THE RESULTS OF HERBICIDE TRIALS, 1963-64

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Summary

In a general herbicide trial taken through to harvest no significant reduction in cane yield was caused by Paraquat; in fact increasing levels of Paraquat produced increasing yields of cane. Diquat was inferior to Paraquat, and of the pre-emergent herbicides, DCMU was the best. In another dryland trial no pre-emergent treatment was successful, but in an irrigated trial Atrazine and Simazine were successful, and DCMU was also good. Of the post-emergent treatments Bromacil at $1\frac{1}{3}$ and 2 lbs. per acre was very successful in the control of weeds but caused damage to the cane. At lower rate ($\frac{2}{3}$-$1\frac{1}{3}$ lbs. per acre) in combination with Paraquat, weed control was also excellent, and the damage to cane was less. DCMU plus Paraquat was also successful under moist conditions. Paraquat at $\frac{2}{3}$ to 1 pint per acre gave excellent short period control of dense *Cyperus esculentus*, being equivalent to and cheaper than hand weeding. Delapon at 15 lbs. gave good all round control of grasses in drainage ditches for four months and Garlon at 16 pints gave total control of *Phragmites* reed for at least five months.

Introduction

In addition to screening a number of new herbicides during the past year, more intensive studies were made on the use of Paraquat to control watergrass (*Cyperus* spp.) in plant cane, and attempts were made to find a suitable chemical to mix with Paraquat in order to obtain more residual weed control. In addition, some work on weed control in drainage ditches was carried out.

In all experiments where weeds in cane land were sprayed (except the Mtunzini trial), only an 18 inch swath over the row was sprayed, and the equivalent full-cover rates of application would therefore be three times those quoted. Herbicides have been described in quantities of commercial material per acre and yields in short tons cane per acre. Scorings were carried out on a basis of 0 (no weed control) to 9 (complete weed control).

To avoid any confusion regarding the types and amounts of chemicals used, the following table is presented. The composition is reported in terms of either active ingredient (a.i.) or acid equivalent (a.e.).

Where the costs of chemical treatments have been given in the ensuing text, these have been based on current bulk retail prices. A cost for application should be added to the cost of herbicide material, and unless a more accurate local figure is available, this can be estimated at 50 cents per acre.

Chemical Compound(s)	*Commercial Formulation*	*Composition*
2, 3, 6-TBA+MCPA	Fisons 1815	0.48 lb.+1.5 lb. per gall.
2, 4-D Amine	Fernimine Selective	5 lb. a.e. per gall.
2, 4-D Ester	Fernesta	4 lb. a.e. per gall.
2, 4, 5-TP	Kuron	4 lb. a.e. per U.S. gall.
Ametryne 50 W.	Ametryne 50 W.	50% a.i.
Atrazine 80 W.	Atrazine 80 W.	80% a.i.
Bromacil	Hyvar X	80% a.i.
CMU	Telvar	80% a.i.
Dacthal	Dacthal	75% a.i.
Dalapon	Dowpon	85% a.i.
Dalapon+2, 4, 5-TP	Garlon	4.0 lb. a.e.+0.5 lb. a.e. per U.S. gall.
Diquat	Reglone	2 lb. a.i. per gall.
Dichlobenzamide	W.L. 5792	50% a.i.
DCMU	Karmex	80% a.i.
Eptam	Eptam	7.2 lb. a.i. per gall.
Linuron	Lorox L	3.2 lb. a.i. per U.S. gall.
Paraquat	Gramoxone	2 lb. a.i. per gall.
Prometone 50 W.	Prometone 50 W.	50% a.i.
Prometryne 50 W.	Prometryne 50 W.	50% a.i.
Simazine 80 W.	Simazine 80 W.	80% a.i.
Stam F. 34	Stam F.W. 734	2 lb. a.i. per U.S. gall.
TCA	Tricate	95% a.i.
Tordon	Tordon	2 lb. a.i. per U.S. gall.

Experimental Results

1. *Second General Herbicide Trial (Mtunzini)*

The treatments applied, together with visual ratings of effects have been given in a previous paper (Thompson & Gosnell, 1963). The experiment was harvested during the year under review. This was the first trial involving Paraquat to have been taken through to harvest, and it is interesting to note that there was no significant difference between the mean of some eight treatments containing Paraquat, and the hand-weeded controls. Two of the treatments gave somewhat higher yields (non-significant) than control, the remaining six being lower, but only two significantly so. The scorching effect on the cane was extremely severe since it was standing about 18 inches high, well above the existing weed growth when it was sprayed. The recovery was thus remarkably good. The damage to cane and weeds was apparently uniform, with low rates of Paraquat causing the same visual effect as high rates. Higher rates evidently achieved better weed control, however, since there is a marked trend towards higher yields with these rates. This is borne out by examining the weed control ratings, which were made on four occasions between 9 and 14 weeks after planting. The following summary of Paraquat treatments includes both Full Cover and Row Only sprays, expressed in terms of Full Cover rates:

Treatment	*Yield*	*Weed Control Rating*
Paraquat (6 pt.)	42.4	6.8
Paraquat (4 pt.) + 2, 4-D (3 pt.)	40.4	7.3
Paraquat (4 pt.)	37.4	5.9
Paraquat (2 pt.)	34.6	5.2
Hand Weeded	42.2	6.9

If equal scorching of weeds was obtained in all treatments in the first instance, these figures infer that translocation of Paraquat may have taken place and that this was greater with higher rates.

