THE EFFECTS OF HERBICIDES ON *CYPERUS* SPP.

by J. M. GOSNELL
and
G. D. THOMPSON
South African Sugar Association Experiment Station

Two of the most troublesome weeds in Natal sugarcane fields are the sedges *Cyperus esculentus* and *Cyperus rotundus*, known locally as either watergrass or nutgrass. Much of the experimental work conducted with herbicides over the past 18 years has been directed towards the chemical control of these species. McMartin (6) reported that in his early experiments the leaves of both weeds were killed by 4 lb. a.e. 2,4-D per acre, but that regrowth occurred from the underground tubers, and that second and third applications were sometimes necessary. Even then the plants were not entirely controlled. In a subsequent report McMartin (7) stated that pre-emergent applications of 2,4-D reduced the number of nutgrass plants appearing above ground.

These observations were followed by those of Stewart (9) who stated that "in general, pre-emergent applications of 2,4-D formulations, at economic rates (2 lb. per acre), have given little or no positive control of nutgrass. Under particular conditions 2,4-D may retard development of the shoots and delay flowering to a certain extent, but this condition is temporary and the weed soon recovers".

McMartin (7) found that good post-emergent effects were obtained by spraying nutgrass with a mixture of 2 lb. pentachlorophenol (PCP) and 2 lb. of a wetting agent in four gallons of an oil with a high aromatic content. This combination was diluted with 96 gallons of water for spraying on one acre. The treatment was used extensively in the industry, as described by Steward (8), who found that commercial applications of the PCP mixture and 2,4-D destroyed all weed growth within six days, and that watergrass then reappeared after two weeks.

In a report on experiments conducted at Tongaat, Cleasby (1) showed that pre-emergent applications of MCPA with 10 lb. or 20 lb. of TCA per acre gave only slight reductions in the growth of watergrass, but that post-emergent applications of PCP gave up to 87% control four weeks after spraying, with considerable regrowth after a further three weeks. A post-emergent application of 2,4-D caused a 50% reduction in watergrass populations after four weeks, and the addition of TCA or Dalapon to the 2,4-D increased this reduction to 65%. At Illovo, Thompson and Trichardt (11) found that 2,4-D and MCPA, applied pre-emergent at 6 lb a.e. per acre, were not effective against watergrass, but that post-emergent treatments with 20 lb. TCA per acre, or 15 lb. TCA and 2½ lb. a.e. 2,4-D per acre, gave good control. Even better results were obtained with 10 lb. Dalapon and 2½ lb. a.e. 2,4-D per acre, but Dalapon at this rate caused the cane to be severely stunted.

Excellent control of *Cyperus esculentus* was obtained at Chaka's Kraal when Karmex and Eptam were sprayed pre-emergent (Thompson and Gosnell, 10), and both Gramoxone and Reglone were shown to be much superior to PCP in suppressing watergrass. Eptam, however, affected germination and cane growth severely. In a separate experiment at Mount Edgecombe, described by the same authors, Karmex gave good control of *Cyperus esculentus* when sprayed post-emergent on a moist soil. The effectiveness of Gramoxone was confirmed in subsequent experiments by Gosnell and Thompson (4), and on an estate scale by Gilfillan (2). The latter author also reported that results varying from good to poor were obtained with post-emergent applications of Afalon on watergrass.

The uracil, Hyvar X, gave excellent control of *Cyperus esculentus* for 12 weeks after application (Gosnell and Thompson, 4), but visually obvious damage to the sugarcane was caused by amounts (4 lb. per acre) which gave the best weed control. The possible relationship between the effectiveness of Hyvar X and soil organic matter content was later described by Gosnell (3), who also confirmed the effectiveness of Karmex as a post-emergent treatment on *Cyperus esculentus* under irrigated conditions. Combinations of Hyvar X and Karmex, in comparison with Hyvar X alone, were studied by Gosnell and Thompson (5), and were found to give good watergrass control without causing any appreciable cane damage when the amount of Hyvar X was limited.

The fragmentary evidence of herbicidal effects on *Cyperus* species has not permitted a full appraisal of the subject to be made. The results of a series of tray experiments and a field micro-plot experiment, conducted during the 1963-66 period, have now been collated and are presented here in an attempt to clarify some of the confusion which exists regarding the effects of 2,4-D on *Cyperus esculentus* and *Cyperus rotundus*, to identify the best conditions for successful use of Gramoxone, and to predict the possible value of other herbicides in controlling watergrass in sugarcane fields.

Materials and Methods

Seven experiments were conducted in trays, 16 inches x 9 inches x 5 inches deep, made of aluminium sheet metal, with perforations in the bottom, and having wooden ends. The trays were filled with a sieved clay loam soil. Fresh tubers of *Cyperus* spp. were collected in the field. Either 6 or 12 tubers of *Cyperus rotundus* were planted per tray, at a depth of about one inch below the surface of the soil. The tubers of *Cyperus esculentus* were washed several times in clean water before planting 12 or 18 tubers per tray. After planting, vigorous growth was ensured by regular watering and the application of a nutrient mixture. In all instances the populations were reduced to six plants per tray after germination had taken place. One experiment was located in the greenhouse but the remainder were conducted out of doors.

