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# THE TOLERANCE OF PASTURE GRASSES TO ASULAM

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Summary Replicated experiments with asulam carried out in 1969 on six different pastures virtually free from broad-leaved weeds showed that ryegrass swards were safe to treat at 1 lb. a.i./ac., provided a three-week recovery period was allowed between mowing and application. Under this cutting regime, swards based on other grasses, with less ryegrass, suffered a small short-term loss of herbage dry matter yield. No marked interactions between nitrogen level and dose or cutting regime were recorded.

## INTRODUCTION

Instances of grass yellowing and sward setback were recorded in the early trials work with asulam in dock-infested pastures, even at doses of 1 and 1½ lb. a.i./ac. Damage in these and later experiments had been assessed simply on the basis of visual scoring systems, so in 1968 it was decided to measure the effect of the chemical in terms of herbage dry matter yield.

Using three sites of different sward composition, it was found that asulam at 1 lb. a.i./acre - the commercial dose in established grassland - applied in the spring, caused significant short-term yield reductions (Soper et al. 1968). This was confirmed in parallel work undertaken by the West Midland Region of the N.A.A.S. (Martin 1970) and by May & Baker in New Zealand (Miles et al. 1969).

The effect on yield appeared to be influenced by pre and post-spraying management as well as by pasture composition, so further experiments were laid down in Spring 1969 to determine the effect of two mowing regimes and two nitrogen levels on the yield of various grass crops treated with asulam.

## METHOD AND MATERIALS

Sites Six representative pasture types were chosen ranging from a good quality ryegrass ley to a permanent pasture containing over 50% of lesser-productive grasses:-

1. Italian and perennial ryegrass/white clover ley established during 1967 (Stondon).
2. Pure perennial ryegrass crop in its first seed year, i.e. sown in Spring 1968 (Roxwell).
3. Perennial ryegrass/meadow fescue/timothy/white clover ley established during 1966 and due for re-seeding in 1970 (Stondon).
4. Perennial ryegrass/meadow fescue/timothy/white clover ley sown in Autumn 1965, with some 'poor' grass infestation (Ongar Research Station).

5. Old water-meadow composed mainly of creeping bent and Yorkshire fog, with some ryegrass (Roxwell).

6. Old established permanent pasture composed mainly of rough-stalked meadow grass and creeping bent (Hazeing).

Hardly any broad-leaved weeds were present. All the fields were within a 10 mile radius of Ongar so that the Research Station weather records would be applicable. Each trial area, approximately 1 3rd of an acre in extent, was fenced in March to keep stock out for the duration of the experiments.

Treatments Asulam as the 40% w/v solution ('Asulox') was applied at 1, 1½ or 3 lb. a.i./ac. in comparison with an unsprayed control. A small-plot experimental sprayer was used delivering 20 gal. of water/ac. All plots were mown at the end of April (sites 1 to 5) or mid-May (site 6) and the sprays were applied one week or three weeks later. Due to weather delays the interval between cutting and spraying was extended to two and four weeks respectively at site 4 only.

Three cwts. of a 20:10:10 compound fertilizer/ac. were applied in March/April as an overall dressing prior to mowing, and thereafter each plot received either no further dressing or the equivalent of 40 units of nitrogen/ac. 2-3 days after mowing and also 2-3 days after the first two post-spray cuts. Hence the low nitrogen plots received a total of 60 units and the high nitrogen plots a total of 180 units/ac.

Experimental Design A split split-plot layout was adopted with the high or low nitrogen regimes, then the two application times i.e. shorter or longer interval between cutting and application and finally the three herbicide doses and control. Each sub sub-plot was 5 ft. x 24 ft. including discards. There were six replicates at sites 1 - 4 and five replicates harvested at sites 5 and 6.

Harvest management The plots cut one week before application were first harvested three weeks after spraying, and the plots cut three weeks before application were first harvested one week after spraying. Two subsequent harvest cuts were taken at each site, mainly in July and September respectively, as the pasture growth demanded (see Figure 1).

Each cut was taken with an Allen motor-scythe (ht. of mowing 2"), removing from all plots a strip of fresh herbage measuring 3 ft. x 18 ft. This was weighed immediately in the field and a 'grab' sample of about 100 g. taken for the determination of dry matter content (sample oven-dried for 24 hours at 90°C).

Pasture composition During late August/September the percentage cover of each grass or clover species was estimated in five one-foot square quadrats on the high nitrogen plots mown three weeks before treatment (sites 1, 2, 3 and 4) and on the low nitrogen plots mown one week before treatment (sites 5 and 6). The same plots on three pastures (sites 1, 5 and 6) were re-assessed in Spring 1970, prior to utilization.

RESULTS

**The results, together with the treatment and assessment dates, are given in the following figures and tables.**

FIGURE 1 Temperature and rainfall at H.R.S. Ongar during the period of the experiments, in relation to the timing of treatments at each site

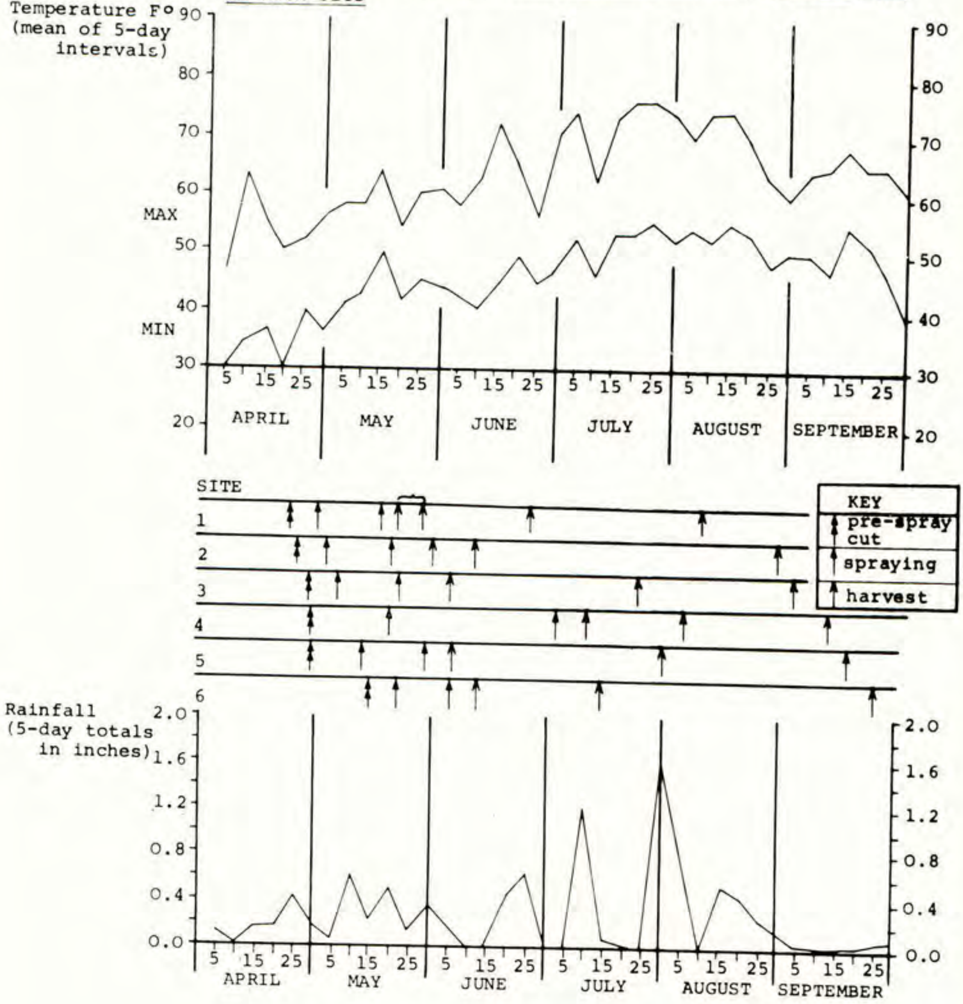


Table 1

Herbage yields: Summary of significance levels of replicates, treatments and treatment interactions

| Site No. | Harvest | Replicates | TREATMENTS Nitrogen (N) | Cutting-Spraying Interval (C) | Herbicide (H) | TREATMENT INTERACTIONS C x N | H x C | H x N | H x N x C |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | NS | *** | NS | *** | NS | *** | NS | NS |
| | 2 | * | *** | *** | NS | NS | *** | NS | NS |
| | 3 | NS | *** | NS | NS | NS | NS | NS | NS |
| | Total | NS | *** | NS | *** | NS | ** | NS | NS |
| 2 | 1 | * | *** | *** | *** | NS | *** | NS | ** |
| | 2 | NS | *** | *** | NS | ** | NS | NS | NS |
| | 3 | * | *** | NS | NS | * | * | NS | * |
| | Total | * | *** | NS | * | NS | NS | NS | NS |
| 3 | 1 | NS | *** | NS | NS | NS | NS | NS | NS |
| | 2 | NS | *** | ** | NS | NS | *** | NS | *** |
| | 3 | NS | *** | NS | NS | NS | NS | NS | NS |
| | Total | NS | *** | NS | NS | NS | NS | NS | * |
| 4 | 1 | NS | NS | *** | *** | NS | *** | NS | * |
| | 2 | NS | *** | * | *** | NS | NS | NS | NS |
| | 3 | NS | *** | NS | *** | NS | NS | *** | NS |
| | Total | NS | *** | *** | *** | NS | NS | NS | NS |
| 5 | 1 | NS | NS | ** | *** | NS | *** | NS | NS |
| | 2 | NS | * | *** | *** | NS | *** | NS | NS |
| | 3 | NS | ** | NS | NS | NS | NS | NS | NS |
| | Total | NS | ** | NS | *** | NS | NS | NS | NS |
| 6 | 1 | NS | *** | ** | *** | NS | *** | NS | * |
| | 2 | NS | ** | *** | *** | NS | ** | NS | NS |
| | 3 | NS | *** | NS | NS | NS | NS | NS | NS |
| | Total | NS | ** | NS | *** | NS | NS | NS | NS |

* significant at 5% level
** significant at 1% level
*** significant at 0.1% level
NS not significant

Site 1 - Italian and perennial ryegrass ley
Site 2 - Perennial ryegrass seed crop
Site 3&4 - Perennial ryegrass/meadow fescue leys
Site 5&6 - Perm. pastures composed mainly of 'Poor' grasses

Table 2

Effect on pasture yields of dose of asulam at two intervals between cutting and spraying

mean yields (cwts d.m.+/acre) of high and low nitrogen plots combined - 12 replicates

| Herbicide dose/ac \ cutting-spraying interval | SITE 1 Lolium spp. 68% Poa annua 18% Trif. repens 9% | | SITE 2 Lolium perenne 100% | | SITE 3 L. perenne 52% Festuca pratensis 26% T. repens 15% | |
|---|---|---|---|---|---|---|
| | 1 week | 3 weeks | 1 week | 3 weeks | 1 week | 3 weeks |
| **First harvest** | | | | | | |
| Control | 27.5 | 28.7 | 27.5 | 26.8 | 31.7 | 32.0 |
| asulam 1 lb. | 26.5 | 26.5 | 26.6 | 28.4 | 32.4 | 31.7 |
| 1½ lb. | 24.2** | 27.8 | 22.6** | 26.9 | 31.7 | 31.9 |
| 3 lb. | 19.3** | 27.8 | 17.4** | 26.9 | 27.2 | 30.9 |
| S.E. of treatment means | 0.793 | 0.793 | 0.793 | 0.793 | 2.935 | 2.935 |
| **Second harvest** | | | | | | |
| Control | 5.3 | 5.8 | 13.4 | 12.7 | 10.7 | 13.4 |
| asulam 1 lb. | 5.9 | 5.5 | 16.6 | 12.7 | 11.6 | 10.9** |
| 1½ lb. | 6.2(*) | 5.1 | 17.3 | 11.9 | 11.5 | 10.5** |
| 3 lb. | 7.3(**) | 4.3** | 19.7 | 11.2 | 13.8(*) | 8.4** |
| S.E. of treatment means | 0.286 | 0.286 | 2.903 | 2.903 | 0.524 | 0.524 |
| **Third harvest** | | | | | | |
| Control | 8.4 | 7.8 | 8.0 | 7.1 | 10.8 | 11.1 |
| asulam 1 lb. | 7.9 | 8.2 | 6.8* | 8.1 | 10.7 | 10.5 |
| 1½ lb. | 8.3 | 8.0 | 7.6 | 7.6 | 10.9 | 10.7 |
| 3 lb. | 8.2 | 8.7 | 7.7 | 8.1 | 12.9 | 10.4 |
| S.E. of treatment means | 0.397 | 0.397 | 0.365 | 0.365 | 1.015 | 1.015 |
| **Total harvest** | | | | | | |
| Control | 41.2 | 42.3 | 48.9 | 46.7 | 53.3 | 56.4 |
| asulam 1 lb. | 40.3 | 40.1 | 50.0 | 49.2 | 54.6 | 53.1** |
| 1½ lb. | 38.7* | 40.9 | 47.5 | 46.4 | 54.1 | 53.1** |
| 3 lb. | 34.8** | 40.9 | 44.8 | 46.2 | 53.9 | 49.7 |
| S.E. of treatment means | 0.920 | 0.920 | 1.317 | 1.317 | 0.476 | 0.475 |

* yield decrease significant at 5% level
** yield decrease significant at 1% level
() significant yield increase
+ corrected to 85% dry matter
Botanical composition based on control plots (mean of 30 throws) assessed in September (August - site 3)

Table 3

Effect on pasture yields of dose of asulam at two intervals between cutting and spraying

mean yields (cwts d.m.✝/acre) of high and low nitrogen plots combined- 10 replicates (12 at site 4)

| Cutting-spraying interval / Herbicide dose/ac | SITE 4 | | SITE 5 | | SITE 6 | |
|---|---|---|---|---|---|---|
| | Lolium perenne 46%<br>Festuca pratensis 22%<br>Dactylis glomerata 11%<br>Trifolium repens 9%<br>Poa trivialis 8% | | Agrostis spp. 33%<br>Holcus lanatus 25%<br>Lolium perenne 22%<br>Poa trivialis 13%<br>Dactylis glomerata 8% | | Agrostis spp. 29%<br>Poa trivialis 27%<br>Lolium perenne 13%<br>Trifolium repens 8%<br>Holcus lanatus 7% | |
| | 2 weeks | 4 weeks | 1 week | 3 weeks | 1 week | 3 weeks |
| **First harvest** | | | | | | |
| Control | 19.7 | 20.3 | 31.4 | 30.5 | 12.3 | 12.7 |
| asulam 1 lb. | 14.9** | 19.9 | 22.0** | 27.5 | 4.9** | 13.0 |
| 1½ lb. | 13.0** | 19.7 | 20.6** | 29.2 | 4.5** | 12.8 |
| 3 lb. | 11.0** | 19.8 | 19.2** | 30.3 | 3.8** | 12.1 |
| S.E. of treatment means | 0.397 | 0.397 | 1.126 | 1.126 | 0.476 | 0.476 |
| **Second harvest** | | | | | | |
| Control | 13.9 | 15.0 | 17.7 | 17.7 | 20.2 | 18.6 |
| asulam 1 lb. | 14.7 | 11.5** | 22.7(**) | 12.2** | 19.8 | 17.3 |
| 1½ lb. | 11.9* | 10.3** | 21.9(**) | 8.4** | 19.3 | 14.1** |
| 3 lb. | 8.8** | 7.8** | 15.1 | 4.2** | 15.2** | 8.3** |
| S.E. of treatment means | 0.619 | 0.619 | 0.936 | 0.936 | 0.809 | 0.809 |
| **Third harvest** | | | | | | |
| Control | 10.1 | 10.8 | 12.7 | 12.2 | 9.8 | 9.2 |
| asulam 1 lb. | 10.2 | 9.6** | 12.1 | 14.6 | 10.6 | 10.3 |
| 1½ lb. | 9.3** | 8.5** | 13.0 | 15.5(*) | 9.8 | 11.1(*) |
| 3 lb. | 8.8** | 8.2** | 14.6 | 13.2 | 10.4 | 9.1 |
| S.E. of treatment means | 0.159 | 0.159 | 0.873 | 0.873 | 0.635 | 0.635 |
| **Total harvest** | | | | | | |
| Control | 43.8 | 46.1 | 61.7 | 60.4 | 41.3 | 40.5 |
| asulam 1 lb. | 39.8** | 41.0** | 56.8 | 54.3* | 35.2** | 40.5 |
| 1½ lb. | 34.2** | 38.4** | 55.6* | 53.1** | 33.7** | 38.0 |
| 3 lb. | 28.5** | 35.8** | 48.9** | 47.6** | 29.4** | 29.4** |
| S.E. of treatment means | 0.952 | 0.952 | 1.586 | 1.586 | 1.333 | 1.333 |

* yield decrease significant at 5% level

** yield decrease significant at 1% level

() significant yield increase

✝ corrected to 85% dry matter

Botanical composition based on control plots (mean of 30 throws) assessed in September

FIGURE 2 Effect on pasture yields of the interval between cutting, and applying asulam