The degree of weed control achieved by Diquat was not as good as that by Paraquat, as can be seen from the difference between mean yields of all Paraquat and Diquat treatments. This was 4 tons cane per acre in favour of Paraquat.

Other interesting results were that Dalapon gave consistently lower (non-significant) yields than the No Weeding treatment, indicating damage to the cane which was not observed visually. TCA gave variable results but always better than Dalapon. Of the pre-emergent treatments, only DCMU was successful, giving almost as high yields as the hand weeded control. Eptam caused severe damage to the cane and a highly significant reduction in yield. Final results were:

Pre-Emergent Applications (row only)

Treatment	*Yield*	*Cost of Herbicide*
Hand Weeded	58.4	—
DCMU 1⅓ lb.	56.7	R 3.29
Kuron, 8 U.S. pts.	54.0	?
2, 4-D amine 1.6 pts.	53.2	0.55
CMU 1⅓ lb.	52.7	3.29
Eptam 1 pt.	48.0	2.75

C.V. 8.1% L.S.D. 6.6 (5%) 9.1 (1%)

POST-EMERGENT APPLICATION

Treatment	Full Cover		Row Only*		Cost* of Herbicide
	Yield	Rank	Yield	Rank	
Paraquat + 2, 4-D Ester 4 pt. + 3 pt.	44.2	1	36.6	6	R 3.39
Paraquat 6 pt.	44.0	2	40.8	2	4.58
Hand Weeded	42.3	3	42.0	1	—
Paraquat 4 pt.	40.5	4	34.4	8	3.05
Diquat + 2 4-D Ester + TCA 2 pt. + 3 pt. + 7½ lb.	38.3	5	31.2	11	3.76
Diquat 2 pt.	36.5	6	37.1	4	1.30
Diquat 1 pt.	35.4	7	35.1	7	0.65
Paraquat 2 pt.	35.3	8	33.8	9	1.52
Diquat + 2, 4-D Ester 2 pt. + 3 pt.	34.0	9	36.7	5	1.64
Diquat 3 pt.	33.6	10	28.5	13	1.95
No Weeding	30.1	11	31.3	10	—
TCA + 2, 4-D Ester 15 lb. + 3 pt.	29.5	12	37.5	3	1.76
Dalapon + 2, 4-D Ester 7½ lb. + 3 pt.	28.0	13	30.7	12	2.59
C.V.	17.2		12.5		
L.S.D. (5%)	8.9		6.3		
(1%)	12.0		8.5		

* Spray applied at ⅓ of Full Cover Rates on an 18-in. swath. 0.1% Agral added to all Paraquat and Diquat treatments.

2. *Herbicide Screening Trial* (2 4 by 4 Triple Lattices)

This was planted on 25th September, 1963, at Mount Edgecombe. The soil was a Mount Edgecombe loam with some overwash from surrounding dolerite slopes. The treatments, together with the means of visual scorings carried out on 18th January and 27th February, 1964, are presented below:

Treatment	*Quantity*	*Scoring*
Pre-Emergent (sprayed 27.9.63):		
Hand Weeded	—	6.7
Tordon	⅓ pt.	0.7
Tordon	⅔ pt.	0.7
Tordon	1⅓ pt.	0.3
Tordon	2 pt.	0.7
Prometryne	1 lb.	1.0
Prometryne	2 lb.	0.7
Prometone	1 lb.	0
Prometone	2 lb.	0.7
Ametryne	1 lb.	0.7
Ametryne	2 lb.	0.7
2, 3, 6-TBA + MCPA	4 pt.	1.3
2, 3, 6-TBA + MCPA	12 pt.	3.0
2, 4-D Amine	1⅓ pt.	2.0
Dacthal	5 lb.	2.3
Nil	0	0.7
Post-Emergent (sprayed 15.11.63):		
Hand Weeded	—	8.8
Bromacil	⅔ lb.	2.7
Bromacil	1⅓ lb.	5.7
Bromacil	2 lb.	6.6
Bromacil + Paraquat	⅔ lb. + ⅔ pt.	6.0
Bromacil + Paraquat	1⅓ lb. + ⅔ pt.	7.3
Tordon + Paraquat	⅓ pt. + ⅔ pt.	2.5
Tordon + Paraquat	⅔ pt. + ⅔ pt.	3.1
Dichlobenzamide	2 lb.	2.0
Dichlobenzamide + Paraquat	½ lb. + ⅔ pt.	2.8
Dichlobenzamide + Paraquat	1 lb. + ⅔ pt.	3.9
Linuron	1.4 pt.	2.6
Linuron	2.8 pt.	3.4
Linuron + Paraquat	1.4 pt. + ⅔ pt.	4.5
Stam F. 34 + 2, 4-D amine	6⅔ pt. + 1 pt.	2.4
Nil	0	—

B.—Agral 90 was used as a wetting agent with Paraquat and WK with Linuron.

