A COMPARISON OF HERBICIDE TREATMENTS FOR THE CONTROL OF GRASS AND *CYPERUS* SPECIES

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Abstract

The results are presented of a series of herbicide experiments conducted on two soils in Natal; a heavy clay and a light sand respectively having high and low organic matter contents. The experiments were designed to evaluate pre- and post-emergent herbicide treatments on the specific weeds *Panicum maximum, Cyperus rotundus, C. esculentus* and annual grasses.

Alachlor/2,4-D was the most successful herbicide mixture for pre-emergent grass control. No pre-emergent treatment effectively controlled the Cyperaceae. Post-emergent grass control was dependant upon the stage of growth when treatments were applied. Mixtures of ametryne/2,4-D and diuron/2,4-D were highly satisfactory for the post-emergent control of grass and *Cyperus* species. The addition of a non-ionic surfactant was always beneficial.

Introduction

The South African sugar industry has for some time accepted the value of chemical weedkillers and many growers now use herbicides as a principal, rather than as a supplementary, method of weed control. A considerable number of experiments have been conducted in the past on the control of the two sedges, *Cyperus esculentus* and *C. rotundus* (known locally as watergrass or nutgrass). Watergrass is one of the most important weed problems in the sugar industry. Annual and perennial grasses (especially *Panicum maximum)* also constitute a problem in certain areas.

The grasses and watergrass unfortunately flourish together and a common chemical method of control is therefore desirable. This paper presents the results of a number of field experiments conducted in the spring of 1970 to evaluate herbicide treatments for grass and watergrass control.

Materials and methods

A series of similar field trials was carried out in two different ecological areas: on a Clansthal sand at the coast (Mt. Edgecombe) and on a Farningham clay in the midlands mistbelt (Seven Oaks). The physical characteristics of the soils, both of which belong to the Hutton form (Van der Eyk, MacVicar and De Villiers[1]), are to be found in Table I. The sites were selected for heavy weed infestations representative of many sugarcane areas where annual and perennial grasses, and the two watergrass species, are considered a major problem. Sugarcane was not included in the experiments except for one trial in the midlands where a second ratoon (variety NCo 293) was present.

TABLE I

Soil characteristics of experimental sites

Location	Coast	Midlands
Soil series	Clansthal	Farningham
Description	Red sand	Clay loam
per cent clay (0-15 cm)	8	42
per cent silt (0-15 cm)	2	14
per cent sand (0-15 cm)	89	38
per cent organic matter	0,8	8,0
pH	8,5	4,6

Selected pre-emergent herbicide treatments were applied immediately after disc harrowing. Post-emergent treatments were applied early, medium and late post-emergence, according to the development stage of the dominant grass species. The weed spectrum present at the two sites differed considerably; at the coastal site *Panicum maximum* and *Cyperus rotundus* were the only species present, whilst the population at the midlands site contained a large number of annual grasses, *Cyperus esculentus* and a few broad-leaf weeds. Of the annual grasses present *Digitaria adscendens* and *D. ternata* were the most common and were considered the dominant species. *Panicum laevifolium, Setaria pallidefusca, Paspalum urvillei, Phalaris angusta* and *Eragrostis curvula* were also abundant.

The experiments were generally of a similar randomised block design. Treatment were replicated four times and the plot size was 0,002 4 ha. Sprayed plots were entirely surrounded by an unsprayed path (minimum width one metre) and this was useful as a control area for comparative purposes.

The techniques of herbicide application and assessment were common to all experiments. Overall treatments were applied using a "Platz Frankonia" knapsack, fitted with a "Spraying Systems" T.K. 2,5 floodjet and a constant pressure valve. The pace of the operator was maintained so that approximately 270 litres per hectare were delivered at a pressure of 2 kg/cm^2, the floodjet tip being 50 cm above the target. The soil moisture status at, and following, spraying was satisfactory for soil-applied herbicides to be effective.

Visual assessments of weed control were carried out in the experiments at regular intervals using a scale of 1 (=complete weed control) to 9 (=no weed control). A score of 4 reflects the situation where the weed population is just acceptable and further control operations are not immediately necessary. A score of 5 is just unacceptable. Absolute values may

vary according to the assessor but over a period of time a reliable evaluation of a treatment relative to other treatments is obtained.