Herbage yield (dry matter) per harvest as percentage of control

(A) Sprayed one week after cutting

(B) Sprayed three weeks after cutting

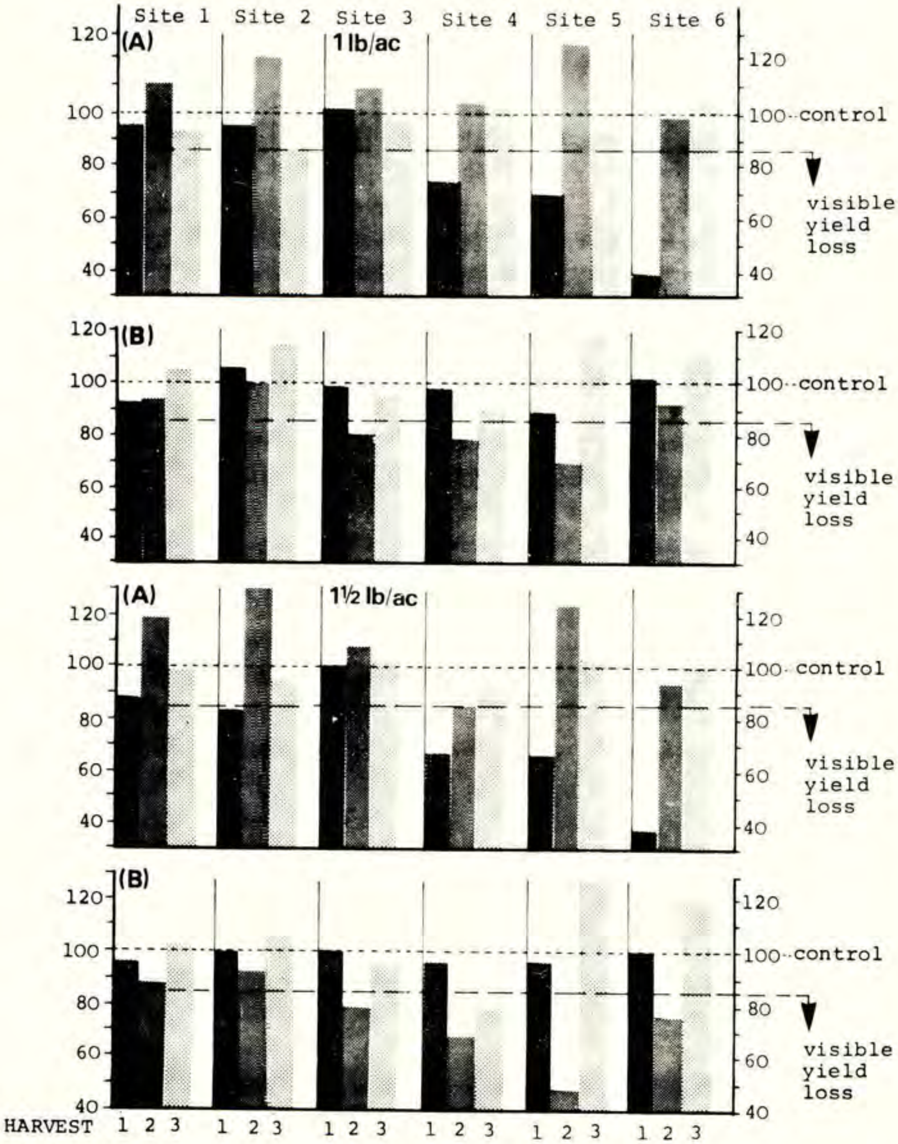
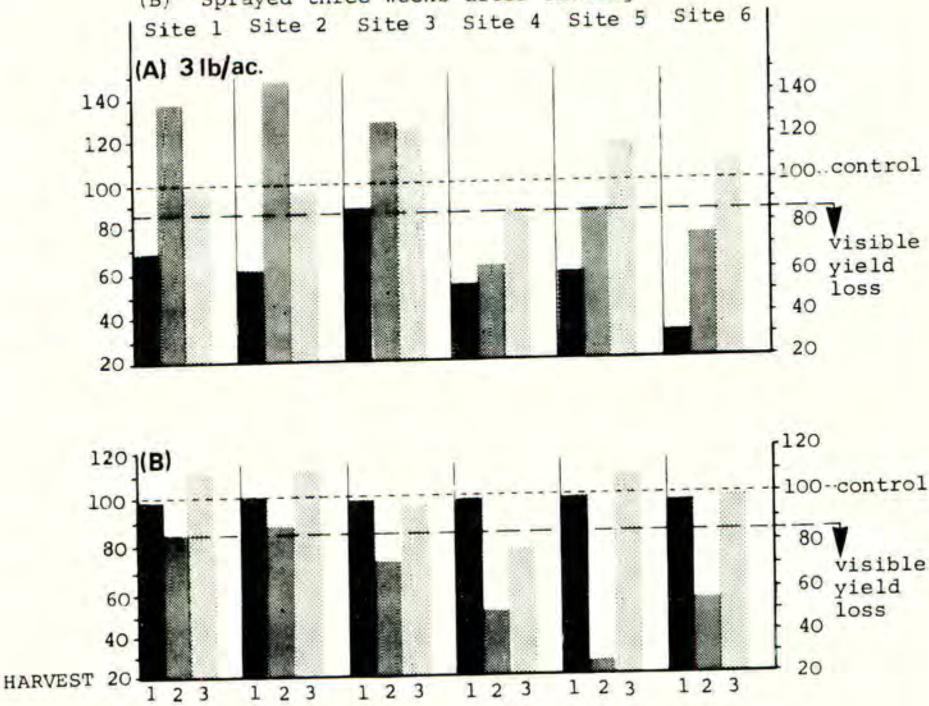


FIGURE 3 Effect on pasture yields of the interval between cutting, and applying asulam
Herbage yield (dry matter) per harvest as percentage of control

(A) Sprayed one week after cutting
(B) Sprayed three weeks after cutting




Effect on pasture yields of dose of asulam and cutting and spraying
Herbage yield (dry matter) as percentage of control

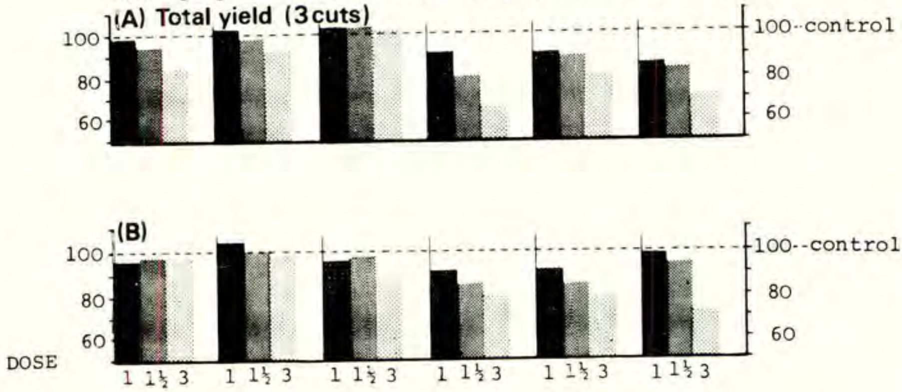


Table 4

Effect of asulam on pasture composition 4½ and 12 months after treatment
% cover (Mean of 30 throws, i.e. 5 per replicate)

| Site no. | Dates | Asulam lb/ac. | Lolium spp. A | Lolium spp. B | Poa annua A | Poa annua B | Agrostis spp. A | Agrostis spp. B | Holcus lanatus A | Holcus lanatus B | Poa trivialis A | Poa trivialis B | Dactylis glomerata A | Dactylis glomerata B | Trifolium repens A | Trifolium repens B | Other grasses, weeds, plus bare ground A | Other grasses, weeds, plus bare ground B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Sprayed: 24.4.69 Assessed: A 19.9.69 B 18.5.70 | 0 | 68 | 66 | 17 | 20 | | | | | | | | | 9 | 3 | 6 | 11 |
| | | 1 | 80 | 70 | 10 | 7 | | | | | | | | | 8 | 2 | 2 | 21 |
| | | 1½ | 84 | 80 | 6 | 5 | | | | | | | | | 8 | 2 | 2 | 13 |
| | | 3 | 81 | 75 | 10 | 8 | | | | | | | | | 6 | 4 | 3 | 13 |
| 5 | Sprayed: 29.4.69 Assessed: A 25.9.69 B 8.5.70 | 0 | 22 | Trace | | | 33 | 14 | 25 | 37 | 13 | 19 | 8 | 23 | | | 2 | 7 |
| | | 1 | 33 | | | | 20 | 7 | 31 | 45 | 5 | 25 | 3 | 11 | | | 8 | 12 |
| | | 1½ | 36 | | | | 25 | 13 | 15 | 42 | 7 | 28 | 10 | 11 | | | 7 | 6 |
| | | 3 | 35 | | | | 25 | 14 | 4 | 40 | 4 | 21 | 7 | 19 | | | 25 | 6 |
| 6 | Sprayed: 13.5.69 Assessed: A 22.9.69 B 5.5.70 | 0 | 13 | Trace | | | 29 | 60 | 7 | 14 | 27 | 25 | | | 8 | 1 | 16 | Trace |
| | | 1 | 15 | | | | 35 | 42 | 4 | 21 | 18 | 33 | | | 4 | 1 | 24 | 3 |
| | | 1½ | 14 | | | | 43 | 41 | 5 | 20 | 13 | 35 | | | 3 | 1 | 22 | 3 |
| | | 3 | 27 | | | | 39 | 19 | 4 | 17 | 6 | 36 | | | 1 | Trace | 23 | 8 |

## DISCUSSION

It is clear from the statistical analyses (Table 1) that the addition of nitrogen did not alter the effect of asulam on the sward under the two management regimes. Nitrogen per se increased the dry matter yields from those grasses that responded to it, but this phenomenon is, of course, well-known. The interaction between herbicide and cutting interval was highly significant, particularly for the first two post-treatment yields.

The histograms of the individual harvest cuts (Figures 2 and 3) show that there is a greater loss of yield from the initial cut when only a one week interval has been allowed between mowing and spraying. This loss attains larger significance as the proportion of ryegrass diminishes and as the dose increases. The loss is not altogether avoided under the alternative management regime (spray 3 weeks after cutting, harvest one week after spraying) since it is revealed in the second cut. It is probably a good plan to utilize susceptible pastures one week after treatment with asulam before any reduction of existing herbage occurs. The eventual extent of dry matter yield reduction will depend on the contribution of susceptible species to bulk and their ability to recover from spraying.

Minor differences of yield between the treated plots and the controls can be entirely discounted because the high sensitivity of the experiments (see the low standard errors in Tables 2 and 3) has revealed them. It is suggested that a grass yield loss of 15% or less over a complete field (see the indication in Figures 2 and 3) is unlikely to be detected by eye, and also, because of the general under-utilisation of grassland it is felt that this loss is unlikely to be of universal significance. There are, however, two field situations where a small loss may be of practical importance - under an intensive management system (e.g. rotational or strip grazing), or under an extensive system on pastures with a very high proportion of asulam susceptible grasses. Recovery of the pastures was always complete (see the third harvest cut) though there was an indication that sward balance could be altered (see Table 4).

Although total production is only slightly diminished (even at 1½ lb a.i./ac asulam) the actual time of year a depression occurs may be of importance, e.g. hay cut in June is essential for winter-keep. As a counter to this, however, there will be the longer term benefits of dock removal and a possible improvement in pasture composition. An overall treatment of asulam becomes more worthwhile as dock populations increase (Savory *et al*. 1970).

So long as damaged, bruised, or recently cut swards are not treated, it is generally concluded that ryegrass pastures will tolerate 1 lb a.i./ac asulam without any herbage dry matter reduction; other pastures, with or without ryegrasses, will unavoidably sustain a variable loss at this dose. In addition to the effects of dose, pasture composition and climate, the herbage yields obtained from asulam treated swards will depend on pre- and post-spraying management.

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# THE EFFECT OF ASULAM APPLIED AS FOR DOCK CONTROL (RUMEX SPP.) ON THE PRODUCTION OF THE GRASS SWARD

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Summary Results are given of two studies on the effect of asulam on grass growth when used to control mature *Rumex* spp. (mostly *Rumex obtusifolius*) in established grassland. In the first study in 1968 asulam at various doses was used in the spring as a single application and in the second study (1968/69) a comparison was made between asulam applied in the autumn, spring and combined autumn and spring applications. In the first trial the sward which contained approximately 20% timothy suffered yield reductions which increased with the dose but other trials on different swards, though showing similar trends did not show such significant results. The control of *Rumex* spp. in the first trial showed a dose effect and in another trial the effect of autumn spraying was greater than the spring application.

## INTRODUCTION

In 1965 it was shown that a derivative of methyl 4-amino benzene sulphonyl carbamate (MB 9057 - asulam) was active against some grass species and certain dicotyledons. *Rumex* spp. in pastures and orchards were reasonably well controlled. Blair (1968) showed that asulam applied in September at 4 lb a.i./ac gave better control of *Rumex obtusifolius* in a specially planted pure stand than when applied in May. Ford and Combellack (1966) reported favourable control of *Rumex* spp. but said the grass sward showed considerable chlorosis. *Holcus lanatus* was susceptible and perennial ryegrass was particularly resistant. Soper *et al*. (1968) using 3 sites of different sward composition, showed that asulam applied in spring reduced herbage dry matter yield of a timothy/meadow fescue/perennial ryegrass/white clover sward by 30% and 50% at 1 lb and 3 lb a.i./ac respectively after 6 weeks and another sward of similar composition, but including cocksfoot, by 36% and 60% in the same period and doses. The other site was a sward consisting of creeping bent/red fescue/cocksfoot/ Yorkshire fog and the effect was a yield reduction of 3% and 20%.

These investigations were established to verify the activity of asulam on grassland when applied by users under a wide variety of practical conditions.

## METHOD AND MATERIALS

In the spring of 1968 asulam (as MB 9057 a 40% e.c.) was applied at 0, 1, 2, 3 and 4 lb a.i./ac to plots laid down at two sites in Staffordshire. A randomised block design with four replicates was used. Plot size was 12 yd x 2 yd. An Oxford Precision Sprayer with 00 nozzles working at 35/40 p.s.i. was used.

In the autumn of 1968 a further two trials were laid down in the West Midlands. Asulam was applied at the following times and doses (a.i./ac): 0, 1 lb autumn, 2 lb autumn, 1 lb autumn and 1 lb spring, 1 lb spring and 2 lb spring. A randomised block design replicated three times was used. Plot size and method of spraying were the same as the previous trial.

At all sites Rumex assessments were made by counting the total plants per plot. Herbage production was measured by cutting three times at Site 1 but only once at all the other sites. A 3 ft wide strip was cut down the length of each plot using an Autoscythe. The total herbage was weighed in the field and sampled for laboratroy dry matter determination. After each yield cut the entire trial area was mown and the herbage was removed.

Details of the sites are given in Table 1.

Table 1

| | Site 1 | Site 2 | Site 3 | Site 4 |
|---|---|---|---|---|
| Location | Market Drayton, Staffs. | Stanton, Staffs. | Sheriffhales, Shropshire | Stockport, Cheshire |
| Composition of sward (visual assessment of grass component only) | 50% perennial ryegrass<br>30% Italian ryegrass<br>20% timothy | 30% perennial ryegrass<br>40% meadow fescue<br>30% timothy | 90% perennial ryegrass<br>10% Poa trivialis | 75% perennial ryegrass<br>15% Poa trivialis<br>10% bare ground |
| | ley | old ley | ley | ley |
| Date sprayed | 8.4.68 | 17.4.68 | 9.10.68<br>19.5 .69 | 4.10.68<br>7.5 .69 |

RESULTS

Site 1

This sward with 20% timothy showed how vulnerable timothy was to asulam at the 4 lb a.i./ac dose. Growth was severely checked and scorched. All treatments showed retarted growth which was in direct proportion to the treatment applied. Recovery in growth was not observed until six weeks after spraying. Three cuts were taken during the season and 63 units of nitrogen were applied after cuts 1 and 2.

Table 2

Yields dry matter cwt/ac

| Treatment Asulam lb a.i./ac | Cut 1 24.5.68 | Cut 2 30.7.68 | Cut 3 16.10.68 | Total yield | % of control |
|---|---|---|---|---|---|
| 0 | 43.8 | 22.0 | 23.6 | 89.4 | 100.0 |
| 1 | 37.6 | 21.4 | 24.5 | 83.4 | 93.3 |
| 2 | 29.5 | 28.4 | 24.7 | 82.6 | 92.4 |
| 3 | 23.0 | 27.0 | 27.1 | 77.0 | 86.1 |
| 4 | 19.2 | 27.3 | 24.5 | 71.1 | 79.5 |
| SE | ± 1.23 | ± 1.33 | ± 1.01 | ± 1.72 | |

Table 3

Rumex spp. populations 4 and 14 months after spraying

| Treatment<br>Asulam lb a.i./ac | Mean no. of *Rumex* spp. per plot<br>23.8.68 | <br>6.6.69 |
|---|---|---|
| 0 | 42.0 | 42.0 |
| 1 | 15.75 | 21.5 |
| 2 | 10.5 | 14.25 |
| 3 | 4.5 | 8.75 |
| 4 | 5.75 | 6.50 |

Site 2

This sward was an old ley heavily infected with *Rumex* spp. Shortly after spraying heavy rain fell. Two weeks after spraying, the plots treated with 2, 3 and 4 lb a.i./ac asulam showed retarded growth and scorch but there was little sign of effect on docks. A yield cut was taken on 13th June.

Table 4

Yield dry matter cwt/ac

| Treatment<br>Asulam lb a.i./ac | Dry matter yield | Yield as % of control |
|---|---|---|
| 0 | 46.6 | 100.0 |
| 1 | 42.7 | 91.6 |
| 2 | 40.4 | 86.7 |
| 3 | 37.9 | 81.3 |
| 4 | 34.2 | 73.4 |
| SE | ± 2.33 | |

Site 3

This site had a sward that was 90% perennial ryegrass and 10% rough stalk meadow grass. Six weeks after the autumn spraying the ryegrass was beginning to become chlorotic and the meadow grass was severely chlorotic. *Rumex* spp. present were also chlorotic. When growth recommenced in April 1969 there was no evidence that the check to the grasses was still present. On 12th May grass growth was uniform throughout the trial and the Rumex spp. in plots treated with 2 lb a.i./ac asulam were still chlorotic. The spring spraying on 19th May although applied in dry weather was followed some days later by excessive rain which waterlogged the trial. A cut was taken 10th June.