The weed population was a mixture of *Portulaca oleracea, Bidens pilosa, Siegesbeckia orientalis, Digitaria adscendens, Eleusine indica, Cleome monophylla, Cyperus esculentus, C.rotundus, Oxalis* sp. *Setaria pallide-fusca* and *Urochloa panicoides.*

Extremely dry conditions prevailed for 11 days after spraying the pre-emergent trial, and this is the probable reason for the failure of any of these herbicides to achieve a commercially acceptable control. The soil moisture contents in the top 12 inches of soil determined twice weekly in six-inch strata for the first four weeks of the experiment are shown in Figure I. The organic matter content of the soil was 3.74 per cent for the 0-6 inch depth and 3.66 per cent for the 6-12 inch depth. Whilst none of the pre-emergent treatments produced acceptable weed control, marked differences due to treatment in weed populations were observed. These may be summarized as follows:

Tordon controlled all broadleaf species effectively, including *Portulaca*, but had no effect on monocotyledons. The plots were dominated by *Digitaria adscendens*. The $\frac{1}{3}$ pint treatment was inadequate, but there was little difference in effect between the three higher rates.

Prometryne achieved fairly good control of all annual grasses, especially at the higher rate, but had no effect on broadleafed weeds.

Prometone appeared to exercise some control on *Eleusine* but had no other visible effects.

Ametryne was slightly more effective than Prometryne on *Cleome* and *Bidens* but was much less effective on grasses.

2, 3, 6-TBA plus MCPA at 12 pints gave acceptable control of both broadleafed weeds (including *Portulaca* and annual grasses) and was the most effective herbicide in the trial. Unfortunately there was no control of *Cyperus* sp., which became dominant.

Dacthal gave complete control of grasses, but did not control broadleafed weeds at all.

The post-emergent treatments were considerably more successful than the pre-emergent, but were not entirely effective due to slow cane growth. Bromacil was easily the most effective, but the highest rate, 2 lb., caused a fairly severe setback to the cane. The $1\frac{1}{3}$ lb. Bromacil plus $\frac{2}{3}$ pt. Paraquat treatment appeared to give optimum results with minimal cane damage, with weed control lasting for over 12 weeks, while $1\frac{1}{3}$ lb. Bromacil alone was also good. The $\frac{2}{3}$ lb. level of Bromacil was inadequate. Linuron appeared to give better results than Bromacil during the first month after spraying, but its degree of control deteriorated, whereas Bromacil was still giving good control after

FIG. 1
Screening Trial

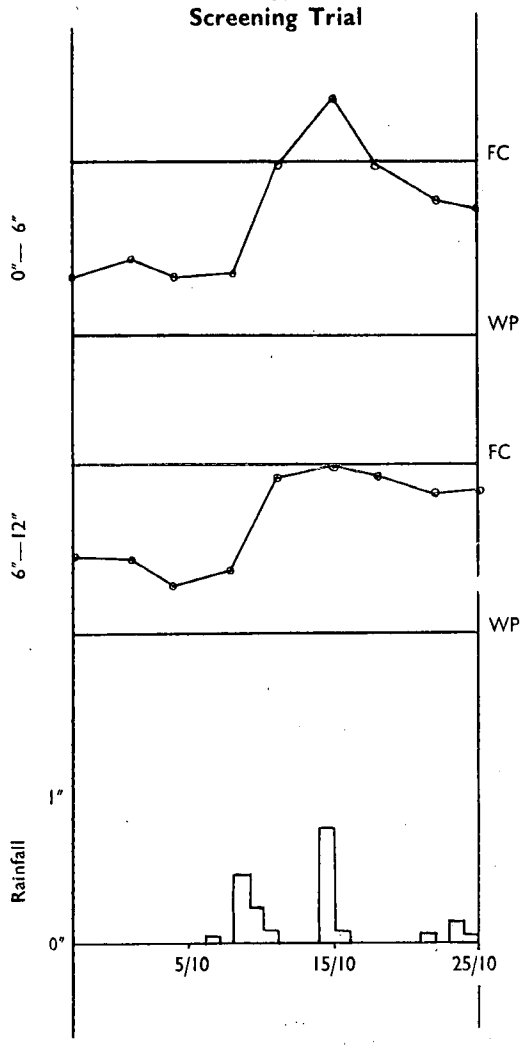
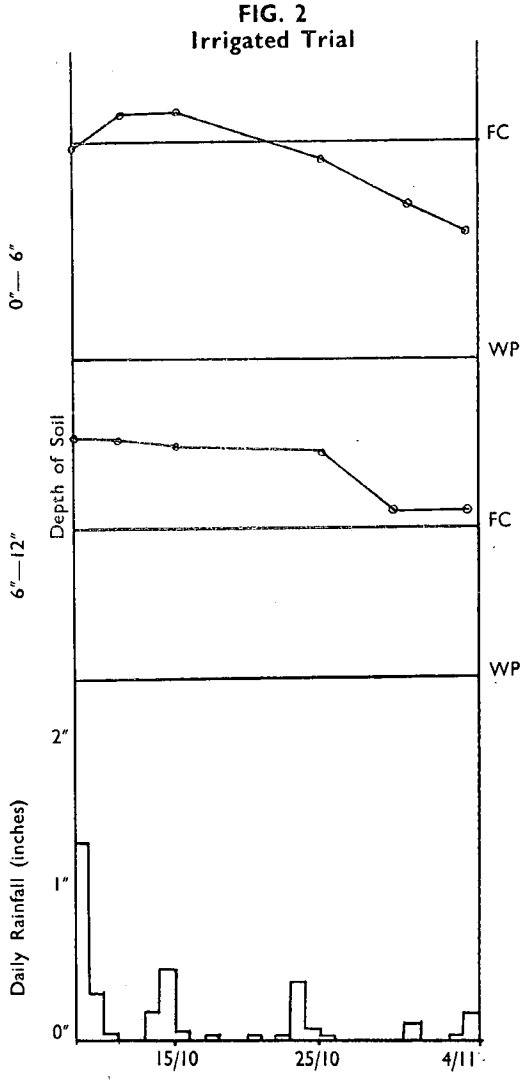
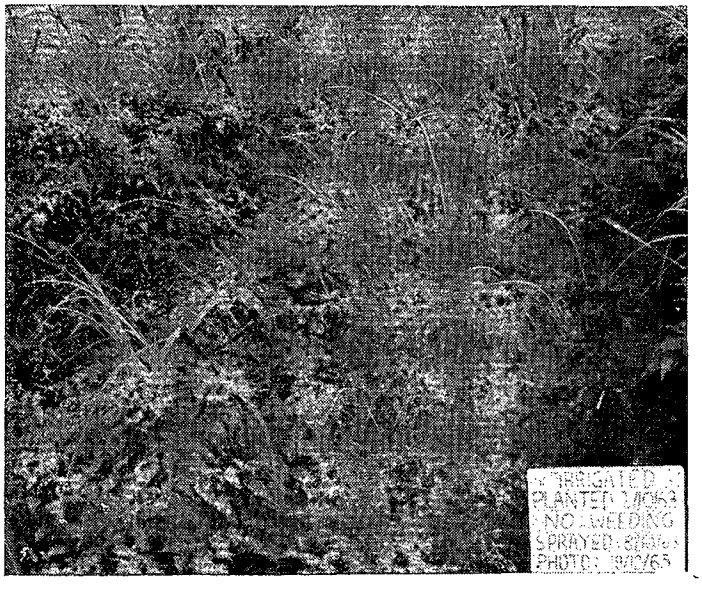