Technical details of the herbicides, and the amounts of active ingredient actually applied for selected trade products, are given in Appendix I.

Pre-emergent experiments

A pre-emergent experiment was conducted on each of the two sites. Herbicide treatments were identical in the two experiments.

Results

The mean visual scores for the control of *Panicum maximum* on the coastal sand and annual grasses on the midlands site are presented in Table II.

Discussion

Outstanding long-term control of the common annual grasses of the midlands, and seedling *P. maximum* at the coast was exhibited by nearly all treatments. No treatment effectively controlled *Cyperus rotundus*. The lack of *P. maximum* seedling development after about six weeks can be partly attributed to natural shading out by, and the competition from, heavy *C. rotundus* growth.

The control given by alachlor alone and as Lasso D (a commercially formulated mixture of alachlor and 2,4-D), was excellent and the results agreed closely with previous work (Richardson[2], Hebblethwaite[3]). Lasso D at an application rate of 6 l/ha contains 2,1 kg a.i. alachlor and 0,7 kg a.e. 2,4-D. Improved weed control was obtained from this small additional 2,4-D content. Such a result could have been expected for broad-leaf weed control but, as seen in Table II, a slight improvement in the control of *P. maximum* was also obtained.

By comparison with unsprayed areas the standard pre-emergent treatment of 3 kg a.e. 2,4-D amine per hectare (Anon[4]), gave adequate short-term control at very low cost, but compared with other treatments it was not satisfactory. Gesapax H (a commercial formulation of ametryne and 2,4-D) gave slightly better control than that obtained from the standard 2,4-D treatments. Gesapax H has given poor pre-emergent results in other trials and at its price the product cannot be recommended for pre-emergence use in the Natal sugar industry.

Higher application rates of ametryne/2,4-D and diuron/2,4-D were less effective for the control of annual grasses than treatments based on alachlor. The manufacturers have unfortunately withdrawn P.P.493 from further development. Its pre-emergence activity on grasses, especially on *P. maximum,* has been found previously to be satisfactory (Richardson[2]).

It is clear that where fields have either a history of heavy grass infestation, or where 2,4-D has previously proved inadequate, or where single-application long-term control may be required, cocktail treatments based on alachlor should be considered.

Post-emergent experiments

Description

Five field experiments were conducted on grasses at different stages of development. In a number of experiments the watergrass species *Cyperus rotundus* and *C. esculentus* were also present in sufficient quantity, and their distribution was sufficiently uniform, for valid assessments of their control to be made. Most of the herbicide treatments were common to all experiments. Two experiments were conducted on the *Panicum maximum/Cyperus rotundus* site and the others were conducted on the annual grass/*Cyperus esculentus* site. The experiments will be discussed in relation to the weed species or species-group.

Control of *Panicum maximum*

Results

Mean visual scores for the control of *P. maximum* at different growth stages are presented in Table III.

Discussion

Post-emergent chemical control of *P. maximum* is only possible if the treatments are applied at an early growth stage. Even high (and therefore expensive) rates of diuron and ametryne with 2,4-D and surfactants failed to effectively control this perennial grass at the later post-emergent stages of growth.

TABLE II

Mean visual scores for pre-emergent grass control

1 = Complete kill
4 = Adequate; just acceptable
5 = Inadequate; just unacceptable
9 = No effect

Treatments			Days after application						
			Panicum maximum			Annual grasses			
Formulations	Rate (units/ha)	Cost (Rands/ha)	30	40	70	20	40	60	80
2, 4-D amine	3,0 kg a.e.	2,64	2,5	5,3	6,3	4,0	4,3	5,5	7,0
Alachlor	2,1 kg a.i.	14,50	2,0	2,3	3,8	1,0	1,8	2,0	3,5
Lasso D	6,0 litre product*	14,82	1,0	2,0	2,8	1,0	1,0	2,0	3,5
Lasso D	4,0 "	9,88	1,3	2,0	4,0	1,0	1,5	3,0	5,0
P.P. 493	2,0 kg a.i.	—	1,5	1,3	1,5	1,0	1,0	1,5	2,5
Gesapax H	5,0 litre product	11,00	2,3	3,5	4,0	3,5	4,0	5,5	7,0
Diuron+2,4-D amine	1,6 kg a.i.+3 kg a.e.	11,18	1,0	2,0	3,3	2,5	3,3	3,5	5,5
Ametryne+2,4-D amine	"	11,54	1,5	2,0	2,5	2,0	2,5	3,0	5,5

*Lasso D at 6 1/ha contains 2,1 kg a.i. alachlor+0,7 kg a.e. 2,4-D.