The spraying procedure was to transfer the trays from the experiment site to excavations in the field, these being so constructed that the trays fitted neatly and were level with the surrounding soil. The individual trays were located in random positions with respect to the swath of a triple-nozzle boom, thus simulating conditions of field application as closely as possible. Knapsack spraying was carried out in the early morning following calibration of the equipment over measured distances, the herbicide being diluted in water to give a total volume application of 20 gallons per acre. After spraying the trays were immediately returned to the site of the experiment.

Details of each of the seven tray experiments are shown in Table I. There were four replications of the treatments in each trial. Weekly tiller and flower counts were made in some experiments and the weeds were harvested when they were approximately 11 weeks old. At harvest, all of the green foliage was cut at ground level, oven dried and weighed. Roots and tubers were washed free of soil before drying and weighing. In some instances tuber counts and germination tests were also carried out. All results were calculated on the basis of the number of tubers or tillers per tray, and the dry weight of foliage, tubers and roots per tray.

A further experiment consisting of micro-plots was conducted in a field at Chaka's Kraal where a uniform, dense stand of *Cyperus esculentus* had developed. Plots 6 ft. by 1.5 ft. were marked out and sprayed with herbicides at the early flowering stage in September, 1965, about three weeks after emergence. Regular visual ratings of herbicidal effects were carried out. When the weeds were harvested 11 weeks after spraying, foliage from the entire plots was weighed, and the tubers separated from two soil quadrats, each 12 inches by 9 inches by 4.5 inches deep, were washed and weighed. Germination tests were carried out on a sample of tubers from each treatment.

Details of the various herbicides used in the experiments and mentioned in the discussion are shown in Appendix I.

Results

Effects of 2,4-D

Experiments 1 and 2 were planted during the early spring period when *Cyperus* spp. are most troublesome in many sugarcane fields. The results shown in Table II indicate that increasing amounts of 2,4-D amine up to 3.6 lb. a.e. per acre did not affect the development of either *C. esculentus* or *C. rotundus* appreciably. An apparent slight trend towards lower foliage and tuber production was not statistically significant.

The failure of pre-emergent treatments with 2,4-D even at 4.8 lb. a.e. per acre, to suppress either foliage or tuber production of *C. rotundus* was confirmed in Experiment 3. As shown in Table III, an apparent reduction in the number of tillers was not reflected in the weight of foliage produced when the weeds were 12 weeks old, but as noted previously flowering was either delayed or inhibited. In contrast to the lack of pre-emergent effects due to 2,4-D, there were highly significant effects due to post-emergent application of 4.8 lb.

TABLE I

Details of seven experiments conducted with *Cyperus* spp. in trays

Expt. No.	Species	Date planted	Time of spraying	Date sprayed	Age at harvest
1	C. esculentus	19/9/64	Pre-emergent	22/9/64	11 weeks
2	C. rotundus	23/10/64	Pre-emergent	25/10/64	9 weeks
3	C. rotundus	9/9/65	Pre-emergent	10/9/65	12 weeks
			Early post-emergent	27/9/65	12 weeks
			Late post-emergent	20/10/65	12 weeks
4	C. rotundus	4/1/65	Early post-emergent	22/1/65	10 weeks
			Late post-emergent	5/2/65	10 weeks
5	C. esculentus	18/9/64	Post-emergent	Weekly	14 weeks
6	C. rotundus	17/9/63	Post-emergent	Weekly	11 weeks
7	C. rotundus	9/9/65	Pre-emergent	10/9/65	12 weeks
			Post-emergent	20/10/65	12 weeks

TABLE II

Effects of increasing amounts of 2,4-D amine applied pre-emergent on *Cyperus esculentus* and *Cyperus rotundus*

Expt. No.	Species	Treatment lb. a.e./ac	Tillers counted after emergence							Foliage wt., g.	Tuber wt., g.	No. of tubers
			1 wk	2 wks	3 wks	4 wks	5 wks	6 wks	7 wks			
1	C. esculentus	0	35	57	119	137	207	234	293	25.7	4.82	105
		1.2	27	42	97	114	182	209	236	22.2	3.60	82
		2.4	31	37	108	116	167	186	226	23.5	3.64	79
		3.6	31	39	93	102	160	183	213	23.0	3.36	79
2	C. rotundus	0	63	99	139	204	264	420	796	24.4	15.2	98
		1.2	47	83	110	171	222	347	781	20.7	11.3	85
		2.4	57	95	132	194	256	406	819	24.4	12.9	99
		3.6	54	92	127	194	236	413	877	22.1	12.2	75

TABLE III

Effects of spraying *Cyperus rotundus* with 4.8 lb a.e. per acre of 2,4-D at different stages of growth