Table 5

Yield dry matter
cwt/ac

| Treatment Asulam lb a.i./ac | Dry matter yield | Yield as % of control |
|---|---|---|
| 0 | 46.9 | 100.0 |
| 1 autumn | 49.9 | 106.4 |
| 2 autumn | 51.6 | 110.0 |
| 1 autumn and spring | 51.7 | 110.0 |
| 1 spring | 50.8 | 108.3 |
| 2 spring | 46.1 | 98.3 |
| SE | ± 1.55 | |

## Site 4

This was an open sward of S.23 and S.321 ryegrass sown September 1967. A month after the autumn spraying plots treated with 2 lb a.i./ac asulam showed considerable chlorosis and grass growth had ceased. The effect was not as severe on plots treated with 1 lb a.i./ac asulam. The spring spraying was followed by heavy rain some six hours later. The plots were cut on 17th June.

Table 6

Yield dry matter
cwt/ac

| Treatment Asulam lb a.i./ac | Dry matter yield | Yield as % of control |
|---|---|---|
| 0 | 50.1 | 100.0 |
| 1 autumn | 45.4 | 90.6 |
| 2 autumn | 39.7 | 79.2 |
| 1 autumn and spring | 42.6 | 85.0 |
| 1 spring | 49.7 | 99.2 |
| 2 spring | 49.6 | 99.2 |
| SE | ± 3.56 | |

Table 7

Rumex spp. populations 2 and 8 months after autumn spraying

| Treatment | Mean no. of *Rumex* spp. per plot | |
|---|---|---|
| Asulam lb a.i./ac | 13.12.68 | 17.6.69 |
| 0 | 8.6 | 65.0 |
| 1 autumn | 11.3 | 31.6 |
| 2 autumn | 10.6 | 39.6 |
| 1 autumn and spring | 19.6 | 36.6 |
| 1 spring | 8.0 | 69.3 |
| 2 spring | 9.3 | 67.0 |

## DISCUSSION

The trial that started in spring 1968 suggested that asulam had an adverse effect on grass growth as shown in Table 2. It also showed a dose effect on the Rumex spp. (Table 3). In the subsequent trials the results have not been so significant. At Site 2 a dose response trend is shown but hardly significant. In the autumn/spring trials the effect of asulam was noticeable after the autumn spraying but this effect is not translated into a reduction of dry matter yield when harvested in June the following year. At Site 4 a trend is suggested in the autumn treatments.

The first cut at Site 1 shows the serious yield reductions that are possible as the dose is increased. This result and the yield reductions quoted by Soper et al. highlights the need for accurate application with this chemical. In addition to the reduction of yield of grass asulam can have a delaying effect on peak production. This is shown by the yields at the second cut at Site 1 where the treated plots have out yielded the control (Table 2). It is doubtful if this has happened because the competition from the Rumex spp. has been removed but is more likely to be due to compensatory growth as a result of a reduced yield at the first cut.

The reduction in yield of the spring growth can have an adverse economic effect on the intensively stocked farm. This 'flush' of grass must provide grazing and silage or hay for winter feeding. It may therefore be better to devote attention to the use of asulam at the end of the summer, even though it is known that this is a less favourable time for the control of Rumex spp.

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# THE TOXICITY OF THREE HERBICIDES TO THE DOCKS (RUMEX SPP) AND GRASSES GROWING IN A MAINLY RYEGRASS PASTURE

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Summary The effects of asulam, maleic hydrazide and dicamba applied in September, 1968 on *Rumex* spp. growing in a perennial ryegrass pasture are described in terms of plant numbers and yield. The effect on the grass content of the pasture was also measured in terms of yield. Asulam and dicamba were effective in controlling *Rumex* spp., but while *L. perenne* displayed only slight damage *A. stolonifera*, *P. trivialis* and *P. pratense* all suffered from doses of these chemicals. Maleic hydrazide was less effective in the control of *Rumex* spp. but caused some damage to *L. perenne* although proving less harmful to *A. stolonifera*, *P. trivialis* and *P. pratense* than were dicamba and asulam.

## INTRODUCTION

Preliminary studies resulted in a short list of chemicals showing promise in the herbicidal control of *Rumex* spp. in perennial ryegrass pasture (Blair 1968). The three chosen for further examination were asulam, maleic hydrazide and dicamba.

The object of the experiment reported here was to investigate the effectiveness of the three herbicides in controlling *R. crispus* and *R. obtusifolius* in a perennial ryegrass pasture that also contained other species, and in addition to measure the response of the main grass species present to the chemical treatments.

## METHOD AND MATERIALS

The experiment was located at the Grassland Research Institute, Hurley, Berkshire on a slight NE facing slope, 250 ft O.D. The soil was a brown loam with flints and pebbles overlying coarse sandy clay with chalk at about 2-3 ft. The average annual rainfall is 27 in. The sward was sown in the autumn of 1966, since when it has been mainly cut for hay although extensive grazing by sheep and young cattle occurred during the following autumns. The percentage area of ground covered by each of the main species, assessed by point quadrat on 12th September, 1968, was *Lolium perenne* 58%, *Agrostis stolonifera* 12%, *Poa trivialis* 23%, *Phleum pratense* 9% and *Rumex* spp, 8%. The experiment contained a fully randomised block design of three replicates with plots 2.5 yd x 10 yd.

### Treatments and conditions at spraying

Asulam at 0.75, 1.5 and 3 lb ai/ac, maleic hydrazide at 0.75, 1.5 and 3 lb ai/ac and dicamba at 0.5, 1 and 2 lb ai/ac, were applied on 12th September, 1968. The chemicals were applied in 20 gal/ac aqueous solution containing 0.1% Agral 90. The solutions were sprayed at 30 psi pressure through '00' ceramic fan jets fitted to the 7 ft 6 in. boom of an Oxford Precision Sprayer. The sward had been cut with a farm mower 14 days earlier. The herbage was dry, the grass content standing 4-7 in. high and Rumex spp. 9-15 in. high. Temp 18.0°C. Relative humidity 86%. Cloud cover 9/10.

The subsequent management of the sward

An initial application of 3 cwt/ac 20:10:10: compound fertiliser was given to the entire experimental area in the spring following spraying. Further applications of nitrogenous fertiliser, following the harvests of grass material, brought the total N application to 200 units/ac. by the end of the experiment. The entire area was cut down to a height of 2-3 in. following yield harvests on 8th May, 11th June, 16th July and 7th October, 1969.

Assessments.

1. The effects of the herbicides on the vegetative growth of Rumex and grass spp. following treatment was scored periodically in comparison with that on the unsprayed control (Fig. 1).

2. Counts of Rumex spp. plants were made immediately prior to and at intervals after spraying. All plants were counted within a 1.5 yd x 10 yd area on each plot (Table 1).

3. Yields of Rumex spp. were obtained by cutting all plants growing in a 1.5 yd x 10 yd area on each plot down to ground level with a hand razor blade. The cut material was removed and left in cold storage until fresh/dry weight reductions were carried out (Table 2).

4. In all grass yield assessments (Table 3) a motor-scythe was used to cut a 3 ft wide swathe down the centre of each 10 yd plot length, leaving a stubble approx. 2 in. high. All cut material was weighed fresh. Random samples of the cut herbage were weighed and left in cold storage until they were removed for sorting into species. In all fresh/dry weight reduction studies Rumex and grass samples were dried at 100°C for at least 6 hours before weighing.

As the existence of a hybrid of R. crispus and R. obtusifolius was suspected on the experiment area, all plants encountered in assessments were grouped under a single heading = Rumex spp.

## RESULTS

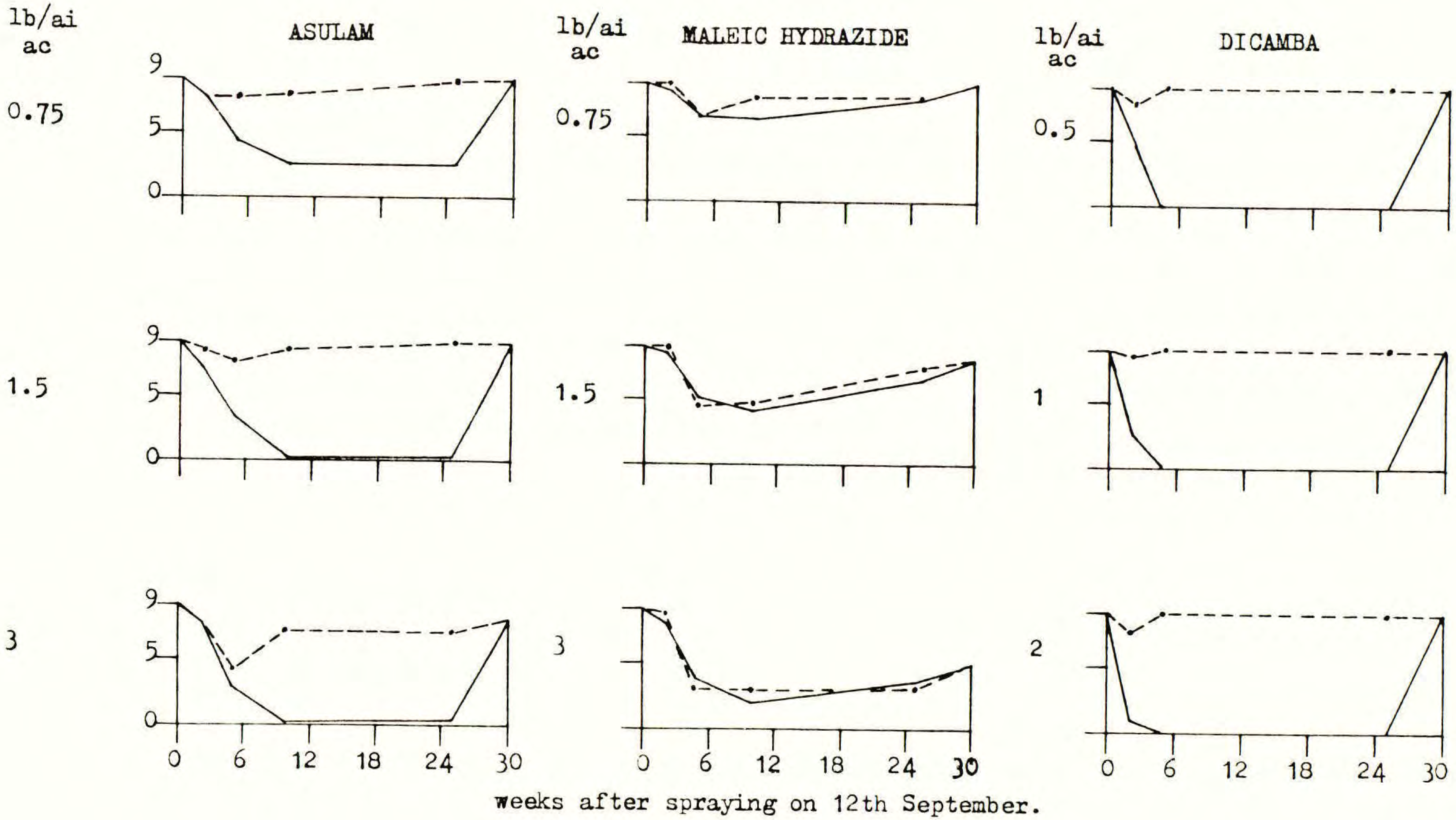
During the phase of direct herbicidal action (and the resumption of normal growth) the first of the main periods of sward change following herbicidal application distinguished by Elliott (1960), the reduction of Rumex spp. and general green material was positively related to increase in dose of herbicide. The most severe visual effects on Rumex spp. were generally caused by dicamba and reached a maximum five weeks after spraying. The effects caused by maleic hydrazide and asulam reached a maximum by 10 weeks (Fig 1). Direct effects on the grasses were almost absent following dicamba and only moderately present following asulam at 3 lb/ac. Maleic hydrazide had a detrimental effect on grass colour and growth at 1.5 and 3 lb/ac, such effects being prolonged.

Counts of Rumex spp. plants were made during the spring 1969 period and continued during the recovery of the treated sward (Table 1). The persistence of reductions in plant numbers appeared to be enhanced by increasing the dose of each chemical applied. At equivalent doses dicamba and asulam appeared to have a similar effect, both chemicals being more toxic than maleic hydrazide which, especially at

Fig. 1 Visual effects after spraying expressed as scores for the amount of green material present.

Green material: grass - - - *Rumex* spp. ______

Scored 0 = absence. 9 = amount comparable with unsprayed control.



the low and medium dose had much less apparent effect.

Yield of Rumex spp. plants showed a dry matter reduction on all treated plots over untreated controls from the initial harvest to the final yield cut although a tendency to increase weight was recorded at each successive harvest (Table 2). Otherwise the weights of Rumex spp. vegetation followed the trends described in the population assessment.

Table 1

Numbers of live Rumex spp. plants present during the 55 weeks after spraying. Means of 3 replicates

| Treated 12th September, 1968 with: | Dose lb ai /ac | Times of assessment (weeks) Pre- 0 | Post- Spraying 10 | 25 | 30 | 34 | 39 | 44 | 55 |
|---|---|---|---|---|---|---|---|---|---|
| Asulam | 0.75 | 48 | 14 | 12 | 23 | 33 | 35 | 36 | 45 |
| " | 1.5 | 58 | 5 | 5 | 8 | 19 | 26 | 21 | 35 |
| " | 3.0 | 50 | 3 | 3 | 2 | 3 | 5 | 8 | 18 |
| Maleic hydrazide | 0.75 | 68 | 45 | 32 | 44 | 49 | 53 | 51 | 60 |
| " | 1.5 | 66 | 41 | 16 | 25 | 40 | 40 | 52 | 61 |
| " | 3.0 | 59 | 19 | 3 | 4 | 12 | 15 | 23 | 41 |
| Dicamba | 0.5 | 66 | 9 | 6 | 18 | 31 | 31 | 39 | 45 |
| " | 1.0 | 58 | 2 | 2 | 4 | 14 | 16 | 25 | 25 |
| " | 2.0 | 69 | TR | 0 | 1 | 2 | 6 | 10 | 12 |
| Unsprayed Control | | 70 | 50 | 35 | 61 | 67 | 57 | 56 | 75 |
| S. E. (Treatments) ± | | 10.9 | 5.5 | 4.7 | 6.4 | 7.9 | 6.7 | 6.6 | 8.6 |
| S. E. (Difference) ± | | 12.6 | 6.4 | 5.4 | 7.4 | 9.1 | 7.8 | 7.6 | 10.0 |

Table 2

Production (lb dm/ac) of Rumex spp. during the year following spraying. Means of 3 replicates

| Treated 12th September, 1968 with: | Dose lb ai /ac | Harvest dates 8 May 1969 | 11 June 1969 | 16 July 1969 | 6 Oct. 1969 | Total weight from 4 harvests |
|---|---|---|---|---|---|---|
| Asulam | 0.75 | 64 | 95 | 100 | 243 | 502 |
| " | 1.5 | 30 | 100 | 68 | 245 | 447 |
| " | 3.0 | 5 | 23 | 25 | 106 | 159 |
| Maleic hydrazide | 0.75 | 112 | 155 | 153 | 317 | 737 |
| " | 1.5 | 54 | 101 | 148 | 355 | 678 |
| " | 3.0 | 4 | 28 | 59 | 147 | 238 |
| Dicamba | 0.5 | 26 | 71 | 54 | 126 | 277 |
| " | 1.0 | 6 | 32 | 42 | 118 | 198 |
| " | 2.0 | 0.3 | 6 | 13 | 26 | 45.3 |
| Unsprayed Control | 0 | 149 | 170 | 189 | 458 | 966 |
| S. E. (Treatments) ± | | 18.2 | 22.9 | 23.9 | 59.9 | 105.4 |
| S. E. (Difference) ± | | 21.0 | 26.4 | 27.6 | 69.2 | 121.7 |

Table 3

Yield (lb dm/ac) of total grass content (T) and L. perenne (L) approx. 8, 9 and 13 months after spraying. Means of 3 replicates

| Treated 12th September, 1968 with: | Dose lb ai ac | | Harvest dates 8 May 1969 | 11 June 1969 | 7 Oct 1969 | Total weight from 3 harvests |
|---|---|---|---|---|---|---|
| Asulam | 0.75 | T | 526 | 3104 | 2249 | 5879 |
| " | " | L | 408 | 2133 | 1382 | 3923 |
| " | 1.5 | T | 595 | 3063 | 1989 | 5647 |
| " | " | L | 261 | 2422 | 1277 | 3960 |
| " | 3.0 | T | 262 | 3100 | 2301 | 5663 |
| | " | L | 198 | 2397 | 1521 | 4116 |
| Maleic hydrazide | 0.75 | T | 425 | 2987 | 2193 | 5605 |
| " | " | L | 256 | 1877 | 1112 | 3245 |
| " | 1.5 | T | 298 | 3037 | 1992 | 5327 |
| | " | L | 113 | 1280 | 1163 | 2556 |
| " | 3.0 | T | 162 | 3030 | 2134 | 5326 |
| " | " | L | 44 | 893 | 1206 | 2143 |
| Dicamba | 0.5 | T | 540 | 3085 | 2265 | 5890 |
| " | " | L | 373 | 2135 | 1390 | 3898 |
| " | 1.0 | T | 489 | 3240 | 1914 | 5643 |
| | " | L | 351 | 2057 | 1110 | 3518 |
| " | 2.0 | T | 613 | 3133 | 2262 | 6008 |
| | " | L | 490 | 2331 | 1483 | 4304 |
| Unsprayed Control | 0 | T | 546 | 2899 | 2148 | 5593 |
| " | " | L | 351 | 1798 | 1178 | 3327 |
| S.E. (Treatments) ± | | T | 46.2 | 128.4 | 198.4 | 250.1 |
| S.E. (Difference) ± | | T | 53.3 | 148.3 | 229.1 | 288.8 |
| S.E. (Treatments) ± | | L | 53.5 | 165.9 | 141.0 | 238.3 |
| S.E. (Difference) ± | | L | 61.8 | 191.6 | 162.8 | 275.2 |

The total yield of grass vegetation during 1969 indicated little difference in the effects of the three chemicals. Although asulam and maleic hydrazide caused reductions in growth recorded at the first cut on 8th May, 1969, the reduction being greatest at the higher doses, compensating growth occurring later alleviated these reductions (Table 3). L. perenne shared with the other species in these reductions. Dicamba was without this effect of delaying grass growth in spring.

