of Velpar (hexazinone) + diuron and sulfentrazone on *C. esculentus* tuber numbers seven months after spraying in June, six months after spraying in July and five months after spraying in August, and germination viability up to four months after sampling.

Treatments	Rates (L or kg/ha)	Number of tubers/ha (10^6)	Number of viable tubers/ha (10^6)
June spray			
Control	–	16,2	10,6
Velpar + diuron	2,5 + 1,5	11,6	7,1
Sulfentrazone	1,2	0,5	0,4
July spray			
Control	–	1,2	0,8
Velpar + diuron	2,5 + 1,5	1,1	0,5
Sulfentrazone	1,2	0,2	0,2
August spray			
Control	–	27,2	17,0
Velpar + diuron	2,5 + 1,5	6,1	3,3
Sulfentrazone	1,2	6,1	2,4

foliage. This is a significant advantage as *Cyperus* species can now be treated within the cane row at any growth stage of the crop. Although Katana and sulfentrazone were phytotoxic to irrigated N14, the reduction in yield was less than that caused by the Sencor + diuron standard. Nevertheless, it would be unwise to apply either of these products to cane foliage until more data on varietal suseptibility and the effects of repeated applications are available. Canopy appears only mildly phytotoxic to sugarcane, but the question of possible increases in damage to cane in sandy soils of higher pH needs further investigation.

Weed control efficacy

High soil pH coupled with adequate moisture may have influenced the exceptional performance of Canopy on *C. rotundus* in sandy soils where there was clear evidence that populations are reduced substantially in subsequent seasons. However, the contribution of discing or rotavating to the success of the treatment needs to be ascertained. Pre-emergence control of *Cyperus* species with sulfentrazone was erratic in sandy soils. This may be a function of the product's mobility in soil, as field observations showed greater weed control in surface depressions as opposed to the crest of ridges ([5]unpublished data). Sulfentrazone was more successful in controlling nutsedge on heavier soils, even when application was carried out under extremely dry conditions. There is real potential for the early season use of this product. The fact that the full benefit on *Cyperus* is reached sometimes months after application could also be a disadvantage, as competition with the crop may have already occurred. However, with *C. esculentus* this is compensated for as tuber development in the treated population is significantly reduced with sulfentrazone. This would have far reaching effects in subsequent seasons.

Both Katana and Servian outperformed MSMA in the post-emergence control of *C. rotundus* and mixed *Cyperus* species

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stands. The initial reaction of weeds to the new products is slower than the standard, but regeneration is also retarded after treatment with sulfonylurea. This means that intervals between first and subsequent applications of the new products can be longer than is the case with MSMA. Trial results indicate that, unlike the dramatic effect of sulfentrazone on *C. esculentus* tuber numbers, post-emergence applications of Katana and Servian had little or no influence on *C. rotundus* tuber populations. This was also the case where standard rates of sulfentrazone were used post-emergence on this species. Preliminary studies indicate that repeated MSMA treatments may have a greater effect on *C. rotundus* tuber development than the sulfonylureas, but this will have to be verified in further trials. Work on the influence of these treatments on *C. rotundus* tuber germination is currently in progress.

There is potential to further improve post-emergence weed control efficacy of the new products with certain adjuvants. However, the merit of these products will have to be investigated further as increased efficacy may raise cane phytotoxicity to unacceptable levels.