Expt. No.	Time of application	No. of tillers	Foliage wt. g.	Tuber wt. g.	No. of viable tubers	No. of flowers
3	Control	237	72	100	—	13.7
	Pre-emergence	181	70	100	—	5.5
	Early post-emergence	95	50	60	—	0.5
	Late post-emergence	73	34	46	—	—
4	Control	224	77	141	318	13
	Early post-emergence	68	12	13	13	10
	Late post-emergence	61	10	26	18	1

a.e. 2,4-D per acre on *C. rotundus* in Experiments 3 and 4, which were planted in September and January respectively. Both early and late post-emergent applications of 2,4-D caused highly significant reductions in tiller counts, foliage weights and tuber weights. There was also a marked suppression of flowering, particularly due to the late application. In Experiment 4 the number of viable tubers per tray was also reduced to a highly significant extent due to the 2,4-D treatments. There were no significant differences between the amounts of foliage or tuber produced when the weeds were sprayed "early post-emergent", 2½ weeks after planting, and when they were sprayed "late post-emergent", 4½ or 5 weeks after planting.

The successful suppression of *C. rotundus* by post-emergent applications of 2,4-D amine increased with increasing amounts of herbicide up to 7.2 lb. a.e. per acre. This is shown by the results of Experiment 7 given in Table IV. It can be seen that approximately 50% reductions in the numbers of tillers, foliage weight and root + tuber weight were effected by 7.2 lb. compared with 4.8 lb. a.e. 2,4-D per acre. The maximum treatment with 9.6 lb. a.e. 2,4-D per acre was not apparently any better than the 7.2 lb. treatment.

TABLE IV

Effects of increasing amounts of 2,4-D amine applied post-emergent on *Cyperus rotundus* in Experiment 7

Treatment lb a.e./ac	No. of tillers	Foliage wt., g.	Tuber & root wt., g.
Control	848	79	102
0.6	1018	59	54
1.2	794	51	62
2.4	486	50	57
3.6	384	43	38
4.8	269	32	29
7.2	125	15	17
9.6	135	17	12

In Experiments 3 and 4 different 2,4-D formulations and MCPA were compared at the rate of 4.8 lb. a.e. per acre. The results are given in Table V for the late post-emergent treatments only, and show that there was no significant evidence of differ-

ences between formulations in either experiment in terms of foliage or tuber weights. Treatments with all formulations, however, caused foliage and tuber weights to be highly significantly lower than those in the control trays.

TABLE V

Effects of late post-emergence applications of different 2,4-D formulations at 4.8 lb per acre on *Cyperus rotundus*

Expt. No.	Formulation	No. of tillers	Foliage wt., g.	Tuber wt., g.
3	Control	237	72	100
	Amine	125	33	58
	Butyl ester	112	32	42
	Glycol ester	115	25	30
	Iso-octyl ester	133	40	54
	MCPA K salt	96	40	47
4	Control	224	77	141
	Amine	67	11	31
	Butyl ester	84	13	35
	Glycol ester	44	10	15
	Iso-octyl ester	49	7	22

effect due to the amount of Gramoxone sprayed. The trays sprayed three weeks after the emergence of the *C. esculentus* had the least amounts of foliage and tuber, and except for the latest-sprayed trays, also the smallest number of flowers per tray.

In Experiment 6 all treatments caused a complete scorch of the aerial parts of the *C. rotundus*, including flowers, within one or two days of spraying. The effects of the time of spraying treatments on live tiller counts, averaged for the two levels of Gramoxone, are shown in Fig. 1. It is apparent that the above-ground competitive effect of watergrass was reduced to a minimum level for the longest period of time following spraying at 2 or 3 weeks after weed germination. Earlier spraying resulted in excessive weed recovery, whilst later spraying would have led to unnecessarily prolonged competition with a crop.

All treatments reduced the green foliage remaining after 11 weeks, compared with control, at a highly significant level, and spraying one week after germination resulted in a significantly greater final amount of green foliage than in any of the other herbicide treatments. These results are illustrated in Fig. 2, where it can be seen that weeds sprayed

TABLE VI

Effects of spraying *Cyperus esculentus* and *Cyperus rotundus* with Gramoxone at different stages of growth (mean data for 2 pt. and 4 pt per acre treatments)

Expt. No.	Species	Stage—weeks after emergence	Foliage wt., g.	Tuber wt., g.	No. of flowers
5	C. esculentus	Control	64	7.7	32.0
		1	38	1.9	17.5
		2	23	0.7	8.9
		3	19	0.6	5.2
		4	37	0.7	15.0
		6	29	1.5	10.8
		8	15	3.3	0.4
6	C. rotundus	Control	145	237	9.8
		1	84	95	1.0
		2	56	57	1.2
		3	42	39	0.4
		4	46	42	0.8
		6	35	69	2.0
		8	34	143	2.5