TABLE III

Mean visual scores for the post-emergent control of *P. maximum* on a coastal sand

Treatment			Stage of post-emergence				
			Medium 3-4 leaves produced 5-7 cm leaf length			Late 5 leaves: 3 culms 15 cm culm length	
Formulations	Rate (units/ha)	Cost (Rands/ha)	Days after application			Days after application	
			10	20	30	15	35
2,4-D+Diuron	3 kg a.e.+3,2 kg a.i.	19,72	3,3	2,0	3,3	7,0	7,0
2,4-D+Diuron+surfactant	,, ,, +0,5% v/v	20,26	2,0	1,0	1,8	5,5	5,0
2,4-D+Ametryne+surfactant	,, ,, ,,	20,98	2,0	1,3	2,3	7,0	6,8
Gesapax H	5 litre product*	11,00	6,5	7,8	7,8	8,3	7,8
Gesapax H+Sun Oil 11 E	5 litre +5 litre products	12,00	5,5	6,3	6,3	8,0	7,8
2,4-D+Diuron+surfactant	1,5 kg a.e.+1,0 kg a.i.+0,5% v/v	7,20	3,0	2,5	4,5	8,8	8,3
2,4-D+Ametryne+surfactant	,, ,, ,,	7,42	3,0	5,5	5,5	7,3	7,3
Actril D	7 litre product	—	7,3	8,5	8,0	—	—
2,4-D+Paraquat	3 kg a.e.+2,5 litre product	12,51	—	—	—	5,8	6,3

*Gesapax H at 5 L/ha contains 1,5kg a.e. 2,4-D+1,0 kg a.i. ametryne

TABLE IV

Mean visual scores for the post-emergent control of annual grasses in the midlands mistbelt

Treatments		Stage of post-emergence							
		Early 1-2 leaves 1 cm leaf length			Medium 3-4 leaves 5-6 cm leaf length			Late 8 leaves 12 cm stolon length	
Formulations	Rate (units/ha)	Days after application			Days after application			Days after application	
		20	50	70	20	50	70	20	35
2,4-D+Diuron	3 kg a.e.+3,2 kg a.i.	1,8	1,8	5,0	—	—	—	4,0	6,3
2,4-D+Diuron+surfactant	,, ,, +0,5% v/v	1,0	1,5	4,0	2,0	2,5	4,0	2,0	5,0
2,4-D+Ametryne+surfactant	,, ,, ,,	1,5	1,5	3,5	3,0	3,0	4,0	2,0	5,5
Gesapax H	5 litre product*	2,0	3,0	5,5	3,0	4,4	8,0	4,8	6,5
Gesapax H+Sun Oil 11 E	5 litre+ 5 litre products	2,0	2,5	5,3	2,0	4,0	7,0	4,3	6,5
2,4-D+Diuron+surfactant	1,5 kg a.e.+1,0 kg a.i.+0,5% v/v	2,0	3,0	6,0	2,0	3,5	7,0	5,5	7,8
2,4-D+Ametryne+surfactant	,, ,, ,,	2,3	4,0	6,5	2,0	3,5	6,0	5,8	7,3
T.C.A.+Diuron	10 kg product+1,6 kg a.i.	2,8	3,0	6,0	2,0	3,0	5,0	—	—
2,4-D+Paraquat	3 kg a.e.+2,5 litre product	—	—	—	—	—	—	6,8	7,5
2,4-D+Dalapon	3 kg a.e.+3 kg product	—	—	—	7,0	7,0	7,0	—	—

* Gesapax H at 5 L/ha contains 1,5 kg a.e. 2,4-D+1,0 kg a.i. ametryne

Grass species present

Digitaria adscendens
D. ternata
Setaria pallidefusca
Panicum laevifolium
Paspalum urvillei
Phalaris angusta
Eragrostis curvula

It should be noted that herbicides having high contact activity (such as paraquat) also proved to be inadequate. A severe foliar scorch was obtained but this was incomplete and rapid regrowth occurred.