FIG. 2
Irrigated Trial



Atrazine 1½ lb. Pre-emergent. Photo taken 4 weeks after spraying. Note good control of *Solanum nigrum*.

Atrazine 1½ lb. Pre-emergent. Photo taken 10 weeks after spraying. Good commercial weed control.



No weeding. *Solanum nigrum* and *Digitaria adscendens* dominant 11 weeks after planting.

DCMU ⅔ lb.+Paraquat ⅔ pt. Post-emergent. Photo 5 weeks after spraying, 11 weeks after planting. Excellent weed control but slight stunting of cane.

Bromacil 1½ lb. Post-emergent. Photo 5 weeks after spraying, 11 weeks after planting. Excellent weed control; moderate stunting of cane.

Growth of cane 5 days after spraying with Paraquat. Note scorched tips of leaves. *Cyperus esculentus* is completely scorched.

three months. The remaining treatments gave some control of weeds but the level was not commercially acceptable. The weed growth in the no-weeding plots practically eliminated the cane.

3. *Irrigated Herbicide Trial* (4 by 4 Quadruple Lattice and 7 by 4 Youden Square)

This was planted on 2nd October, 1963, at Chaka's Kraal on a Waldene fine sandy loam. The treatments, together with the means of visual scorings carried out on 12th December, 1963, and 18th January, 1964, are detailed below.

Treatment	*Quantity*	*Cost of Herbicides*	*Scoring*
Pre-Emergent (sprayed 8.10.63):			
Hand Weeded	—	—	8.3
Atrazine 80 W.	1⅓ lb.	R2.93	5.9
Simazine 80 W.	1⅓ lb.	2.93	4.9
DCMU	1⅓ lb.	3.29	3.2
DCMU	1 lb.	2.47	3.1
DCMU	⅔ lb.	1.65	3.0
Nil	—	—	1.5
Post-Emergent (sprayed 13.11.63):			
Bromacil + Paraquat	⅔ lb. + ⅔ pt.	4.22	8.9
Bromacil	1⅓ lb.	5.44	8.7
Hand Weeded	—	—	8.2
DCMU + Paraquat	⅔ lb. + ⅔ pt.	3.15	7.5
Linuron + Paraquat	1.4 pt. + ⅔ pt.	?	7.3
DCMU	1⅓ lb.	3.29	7.1
Linuron	2.8 pt.	?	6.2
DCMU	⅔ lb.	1.65	6.1
Bromacil	⅔ lb.	2.72	5.9
Linuron	1.4 pt.	?	5.0
Stam F.34+2, 4-D amine	6⅔ pt. + 1 pt.	8.67	3.4
Stam F.34+2, 4-D amine	3⅓ pt. + 1 pt.	4.50	2.9
Stam F.34+2, 4-D amine	10 pt. + 1 pt.	12.84	2.8
TCA + Paraquat	5 lb. + ⅔ pt.	2.95	2.7
TCA	5 lb.	1.45	1.4
Nil	—	—	1.1

N.B.—Agral 90 was used as a wetting agent with Paraquat and WK with Linuron and DCMU.