Effects of Gramoxone

The effects of 2 pt. and 4 pt. of Gramoxone per acre on *C. esculentus* and *C. rotundus* were studied in Experiments 5 and 6 respectively. Both levels of treatment were applied to four replications of each species, 1, 2, 3, 4, 6 and 8 weeks after emergence of the weeds. The mean effects for both levels of herbicide on foliage weight, tuber weight and the number of flowers per tray are shown in Table VI. For *C. esculentus* the treatment means were all significantly lower than the control for foliage and tuber weights, and significant differences existed between the "stage of growth" treatments. There was no significant evidence of any three weeks after emergence had not recovered at all by the end of the ninth week. In contrast, earlier-sprayed weeds had regenerated considerably, and weeds sprayed after the fourth week were not completely suppressed. No differences between the two rates of Gramoxone were demonstrated.

In the treated trays the weights of tubers were much less than in the control trays, the differences being highly significant. In addition, the tuber production when spraying was conducted 3 and 4 weeks after germination was very much lower than those sprayed 1 and 8 weeks after germination. There was no apparent difference between the effects of different rates of herbicide on tuber weight.

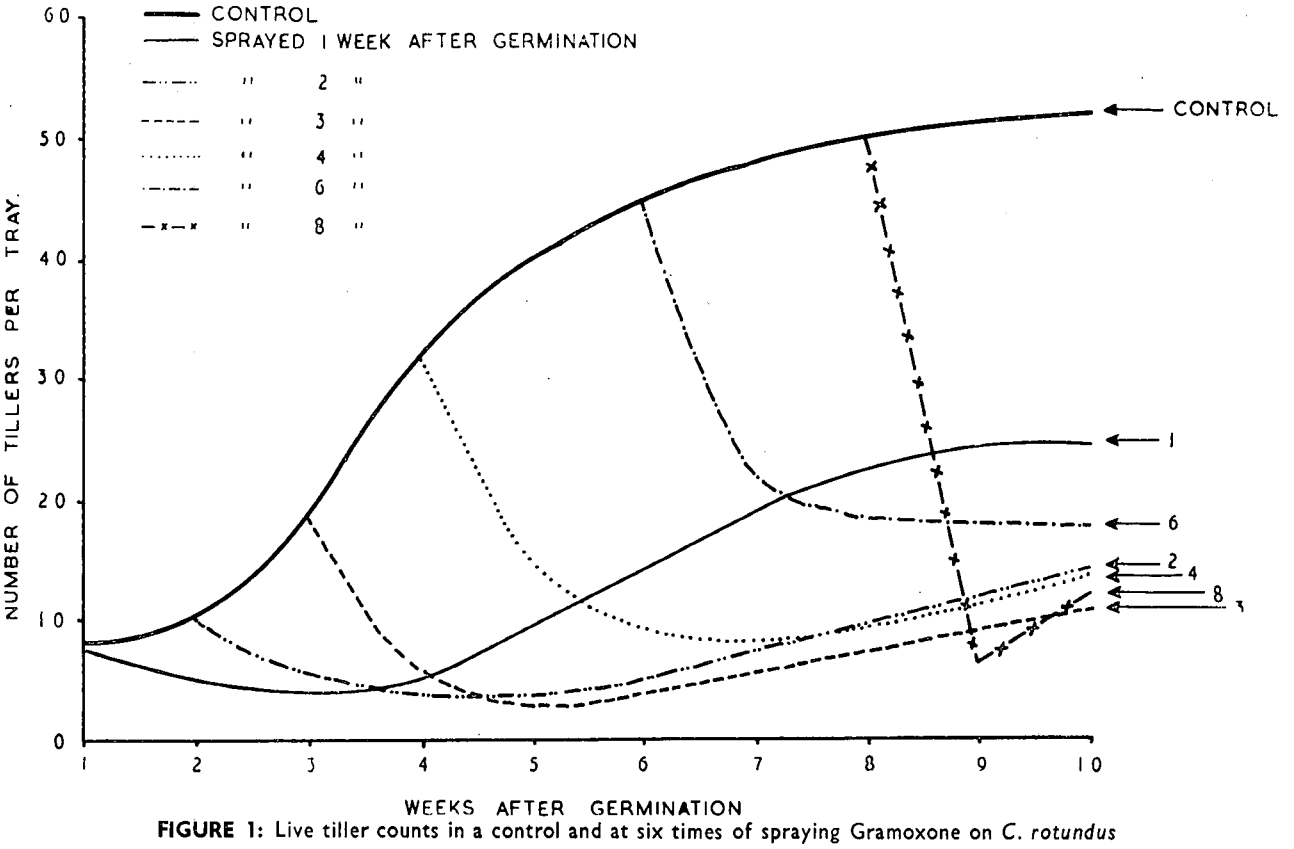

FIGURE 1: Live tiller counts in a control and at six times of spraying Gramoxone on *C. rotundus*

Inferior results were obtained when Gramoxone was sprayed on *C. rotundus* at a rate of 2 pt. per acre in October, six weeks after planting. Although the reductions in foliage and tuber weights were significant (Table VII), there was no appreciable reduction in the number of tillers per tray due to treatment with Gramoxone. A pre-emergent application of 4 lb. a.e. 2,4-D per acre had no apparent effect on the watergrass, but when an additional application of 4 lb. a.e. per acre was made six weeks after planting, highly significant effects were obtained in terms of reductions in tiller counts, foliage weights and tuber weights. A combination of 2 pt. Gramoxone and 4 lb. a.e. 2,4-D amine per acre post-emergent six weeks after planting gave even better results.