The percentage contribution by weight of L. Perenne increased with increases in dose of asulam and dicamba at all dates but only at the final harvest following the maleic hydrazide treatment (Table 4). A. stolonifera and P. trivialis showed susceptibility towards asulam and dicamba but P. pratense was partially resistant to all chemical treatments. The amount of dead vegetation was high at the final harvest due to the onset of natural senescence.

Table 4

The percentage contribution by dry weight of the 5 main species present plus dead vegetation on 3 dates after spraying. Means of 3 replicates

| Harvest date | Chemical | Dose lb ai/ac | Lol. per. | Ag. stol. | Poa triv. | Ph. prat. | Rumex spp. | Dead Veg. |
|---|---|---|---|---|---|---|---|---|
| 8th May, 1969 | Asulam | 0.75 | 69 | 3 | 5 | 9 | 11 | 3 |
| | " | 1.5 | 42 | 9 | 12 | 15 | 5 | 17 |
| | " | 3.0 | 72 | 3 | 8 | 8 | 2 | 8 |
| | Maleic hydrazide | 0.75 | 48 | 9 | 9 | 10 | 21 | 4 |
| | | 1.5 | 32 | 2 | 15 | 31 | 15 | 5 |
| | " | 3.0 | 26 | 20 | 32 | 11 | 12 | 8 |
| | Dicamba | 0.5 | 66 | 3 | 11 | 10 | 5 | 6 |
| | " | 1.0 | 70 | 8 | 9 | 7 | 1 | 5 |
| | " | 2.0 | 79 | 2 | 6 | 6 | TR | 6 |
| | Control | 0 | 51 | 3 | 10 | 10 | 21 | 6 |
| 11th June, 1969 | Asulam | 0.75 | 68 | 1 | 9 | 19 | 3 | TR |
| | " | 1.5 | 78 | 1 | 10 | 8 | 3 | 1 |
| | " | 3.0 | 79 | TR | 7 | 12 | 1 | 1 |
| | Maleic hydrazide | 0.75 | 61 | 2 | 24 | 9 | 5 | 1 |
| | | 1.5 | 43 | 0 | 31 | 23 | 3 | TR |
| | " | 3.0 | 31 | 1 | 43 | 24 | 1 | TR |
| | Dicamba | 0.5 | 68 | TR | 17 | 11 | 2 | 1 |
| | " | 1.0 | 64 | 2 | 10 | 23 | 1 | 1 |
| | " | 2.0 | 74 | 1 | 8 | 16 | TR | 1 |
| | Control | 0 | 59 | 1 | 13 | 21 | 6 | 1 |
| 7th October, 1969 | Asulam | 0.75 | 56 | 2 | 1 | 12 | 10 | 19 |
| | " | 1.5 | 58 | 1 | 1 | 8 | 11 | 20 |
| | " | 3.0 | 63 | 5 | 1 | 8 | 4 | 19 |
| | Maleic hydrazide | 0.75 | 45 | 10 | 1 | 18 | 13 | 13 |
| | | 1.5 | 50 | 4 | 1 | 16 | 16 | 14 |
| | " | 3.0 | 53 | 13 | 1 | 10 | 7 | 17 |
| | Dicamba | 0.5 | 59 | 5 | 1 | 8 | 5 | 22 |
| | " | 1.0 | 52 | 7 | 1 | 12 | 6 | 23 |
| | " | 2.0 | 65 | 3 | 1 | 8 | 1 | 22 |
| | Control | 0 | 45 | 11 | 1 | 9 | 18 | 16 |

## DISCUSSION

The results of the experiment reported here indicate that both asulam and dicamba were effective in the control of Rumex spp. in the perennial ryegrass pasture while causing relatively little damage to the ryegrass. Maleic hydrazide was not as effective in controlling Rumex spp. and tended to reduce the perennial ryegrass to a greater degree than did the other two herbicides.

All chemical doses caused reduction of Rumex spp. plant numbers up to 25 weeks after spraying when recovery commenced. This recovery was almost entirely from regenerating rootstocks. Regeneration of Rumex spp. was severely checked by all doses of both asulam and dicamba and to a lesser extent by maleic hydrazide.

L. perenne suffered little from treatment with either asulam or dicamba but was susceptible to doses of maleic hydrazide. Amounts of A. stolonifera, P. trivialis and P. pratense were reduced by asulam and dicamba but these species were more resistant to maleic hydrazide.

Visual effects immediately after spraying differed slightly with each chemical. Dicamba, which was the first to show effect, and reached a maximum 5 weeks after spraying, caused a yellow chlorosis on Rumex plants associated with a severe twisting of stems and leaves. Almost no effect was visible on grasses. The effects of asulam took more time to materialise, the maximum being reached after 10 weeks and caused an apple green coloured chlorosis plus slight twisting on Rumex plants, a slight chlorosis being noticed on the grass content. Maleic hydrazide caused a scorch on the Rumex plants but little twisting. Grass vegetation also appeared scorched after treatment with this chemical.

During the early part of the season the apparent colonisation by both P. trivialis and P. pratense of spaces left by chemical control of susceptible species in the sward was noted. The question of ingress (its origin and measurement) is an important one and it is suggested that experiments involving the control of weeds such as Rumex spp. or weed grass species which leave uninhabited areas in the sward should include assessment of the colonisers.

## Acknowledgments

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# CONTROL OF RUMEX SPP. IN N. IRELAND AND THE INFLUENCE OF HERBICIDAL TREATMENT ON HERBAGE YIELD AND COMPOSITION

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Summary At four sites in Northern Ireland a range of herbicide treatments was applied to control mature Rumex spp. in grassland. Each of the treatments has to date been applied on at least three occasions. Counts of dock shoot numbers indicated that a dicamba/mecoprop mixture (1.5 lb total a.e./ac) gave the greatest degree of persistent control. Also good were mecoprop (3.2 lb a.e./ac), dichlorprop (3.2 lb a.e./ac) and an asulam/mecoprop mixture (1.0 lb a.i. + 0.8 lb a.e./ac). Where the docks were making a considerable contribution to the dry matter yield, sample cuts of the herbage from these areas indicated that although the grass content of the cuts increased when the docks were controlled it did not immediately compensate for the production of the docks.

## INTRODUCTION

In Northern Ireland, where the major emphasis in agriculture is on grassland production, Rumex spp, mainly obtusifolius (broad leaved docks) are now a major problem. This series of trials was laid down to compare various recommendations made for Rumex control and to enable comparative observations to be made on the effect of the treatments on the production and botanical composition of the sward.

## METHOD AND MATERIALS

The trial sites, with a moderate to severe infestation of docks, were selected from a range of areas in Northern Ireland.

| | Site | Pasture type | Management |
|---|---|---|---|
| 1. | Ballygowan<br>Co. Down | Permanent pasture mainly *Agrostis* spp. and *Poa trivialis* | Rotational grazing |
| 2. | Ardshaw<br>Co. Tyrone | Permanent pasture<br>*Poa trivialis*, *Agrostis* spp.<br>high content *Cirsium arvense* | Accommodation pasture |
| 3. | Loughry<br>Co. Tyrone | Ley<br>Ryegrass dominant | Silage and rotational grazing |
| 4. | Magheragall<br>Co. Antrim | 4 year ley<br>Ryegrass, *Poa trivialis* | Silage and grazing |

The herbicide treatments which were compared were as follows:

| | | |
|---|---|---|
| 1. | Dicamba + mecoprop | 1.5 lb total a.e./ac |
| 2. | Asulam | 1.0 lb a.i./ac |
| 3. | Asulam | 1.0 lb a.i. + MCPB/MCPA 1.6 lb total a.e./ac |
| 4. | Asulam | 1.0 lb a.i. + mecoprop 0.8 lb a.e./ac |
| 5. | Mecoprop | 3.2 lb a.e./ac |
| 6. | 2,4-D ester | 1.5 lb a.e./ac |
| 7. | MCPA | 1.5 lb a.e./ac |
| 8. | Dichlorprop | 3.2 lb a.e./ac ) sites 3 and 4 only |
| 9. | MCPA + dicamba | 1.1 lb total a.e./ac ) sites 3 and 4 only |
| | Untreated control area | |

The individual plot size was 100 $yd^2$ at Site 1, 80 $yd^2$ at Site 2 and 45 $yd^2$ at the other two sites. The plots were laid out in a randomised block design, each treatment being replicated four times, except at Site 2 where only three replicates were possible.

Sites 1 and 2 were first sprayed in autumn 1968 and Sites 3 and 4 in the following spring. To date all four sites have received three applications of spray and at Site 1 a fourth application of treatment 6 (2,4-D) was applied in the spring of 1970. The herbicides were applied with a knapsack sprayer at a rate equivalent to 25 or 30 gal/ac water. In each instance there was an interval of about two weeks from the time the plots were last grazed or mown before the spray treatments were applied.

The degree of dock control was recorded, on the dates shown in Table 1, by counting dock shoot numbers in 20 x 1 $ft^2$ quadrats thrown at random within each plot. Dock shoot numbers, prior to spraying, were fairly uniform on the selected trial areas (Table 1) and were of the order of 35 in 20 x 1 $ft^2$ quadrats at each of the sites. At Site 1 the initial count of dock shoot numbers was made only on the control plots.

In the analysis of the Rumex shoot counts, a square root transformation was applied, and the transformed data for the final dates of recording, at each of the sites, is shown in Table 1.

Sample cuts were taken from each of the sites to determine the contribution which the docks were making to herbage production and the extent to which the grass component was benefiting from control of the docks.

The management of the four trial sites and the interval between spray treatments and collection of the sample cuts (Table 2) was as follows:

Site 1 The third spray treatment was applied on 27.8.69, the area was grazed once that autumn and again the following spring. The cut was taken 15.5.70 when the grass was at a stage suitable for silage.
Site 2 This area had been intermittently grazed, by young stock and used as overnight accommodation, between the third spray application and the time the sample cut was taken in September 1970.
Site 3 The plots were cut for silage two weeks after the first spray application and the sample cut was taken when the regrowth was again at the silage stage.
Site 4 In each of the seasons 1969, 1970 the sample cut was taken from the herbage produced immediately after the first and third spray applications respectively.

For the sample cuts a strip 20 ft long and 3 ft in width was taken down the middle of each of the plots with an Autoscythe and the fresh weight of docks and other herbage measured in the field. From this material samples were taken to determine dry matter (d.m.) and botanical composition.

## Table 1

**Reduction in dock shoot numbers, as % of shoots on the untreated plots, after a sequence of herbicide treatments**

**Site 1**

| Recording Dates / Spray Dates | 18.10.68 † | 13.5.69 | 5.6.69 ↑ | 21.7.69 | 27.8.69 ↑ | 28.10.69 | 8.6.70 † | 29.7.70 | A |
|---|---|---|---|---|---|---|---|---|---|
| **Treatments** | | | | | | | | | |
| 1. Dicamba/Mecoprop | - | 80 | 91 | 83 | 67 | 97 | 93 | 89 | 2.36 |
| 2. Asulam | - | 18 | 38 | 85 | 61 | 87 | 60 | 52 | 5.30 |
| 3. Asulam/MCPB/MCPA | - | 7 | 43 | 73 | 25 | 74 | 46 | 42 | 5.92 |
| 4. Asulam/mecoprop | - | 60 | 67 | 79 | 33 | 84 | 78 | 80 | 3.33 |
| 5. Mecoprop | - | 53 | 64 | 83 | 72 | 90 | 79 | 83 | 2.90 |
| 6. 2,4-D | - | -7 | 22 | 71 | 11 | 77 | 19 | 89 | 2.47 |
| 7. MCPA | - | 12 | 8 | 60 | 11 | 71 | 51 | 50 | 5.69 |
| Untreated | (33) | (60) | (63) | (48) | (36) | (31) | (35) | (66) | 7.95 |
| | | | | | | | (D.F.21) | S.E. | ± 0.79 |

**Site 2**

| Recording Dates / Spray Dates | 17.10.68 ↑ | 6.6.69 ↑ | 25.7.69 | 19.6.70 ↑ | 7.9.70 | A |
|---|---|---|---|---|---|---|
| **Treatments** | | | | | | |
| 1. Dicamba/Mecoprop | (32) | 36 | 98 | 80 | 95 | 1.00 |
| 2. Asulam | (34) | 70 | 96 | 68 | 48 | 3.30 |
| 3. Asulam/MCPB/MCPA | (30) | 21 | 93 | 53 | 77 | 2.24 |
| 4. Asulam/mecoprop | (30) | 49 | 96 | 63 | 72 | 2.39 |
| 5. Mecoprop | (31) | 30 | 96 | 84 | 88 | 1.71 |
| 6. 2,4-D | (30) | 0 | 93 | 57 | 43 | 3.46 |
| 7. MCPA | (33) | 17 | 89 | 39 | 54 | 2.99 |
| Untreated | (37) | (53) | (55) | (32) | (22) | 4.61 |
| | | | | (D.F.14) | S.E. | ± 0.39 |

**Site 3**

| Recording Dates / Spray Dates | 13.5.69 ↑ | 11.7.69 | 5.9.69 ↑ | 24.10.69 | 22.5.70 ↑ | 3.9.70 | A |
|---|---|---|---|---|---|---|---|
| **Treatments** | | | | | | | |
| 1. Dicamba/mecoprop | (36) | 86 | 76 | 96 | 85 | 89 | 2.43 |
| 2. Asulam | (43) | 63 | 58 | 86 | 68 | 86 | 3.24 |
| 3. Asulam/MCPB/MCPA | (43) | 68 | 55 | 93 | 68 | 84 | 3.28 |
| 4. Asulam/mecoprop | (39) | 86 | 62 | 96 | 81 | 94 | 1.82 |
| 5. Mecoprop | (48) | 72 | 62 | 98 | 86 | 81 | 3.51 |
| 6. 2,4-D | (55) | 0 | -4 | 69 | 21 | 51 | 5.56 |
| 7. MCPA | (60) | -8 | -4 | 44 | 15 | 48 | 5.70 |
| 8. Dichlorprop | (41) | 57 | 55 | 96 | 76 | 80 | 3.78 |
| 9. MCPA/dicamba | (49) | 54 | 43 | 35 | 48 | 30 | 7.00 |
| Untreated | (37) | (76) | (53) | (55) | (70) | (76) | 8.66 |
| | | | | | (D.F.27) | S.E. | ± 0.81 |

**Site 4**

| Recording Dates / Spray Dates | 16.5.69 ↑ | 24.7.69 | 28.8.69 ↑ | 13.5.70 ↑ | 11.9.70 | A |
|---|---|---|---|---|---|---|
| **Treatments** | | | | | | |
| 1. Dicamba/mecoprop | (40) | 85 | 80 | 78 | 90 | 2.14 |
| 2. Asulam | (37) | 61 | 51 | 25 | 46 | 4.80 |
| 3. Asulam/MCPB/MCPA | (40) | 57 | 55 | 39 | 72 | 3.65 |
| 4. Asulam/mecoprop | (44) | 76 | 69 | 55 | 69 | 3.74 |
| 5. Mecoprop | (42) | 67 | 76 | 62 | 87 | 2.45 |
| 6. 2,4-D | (38) | 56 | 47 | 55 | 59 | 4.50 |
| 7. MCPA | (40) | 44 | 39 | 63 | 47 | 5.18 |
| 8. Dichlorprop | (41) | 57 | 63 | 47 | 69 | 3.92 |
| 9. MCPA/dicamba | (40) | 69 | 57 | 45 | 26 | 6.07 |
| Untreated | (32) | (54) | (49) | (51) | (51) | 6.91 |
| | | | | (D.F.27) | S.E. | ± 0.65 |

(  ) Dock shoot number 20 x 1 $ft^2$ quadrats

† Treatment 6 only, sprayed on this date

A - Transformed, dock number for the final recording date, S.E. Mean (D.F.)

## RESULTS

### Rumex Control

The percentage reduction in dock shoot numbers subsequent to the series of sprayings is shown for each site in Table 1. The general conclusions drawn from the four sites after three applications of each treatment are:

Dicamba + mecoprop

This treatment gave at least 80% control at three of the four sites after the first spraying and the follow up treatments increased this to nearly 90%

Asulam

Two applications were required to give good control but even with three applications control remained at about 50% on three of the four sites.

Asulam + MCPB/MCPA

This mixture, which would normally be recommended where docks and buttercup or dandelion were growing in association, did not differ greatly from the asulam alone in the degree of control achieved. After three applications it gave superior control at two sites, identical control at one and inferior control at the fourth.

Asulam + mecoprop

The addition of the mecoprop (0.8 lb a.e./ac) whilst sacrificing the clover gave better dock control than the asulam alone at all four sites.