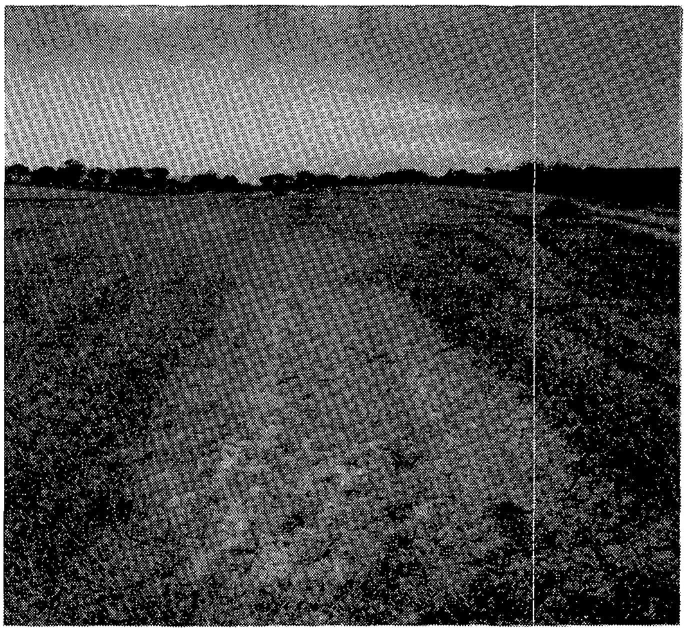
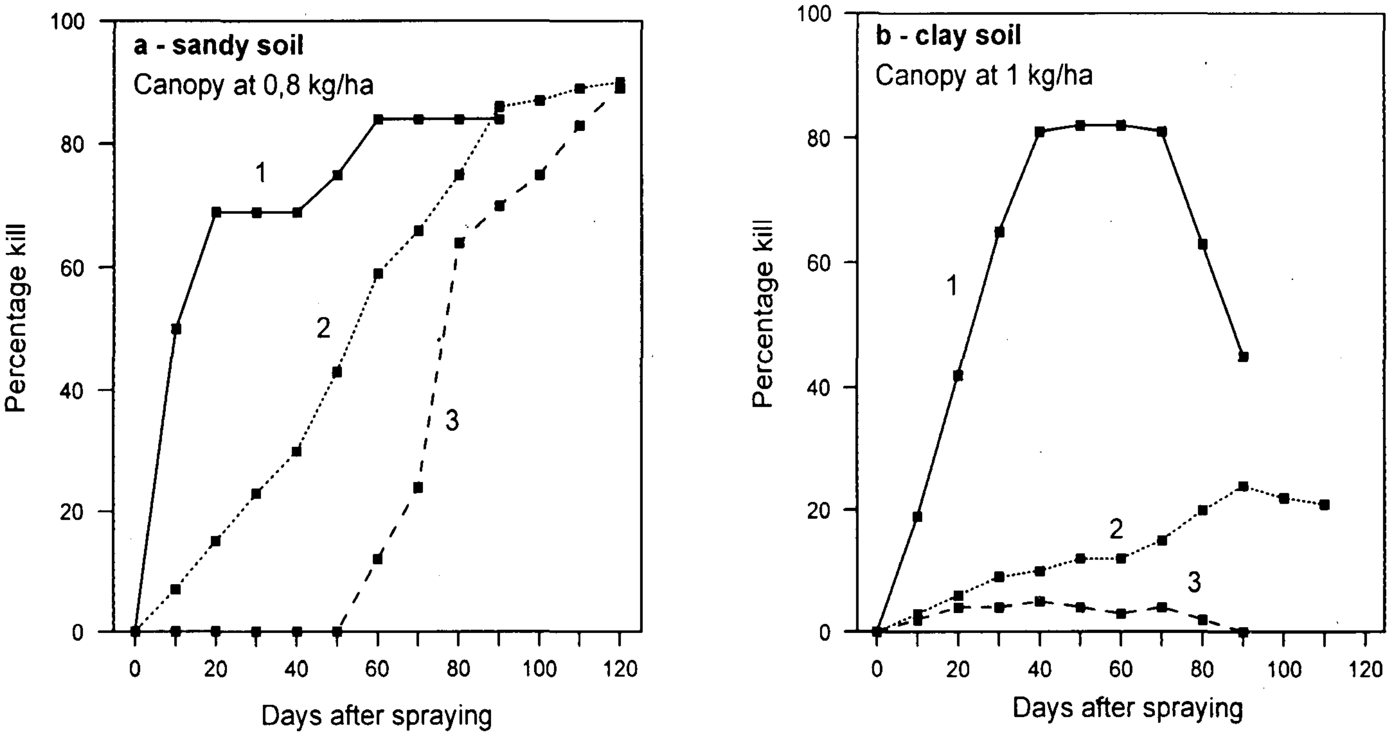


Figure 2. Effects of Canopy at 0,8 kg/ha on *Cyperus rotundus* populations one year after spraying.



1 Canopy applied to a saturated soil (23,8% moisture)
16 mm rainfall with 14 days of spraying

2 Canopy applied to a damp soil (10,4% moisture)
2 mm rainfall within 14 days of spraying

3 Canopy applied to a dry soil (2,2% moisture)
0,4 mm rainfall within 14 days of spraying

1 Canopy applied to a saturated soil (25% moisture)
115 mm rainfall within 14 days of spraying

2 Canopy applied to a dry soil (5,6% moisture)
28 mm rainfal within 14 days of spraying

3 Canopy applied to a dry soil (7,7% moisture)
10 mm rainfall within 14 days of spraying

Figure 3. *Cyperus rotundus* control with Canopy applied under different soil moisture conditions.