TABLE VII

Effects of Gramoxone and 2,4-D alone and in combination on *Cyperus rotundus* in Experiment 7

Treatment	No. of tillers	Foliage wt., g.	Tuber wt., g.
Control	848	79	102
Gramoxone (2 pt./ac)	822	61	61
2,4-D (4.8 lb a.e. pre- and post-emergence)	269	32	29
Gramoxone (2 pt./ac) and 2,4-D (4.8 lb a.e. post-emergence)..	148	12	15

Other herbicides

The effects of various uracils, Afalon, Dalapon and TCA on *C. rotundus* were studied in Experiments 4 and 7 and the results are shown in Table VIII. The best results were obtained with the uracils, Hyvar X and Sinbar being outstanding even at 2 lb per acre. Foliage, tubers, roots, flowers and tuber viability were all suppressed almost completely. Experiment 4 was harvested after 10 weeks, and at this stage TCA at 24 lb per acre was slightly better than 6 lb Dalapon per acre, but both these treatments had exercised commercially acceptable control of *C. rotundus*. The lower levels of these two chemicals, however, did not adequately control the weeds. Afalon was not successful in causing significant reductions of either foliage or roots and tubers.

Micro-plots

The efficacy of various post-emergent herbicides in controlling *C. esculentus* in the field was estimated initially by means of visual ratings on the basis of a range from 0 for no weed control to 9 for complete weed control, a value of 7 representing approximately what is considered to be commercially acceptable weed control. Ratings carried out at 2 and 6 weeks after spraying are shown in Table IX together with the harvest data for foliage and tuber weights and per cent tuber viability. The ratings show that all three of the uracils at 4½ lb per acre gave adequate control of *C. esculentus* after 6 weeks; that Afalon gave fairly good early control which deteriorated between 2 and 6 weeks after spraying; that even at 7.2 lb a.e. per acre 2,4-D was poorly effective; and that 3 pt. of Gramoxone per acre caused the greatest effect after 2 weeks, but after 6 weeks recovery of the watergrass had begun to take place.

TABLE VIII

The effects of different herbicides sprayed post-emergent on *Cyperus rotundus*

Expt. No.	Treatment	Rate/ac.	Foliage wt., g.	Roots & tuber wt., g.	No. of viable tubers	No. of flowers
4	Control	—	77	141	318	13
	Hyvar X	2 lb	0	7	0	0
	Hyvar X	4 lb	0	8	0	0
	Dalapon	3 lb	50	92	233	12
	Dalapon	6 lb	18	35	37	6
	TCA	12 lb	46	59	96	6
	TCA	24 lb	4	19	13	3
7	Control	—	79	102	—	—
	Afalon	1 lb	73	93	—	—
	Afalon	2 lb	70	68	—	—
	Afalon	4 lb	69	76	—	—
	Afalon	6 lb	61	81	—	—
	Hyvar X	2 lb	17	15	—	—
	Sinbar	2 lb	13	12	—	—
	U 767	2 lb	31	24	—	—

TABLE IX

The effects of different herbicides sprayed post-emergent on *Cyperus esculentus* in the field

Treatment	Rate/ac	Visual rating		Foliage wt., g.	No. of tubers	% Tuber viability
		2 wks	6 wks			
Control	—	0	0	204	348	53
Hyvar X	1½ lb	5.7	5.7	75	180	67
Hyvar X	3 lb	6.7	6.7	15	123	53
Hyvar X	4½ lb	7.3	8.3	4	179	40
Sinbar	1½ lb	5.7	5.0	75	148	40
Sinbar	3 lb	6.0	6.7	54	171	47
Sinbar	4½ lb	7.0	7.7	3	134	60
U 767	1½ lb	3.3	3.7	126	202	63
U 767	3 lb	6.0	6.0	35	137	33
U 767	4½ lb	6.7	7.0	15	118	47
Afalon	2.4 lb	6.7	4.0	157	204	70
Afalon	4.8 lb	7.0	6.0	76	164	47
Afalon	7.2 lb	6.7	5.3	93	231	63
2,4-D amine	3.6 lb a.e.	0.7	2.3	169	155	60
2,4-D amine	7.2 lb a.e.	2.0	3.3	84	240	50
Gramoxone	3 pt	8.7	6.0	82	153	57

The weights of foliage harvested after 11 weeks correlated well with the visual ratings at 6 weeks, but tuber viability was much higher than observed in Experiment 4, where Hyvar X completely suppressed *C. rotundus* tuber viability. The numbers of tubers in all treatments in the micro-plots, however, were significantly less than those in control plots.