Mecoprop

The repeated treatments gave good control (greater than 80%) at all four sites.

2,4-D

This treatment gave good control for a transitory period after each spray treatment but this subsequently dropped to only about 50%

MCPA

This showed a similar degree of short term control to that of the 2,4-D.

Dichlorprop

From the two sites where this material was used at an equivalent dose to the mecoprop it appeared to be slightly less effective.

MCPA + dicamba

This treatment was applied only once on two sites and because it was not giving very good control and had visually a fairly severe effect on the grass it was discontinued.

### Herbage Yields

The yield data for Site 2 has not been included. On this site there was an exceptionally heavy infestation of *Cirsium arvense* which so discouraged the cattle from attempting to graze the unsprayed plots that when a clip was taken in September 1970 there was ten times the amount of grass on the control plots that there was on those plots on which *Cirsium arvense* had been controlled.

The percentage contribution which the docks made to the total herbage at the four sites was: Site 3 (1969) 54.0% (475 lb d.m./ac); Site 4 (1969) 19.5% (207 lb d.m./ac); Site 4 (1970) 8.0% (95.21 lb d.m./ac) and Site 1 (1970) 6.3% (35.9 lb d.m./ac).

The total herbage production (Table 2) was reduced on the majority of the treated plots and it is clear that the dock component made a considerable contribution to the yield. In general it is the treatments which have given the best dock control which show the greatest reduction in total dry matter e.g. at Sites 3 and 4 in 1969 the dicamba/mecoprop treatment gave only 84% and 86% of the yield from the control plots whereas the MCPA treatment gave 91% and 114% compared with the control.

Table 2

Yield of (A) Total Herbage, including Rumex, (b) Grass, as a % of the yield on the unsprayed plots

| Site | 3 | | 4 | | 4 | | 1 | |
|---|---|---|---|---|---|---|---|---|
| Date of cut | 11.7.69 | | 17.6.69 | | 5.6.70 | | 15.5.70 | |
| | A | B | A | B | A | B | A | B |
| Treatment | | | | | | | | |
| 1. Dicamba/mecoprop | 86 | 190 | 84 | 103 | 103 | 110 | 78 | 87 |
| 2. Asulam | 94 | 191 | 89 | 105 | 96 | 97 | 81 | 79 |
| 3. Asulam/MCPB/MCPA | 83 | 158 | 84 | 94 | 97 | 100 | 76 | 84 |
| 4. Asulam/mecoprop | 108 | 232 | 77 | 91 | 97 | 104 | 86 | 97 |
| 5. Mecoprop | 81 | 164 | 91 | 110 | 114 | 118 | 94 | 107 |
| 6. 2,4-D | 111 | 114 | 84 | 98 | 95 | 98 | 88 | 96 |
| 7. MCPA | 114 | 129 | 91 | 96 | 119 | 129 | 89 | 96 |
| 8. Dichlorprop | 97 | 172 | 114 | 134 | 114 | 119 | - | - |
| 9. MCPA/dicamba | 86 | 129 | 75 | 88 | 90 | 94 | - | - |
| Untreated Yield (d.m.lb/ac) | (879) | (397) | (1062) | (859) | (1190) | (1091) | (564) | (497) |
| F Test Control v rem. treat | N.S. | | N.S. | N.S. | N.S. | N.S. | | N.S. |

Table 3

The Botanical Composition (% d.m.) at Site 4 in 1969 and 1970

| Species | Ryegrass | | Poa spp. | | Timothy | | Rumex | | Other spp. | | Total herbage d.m.lb/ac | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date of cut | 69 | 70 | 69 | 70 | 69 | 70 | 69 | 70 | 69 | 70 | 69 | 70 |
| Treatment | | | | | | | | | | | | |
| 1. Dicamba/ mecoprop | 55.9 | 59.6 | 37.8 | 22.5 | 2.9 | 12.9 | 0.4 | 2.3 | 3.0 | 3.0 | 888 | 1225 |
| 2. Asulam | 52.0 | 58.0 | 34.8 | 25.8 | 3.4 | 7.4 | 4.3 | 7.2 | 5.3 | 1.7 | 932 | 1142 |
| 3. Asulam/ MCPB/MCPA | 33.1 | 46.7 | 48.6 | 38.0 | 7.7 | 7.9 | 7.6 | 5.5 | 3.1 | 2.0 | 881 | 1152 |
| 4. Asulam/ mecoprop | 40.2 | 49.0 | 44.6 | 27.2 | 5.2 | 20.9 | 4.5 | 2.5 | 5.8 | 0.5 | 906 | 1158 |
| 5. Mecoprop | 45.1 | 60.3 | 43.7 | 14.8 | 4.9 | 17.3 | 2.6 | 5.0 | 3.8 | 2.5 | 975 | 1350 |
| 6. 2,4-D | 25.0 | 48.2 | 49.5 | 32.7 | 8.7 | 16.6 | 13.9 | 1.1 | 2.9 | 1.2 | 956 | 1421 |
| 7. MCPA | 43.7 | 53.6 | 39.8 | 25.2 | 7.7 | 14.8 | 5.1 | 3.9 | 3.7 | 2.7 | 1203 | 1355 |
| 8. Dichlorprop | 40.8 | 49.5 | 42.3 | 34.0 | 6.2 | 10.4 | 5.5 | 4.8 | 5.3 | 1.4 | 893 | 1126 |
| 9. MCPA/dicamba | 31.9 | 49.2 | 51.3 | 30.6 | 3.2 | 14.3 | 7.2 | 3.6 | 6.5 | 2.3 | 806 | 1068 |
| Untreated | 22.9 | 51.7 | 46.1 | 25.3 | 5.9 | 7.9 | 19.5 | 8.0 | 5.6 | 7.2 | 1062 | 1190 |

The yield of grass shows an increase where the docks have been controlled. This was particularly evident at Site 3 where Rumex spp. formed 54% of the d.m. yield on the untreated plots. This was the only site where the difference between treatment means were statistically significant, treatments 1, 2, 4, 5 and 6 being greater than the other treatments.

At Site 4, where the main species present were ryegrass, rough-stalked meadow grass and timothy, cuts taken at about the same date each year, on the regrowth following the spray application, showed a general tendency for both the total yield and the grass yield, relative to the control, to increase in 1970 compared with 1969 (Table 2). The one site where grass yield decreased from all the treatments except the mecoprop (3.2 lb a.e./ac) was Site 1. This was nine months after the application of the third spray treatment on this trial. The mecoprop and dichlorprop treatments were the only two treatments where the grass yield increased on all the sites relative to the unsprayed area.

## Botanical Composition

It is not possible to present the complete botanical analysis data for all the sites but clear changes in the species representation did occur according to the treatment applied. The botanical analysis of the cut herbage from Site 4, where there was a dock infestation equivalent to 19.5% and 8.0% in the years 1969 and 1970, is shown in Table 3. In the two seasons there was a marked difference in the balance of species on the control plot, in 1969 *Poa* spp. (mainly *Poa trivialis*) were dominant whereas in 1970 ryegrass was the major component. In this instance it was the ryegrass which derived the greatest benefit from good control of *Rumex* spp. The dicamba/mecoprop, asulam/mecoprop and mecoprop treatments alone, show this response. On these treatments the representation of *Poa* spp. was diminished although in 1970 this reduction was small. The timothy component although not large was impaired by the asulam (treatment 2) in both seasons.

## DISCUSSION

The dicamba/mecoprop (1.5 lb total a.e./ac) has given the most satisfactory degree of control in these trials. However even with the three applications of this treatment control was not complete and the eradication of the final 10% of an infestation appears to present considerable problems. It is intended that these plots should be maintained so that the process of re-infestation can be recorded. The other treatments which have given good dock control are mecoprop (3.2 lb a.e./ac), dichlorprop (3.2 lb a.e./ac) and the asulam/mecoprop mixture (1.0 lb a.i. + 0.8 lb a.e./ac). Although the control achieved by asulam (1.0 lb a.i./ac) was disappointing, it is now known that the initial treatment, applied at two sites in early October, was too late particularly for this material. (Soper *et al.* 1968). In addition with the number of treatments compared in these trials not all the plots were at precisely the same stage of regrowth when the next spray applications were made. It was necessary to compromise to some extent in selecting the date of spraying.

Again with respect to the time of spraying there appeared to be a seasonal increase in the dock shoot counts on the control plots during the May/June period each year and this could well have had a bearing on the more consistent control achieved from herbicides applied at this time.

From the sample cuts taken on these sites, it appeared that the total herbage yield decreased, at least in the short term, when the *Rumex* component was removed. Although the grass did increase it did not always compensate for the lost production of the docks. At Site 4, where ryegrass was a major sward component it did appear that this compensation, by the grass, had occurred in the second season. In contrast, at Site 1 where the sward was predominantly *Agrostis* spp. and *Poa trivialis* the grass had apparently been more severely affected directly by all the herbicide treatments and had not shown the same capacity to respond in the absence of docks.

The botanical analysis of the swards involved gave an indication of the extent to which changes in sward composition had occurred as a result of the treatments at the four sites. The mechanisms of change in sward composition, consequent to the application of herbicides, as defined by Elliott (1960), clearly operated in this situation, the balance being struck between the benefits deriving from removal of competition from the *Rumex* component, and from any directly adverse effects the individual treatments were having on other sward constituents.

## Acknowledgments

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Proc. 10th Br. Weed Control Conf. 1970

# HERBICIDES FOR CONTROL OF GRASS WEEDS WHEN ESTABLISHING RYEGRASS

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Summary Three experiments are described, two in which methabenzthiazuron at doses of 0.5, 1, 2 lb a.i./ac and fluorodifen at doses of 0.375, 0.75, 1.5 lb a.i./ac, applied pre-emergence in spring and autumn, gave good selective control of Poa trivialis in S23 perennial ryegrass. In the third experiment methabenzthiazuron at similar doses was applied at three stages of growth after emergence; P. trivialis was very much more susceptible and Agrostis stolonifera more susceptible than S23 perennial ryegrass, Holcus lanatus or Festuca rubra. This herbicide had little or no effect on tillered plants.

## INTRODUCTION

Poa trivialis has been recorded in every vice-county in Great Britain, Ireland and the Channel Islands (Allen 1966). Baker (1962) discussed the importance of P. trivialis as a grass weed and concluded that with Agrostis species it was often a major problem in leys by the second and third year.

The thin creeping stolons are very shallow rooted and the plant is therefore very dependent upon surface moisture for survival. Hence in dry periods this grass becomes very dwarfed and the low productivity under dry conditions is one of the reasons why it is not now considered suitable as a crop species (Allen 1966).

In recent years the approach at WRO to the problem of selective weed grass control in grassland has been increasingly concerned with preventing the establishment of undesirable species rather than trying to eliminate them when fully established.

In this paper three experiments carried out in 1969 are described. Methabenzthiazuron was applied pre-emergence in the spring (experiment A) and autumn (experiment B), and post-emergence in the spring (experiment C); fluorodifen was only applied in experiments A and B.

Methabenzthiazuron has been approved for control of black-grass pre-emergence in winter wheat (Ministry of Agriculture, Fisheries and Food, Great Britain 1969). A technical data sheet (Bayer, 1968) lists a wide range of broad leaved weeds in addition to annual grass weeds controlled by 2-3 lb a.i./ac.

Fluorodifen is suggested for control of some broad leaved and grass weeds in crops such as rice, soyabeans, cotton, groundnuts and alfalfa in a technical data sheet which lists susceptible species (Ciba, 1968).

## METHOD AND MATERIALS

A normal seed bed was prepared on a sandy clay loam over Oxford clay for experiment A, and 2 cwt/ac 13.13.20 compound fertiliser applied. The area was sown with S23 perennial ryegrass and P. trivialis. Each species was broadcast independently and then harrowed and rolled. Each plot was 8x2 yd in a randomised block design with three replicates. Herbicide treatments were applied immediately after drilling on 18/4/69 using an Oxford Precision Sprayer fitted with 8002 'Teejets' delivering 20 gal/ac at 30 p.s.i.

Experiment B was carried out exactly as above but in the autumn on 22/9/69.

A similar seed bed was prepared for experiment C and the area sown on 16/4/69 with 2 yd wide strips of each species. These were: S23 perennial ryegrass, A. stolonifera, H. lanatus, P. trivialis and F. rubra: ryegrass was drilled 1 week later to allow for quicker initial growth. Herbicide treatments were applied, using an Oxford Precision Sprayer, across the five swards at three different growth stages after emergence: these were at the 1 leaf, 2-3 leaf and 1-2 tiller stage and were treated on 12/5/69, 20/5/69 and 13/6/69 respectively. Each treatment was replicated twice.

All experimental areas were cut over as required to maintain the sward at about 4-6 in. in height. Experiments A and B were assessed by the random sampling of ten 4.25 in. diameter cores from a 2 yd$^2$ area of each plot. The cores were then broken down and individual tillers of the two species counted. Experiment C was assessed by scoring at intervals for the bulk of green material on treated as compared to untreated control plots: a score of '0' represented complete kill, '9' as control.

## RESULTS

The results of experiment A are presented in table 1, those of experiment B in table 2, and those of experiment C in figure 1. In the latter experiment there was no effect on any of the species when treated after tillering.

Table 1

Tiller counts 9 and 29 weeks after treatment (Experiment A)

(each figure is mean of 3 replicates i.e. 30 cores and the control is mean of 9 replicates)

| | | assessed: 25/6/69 | | | assessed: 5/11/69 | | |
|---|---|---|---|---|---|---|---|
| | dose lb a.i./ac | Lp | Pt | log (x+1) | Lp | Pt | log (x+1) |
| Fluorodifen | 0.375 | 409 | 24 | 1.365 | 395 | 40 | 1.515 |
| Fluorodifen | 0.75 | 410 | 6 | 0.664 | 360 | 6 | 0.842 |
| Fluorodifen | 1.5 | 269 | 4 | 0.661 | 292 | 5 | 0.410 |
| Methabenzthiazuron | 0.5 | 449 | 136 | 1.733 | 365 | 106 | 1.941 |
| Methabenzthiazuron | 1 | 414 | 78 | 1.739 | 336 | 13 | 1.085 |
| Methabenzthiazuron | 2 | 192 | 1 | 0.159 | 314 | 1 | 0.201 |
| Untreated control | | 405 | 622 | 2.775 | 325 | 197 | 2.281 |
| S.E. treatment means ± | | 50.8 | | 0.201 | 28.0 | | 0.185 |
| S.E. control treatment difference ± | | 58.7 | | 0.232 | 32.3 | | 0.213 |

Lp = S23 perennial ryegrass Pt = Poa trivialis

Table 2

Tiller counts 43 weeks after treatment (Experiment B)

(each figure is mean of 3 replicates i.e. 30 cores and the control is mean of 6 replicates)

assessed: 17/7/70

| | dose lb a.i./ac | Lp | Pt | Pt log (x+1) |
|---|---|---|---|---|
| Fluorodifen | 0.375 | 427 | 123 | 2.062 |
| Fluorodifen | 0.75 | 426 | 95 | 1.970 |
| Fluorodifen | 1.5 | 462 | 11 | 0.966 |
| Methabenzthiazuron | 0.5 | 461 | 192 | 2.286 |
| Methabenzthiazuron | 1 | 504 | 124 | 2.091 |
| Methabenzthiazuron | 2 | 479 | 20 | 1.310 |
| Untreated control | | 371 | 233 | 2.280 |
| S.E. treatment means ± | | 42.6 | | 0.132 |
| S.E. control treatment difference ± | | 52.26 | | 0.162 |

Lp = S23 perennial ryegrass   Pt = Poa trivialis

DISCUSSION

The data in table 1 show that fluorodifen at 0.75 and 1.5 lb a.i./ac and methabenzthiazuron at 2 lb a.i./ac applied in April gave good control of P. trivialis. The ryegrass content at the first assessment was somewhat reduced by the top dose of both herbicides but this reduction had largely disappeared by the second assessment in November; by this time there had also been a reduction of P. trivialis on plots treated with methabenzthiazuron at 1 lb a.i./ac. When applied in September (table 2) treatments were less effective but fluorodifen at 1.5 lb a.i./ac and methabenzthiazuron at 2 lb a.i./ac still gave good reductions of P. trivialis when assessed in July the following year. In experiment C (fig. 1) at the 1 leaf and 2-3 leaf stages both P. trivialis and A. stolonifera were affected more than perennial ryegrass, H. lanatus or F. rubra by 0.5 lb a.i./ac. The various species showed a similar response when treated with 1 lb a.i./ac: P. trivialis was completely killed at 1 leaf stage and severely reduced at the 2-3 leaf stage. Perennial ryegrass was virtually unaffected and A. stolonifera was more susceptible than either H. lanatus or F. rubra. 2 lb a.i./ac caused an unacceptable amount of damage to all species at the 1 leaf stage but at 2-3 leaf stage P. trivialis was killed whereas perennial ryegrass was little affected: A. stolonifera was again more susceptible than the other two grasses.