Comparisons of treatment efficacy are most interesting at the medium post-emergent stage, where maximum differences were to be expected. The standard high rate treatments of diuron and ametryne gave excellent control, and where *P. maximum* is a major problem should, in spite of their cost, continue to be recommended.

All treatments containing low rates of ametryne, whether as the wettable powder or as the commercially formulated product Gesapax H, failed to effectively control the seedlings. Observations confirmed that only when the seedlings were at a very early post-emergent stage (1-2 leaves produced; 2 cm leaf length) was Gesapax H or a low rate of ametryne and 2,4-D fully effective.

It is of interest that the control given by treatments containing diuron was generally superior to that given by ametryne-containing treatments. This difference in activity was probably due to the main mode of uptake, i.e. root absorbed for diuron and foliar absorbed for ametryne.

The advantages of added surfactants or light oils were clearly seen, both in assessment counts and in the degree of foliar scorch.

Control of annual grasses

Results

Although a number of grasses were present in the experiments, *Digitaria adscendens* was the dominant species and descriptions of the various post-emergent stages refer only to this grass. Mean visual scores for the control of annual grasses in the midlands are presented in Table IV.

Discussion

High rate treatments of ametryne and diuron again gave the best weed control, the addition of surfactant and oil additives improving the results. Timing was again critical and, except for the high rate treatments, the late post-emergent sprays were not effective.

There is no doubt that satisfactory chemical weed control is easier to achieve on annual grass populations than on perennial ones. Despite the higher organic matter and clay content of the midlands soil; both of which factors reduce the efficacy of root absorbed herbicides (Audus[5]), the control exhibited by the treatments on the annual grasses was superior to that obtained for the perennial grass on the Clansthal sands.

All low rate, low cost treatments of diuron and ametryne were effective, the best results being obtained when the herbicides were applied early. Gesapax H with, and without, oil additives was most satisfactory, and in fact appeared to be slightly superior to equivalent low rate mixtures at late post-emergent stages. A mixture of T.C.A. and diuron (costing R15-14 per hectare) appeared to be satisfactory as an alternate control method.

Control of *Cyperus rotundus*

Results

Mean visual scores for the post-emergent control of *C. rotundus* on the Clansthal sand are presented in Table V.

Discussion

Marked differences in the activity of ametryne and diuron occurred. Ametryne-containing treatments caused an effective early foliar scorch whereas the results from diuron-based treatments were not immediately apparent. The root absorbed nature and residual action of diuron subsequently resulted in better control being obtained from this chemical than from ametryne.

Gesapax H with an oil additive was fairly satisfactory when applied before the flowering stage. Subsequent observations indicate that field control is generally not acceptable if the product is applied after the species has started to flower.

With all the low rate, low cost treatments the control of *C. rotundus* was relatively short-term; new growth from tubers occurred rapidly. Occasionally very young plants were seen to recover. The timing of the application of such treatments should therefore be after the bulk of the *C. rotundus* population has emerged, and before the flowering stage is reached: a total period of 2-3 weeks.

Though the assessment figures do not indicate it adequately the commercial emulsifiable solution of Gesapax H was always better than the equivalent rates of ametryne wettable powder and 2,4-D. This difference could be due to a number of factors, including the additional solvents and solubilisers in the commercial formulation (Anon[6]). A further difference between the two treatments was that Gesapax H contained the isobutyl ester form of 2,4-D whereas the amine form of 2,4-D was used for the equivalent rate treatments.

Where the control of *C. esculentus* and *C. rotundus* could be directly compared under identical conditions it was clear that the latter species was far more tolerant to the herbicides. High rate, high cost treatments appear to be generally effective on *C. rotundus* for a five-week period. Low rate, low cost mixtures of ametryne/2,4-D and diuron/2,4-D as formulated liquids or as wettable powders give good short-term control which, in spring or summer, rarely exceeds three weeks.