The weed population was predominantly *Solanum nigrum* and *Cyperus esculentus* with *Portulaca oleracea*, *Commelina* spp., *Digitaria adscendens* and *Nicandra physaloides* also present.

Soil moisture conditions were maintained at a high level throughout the first few weeks as can be seen in Figure 2. The organic matter content of the soil was 2.54 per cent for the 0-6 inch depth and 1.24 per cent for the 6-12 inch depth.

Atrazine and Simazine, which have usually failed under dryland conditions, gave very good control of most weeds except *Cyperus* until the full cane canopy formed. DCMU at 1 lb. and 1⅓ lb. gave good control for about 8 weeks when applied pre-emergent.

Of the post-emergent treatments Bromacil was outstanding and there was little to choose between Bromacil at 1⅓ lb. and Bromacil ⅔ lb. plus Paraquat ⅔ pt., which showed almost perfect weed control, 12 weeks after application, or 18 weeks after planting. However, both treatments caused damage to the cane. While recovery from the latter treatments was swift, it was relatively slow from Bromacil at 1⅓ lb., the symptoms being stunted growth and a yellowish appearance, followed by reddish necrosis of the leaves especially at the centre. Bromacil at 2 lb. alone did not visually damage the cane, but its effect on weeds, though marked, did not reach a commercially acceptable level. DCMU applied post-emergent was far more effective than pre-emergent, and at 1⅓ lb. it gave about 8 weeks good weed control (14 weeks from planting) with little or no visual damage to the cane. DCMU ⅔ lb. plus Paraquat gave rather better weed control but caused some apparent damage to the cane. Linuron was initially more effective than DCMU, causing scorch on *Cyperus* and other weeds, but control was lost after about 6 weeks; this was evidently related to its greater solubility. It caused slight damage to the cane. Both Stam F34 and especially TCA treatments controlled grasses and to some extent *Cyperus*, but these plots were overrun by *Solanum nigrum* and consequently the treatments were not commercially acceptable. Stam caused some scorch on cane, especially at the higher rates.

4. *Paraquat on Watergrass* (6 by 6 Randomised Blocks)

This was planted on 23rd August, 1963, at Chaka's Kraal, also on a Waldene fine sandy loam. The site was selected for its uniform and dense stand of *Cyperus esculentus*, and spraying was carried out on 21st September when the *Cyperus* was about 9-12 inches high and just beginning to come into flower. The cane was only about 3 inches high and well covered by the watergrass. The treatments, applied to the row only, were:

Paraquat: ⅔ pt.	R 1.52
Paraquat: 1 pt.	2.29
Paraquat: 1⅓ pt.	3.05
Paraquat + TCA: ⅔ pt. + 5 lb.	2.93
Paraquat + DCMU: ⅔ pt. + 1⅓ lb.	4.81
Hand Weeded	—

All Paraquat treatments gave the same visual result of at least 99 per cent scorch, and a week later the cane had regrown vigorously through the dead *Cyperus*. Regrowth of *Cyperus* took place at the same rate as the regrowth in the hand weeded plots, and after a month all treatments required a further hand weeding, which was carried out. The potential use of Paraquat under these circumstances is therefore determined by the availability of labour and the economics of the comparative operations. Under the conditions of dense watergrass growth, as in this experiment, much hand work would have been required; this was estimated at 8 man-days per acre, that is R4.00, compared with R1.52 or R2.29 for chemicals plus R0.50 for application costs, i..e, R2.00 to R2.80 for herbicidal control.

No visual differences whatever could be detected between herbicide treatments; the absence of residual effect in the TCA and DCMU treatments was probably due to the dry conditions which persisted for 16 days after spraying.

5. *Paraquat plus* 2, 4-*D on Watergrass* (4 by 5 Randomised blocks)

No cane was planted in this trial, which was designed to investigate whether the addition of 2, 4-D amine or a surfactant improved the results obtained with Paraquat on *Cyperus esculentus* and *C. rotundus*. Spraying was carried out on 21st November, 1963, at

Mount Edgecombe on full cover basis. The soil is a Mount Edgecombe sandy loam. Besides the dominant *Cyperus* spp., a variable population of *Panicum maximum*, *Digitaria adscendens*, *Eleusine indica* and *Euphorbia hirta* existed. The treatments were:

Paraquat 3 pt.
Paraquat 3 pt. + Agral. (0.1%)
Paraquat 3 pt. + Agral + 3 pt. 2, 4-D amine
Paraquat 3 pt. + Agral + 6 pt. 2, 4-D amine.

While *Cyperus* spp. and *D. adscendens* were severely scorched, it was noticed that *Panicum maximum* was almost unaffected, contrasting with previous results where it was well controlled (Thompson & Gosnell, 1963). Regrowth of *Cyperus* spp. was negligible in all treatments, this being partly due to their suppression by the grasses, especially *Digitaria*, which produced vigorous regrowth. This is evidently a seasonal effect, since the vigour of *Cyperus* is much reduced from December onwards. No consistent differences between treatments could be observed except in the broadleafed population which was much lower on the 2, 4-D treated plots. The addition of Agral gave no improvement in control of *Cyperus*, possibly due to the nature of its foliage which causes it to retain and spread aqueous solutions efficiently without a wetter. (Ennis *et al*, 1952.)