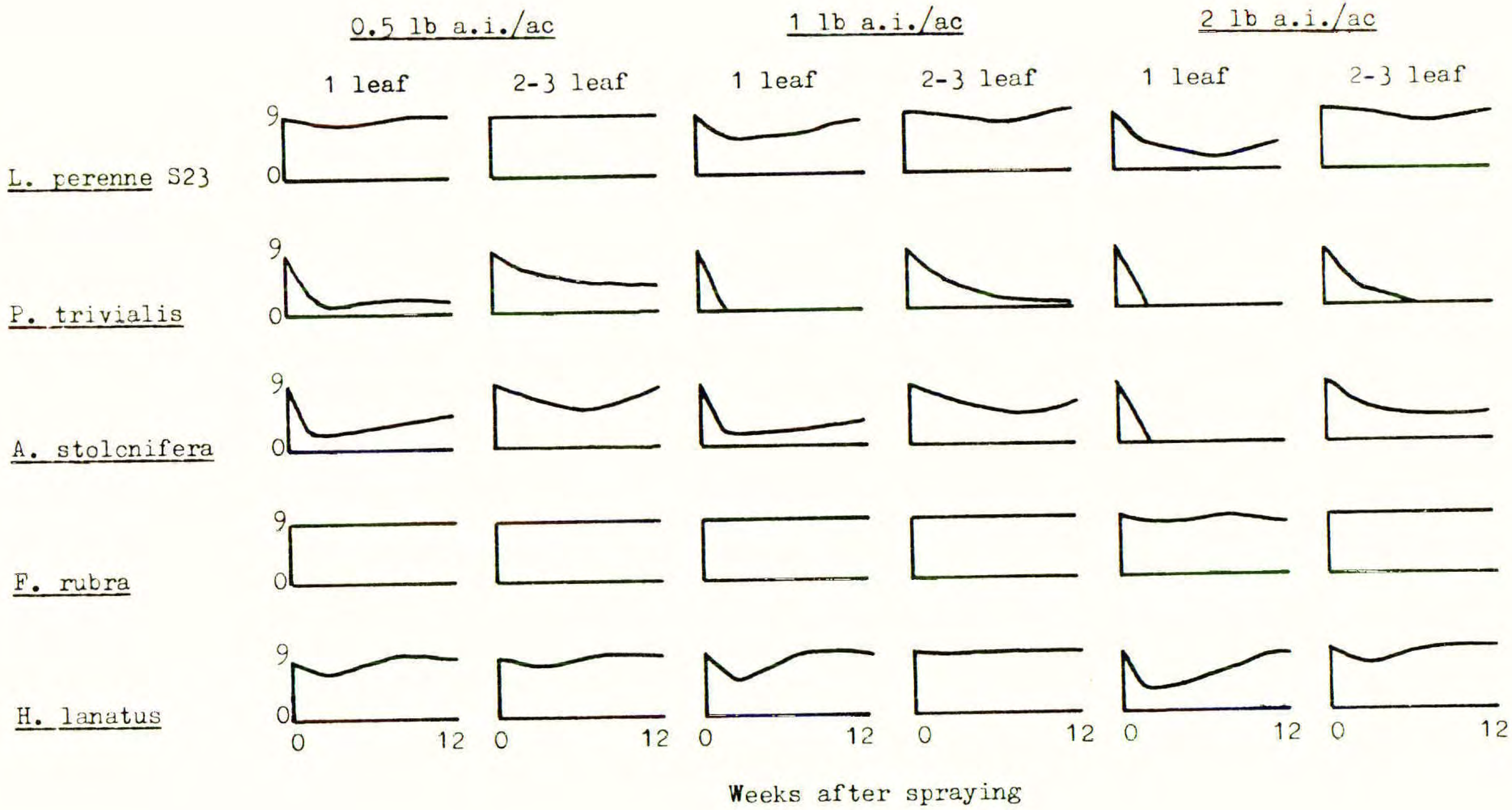
These experiments show clearly that methabenzthiazuron and fluorodifen can, under the conditions of these experiments, give good selective control of P. trivialis in perennial ryegrass during establishment. It should be remembered however that the stands of P. trivialis were artificially established and these effects require verification on natural populations. Time of application is not critical with methabenzthiazuron for it was selective up to the stage when P. trivialis started to tiller.

Application in the autumn seemed less effective with both herbicides, but even under these conditions there was useful control of P. trivialis. In the autumn the weather was relatively dry with only 5 mm rainfall in the month following spraying: by contrast in the month following the spring application there was 54 mm rainfall. Minimum temperatures were somewhat higher in the autumn.

Figure 1

The effect of methabenzthiazuron applied at two stages after emergence

scored 0-9 for bulk of green material as compared to control



These pre-emergence and seedling treatments open up possibilities for controlling the ingress, into newly sown leys, of P. trivialis which is a species able to withstand intensive management. The control of germinating P. trivialis in established pasture on bare soil exposed by poaching is another possible use for these herbicides. More work however on these and other aspects is required. Both these herbicides can also give useful broad leaved weed control and this year experiments are in progress using methabenzthiazuron and fluorodifen in barley undersown with ryegrass; results so far appear promising.

Acknowledgments

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# THE SELECTIVE CONTROL OF POA TRIVIALIS, POA ANNUA, ALOPECURUS MYOSUROIDES AND SOME BROAD LEAVED WEEDS IN GRASS CROPS GROWN FOR SEED

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Summary In a preliminary trial several herbicides were applied to new sowings of various crop grasses to determine their selectivity in controlling *Poa trivialis* and *Alopecurus myosuroides* in grass crops intended for seed production.

Methabenzthiazuron was found to be particularly promising and subsequent trials suggest that it could be used as a pre- or post-emergence herbicide to control *Poa trivialis*, *Poa annua* and some broad leaved weeds in new sowings of perennial and Italian ryegrass, meadow fescue and cocksfoot. Timothy, however, appears to be susceptible to damage, particularly at the seedling stage. The control of *Poa trivialis* greatly facilitates the cleaning of the crop seed to the required purity standards.

## INTRODUCTION

Shildrick and Arthur (1968), Wagner (1969), Lescar, Bouchet and Audy (1968) all attempted to control seedlings and mature grass weeds mainly in established grass seed crops by spraying with overall applications of herbicides. Success was achieved in controlling *Poa trivialis*, *Poa annua*, *Alopecurus myosuroides*, *Hordeum sativum*, *Agrostis vulgaris* and *Bromus* sp.

This investigation, however, attempts to find which herbicide will selectively control some or all of these grass weeds when applied before or after the emergence of a newly sown crop. Such an approach was used by Ziegenbein (1969) who included some of the same herbicides in tolerance tests on crop grasses only. Blair (1970) in preliminary trials, also investigated the selective control of a number of weed grasses which included *Poa trivialis* and *Alopecurus myosuroides* - two important weeds in grass seed crops. In trials at the N.I.A.B., methabenzthiazuron was picked out as particularly promising, and its performance in controlling *Poa trivialis*, *Poa annua* and some broad leaved weeds in ryegrass crops is reported.

## METHOD AND MATERIALS

### Preliminary screening trials

In 1969 seven herbicides were screened to measure their selectivity in controlling *Poa trivialis* and *Alopecurus myosuroides* in new spring sowings of S.22 Italian ryegrass, S.24 and S.23 perennial ryegrass, S.215 meadow fescue, S.48 and S.352 timothy, S.143 and S.37 cocksfoot. The herbicides used were methabenzthiazuron, metoxuron, noruron, fluometuron + dichlobenil, chlortoluron, nitrofen and fluordifen.

The crop grasses were drilled in 7 in rows at a seed rate of 15 lb per acre on the 28th April. Seed of Poa trivialis and Alopecurus myosuroides was broadcast with a 'lawn seeder', in a band 4 ft wide at a rate sufficient to ensure the establishment of at least one weed seedling/in$^2$.

The herbicides were applied in a band 6 ft wide at right angles to the sowing direction of the crop and weed grasses, using a knapsack sprayer at a volume of 40 gal/ac and 40lb/in$^2$ pressure. The cone jets used were Dorman's No. 15. The treatments were applied separately in two replicates, at two doses, both pre- and post emergence on the newly sown crop and weed grasses.

All treatments were scored visually on a crop tolerance and weed susceptibility basis and compared with the untreated controls. The pre- and post-emergence treatments were scored 56 and 48 days after spraying, respectively.

Field trials with methabenzthiazuron

Following the success of methabenzthiazuron in the preliminary trial, the performance was further measured under actual farming conditions. Two perennial ryegrass crops were chosen -

(1) S.321 perennial ryegrass broadcast in September 1969, near Winchester, Hampshire.

(2) S. 24 perennial ryegrass undersown to Sultan spring barley in April 1970, near Winchester, Hampshire.

Both trials were sown and sprayed using farm implements, each treatment was carried out separately pre- and post-emergence, using three doses of herbicides at each stage replicated four times. Each treatment was on an area measuring 7 x 60 yd. The vegetative stages of the crop and weed grasses at the post-emergence treatment were as follows:

| | |
|---|---|
| September 1969 sown grass crop, and Poa annua | - 2 to 3 leaves for both. |
| April 1970 sown grass crop, and Poa trivialis | - 1 to 2 leaves for both. |
| " " " barley crop | - 3 to 6 leaves. |

In the September sown S.321 the control of Poa annua and Stellaria media was measured in February with a point quadrat to determine the percentage ground cover occupied by crop and weed. 0.05 ac from each treatment was combine harvested in July and the seed yield measured.

In the April sown S.24, the control of Poa trivialis and of some broad leaved weeds, was measured in each treatment by counting the number of crop and weed seedlings in 5 x 1 ft$^2$ quadrats. The barley yields from the same 0.05 ac areas were measured when the crop was combined in August. The grass seed crop will be harvested in 1971.

## RESULTS

Preliminary screening trials: Table 1 shows the scores achieved by the spring application of seven herbicides at pre- and post-emergence of the crop and weed species. The most desirable score is a figure of 9 for crop tolerance and 0 for the best kill of grass weeds.

1970 Field Trials: Tables 2, 3, 4 and 5 summarise the field trials with methabenzthiazuron to control Poa trivialis, Poa annua and some broad leaved weeds in new sowings of S.24 and S.321 perennial ryegrass.

Table 1

Herbicide screening trials, 1969 spring sowings

Mean tolerance of crop and weed
Scoring: 9 = full crop and maximum presence of weed

| Herbicide application stage | | PRE-EMERGENCE | | | | | | | | | | POST-EMERGENCE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of leaves at treatment | | - | - | - | - | - | - | - | - | - | - | 7 | 6 | 4 | 3 | 3 | 4 | 3 | 3 | 4 | 5 |
| Crop and weed | | S. 22 Italian ryegrass | S. 24 perennial ryegrass | S. 23 perennial ryegrass | S.143 cocksfoot | S. 37 cocksfoot | S.215 meadow fescue | S. 48 timothy | S.352 timothy | Poa trivialis | Alopecurus myosuroides | S. 22 Italian ryegrass | S. 24 perennial ryegrass | S. 23 perennial ryegrass | S.143 cocksfoot | S. 37 cocksfoot | S.215 meadow fescue | S. 48 timothy | S.352 timothy | Poa trivialis | Alopecurus myosuroides |
| Herbicide | Dose lb ai/ac | | | | | | | | | | | | | | | | | | | | |
| methabenz-thiazuron | 2.8 | **8** | 4 | 3 | **7** | **6** | 2 | 0 | 0 | **0** | 1 | **9** | **9** | **9** | **9** | **9** | **9** | **7** | **8** | **2** | 9 |
| | 1.4 | **8** | **6** | **6** | **8** | **8** | **6** | 2 | 1 | **0** | 5 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 5 | 9 |
| nitrofen | 2.0 | 5 | 4 | 4 | 1 | 1 | 3 | 0 | 0 | 0 | 2 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 |
| | 1.0 | **8** | **6** | 5 | 1 | 1 | **6** | 1 | 1 | **1** | 6 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| metoxuron* | 4.4 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | **9** | **9** | **9** | **8** | **8** | **7** | 4 | 5 | **1** | 7 |
| | 2.2 | 1 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 9 | 9 | 9 | 8 | 9 | 8 | 7 | 8 | 4 | 9 |
| noruron* | 1.2 | 4 | 2 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | 2 | 9 | 9 | 9 | 8 | 9 | 9 | 8 | 9 | 8 | 9 |
| | 0.6 | 7 | 7 | 7 | 9 | 9 | 8 | 3 | 4 | 9 | 6 | 9 | 9 | 9 | 8 | 9 | 7 | 7 | 8 | 9 | 9 |
| chlortoluron | 1.8 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | **9** | **9** | **9** | **8** | **8** | **9** | **7** | **9** | **2** | 8 |
| | 0.9 | 1 | 1 | 1 | 3 | 3 | 1 | 0 | 0 | 0 | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 7 | 9 | 5 | 9 |
| fluordifen | 2.7 | **8** | 4 | 3 | 4 | 5 | 4 | 0 | 0 | **0** | 8 | 9 | 9 | 9 | 8 | 9 | 9 | 7 | 9 | 7 | 9 |
| | 1.3 | **8** | **6** | **6** | **7** | **8** | 4 | 0 | 0 | **0** | 7 | 9 | 9 | 9 | 7 | 8 | 9 | 8 | 8 | 9 | 9 |
| fluometuron + dichlobenyl | 4.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 9 | 9 | 7 | 8 | 9 | 7 | 9 | 3 | 7 |
| | 2.0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 9 | 9 | 9 | 9 | 9 | 9 | 7 | 9 | 6 | 9 |

NOTE: Figures in bold type indicate satisfactory crop tolerance with good control of Poa trivialis

* Denotes herbicide dose which differs at post-emergence -

Post-emergent application of metoxuron - 3.6 lb ai/ac.
1.8 "

" " " " noruron - 2.0 "
1.0 "

Table 2

Estimations of percentage ground cover occupied by S.321 perennial ryegrass, Poa annua and Stellaria media following treatment with methabenzthiazuron

| Herbicide application stage | PRE-EMERGENCE | | | POST-EMERGENCE | | | |
|---|---|---|---|---|---|---|---|
| Herbicide dose lb ai/ac | 0.5 | 1.0 | 1.5 | 1.0 | 1.5 | 2.0 | Untreated |
| S.321 perennial ryegrass | 86 | 84 | 79 | 86 | 85 | 79 | 78 |
| *Poa annua* | 7*** | 6*** | 3*** | 2*** | 0*** | 0*** | 16 |
| *Stellaria media* | 2 | 0 | 0 | 0 | 0 | 0 | 5 |
| Bare ground | 5 | 10 | 17 | 12 | 15 | 21 | 0 |

*Poa annua* L S D = 6.6, (*** P = 0.001), S.321 perennial ryegrass N.S.

Table 3

Purity and seed yield of S.321 perennial ryegrass after control of Poa annua and Stellaria media following treatment with methabenzthiazuron

| Herbicide application stage | PRE-EMERGENCE | | | POST-EMERGENCE | | | |
|---|---|---|---|---|---|---|---|
| Herbicide dose lb ai/ac | 0.5 | 1.0 | 1.5 | 1.0 | 1.5 | 2.0 | Untreated |
| Yield cwt/ac at 98% purity | 16.3 | 15.4 | 15.8 | 16.3 | 16.2 | 16.3 | 15.0 |
| No. of weed seeds in 3.0 gm. sample (1 replicate only) | | | | | | | |
| *Poa annua* | 638 | 193 | 146 | 92 | 43 | 4 | 647 |
| *Stellaria media* | 60 | 24 | 6 | 0 | 1 | 0 | 63 |

S.321 perennial ryegrass seed yield N.S.

Table 4

Yield of spring barley following treatment with methabenzthiazuron

| Herbicide application stage | PRE-EMERGENCE | | | POST-EMERGENCE | | | |
|---|---|---|---|---|---|---|---|
| Herbicide dose lb ai/ac | 0.5 | 1.0 | 1.5 | 0.5 | 1.0 | 1.5 | Untreated |
| Yield cwt/ac | 24.0 | 23.6 | 18.5* | 23.6 | 20.5* | 19.2* | 24.2 |

L S D = 3.2 cwt/ac., (* P = 0.05)

Table 5

Quadrat estimations of the number of crop and weed seedlings/10 $ft^2$ in an undersown crop of S.24 perennial ryegrass, following treatment with methabenzthiazuron

| Herbicide application stage | PRE-EMERGENCE | | | POST EMERGENCE | | | Untreated |
|---|---|---|---|---|---|---|---|
| Herbicide dose lb ai/ac | 0.5 | 1.0 | 1.5 | 0.5 | 1.0 | 1.5 | |
| S.24 perennial ryegrass | 275 | 242 | 200* | 240 | 250 | 205* | 260 |
| Poa trivialis | 4*** | 0*** | 0*** | 5*** | 1*** | 0*** | 43 |
| Anagallis arvensis | 4 | 2 | 2 | 0 | 0 | 0 | 13 |
| Polygoumn convolvulus | 3 | 5 | 5 | 5 | 0 | 0 | 11 |
| Veronica persica | 3 | 1 | 0 | 2 | 0 | 0 | 7 |
| Chenopodium album | 3 | 2 | 1 | 6 | 1 | 0 | 7 |
| Barley growth check | None | Slight | Slight | None | Slight | Marked | - |

S.24 perennial ryegrass LSD = 43, (*P = 0.05), Poa trivialis LSD = 8,(***P = 0.001)

## DISCUSSION

Preliminary screening trials (Table 1): It should be realised that the scores shown in Table 1 are those which are estimated to be satisfactory for a stand of a grass seed crop. Some crop damage at an early stage is tolerable, as a thin stand of a grass seed crop, particularly of cocksfoot and timothy, often gives a better seed yield.

Post-emergence metoxuron and chlortoluron at the higher doses appear to control Poa trivialis in new sowings of ryegrasses, cocksfoot and meadow fescue. For timothy, however, only chlortoluron is tolerated.

Pre-emergence fluordifen at 1.3 lb ai/ac showed control of Poa trivialis in all but meadow fescue and timothy.

Methabenzthiazuron appears to control Poa trivialis in all crop grasses, both pre- and post-emergence, except timothy at the pre-emergence stage. Selective pre-emergence control of Alopecurus myosuroides was also achieved at 2.8 lb ai/ac in S.22 Italian ryegrass and S.143 cocksfoot.