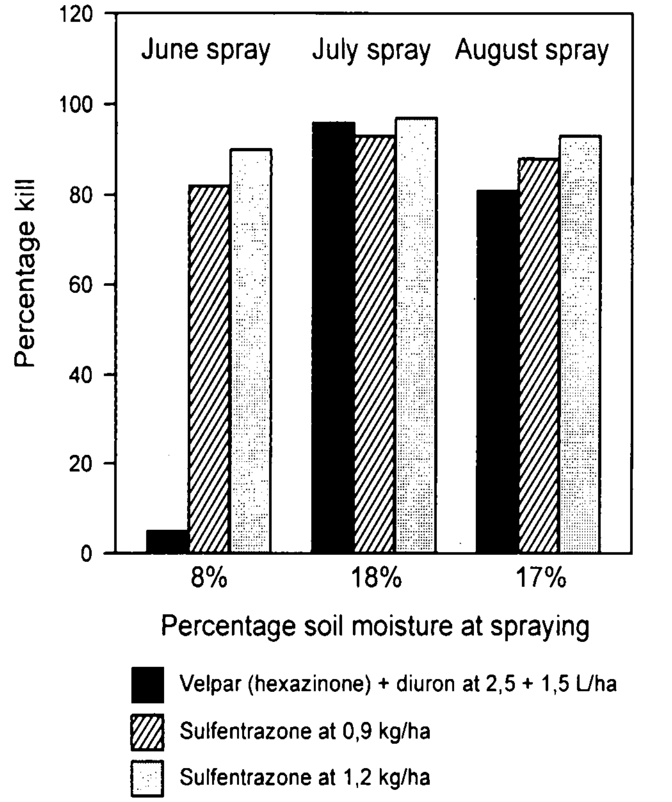


Figure 4. *Cyperus esculentus* control for different soil and climatic conditions. Ratings done 180 days after June spraying, 148 days after July spraying and 120 days after August spraying.

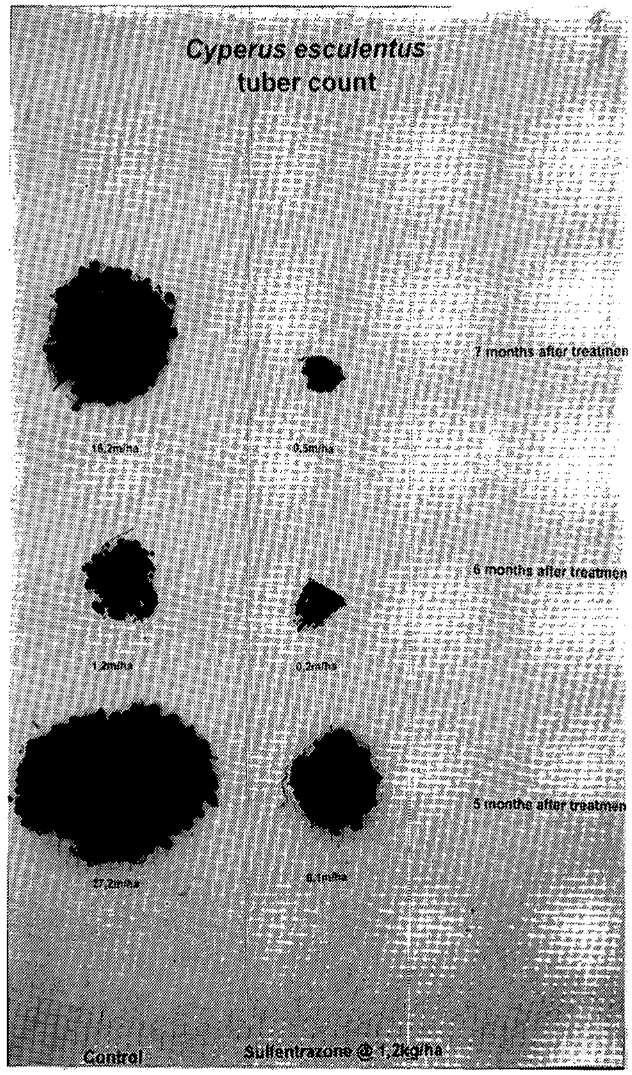


Figure 5. Differences in *Cyperus esculentus* tuber numbers from three trial sites, showing control (left) and 1,2 kg sulfentrazone/ha (right). Each soil core measured 0,35 m² x 0,28 m deep; eight cores per treatment.

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