6. *Time of Application of Paraquat* (4 by 5 Randomised Blocks)

This was planted on 5th September, 1963, at Chaka's Kraal, on a Waldene fine sandy loam. A dense, uniform stand of *Cyperus esculentus* was sprayed on 4th October, 1963, when the *Cyperus* was some 6-9 inches high. All plots were sprayed with a standard rate of 1 pint Paraquat per acre on the row only. The treatments, together with the scoring carried out at midday on the day following spraying, were as follows:

Sprayed at 6 a.m.	6.8
Sprayed at 10 a.m.	5.2
Sprayed at 2 p.m.	4.6
Sprayed at 6 p.m.	4.0

These figures reflect the delay in scorching caused by evening spraying. Three days after spraying, it was visually clear that by then the afternoon treatments had given a better scorching than the morning treatments, which contained a few plants still apparently growing weakly. Regrowth was fairly rapid and consequently the treatments were repeated on 31st October, 1963. Scorings, carried out after one day and one week gave the following results:

	After 1 Day	*After 1 Week*
Sprayed at 6 a.m.	7.2	7.2
Sprayed at 10 a.m.	3.2	6.4
Sprayed at 2 p.m.	2.8	8.4
Sprayed at 6 p.m.	3.0	8.6

As before, the initial delay in scorching with the afternoon treatments was succeeded by a slightly increased scorch of weeds and cane. Regrowth of *Cyperus* occurred after the second spraying, but *Digitaria adscendens* became more prominent and weed control was not commercially acceptable in spite of two sprayings. The cane was apparently severely damaged by the second spraying, but recovery was good. It is apparent that a slight but consistent increase in herbicidal effect was obtained by spraying later in the day. The total radiation in Langleys (cal. cm-^{2}) received by the cane for a period of 12 hours following treatments, as measured by a Kipp solarimeter less than $\frac{1}{4}$ mile from the experiment, was as follows:

	4.10.63	31.10.63
Sprayed at 6 a.m.	500.1	547.9
Sprayed at 10 a.m.	361.7	364.4
Sprayed at 2 p.m.	80.8	57.0
Sprayed at 6 p.m.	0.0	5.3

These figures thus tend to confirm other work (Baldwin, 1963) where more efficient translocation of dipyridilium compounds has been obtained when a period of dark follows spraying.

7. *Herbicides on Ditches*

Three replications of sixteen treatments were sprayed on 4th, 5th and 18th October, 1963, on drainage ditches at Mount Edgecombe containing a mixed population of *Imperata cylindrica*, *Phragmites communis*, *Paspalum urvillei*, *Sorghum verticilliflorum*, *Cyperus distans* and some minor broadleafed species. The soils were a Phoenix clay loam and a Mount Edgecombe loam. Treatments 1-5 were all based on a standard cost of R10.00 per acre, prices for the newer herbicides in treatments 6-15 not being available.

(1) TCA 35 lb.
(2) Paraquat 4.3 pt.
(3) Dalapon 11 lb.
(4) Chlorea (CMU + 2, 4-D + Sodium chlorate + Sodium borate) 36 lb.
(5) TCA 20 lb. + Paraquat 2 pt.
(6) Dichlobenzamide 5 lb.
(7) Dichlobenzamide 15 lb.
(8) Tordon 6.7 pt.
(9) Tordon 3.3 pt. + Dalapon 15 lb.
(10) Tordon 3.3 pt. + Paraquat 2 pt.
(11) Tordon 3.3 pt.
(12) Garlon 16 pt.
(13) Bromacil 3 lb.
(14) Bromacil 6 lb.
(15) Bromacil 3 lb. + Paraquat 2 pt.
(16) Control.

Whilst short-term control of weeds with herbicides in cane may be acceptable, a minimum of 3-4 months effective control is required in ditches. Although Paraquat gave an excellent scorch of most species for a short period, after five weeks all control had been lost. Tordon controlled broadleafed weeds, but was completely ineffective on grasses even at the high rates, and was thus of no practical use. 35 lb. TCA produced a fair scorch initially, and for the first six weeks it produced the best control. Control was still good at 3 months, and fair at 4 months but an invasion of *Sorghum verticilliflorum* and *Cyperus distans* had appeared. 15 lb. Dalapon per acre gave very good results from about 6 weeks onwards, and up to four months there was still relatively little regrowth. This was chiefly *Imperata*, and its flowering was severely retarded. Dalapon at 11 lb. gave similar results to TCA 35 lb.; it was poorer up to about two months, but slightly better thereafter. By four months, considerable regrowth of *Imperata cylindrica* had occurred.

The most outstanding treatment on *Phragmites communis* was 16 pt. Garlon; no sign of regrowth was visible 5 months after spraying. While the effect was no doubt partly due to the Dalapon content (equivalent to 13 lbs. per acre), it has generally been found that 25 lb. or even higher rates of Dalapon are required for effective control of *Phragmites*. Kuron, the other constituent of Garlon, may have been partly responsible for the excellent control, but further work comparing Garlon and Dalapon is required. Unfortunately none of the Dalapon plots in these trials contained *Phragmites* originally.