Field trials (Tables 2, 3, 4 and 5): Table 2 shows that good selective control of Poa annua and Stellaria media was achieved with methabenzthiazuron in the autumn sown S.321 perennial ryegrass. The pre-emergence application appeared to be less satisfactory than the post-emergence, possibly due to the dry conditions following sowing and treatment; the herbicides remaining inactive until the rains came two weeks later. It is noticeable that the removal of the weed species resulted in a corresponding appearance of bare ground recorded in February. However, following re-growth in the spring these bare areas became fully covered by the tillering crop.

Table 3 shows the seed yield of the same crop after harvest in July. Though the removal of 21% of Poa annua and Stellaria media did not give a significant increase in crop yield, purity tests on partly cleaned seed indicate a marked reduction of these weeds in the seed from treated plots.

Table 5 shows good selective control of Poa trivialis and a number of broad leaved weeds in the undersown crop of S.24 perennial ryegrass. Good control was achieved at both the pre- and post-emergence stages but a significant reduction of ryegrass seedlings from 26 to 20 per square foot was detected at the higher dose. This may not be serious since a thin crop often gives the best yield. The post-emergence control of Poa trivialis and the broad leaved weeds was particularly good at the 1.0 lb ai/ac. Table 4, however, shows that the cover crop of Sultan spring barley suffered damage particularly at the post-emergence stage; yield reductions occurred in all treatments except the lower post- and the two lower pre-emergence doses. Hack (1967) came to a similar conclusion and further work needs to be undertaken to determine whether this herbicide can be used economically on cover crops of spring barley.

Chippindale (1932) showed that a proportion of Poa trivialis seed had a light requirement for germination. This could improve the selectivity of the herbicide since some would only germinate near the soil surface and be directly exposed to the spray, whereas the sown crop, germinating independently of light is only exposed following emergence. Also, Poa trivialis seedlings are smaller and probably more susceptible to damage than those of ryegrass. This may account for timothy, which also has small seedlings, being more susceptible to damage.

In conclusion, it is evident that a number of new herbicides, particularly methabenzthiazuron, offer the opportunity of selectively controlling some of the important weed grasses in new sowings of grass seed crops. Such a treatment could complement cultural controls as outlined by Budd (1970).

## Acknowledgments

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# THE GROWTH PERFORMANCE OF RYEGRASS PLANTS OBTAINED FROM LONG ESTABLISHED SWARDS IMPROVED BY THE USE OF DALAPON FOR THE SELECTIVE SUPPRESSION OF WEED GRASSES

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Summary Perennial ryegrass plants from fields at Caythorpe, Lutterworth and Thurgarton, where dalapon had been used for the selective control of weed grasses, were compared with S.23 ryegrass grown at Begbroke Hill. Comparisons were made in respect of tiller and flower head production and growth habit. Perennial ryegrass from Lutterworth and Thurgarton was found to be similar to Begbroke S.23 in all these respects. Although the plants from Caythorpe produced less tillers and flowers and displayed a different growth habit than plants from the other sites they, nevertheless, appeared to be desirable pasture plants.

## INTRODUCTION

Perennial ryegrass - Lolium perenne - is widely accepted as having the most desirable characteristics for inclusion in sown swards and permanent pasture in Britain. These characteristics include abundant production and a leafy growth form. A most persistent strain commonly used and frequently found in sown pastures is S.23 perennial ryegrass. Although S.23 is frequently present at the time of sowing it is possible that ecotypic selection may result over the years in the presence of indigenous ryegrass plants characterised by an ability to survive in the sward but only having a low potential for herbage production.

In research concerned with developing herbicides for grassland it is important, therefore, to establish whether in pasture which is treated with herbicides for the selective control of weeds and the subsequent encouragement of ryegrass that this ryegrass is of a desirable form and in the case of sown swards similar to that which was sown originally or not.

The object of the experiment reported here was to compare with young S.23 ryegrass the performance of plants of perennial ryegrass obtained from pastures treated with dalapon for the selective suppression of weed grasses. The sites were the subject of the investigation of the selective properties of dalapon which has been reported elsewhere. (Allen, 1968).

## METHODS AND MATERIALS

Material for the comparison was collected from three sites, the details of which can be found in Table 1.

Table 1.

| | Caythorpe | Lutterworth | Thurgarton |
|---|---|---|---|
| O.S. Grid Ref. | S.K. 952483 | S.P. 533835 | S.K. 896506 |
| Soil type | Silty loam | Freely drained sandy loam | Slow draining clay loam |
| Average annual rainfall (in.) | 25 | 25-30 | 25 |
| Dalapon applied | 11th July, 1966 | 5th July, 1967 | 7th July, 1967 |
| Pasture type | 20 - 30 yr old perennial ryegrass | Direct re-seed April 1956. Mixture of S.23 and S.101 perennial ryegrass, S.26 and S.143 Cocksfoot and S.100 White Clover | Undersown to Oats-1952. Mixture of Italian and perennial ryegrass, S.37 Cocksfoot, S.48 Timothy and S.100 White Clover plus Chicory |
| Management history | Pre-spraying - Grazed by cattle and sheep. Moderate fertiliser treatment. Post-spraying - Yield cuts taken plus adequate fertiliser. Grazed by cattle from June, 1967 | Pre-spraying - Grazed by dairy cattle and sheep. Moderate fertiliser treatment. Post-spraying - Yield cuts taken plus adequate fertiliser. Grazed by cattle from October, 1967 | Pre-spraying - Grazed by cattle in 1953, '56, '57, '60, '63, '64, '65 and '66. Mown in 1954, '55, '58, '59, '61 and '62. Moderate fertiliser treatment. Post-spraying - Yield cuts taken plus adequate fertiliser. Grazed by sheep from October, 1967 |
| % species composition of pasture before spraying | Lolium perenne 55-60<br>Agrostis stolonifera 50-55<br>Poa trivialis 35-40<br>Holcus lanatus 15<br>Trifolium repens 20 | Lolium perenne 55-60<br>Agrostis tenuis 30-40<br>Poa trivialis 30<br>Trifolium repens 15 | Lolium perenne 50<br>Agrostis stolonifera 35-40<br>Poa trivialis 35-40<br>Holcus lanatus 5-10<br>Phleum pratense 5<br>Trifolium repens 40 |

The plants from the three sites were compared with S.23 perennial ryegrass obtained from a reputable local seedsman and sown in Deal Field, Begbroke Hill Farm on 10th May, 1966. The soil is a sandy loam over gravel. The average annual rainfall is 24 in.

Sampling procedure

A perennial ryegrass plant was taken from each of 5 random locations upon areas treated with dalapon at 5 lb a.i./ac at each of the first 3 sites, on 7th November, 1967. In addition 5 plants of untreated S.23 perennial ryegrass were collected from the Deal site at Begbroke.

On 9th November 3 tillers from each of the 20 plants collected were planted in labelled pots of John Innes compost (7 parts Begbroke loam, 3 parts peat and 2 parts fine gravel + complete fertiliser J. I. base). The 60 pots were placed in a fully randomised single block layout on the south bench of a greenhouse. They were given adequate water and light. The pots were removed from the greenhouse for hardening off under polythene frames on 25th January, 1968.

The plants were planted out in well-cultivated soil in Parker's Field, Begbroke Hill on 22nd February, 1968. The 3 separate tillers from each original plant were allocated one to each of 3 replicates in a fully randomised block design. There were thus 5 plants from each site in each replicate. The plants were spaced at 2 ft on the square. Unfortunately the plants suffered minor damage from hares and/or birds before they were protected. The effect was mainly defoliation and was not thought sufficiently severe to affect the course of the experiment.

A fertiliser application equivalent to 3 cwt/ac 20:10:10 N:P:K was applied to the experimental area on 5th April, 1968.

Assessments

The numbers of tillers per plant were counted on 23rd February on transplanting in the field. From mid-May onwards the plants were visited frequently in order to note the dates at which flowering commenced. Flower-head counts per plant were made at intervals throughout the summer. The total number of vegetative tillers on each plant were counted on 11th November, 1968.

## RESULTS

All the randomly selected tillers collected from the various sites rooted and developed normally in the greenhouse. The mean number of tillers per plant from each of the 4 sites after hardening off and immediately prior to planting was as follows:

| Caythorpe | Lutterworth | Thurgarton | Begbroke |
|---|---|---|---|
| 19.1 | 18.1 | 15.4 | 17.5 |

Frequent observation of the plants showed that on 29th May, 1968, 5 Caythorpe plants and 1 Lutterworth plant were near to emergence from the leaf sheath. On 4th June emergence was confirmed on these plants and 2 more from Lutterworth and 1 from Begbroke S.23 and Thurgarton.

The dates by which 50 and 80% of the plants from each site were flowering were as follows:

| | 50% | 80% |
|---|---|---|
| Lutterworth | 10th June | 13th June |
| Caythorpe | 10th - 13th June | 28th June |
| Thurgarton | 17th - 20th June | 20th June |
| Begbroke S.23 | 17th - 20th June | 25th June |

Fig. 1

Cumulative production of flowerheads of perennial ryegrass from Caythorpe, Thurgarton and Lutterworth and S.23 perennial ryegrass from Begbroke.

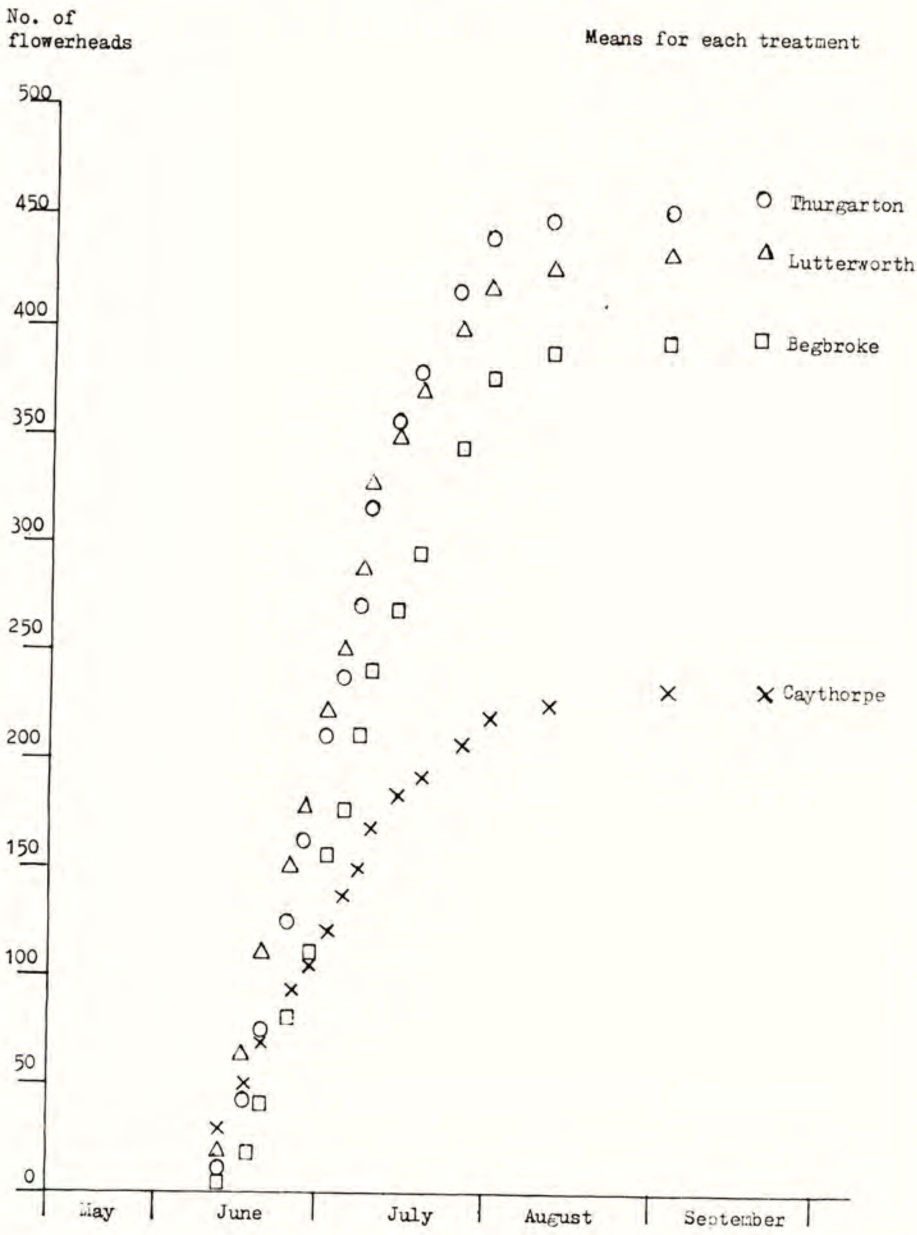
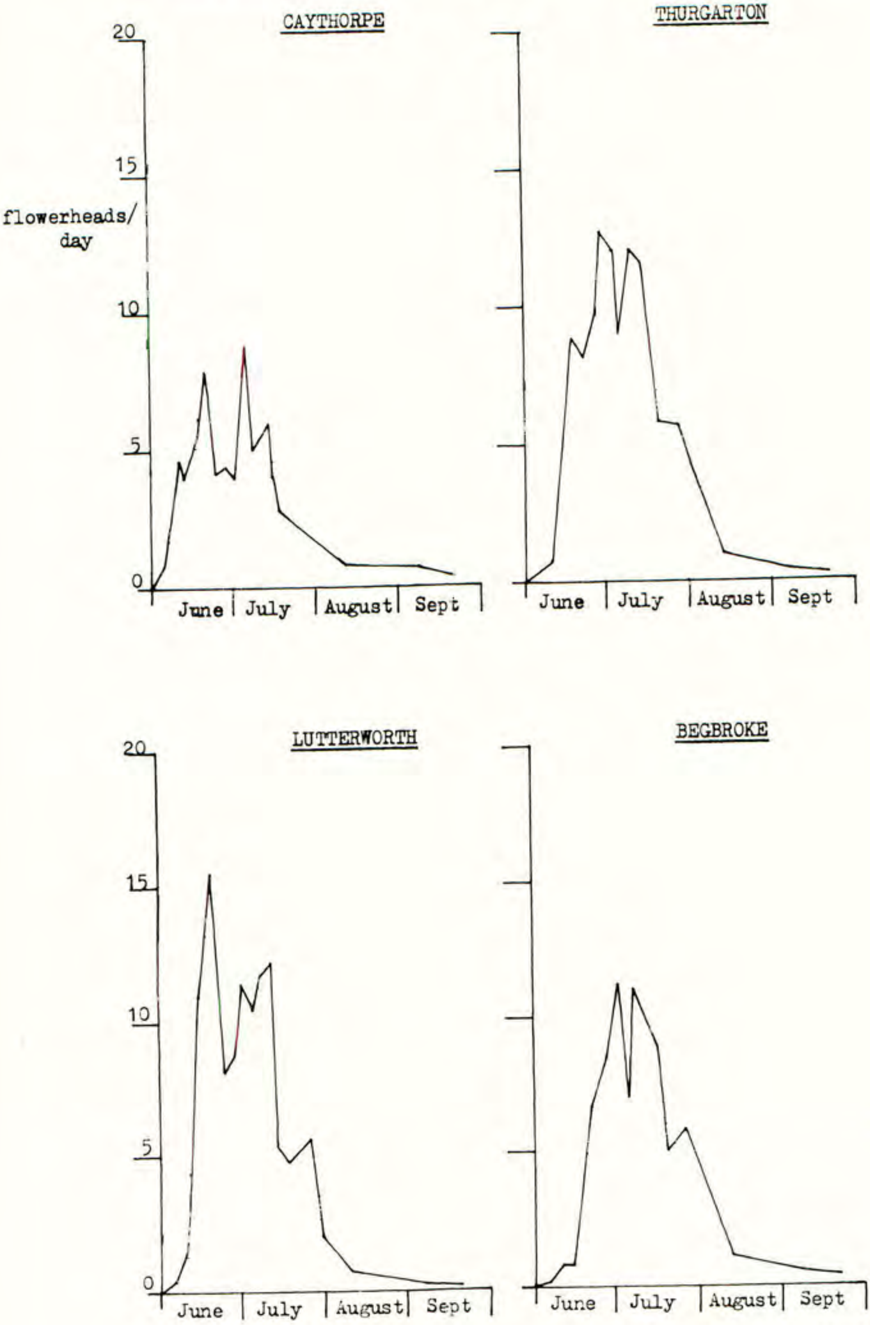


Fig. 2

Mean rate of flowerhead production by perennial ryegrass from Caythorpe, Thurgarton and Lutterworth and S.23 perennial ryegrass from Begbroke



The cumulative production of flowerheads can be seen in fig. 1. The graphs illustrate the common start of flowering in early June. It is also shown that the rates of production levelled off at about the same time from the beginning of August for all sites. Flowering by plants from Lutterworth and Thurgarton showed very similar curves and these plants produced the most flowers. Their graphs were also very similar to that shown for S.23 perennial ryegrass from Begbroke. Caythorpe flowerheads, however, did not reach such large numbers. The graphs in fig. 2 illustrate the mean increase in the number of flowerheads per day for the plants from each site. All the graphs show several peaks but it appears that on average all sites showed a maximum rate during the first week in July (apart from a single peak at Lutterworth on 20th June).

The number of tillers were counted on each plant in the experiment on 11th November, 1968, i.e. one year after being planted as single tillers in pots. The results were as follows:

| Caythorpe | Lutterworth | Thurgarton | Begbroke |
|---|---|---|---|
| 788 | 1447 | 1230 | 1162 |

S.E. difference = $\pm$ 174.3

The figures show a similar pattern to that of flowering at the 4 sites. Lutterworth, Thurgarton and Begbroke S.23 showed similar prolificy but Caythorpe produced significantly fewer tillers per plant. It was noted at this assessment that although the plants had originally been placed 2 ft apart on the square, they had grown so vigorously that very little bare soil was to be seen between them.