Discussion

It is perhaps important to define the term "weed control" when it is used in local parlance, as either the temporary suppression or the elimination of weeds in sugarcane fields. Thus the control of watergrass does not necessarily imply its elimination, but almost invariably its suppression for a relatively short period, so that the sugarcane crop can develop unhindered to the stage when it effects natural further suppression due mainly to shading.

The suggestion that pre-emergent applications of 2,4-D can give a modicum of control of Cyperus spp. is not supported by the results of these experiments. A possible slight but non-significant reduction in the number and weight of tubers of *C. esculentus* in Experiment 1, as shown in Table II, was not sufficient to warrant the treatment commercially if the suppression of watergrass alone were the reason for a pre-emergent herbicide application. It is reassuring, however, to know that any slight effect of 2,4-D on *C. esculentus* would accrue in any event due to the standard applications of this herbicide which are recommended immediately after planting. In neither Experiment 2 nor Experiment 3 was there any real evidence that *C. rotundus* was affected by pre-emergent 2,4-D treatments, except perhaps in terms of the delay or suppression of flowering.

The effects of post-emergent applications of 2,4-D on *C. rotundus* were marked in Experiments 3 and 4, the extent of control due to both early and late

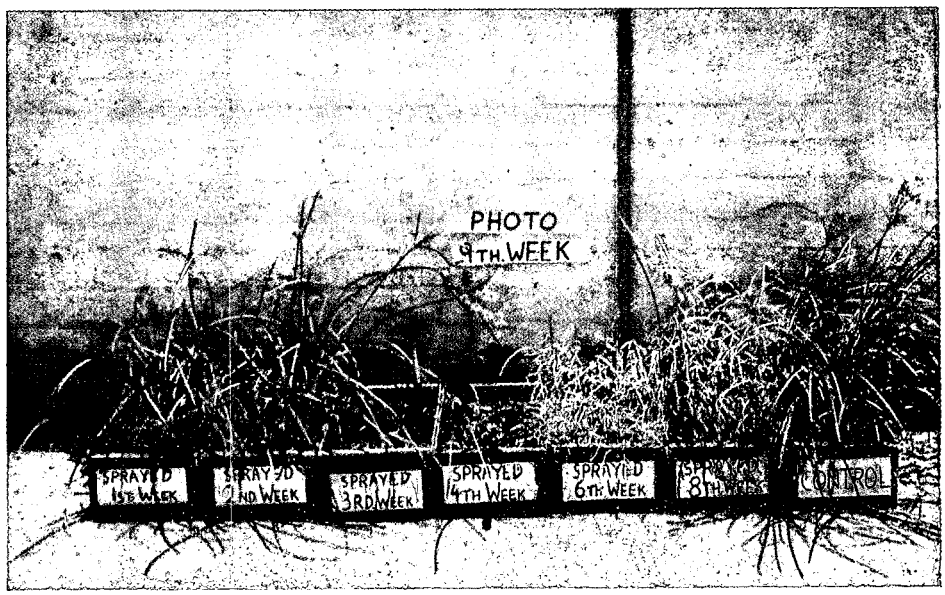

FIGURE 2: Growth of *C. rotundus*, 9 weeks after emergence, in a control and at 6 times of spraying 4 pt. Gramoxone per acre

applications in Experiment 4 being of a commercially acceptable standard. The results shown in Table V confirm the observation made repeatedly in the sugar belt that there are no measurable differences in the effects of different forms of 2,4-D under local conditions.

Contact herbicides have been preferred by many farmers and estates for the control of *C. esculentus* and *C. rotundus* in Natal, mainly because the process is relatively independent of soil moisture conditions, which can vary so widely and unpredictably. There is also little if any disadvantage due to the short-term control which contact herbicides normally give, since the sugarcane canopy itself quickly becomes a weed-deterrent in the cane row. A water-miscible contact herbicide which can be applied at low volume rates per acre has therefore been welcomed, but the high cost of Gramoxone demands that it should always be used to give the greatest and surest possible effect. From the data given in Table VI it is apparent that the optimum time at which *Cyperus* spp. should be sprayed, in order to reduce the reproductive potential in terms of both tubers and seed, is between 2 and 4 weeks after germination. Spraying at a later stage allowed a large number of tubers and inflorescences to develop before the herbicide was applied. Regrowth of the watergrass was most vigorous following early spraying, especially one week after germination. Tiller counts also indicated that above-ground competition with a crop could be minimized by spraying between 2 and 4 weeks after weed germination, and this was confirmed by the amount of green foliage present 11 weeks after germination. The amounts of foliage harvested from the 6- and 8-week treatments indicated only the small amount of weed recovery between these later sprayings and the harvest date.