Bromacil achieved lasting control of broadleafed species, but had little effect on grasses at the rates used. Chlorea produced an initial scorch but regrowth was fast, and Dichlobenzamide had no visible effect on the weed populations.

Discussion

The emergence of Paraquat as an economic and recommendable herbicide has been one of the most significant advances during the season. When applied at $\frac{2}{3}$ to 1 pint per acre, row only, on dense watergrass stands in young cane, complete scorching has been consistently achieved, and regrowth has been at a rate comparable to that following hand-weeding. Where the cost of the latter exceeds R2.00 to R2.80 per acre, more economic results can be expected with the herbicide. When the cane is more developed and the leaves exposed above the weeds, it is also severely scorched, but recovery is fast and indications are that yields are not usually significantly reduced except by late spraying. General observation suggests that to achieve maximum control of *Cyperus*, it should be sprayed at about 3-4 weeks after germination, when it is coming into flower; this is substantiated by experimental results obtained in the greenhouse.

One of the main advantages of using Paraquat is that results are relatively independent of soil moisture conditions; the main disadvantage is the lack of residual effect. The latter is particularly noticeable when watergrass is sprayed at a young stage. Of the systemic herbicides which were tested during the year in combination with Paraquat in order to overcome this deficiency, Bromacil was undoubtedly the most successful.

At a rate of $\frac{2}{3}$ lb. per acre (irrigated trial, organic matter in topsoil 2.54 per cent) to $1\frac{1}{3}$ lb. (dryland, organic matter in topsoil 3.74 per cent), Bromacil extended the effective control to more than twelve weeks without causing appreciable visual damage to cane. However, it cannot be generally recommended until its effect on cane yield has been determined, since rates of $1\frac{1}{3}$ lb. (irrigated trial) and 2 lb. (dryland trial), without Paraquat, were sufficient to cause severe stunting of the cane. DCMU at $\frac{2}{3}$ lb. plus Paraquat also gave excellent weed control under irrigated conditions, as did DCMU $1\frac{1}{3}$ lb. alone. In another dryland trial DCMU plus Paraquat was no better than Paraquat alone, and hence its use, as indicated in earlier trials, is likely to be limited to wetter areas or irrigated land. Linuron is another possible systemic herbicide for use with Paraquat, and it produced better results initially than did DCMU. However, its residual effect was limited to about 6 weeks. The addition of 2, 4-D Amine did not appreciably extend the effect of Paraquat on *Cyperus* spp. but it was of value in giving a residual control of broadleafed weeds.

The effect of light on translocation of Paraquat in the plant is not at present entirely clear. However, the improvement in control obtained with afternoon spraying was substantiated by the fact that probably the best control of *Cyperus* in all the experiments was in the Paraquat on Watergrass trial (No. 4) when the total radiation for the 12-hour period following spraying was only 148 Langleys, compared with a range of 347 to 712 Langleys for the other experiments. Recommendations for spraying on dull days and in the afternoon have been made elsewhere (Darter, 1963). However, it would appear at present that the practical difficulties entailed in restricting spraying operations in the cane belt to such periods are more than likely to counterbalance the slight gain in efficiency achieved. Work with radioactive Paraquat is planned to elucidate this aspect of the herbicidal effect.

The fact that about 8 weeks effective control of *Cyperus* was obtained in many of the 1962-63 trials, and only 4 weeks in most of the 1963-64 trials is evidently due to seasonal effects. In the former case, spraying was applied after the main flush of growth (from mid-November onwards), while much shorter control was obtained when spraying in the most vigorous growth period (September-October).

Work by Ennis *et al.* (1952) has shown that weed species vary tremendously in their ability to retain aqueous sprays. They classified species on a scale from 1 (all droplets retained, spreading) to 5 (essentially all droplets repelled). Examples were *Paspalum dilatatum* 5, *Cynodon dactylon* 4, *Sorghum halepense* 3 and *Cyperus* spp. 1. These results probably explain the lack of effect obtained with the use of Agral 90 in Paraquat solution on pure watergrass stands, but its general success on mixed populations of weeds.

It would appear that soil moisture conditions during the first fortnight after spraying are critical, since the poor results with pre-emergents in the dryland trial (Figure 1) can only be due to the low soil moisture during this period. Subsequently, soil moisture conditions were as good or better than in the irrigated trial (Figure 2).

Conclusions

Paraquat has been established as a commercially successful herbicide for the post-emergent contact control of weeds, particularly the troublesome *Cyperus* spp. Recommendations can be made regarding the best stage at which to spray the weeds and to minimize damage to the sugarcane crop. Whilst research should be pursued to study the translocation of Paraquat and the effects of time of spraying, the major concern remains that of finding a suitable supplementary chemical to mix with Paraquat for maintaining residual weed control. Bromacil is the most promising material for this purpose.

Effective weed control under irrigated conditions appears to be feasible with several available formulations such as Atrazine, Simazine and DCMU. This confirms previous findings that pre-emergent treatments which have been employed successfully in other cane growing countries, have limited applications in Natal because of the predominance of dry-land production with erratic rainfall patterns. The current expansion of irrigation practice in the industry should lead to progressively increasing use of pre-emergent herbicides.