TABLE V

Mean visual scores for the post-emergent control of *C. rotundus* at the coast

Treatments		Stage of post emergence				
		Medium 4 leaves produced 2-3 weeks after emergence			Late 7 leaves produced 5% flowering	
Formulations	Rate (units/ha)	Days after application 10	20	30	Days after application 15	35
2,4-D+Diuron	3 kg a.e.+3,2 kg a.i.	4,5	3,8	5,0	6,3	4,5
2,4-D+Diuron+surfactant	,, ,, +0,5% v/v	4,8	4,3	4,5	4,0	3,0
2,4-D+Ametryne+surfactant	,, ,, ,,	3,0	3,8	5,5	3,8	3,0
Gesapax H	5 litre product	4,8	5,3	7,0	5,3	7,0
Gesapax H+Sun Oil 11E	5 litre+5 litre products	4,3	4,8	6,0	4,3	6,0
2,4-D+Diuron+surfactant	1,5 kg a.e.+1,0 kg a.i.+0,5% v/v	5,3	4,8	6,0	6,5	6,0
2,4-D+Ametryne+surfactant	,, ,, ,,	4,3	5,0	7,0	4,3	6,0
Actril D	7 litre product	6,3	5,8	6,5	—	—
2,4-D + Paraquat	3 kg a.e.+2,5 litre product	—	—	—	4,0	7,5

TABLE VI

Mean visual scores for the late post-emergent control of *C. esculentus* (6 leaves produced: 5% flowering)

Treatments		Days after application	
Formulations	Rate (units/ha)	18	35
2,4-D+Diuron	3 kg a.e.+3,2 kg a.i.	3,5	4,7
2,4-D+Diuron+surfactant	,, ,, +0,5% v/v	2,5	4,5
2,4-D+Ametryne+surfactant	,, ,, ,,	2,5	6,0
Gesapax H	5 litre product	4,3	7,0
Gesapax H+Sun Oil 11E	5 litre+5 litre products	2,8	5,0
2,4-D+Diuron+surfactant	1,5 kg a.e.+1,0 kg a.i.+0,5% v/v	4,0	6,0
2,4-D+Ametryne+surfactant	,, ,, ,,	4,2	6,5
2,4-D+Paraquat	3 kg a.e.+2,5 litre product	5,0	7,8

Control of *Cyperus esculentus*

Results

The distribution of the weed was generally poor and it was only possible to obtain valid mean scores in the late post-emergence experiment. The results are presented in Table VI. The conclusions from recent additional experiments (Richardson[7]), have been included in the discussion.

Discussion

Excellent control of *C. esculentus* was given by Gesapax H treatments. The addition of light oils and surfactants enhanced the results. The control given approached that of high rate treatments but was not effective for so long a period. The timing of sprays does not appear to be as critical for *C. esculentus* as it is for *C. rotundus*, but a tendency for less effective control was nevertheless present once flowering had started.

There appeared to be no real differences between the low rate treatments, with the exception of the emulsifiable concentrate Gesapax H, which again proved to be superior to wettable powder combinations.

Where soil moisture is too limiting for soil-applied herbicides to be fully effective, a condition that frequently occurs during the planting season, formulations based on ametryne (which is primarily a contact herbicide), have a distinct advantage over diuron-based treatments. But heavy rainfall following soon after ametryne-based sprays have been applied has often resulted in unsatisfactory, and occasionally negligible, weed control.

Conclusions

Satisfactory control of grasses in the cane belt can be obtained with available pre- and post-emergence herbicides. Post-emergence treatments are only effective if applied at the earliest stages of seedling development. Timing is critical and should the early post emergence stage be missed there is no chemical control available which is effective at selective or economic rates of application.

A pre-emergence application of 2,4-D provides a cheap short-term treatment which will give adequate control where grasses are not a major problem, and where a subsequent post-emergence treatment is to be applied. In areas with a history of heavy grass infestation, where 2,4-D has previously proved inadequate, or where post-emergence sprays cannot be judiciously applied, an alachlor-based treatment should be used. The commercial product Lasso D at an application rate of 5 l/ha (costing R12-35) is recommended.