The results of Experiment 7 shown in Table VII confirm earlier observations that the effects of Gramoxone applications can be improved by including 2,4-D. It should not be necessary to use as much as 4.8 lb a.e. per acre, and current recommendations are that only 2 or 3 lb a.e. of 2,4-D should be included with a Gramoxone treatment. On a row only basis, the additional cost is very small whilst the advantages to be gained can obviously be considerable.

The control of *Cyperus* spp. in young ratoon cane where the previous crop has been burnt remains one of the major weed problems in sugarcane fields. The results of Experiment 7 shown in Table VIII, and of the micro-plot experiment shown in Table IX, have been confirmed in more recent observational work, and it is now apparent that neither Afalon nor Karmex controls *C. rotundus*, but that both herbicides control *C. esculentus* adequately. On the other hand, 2,4-D has controlled *C. rotundus* fairly consistently, but has not had a similar effect on *C. esculentus*. At least some of the controversial opinions expressed about chemical control of *Cyperus* spp. in sugarcane fields in Natal therefore probably derive from a lack of species identification. The results of the experiments discussed in this paper indicate that both 2,4-D formulations and a substituted urea are selective in their effects and hence combinations of Karmex or Afalon with 2,4-D are required for effective control of mixed watergrass populations.

The use of less expensive herbicides such as TCA or Dalapon may also be recommended where soil moisture conditions are suitable, but damage to cane, particularly by Dalapon, makes these formulations more hazardous than the substituted urea formulations. The uracils remain the most effective chemicals for use on *Cyperus* spp. over a wide range of soil moisture contents, but their phytotoxicity to sugarcane also limits their applicability. Hyvar X has been consistently effective, as shown in Experiments 4 and 7 in the microplot experiment, whilst Sinbar has given comparable results. The compound U767, however, has generally given results inferior to those obtained with the other two compounds.

Conclusions

Increasing amounts of 2,4-D up to 7.2 lb a.e. per acre, applied post-emergent on *C. rotundus*, may give progressively better control, but even at this high rate the effects on *C. esculentus* are limited. Pre-emergent applications of 2,4-D are not effective in suppressing either *Cyperus* spp. appreciably.

Gramoxone should be sprayed on *Cyperus* spp. when the weeds are about 3 weeks old or at the commencement of flowering. The inclusion of 2 lb a.e. of 2,4-D with the Gramoxone should improve the efficacy of the treatment.

Mixed watergrass populations in young ratoons can be sprayed with Karmex and 2,4-D when soil moisture conditions are favourable, but where only one *Cyperus* species is present it should be identified and the correct treatment selected.

Summary

Herbicides have been used in experiments and in field practice over the past 18 years to control *Cyperus esculentus* and *Cyperus rotundus* in Natal. The results of recent experiments confirm that little if any pre-emergent effect can be obtained with 2,4-D formulations, but post-emergent applications up to 7.2 lb a.e. 2,4-D per acre gave increasingly better control of *C. rotundus*. Limited evidence showed that 2,4-D at this rate was not effective in suppressing *C. esculentus*.

Gramoxone was most effective when sprayed on both *Cyperus* species at a rate of 2 or 3 pints per acre, 2 to 4 weeks after weed emergence. This treatment limited the above-ground development of the watergrass and caused the recovery of the weeds to be least. The addition of some 2,4-D to the Gramoxone improved the efficacy of the treatment.

Of the other herbicides tested, the uracils were the most consistently successful, but the phytotoxicity of Hyvar X and Sinbar to sugarcane limit their usefulness. Afalon gave fairly good control of *C. esculentus* but did not control *C. rotundus*. Dalapon at 6 lb per acre and TCA at 24 lb per acre caused above and below-ground development of *C. rotundus* to be severely affected, but at half these rates the chemicals were relatively ineffectual.

References

1. Cleasby, T. G. (1957). The control of weeds by chemicals. Three experiments carried out by the Tongaat Sugar Company Ltd. *Proc. Annual Cong. S. Afr. Sugar Tech. Ass.* 31 : 119-123.
2. Gilfillan, E. C. (1966). Problems in weed control on an estate. *Proc. Annual Cong. S. Afr. Sugar Tech. Ass.* 40 : 315-316.
3. Gosnell, J. M. (1965). Herbicide trials in Natal sugar cane. *Proc. Annual Cong. S. Afr. Sugar Tech. Ass.* 39 : 171-180.
4. Gosnell, J. M. and Thompson, G. D. (1964). The results of herbicide trials, 1963/64. *Proc. Annual Cong. S. Afr. Sugar Tech. Ass.* 38 : 166-174.
5. Gosnell, J. M. and Thompson, G. D. (1966). The results of herbicide screening trials in sugarcane during 1965. *Proc. Annual Cong. S. Afr. Sugar Tech. Ass.* 40 : 304-311.
6. McMartin, A. (1949). Chemical weed-killers: their possible use in Natal cane fields. *Proc. Annual Cong. S. Afr. Sugar Tech. Ass.* 23 : 89-91.
7. McMartin, A. (1950). Further developments in chemical weed-killers. *Proc. Annual Cong. S. Afr. Sugar Tech. Ass.* 24 : 106-108.
8. Steward, E. (1956). The control of weeds in plant cane by chemical spray. *Proc. Annual Cong. S. Afr. Sugar Tech. Ass.* 30 : 125-128.
9. Stewart, M. J. (1955). A survey of chemical weed control in sugarcane. *Proc. Annual Cong. S. Afr. Sugar Tech. Ass.* 29 : 126-133.
10. Thompson, G. D. and Gosnell, J. M. (1963). The results of herbicide trials conducted in the cane belt in Natal, 1962/63. *Proc. Annual Cong. S. Afr. Sugar Tech. Ass.* 37 : 143-152.
11. Thompson, G. D. and Trichardt, H. (1957). Observations and results with weedkillers at Illovo. *Proc. Annual Cong. S. Afr. Sugar Tech. Ass.* 31 : 125-128.