Chemical weed control in drainage ditches can be effected, but the cost is probably too high in comparison with that of hand labour for it to be considered commercially. However, the effect of Dalapon plus Kuron on the persistent *Phragmites communis* may prove to be valuable and warrants further investigation.

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Mr. Bruins Haylett: Do the authors recommend applying herbicides overall, or row only? If they apply row only, I have been doing some work on cane with herbicides. The cane was planted in a ditch eighteen inches deep and had a pre-emergence application of herbicide of two pounds per acre. We worked out that the overall herbicide going on to the surface of the land was about a third. How long do we require herbicide control? I understand that after about three months the standard practice is to rake down the ridge deep into the actual row. What is the point of doing so? Is it for weed control in the row, or is it to stimulate the growth of the sugar cane in the row? I do not see the sense of applying an expensive pre-emergent herbicide, that may be controlled for 5 or 6 months, if one is going to break the ridge down in 3 months.

Mr. Gosnell: I think this emphasises the need for flexibility. If we are going to go in for herbicides we shall probably have to modify our field operations. We have already done this in our experiments with considerable success. We planted many of our herbicide experiments using shallow furrows, so that, by the time the cane was covered over, the ground was absolutely flat. This precluded any falling in of the soil from the inter row when it was cultivated. You could cultivate right up to within 6 inches of the cane row, without throwing any soil down on to the cane row itself. This naturally is important, as mentioned by Mr. Bruins Haylett, because you throw in new weed seeds, which will allow fresh growth of weeds in the row which you have treated. Consequently we recommend shallower planting to planters who are thinking of using herbicides. If you have a shallow furrow and you cover in flat, when you spray you are spraying exactly one third of the total area and you are able to cut down your herbicide costs very substantially by doing so. At the moment we consider that inter-row cultivation by mule or tractor is substantially cheaper than spraying with herbicide and consequently we are doing the experiments on this basis. In ten years time perhaps, we may be in the situation that Hawaii are in now, where they are spraying overall. Over the whole of the island of Hawaii an average of 5 sprays is carried out and the cost I believe is somewhere around fifty rand per acre. That is what they consider they can afford to spend on weed control. We are spending very much less here.

We endeavour to get a length of control of weeds in the row until the cane canopies over, and of course this will vary tremendously. In Swaziland, you get a very quick canopy over the row itself, and consequently your length of weed control perhaps would be only two months. In other areas it might have to be four months. It will vary according to quickness of canopy in the row.

Mr. Hempson: Did any detrimental effect to the soils take place? I know there are many different types of herbicide, but naturally planters are concerned about the possible detrimental residual effects of these herbicides.

Mr. Gosnell: Quite a lot of work has been done over the last five years, especially in America, on what happens to the soil with these herbicides, and more particularly, what the soil does to the herbicide. In almost every case, we find that sooner or later the herbicide is decomposed by either microbial action in the soil, or by photodecomposition by ultra violet radiation. You end up with very little or no harmful residual effect in the soil. The main possible exception that I have been able to find in the literature is P.C.P. That is the one that has been mainly used in the sugar industry in the past of course. The newer ones harm the soil to an infinitely less degree than P.C.P.

Mr. King: I would like to ask the authors of the paper whether they have completely thrown overboard the old weed killer 2, 4-D. It is probably the cheapest of the range of weed killers on the market today, and if one uses it in the line only, as is the common custom now, it works out at about fifty or sixty cents an acre. Because of the rate of application used in the past, reasonably good control may not have been achieved, but one could step up the rate of application, and achieve extremely good results, as had been done in the last year. I see no reason why 2, 4-D in whatever form you might like to use, should be completely discarded.

Mr. Gosnell: I entirely agree with you that 2, 4-D is possibly the most valuable herbicide we have in the cane belt today. But we are trying to look ahead. We all know the uses of 2, 4-D. Natal Estates and many other big concerns are spraying thousands of acres

with it. They know when it is useful and when it is not. By and large 2, 4-D is not a good weed killer against watergrass. Much of our work at present is designed to find a herbicide which will give effective control of watergrass.

Mr. Thompson: You will recall the nineteen regional experiments which we reported last year, Mr. King. On the whole we did not have very good results with 2, 4-D. That was up and down the coast with a variety of climates and a variety of weed populations.

Mr. Stewart: With regard to the use of Paraquat on nut grass, you appeared to get the best results from Paraquat spraying after two o'clock, and progressively up to six. That is a practical disadvantage during spring as the high winds often limit spraying until early morning.

Mr. Thompson: Mr. Gosnell did mention that we do not propose this as a practical proposition in this country, because a severely limiting factor in field spraying here is certainly wind. I believe early morning spraying is the answer, to get away from wind. The introduction of afternoon spraying because of the light factor would not be worth it.

Mr. Glover: I think radiation and evaporation and compaction are involved. Have you observed the change in crop size as the day progresses?

Mr. Grice: Most of the discussion has been about post-emergent rather than pre-emergent treatment. We have had very good responses to pre-emergent spraying with 2, 4-D, which should be carried out in the early morning, when there is abundant moisture. Possibly normal treatment should be carried out first and be followed by a mild application of the new more destructive herbicides.