Post emergence treatments of diuron/2,4-D/surfactant (at 1,0 kg a.i. + 1,5 kg a.e. + 0,5% v/v per hectare) give satisfactory control of annual grasses, and of *P. maximum* if applied before the seedlings pass the 4-leaf stage. Similar results on annual grasses may be obtained by using equivalent rates of an ametryne-based treatment. For very severe infestations of *P. maximum* a high rate treatment of diuron/2,4-D/surfactant (3,2 kg a.i. + 3 kg a.e. + 0,5%) will probably be required for effective, lasting control.

Watergrass could not be satisfactorily controlled with the pre-emergence herbicides tested. Post-emergence applications of ametryne/2,4-D/surfactant or diuron/2,4-D/surfactant (at 1,0 kg a.i. + 1,5 kg a.e. + 0,5% v/v per hectare) will give adequate — but short-term — control of both *Cyperus* species. Unlike paraquat the treatments are selective to cane and any foliar scorch which may result is generally very mild. The commercial product Gesapax H at an application rate of 5 l/ha (costing R11-00) is recommended.

Emulsifiable concentrates (like Gesapax H) have a distinct advantage over home-made cocktails because they are easy to use and have none of the mixing and spraying problems usually associated with wettable powders.

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APPENDIX I

Herbicides used

Approved common name	Code/Trade name	Supplier/Manufacturer	Formulation
2,4-D	Fernimine 7	A.E. & C.I./A.E. & C.I.	725 g a.e./l
Alachlor	Lasso e.c.	A.E. & C.I./Monsanto	480 g a.i./l
Ametryne	Gesapax 80 w.p.	Geigy/Geigy	80% w.p.
Diuron	Karmex 80 w.p.	Agricura/du Pont	80% w.p.
Paraquat	Gramoxone	A.E. & C.I./Plant Protection	200 g a.i./l
Dalapon	Dalspray	A.E. & C.I./Dow	74% a.e.
	P.P. 493	A.E. & C.I./Plant Protection	200 g. a.i./l
	Actril D	Maybaker/Maybaker	350 g. a.e./l
	Lasso D	A.E. & C.I./Monsanto	*
	Gesapax H	Geigy/Geigy	**

a.e.=acid equivalent; a.i.=active ingredient
*Lasso D : 1 litre product contains 0,36 kg a.i. alachlor+0,12 kg. a.e. iso-octyl ester 2,4-D
**Gesapax H : 1 litre product contains 0,21 kg a.i. ametryne+0,29 kg a.e. iso-butyl ester 2,4-D

Surfactants used

Agral 90 (non-ionic) contains an alkylated phenol-ethylene oxide condensate
W.K. (non-ionic) contains the dodecylether of polyethylene glycol.

Discussion

Dr. Cleasby (in the chair): The problem of selective weed control has, chemically, still to be solved. It will become more pressing as labour for weeding becomes scarcer.

Mr. Wilson: Most of the experiments were carried out in the absence of cane. The duration of weed control has a big effect on the growth of cane. Has there been an attempt to relate the increase in yield to cost of application?

Mr. Richardson: Not for these treatments. Experiments on crop yield increase due to weed control are not easy to conduct, because there are interactions between the early breakdown of the herbicide and the resulting increase in the weed population. Where an extremely efficient hand weeding programme is followed, the yields may be slightly higher than where a herbicide programme is followed. Hoe weeding as it is generally practised usually results in lower yields than where herbicides are used.

Mr. Browne: Would Mr. Richardson comment on cane damage by Gesapex H as opposed to ametryne used alone?

Mr. Richardson: Both will cause foliar scorch, that from Gesapax H being worse than that from ametryne. The 2,4-D content of Gesapax H is very low and should not cause trouble. Post-emergent sprays of either product should be directed so as to avoid the direct spraying of cane foliage, and if the correct application rate is used there should be no yield decrease.

Mr. Gilfillan: Tongaat Estate has an over-riding problem with *Cyperus esculentus*. Is there any point in using a pre-emergent teeatment such as 2,4-D if a heavy infestation of *Cyperus* will follow and require a post-emergent treatment?

Mr. Richardson: If it is not used you must apply the post-emergent treatment at the earliest opportunity. Without a pre-emergent treatment there is no safety factor in reserve, and timing is critical.