APPENDIX 1

HERBICIDE FORMULATIONS

Commercial product	Short chemical name	Composition
Shellamine 7.2 ..	2,4-D amine	7.2 lb a.e./gall
Shell D	2,4-D ester	4 lb a.e./gall
Esteron 10-10 ..	2,4-D glycol ester	4.8 lb a.e./gall
Planotox	2,4-D iso-octyl ester	6.7 lb a.e./gall
Fernimine 4	MCPA K-salt	4 lb a.e./gall
Gramoxone	Paraquat	2 lb a.i./gall
Hyvar X	Bromacil	80% a.i.
Sinbar	U 732	80% a.i.
—	U 767	80% a.i.
Dowpon	Dalapon	85% a.i.
Tricate	TCA	94% a.i.
Afalon	Linuron	50% a.i.
Karmex..	Diuron	80% a.i.

Mr. Wyatt: There is a new compound in Louisiana called Banvel D which is apparently effective in controlling water grass.

Dr. Thompson: Banvel D deals with Cyperus species but we do not recommend it as it damages the cane severely.

Mr. Gilfillan: Our experience with 2,4-D at Tongaat on *Cyperus esculentus*, with pre-emergent control, is completely opposite to what appears in this paper as our control is excellent on all soil types when soil moisture is high.

We are using Karmex as a post emergent treatment and are getting good control under all soil moisture conditions. Moisture seems to have no effect at all on post-emergent treatments.

The Karmex must be sprayed when the leaf length of the water grass is at least ten inches.

Mr. Armstrong: Has Dr. Thompson done any field work on combination of 2,4-D and Gramoxone.

Dr. Thompson: Our conclusions are that the effects of Gramoxone with 2,4-D are better than those of Gramoxone alone.

It is of interest that we are getting reports of 2,4-D toxicity, and in a pre-emergent experiment at Pongola we have visual proof of damage from it.

Mr. Gonggryp: Has the pre-emergent effect of long chain esters been compared against the amines.

Mr. Gosnell: In some instances the residual effect of amine has not been as long as the long chain esters but usually we find very little difference.

Mr. Brown: Is the effect of 2,4-D different on water grass grown from seed and that grown from tubers?

Mr. Gosnell: It is far more effective on water grass grown from seed.

Mr. King: It is claimed that if soil moisture is high weed control is good. It would seem that a high water application, possibly 100 gallons an acre, could be justified commercially.

Dr. Thompson: We get good results with 20 gallons per acre, row only, or 40 gallons full cover. Efficient jets must of course be used.

Mr. Bartlett: I cannot see the value of row only treatment as it will allow the water grass to grow in untreated areas and necessitate further treatment in the next season. In fact I do not see why, by more frequent and intensive overall treatment, the water grass cannot be permanently eliminated.

Mr. Gosnell: I do not think you will ever obtain total elimination and there would also be damage to the cane.

Mr. Brown: After weed spraying at Muden, before planting cane in areas that had carried citrus for forty years, we noticed a big reduction in weed population.

Mr. Gilfillan: Is there possibly a difference in formulation of present day herbicides that could account for reported damage to cane?

Dr. Thompson: Reports of damage by 2,4-D to cane appear to coincide with the introduction of more concentrated formulations.

Mr. Wardle: There may be a cumulative effect of herbicide causing damage to the cane and it would be interesting to know if ratoon crops have been more affected than plant crops.

Dr. Thompson: One of our experiments was carried out with plant cane in an area that had been virgin bush and damage was still caused.

Mr. Date: Was the damage apparent at all levels of application?

Dr. Thompson: The application was 3 lb. acid equivalent of 2,4-D per acre.

Mr. Pearson: Has the damage been mainly to N:Co.310?

Dr. Thompson: It has been mainly to N:Co.376 but our current experiments are to test three varieties with different formulations of 2,4-D to gauge the effects of phyto-toxicity.