Observations on the growth habit of the plants from all 4 sites were made immediately after planting in the field on 23rd February and again on 8th July, 1968. It was noted that Caythorpe plants were rather more erect than those from Lutterworth and Thurgarton which were both very similar to Begbroke S.23 in habit. It appeared that the plants from Thurgarton were larger than those from the other sites.

## DISCUSSION

The comparison showed that there was little difference between the perennial ryegrass from unsprayed S.23 at Begbroke and the plants obtained from two of the three sites treated with dalapon. The plants from Lutterworth and Thurgarton were especially like those from Begbroke both in timing and production of flowerheads and in the number of tillers produced per plant. The growth habit of the plants from these three sites was very similar in displaying a prostrate form.

The plants from Caythorpe were less prolific in flowering and tillering and were more erect, unlike the Begbroke S.23 plants. Nevertheless they were desirable plants to have been encouraged by selective weed control.

Of the three sites upon which dalapon was used, on only one (Lutterworth) was it positively recorded that S.23 was sown 11 years before being sampled for the experiment. The field at Thurgarton was sown to a mixture containing perennial ryegrass in 1952, 15 years before sampling: the growth characteristics of plants would suggest that S.23 was a constituent of the seeds mixture. There is no record of what was sown 20-30 years ago at Caythorpe. The results of the experiment suggest that, free from the competition of other grasses and given adequate nutrition, all 4 ryegrasses would grow vigorously enough to justify the minor effort and expense involved in discouraging the weed grasses.

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# EXPERIMENTS USING DICAMBA GRANULES FOR THE CONTROL OF PTERIDIUM AQUILINUM (L) KUHN AND SUBSEQUENT SOWING OF SEEDS MIXTURE

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Summary Three centres were established to examine the use of dicamba granules for Pteridium aquilinum control and to follow chemical treatment with sowing a grass/clover mixture.

Dicamba at 1, 3 and 4 lb a.i./ac was applied in November and January/February followed in April by reseeding with and without cultivations on each treatment.

Results showed satisfactory control of Pteridium aquilinum with the highest doses of dicamba in the absence of a native grass cover but it proved difficult to establish sown seed satisfactorily without some cultivation. There was no apparent residual effect of dicamba on grass or clover establishment where the interval between chemical treatment and sowing exceeded three months.

## INTRODUCTION

The majority of easily ploughable Pteridium aquilinum (bracken) areas in Wales have been reclaimed. P. aquilinum is mainly confined to areas difficult or impossible to reseed by conventional methods. To be acceptable a method of reclaiming these remaining areas, which are often steep with uneven surfaces, must keep machinery involvement to the minimum.

Several workers, e.g. Hodgson (1964), Aldhouse (1964) and Mitchell (1968), have demonstrated the effectiveness of dicamba in P. aquilinum control and recently Farnworth and Davies (1968) had promising results with granulated dicamba as a pre-emergence application. Granulated material is easier to apply on difficult terrain and the experiments described here were initiated to see how granulated dicamba could be incorporated into a system of improving these areas. Parker and Hodgson (1966) showed that small residues of dicamba could persist for some time when the pH is raised and it has been thought that this might be dangerous to clover establishment. The work described examines the feasibility of establishing a grass/clover mixture after dicamba treatments.

## METHOD AND MATERIALS

Three centres were chosen in Wales. All had a dense and uniform cover of P. aquilinum, two sites having little or no underlying vegetation with a thick layer of debris on the soil surface. The third site had up to 85% cover of native vegetation dominantly Agrostis spp.

Each site carried six herbicide treatments as follows:-

| Treatment No. | Dose of dicamba a.i./ac as 10% granules | Time of application |
|---|---|---|
| *1 | 1 lb | Nov |
| *2 | 3 lb | Nov |
| *3 | 4 lb | Nov |
| 4 | 1 lb | Jan/Feb |
| 5 | 3 lb | Jan/Feb |
| 6 | 4 lb | Jan/Feb |

*At centre 2 these were at 2, 6 and 8 lb a.i./ac respectively

The herbicide formulation used was 10% dicamba plus 1.8% related acids on attapulgite clay granules.

Each treatment was divided in half, one half being rotary cultivated twice prior to reseeding with the other getting no cultivation. This gave a total of twelve plots per site, each plot measuring 22 x 7 yd.

The experiments were laid down in the autumn of 1968 and all areas to be treated had a basal dressing of 40 cwt/ac ground limestone in November. Super phosphate at 8 cwt/ac was applied with the dicamba in one centre and separately in the others. When reseeding in April 1969 all treatments were top dressed with 2 cwt/ac of a compound fertiliser. A seeds mixture of S.24, S.23 perennial ryegrass and S.100 white clover was used.

The sites were fenced to exclude stock but following seed establishment the plots have been grazed at intervals by sheep.

RESULTS

Four x 1 $yd^2$ permanent quadrats were established on a randomised basis within each plot and immediately outside the treated area to serve as control. All fronds within these quadrats (including those completely stunted) were counted at various times in 1969 and 1970 and at two centres they were classified as to degree of stunting. The tables below show the degree of control achieved with each treatment.

Table 1

Number of fronds in cultivated plots as a percentage of the control

| | Centres | | | | | |
|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | |
| Treatment | 1969 | 1970 | 1969 | 1970 | 1969 | 1970 |
| 1 | 40 | 61 | 148 | 139 | 53 | 57 |
| 2 | 16 | 40 | 50 | 70 | 40 | 95 |
| 3 | 0 | 6 | 8 | 13 | 55 | 57 |
| 4 | 39 | 40 | 130 | 169 | 68 | 66 |
| 5 | 57 | 56 | 67 | 89 | 46 | 43 |
| 6 | 22 | 44 | 20 | 30 | 52 | 61 |

Table 2

Number of fronds in uncultivated plots as a percentage of the control

| | Centres | | | | | |
|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | |
| Treatment | 1969 | 1970 | 1969 | 1970 | 1969 | 1970 |
| 1 | 29 | 89 | 94 | 143 | 90 | 57 |
| 2 | 9 | 38 | 23 | 47 | 54 | 49 |
| 3 | 0 | 7 | 14 | 21 | 71 | 66 |
| 4 | 92 | 106 | 155 | 254 | 85 | 75 |
| 5 | 58 | 64 | 80 | 211 | 85 | 63 |
| 6 | 51 | 96 | 42 | 133 | 127 | 71 |

Numerical counts did not give a true picture of the herbicidal effect of dicamba on P. aquilinum as many fronds counted were completely stunted. At two centres the fronds were therefore classified as follows:-

A. Shoots completely stunted with no green leaves.
B. Fronds with a few green leaves though stunted.
C. Fronds with all green leaves but sometimes stunted.

Tables 3 and 4 show the number of fronds in each category for all the treatments at centres 1 and 2.

Table 3

Classification of fronds in cultivated plots
(1969 assessment)

| | Centre 1 | | | Centre 2 | | |
|---|---|---|---|---|---|---|
| Treatment | A | B | C | A | B | C |
| 1 | 10 | 18 | 68 | 18 | 20 | 144 |
| 2 | 9 | 9 | 21 | 33 | 17 | 12 |
| 3 | 0 | 0 | 0 | 9 | 1 | 0 |
| 4 | 0 | 14 | 78 | 30 | 35 | 95 |
| 5 | 13 | 48 | 74 | 37 | 33 | 13 |
| 6 | 16 | 13 | 23 | 21 | 4 | 0 |

Table 4

Classification of fronds in uncultivated plots
(1969 assessment)

| Treatment | Centre 1 A | Centre 1 B | Centre 1 C | Centre 2 A | Centre 2 B | Centre 2 C |
|---|---|---|---|---|---|---|
| 1 | 37 | 6 | 25 | 102 | 12 | 2 |
| 2 | 22 | 2 | 0 | 25 | 3 | 0 |
| 3 | 0 | 0 | 0 | 17 | 0 | 0 |
| 4 | 37 | 15 | 166 | 67 | 43 | 80 |
| 5 | 101 | 23 | 14 | 87 | 11 | 0 |
| 6 | 88 | 26 | 8 | 52 | 0 | 0 |

A repeat of this assessment in 1970 indicated an increase in the proportion of fronds in category C in each treatment.

The establishment of sown species was ascertained by botanical analyses in August/September 1969. Ten x ten point quadrats were taken at random in each plot at centres 1 and 2 and the results are shown below.

Table 5

Botanical analysis of plots at centre 1

| Cultivated treatments | Perennial ryegrass | Clover | *Other grasses and weeds | Bare ground |
|---|---|---|---|---|
| 1 | 53 | 21 | 26 | - |
| 2 | 64 | 23 | 13 | - |
| 3 | 64 | 20 | 16 | - |
| 4 | 64 | 24 | 12 | - |
| 5 | 63 | 12 | 25 | - |
| 6 | 65 | 18 | 8 | 9 |
| Uncultivated treatments | | | | |
| 1 | 3 | - | 30 | 67 |
| 2 | 8 | - | 49 | 43 |
| 3 | 41 | - | 14 | 45 |
| 4 | 5 | - | 17 | 78 |
| 5 | 27 | - | 33 | 40 |
| 6 | 28 | - | 36 | 36 |

*Mainly *Agrostis tenuis* and *Agrostis stolonifera*, small quantities of *Festuca ovina*, *Holcus lanatus* and *Anthoxanthum odoratum*.

Table 6

Botanical analysis of plots at centre 2

| Cultivated treatments | Perennial ryegrass | Clover | Other grasses and weeds | Bare ground |
|---|---|---|---|---|
| 1 | 76 | 18 | 1 | 5 |
| 2 | 78 | 11 | 2 | 9 |
| 3 | 81 | 10 | 1 | 8 |
| 4 | 83 | 7 | - | 10 |
| 5 | 84 | 3 | 4 | 9 |
| 6 | 90 | 3 | 3 | 4 |
| Uncultivated treatments | | | | |
| 1 | 27 | - | 1 | 72 |
| 2 | 28 | - | - | 72 |
| 3 | 21 | - | - | 79 |
| 4 | 15 | - | - | 85 |
| 5 | 22 | - | 1 | 77 |
| 6 | 28 | - | - | 72 |

The point quadrat method was not used at centre 3 but visual assessment indicated poorer establishment of sown seed. The cultivated plots had an estimated 40% cover of sown species and the uncultivated plots less than 5%, with no visual difference between treatments.

DISCUSSION

A recognisable pattern of control has emerged at centres 1 and 2 with the highest dose of dicamba completely suppressing effective P. aquilinum growth. It is also apparent at both centres that November treatments are generally superior to January/February treatments although this would be expected at centre 2 where double doses of dicamba were used. Effective control was maintained into the second year at the higher doses.

At the third centre however, no distinct pattern emerged and although total number of fronds were reduced in all treatments, control was generally poor. The dicamba was mixed with superphosphate for application at this site but it is doubtful if this reduced the effectiveness of the herbicide. Probably more significant was the cover of native vegetation on the site which could have interfered with the passage of dicamba to the rhizomes. The pursue this theory all treatments were repeated on this site in 1969/70 but at twice the original doses.

The November applications were again disappointing but all February treatments particularly the two higher doses proved very effective. This suggests that other factors - possibly climatic conditions at time of application were involved but there is no clear evidence of this.

At all centres light cultivations before sowing improved establishment of sown grass seed and in this instance improved clover establishment. Where native vegetation was absent excellent establishment was achieved. Clover appeared normal in all treatments where it established but at centre 2 botanical analyses in September 1969 suggested poorer establishment after February dicamba applications. Here seed was sown five weeks after herbicide treatments. The differences became more apparent in 1970 positively indicating a slight suppression of clover growth in the February treatments. At centre 1 where there were fourteen weeks between herbicide treatment and seed sowing clover was generally well established. No differences emerged at centre 3 where grass and clover establishment was generally poorer.

On the uncultivated plots where seed was sown on the undisturbed surface clover did not establish at any centre and grass establishment was sporadic throughout. This was to be expected, as the spongy debris on two sites and the mat of native vegetation on the other were unsuitable media for seed establishment. It could have been beneficial to use a heavy stocking of sheep for a short time after sowing seed to consolidate the surface, or to leave sowing of seed for twelve months for the lime to decompose much of the surface mat and debris.

Observations on the uncultivated plots in 1970 indicated an improved ground cover of sown ryegrass compared with 1969, with isolated plants of clover coming in.

These experiments indicate the potential of a system incorporating granulated dicamba in improving difficult areas covered with _P. aquilinum_. Further work is necessary to determine how the native vegetation, weather and other factors interfere with the degree of control achieved.

## Acknowledgments

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# WEED CONTROL IN SPRING SOWN FIELD BEANS

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**Summary** A comparison was made of pre and post-emergence herbicides using simazine, two dinoseb formulations and a dinoseb/monolinuron mixture, for the control of dicotyledonous weeds in spring field beans. Simazine at 12 oz ai/ac pre-emergence was confirmed as the most satisfactory treatment. Generally the herbicides did not improve the yield of the crop despite effective control of weeds and in some cases phytotoxic symptoms were noticeable followed by significant reductions in yield.

## INTRODUCTION

Simazine applied pre-emergence is the established herbicide for weed control in field beans. It is active against a wide range of dicotyledons and gives a useful control of germinating grass weeds particularly *Alopecurus myosuroides* (blackgrass). However, crop damage has occurred as a result of overdosing caused by faulty application and also when normal doses have been applied to crops sown with insufficient soil cover. In addition soil and weather conditions can prevent the use of simazine as a pre-emergence spray. The following report gives details of field trials carried out in 1967, 1968 and 1969 to compare alternative herbicides based on dinoseb.

## METHOD AND MATERIALS

Three experiments were situated on silty clay loam soils over the Upper Chalk in Hampshire and one on sandy clay loam in Essex. The cultivars of spring field beans used were Minor, Maris Bead and Blue Roc.

Treatments applied were as follows:-

1. Pre-emergence

    12 oz ai/ac simazine
    40 oz ai/ac dinoseb acetate + monolinuron

2. Post-emergence of crop and weeds

    24 oz ai/ac dinoseb acetate
    40 oz ai/ac dinoseb acetate
    24 oz ai/ac dinoseb amine
    40 oz ai/ac dinoseb acetate + monolinuron
    12 oz ai/ac simazine

Control plots with no herbicide treatment were included in the trials.

The dinoseb amine used was in the form of an emulsifiable concentrate, all other materials were wettable powder formulations.

A Land Rover mounted sprayer unit was used covering an area of 5 yd x 44 yd to allow a combine cut to be taken from the centre of each plot. The pre-emergence sprays were applied in 20 gal/ac with fan nozzles at 35 psi. The boom was set at 20 in above the soil or above the main density of the crop. The post-emergence sprays were applied in 40 gal/ac across the direction of the drills. A light harrowing was included in one of the Hampshire trials and this was applied when the beans were 2 - 3 in high and the weeds mainly in the one leaf stage. The experiments were laid out as randomised blocks with three replications in the Hampshire trials and six in the Essex trial.

Details of site, date of treatment, stage of growth of crop and weed and density of weeds are shown in Table 1.

Table 1

Details of Sites

| Site | Crop | | Weed | |
|---|---|---|---|---|
| | Date of spraying | Stage of growth | No of leaves | Density Plants/$ft^2$ |
| Bridget's EHF Winchester CV Minor sown 22/3/67 | 30/3/67<br>11/5/67 | Pre-emergence<br>2 - 3 leaves | -<br>1 - 2 | -<br>5.4 |
| Bridget's EHF Winchester CV Maris Bead sown 8/3/68 | 8/3/68<br>15/5/68 | Pre-emergence<br>2 - 3 leaves | -<br>1 - 2 | -<br>17.8 |
| West Stoke Farm Stoke Charity CV Blue Roc sown 10/3/69 | 26/3/69<br>29/4/69 | Pre-emergence<br>2 - 3 leaves | -<br>1 - 4 | -<br>4.5 |
| Essex CV Minor sown 29/3/69 | 8/4/69<br>8/5/69 | Pre-emergence<br>4 leaves | -<br>- | -<br>- |

RESULTS

Scores on plant density counts for degree of weed control and effect on crop growth were made during the growing season and are shown in Tables 2 and 3.

Table 2

**Control of broad-leaf weeds by herbicides**

(Scores for weed density 0 = none, 10 = maximum density)

| Site and date | Bridget's EHF 22/5/67 | Bridget's EHF 10/6/68 | | West Stoke 27/5/69 | Essex 17/5/69 | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Score | |
| Treatment | Plants/ft$^2$ | Plants/ft$^2$ | Score | Score | *Stellaria media* | *Polygonum aviculare* | *Veronica* spp. |
| **Pre-emergence** | | | | | | | |
| Simazine | 0.96 | 3.25 | 1.4 | 2.5 | 0 | 4.5 | 0 |
| Dinoseb/monolinuron | - | - | | 3.2 | | | |
| **Post-emergence** | | | | | | | |
| 24 oz dinoseb acetate | 4.02 | 16.7 | 6.2 | - | - | - | - |
| 40 oz dinoseb acetate | 1.79 | 14.4 | 5.0 | 2.0 | 3.8 | 8.2 | 6.5 |
| Dinoseb amine | 1.67 | 14.4 | 3.7 | - | - | - | - |
| Dinoseb/monolinuron | - | - | - | 1.0 | 0 | 6.3 | 4.0 |
| Simazine | - | - | - | 4.7 | - | - | - |
| Harrowed once | - | - | - | 5.6 | - | - | - |
| Untreated | 5.35 | 17.8 | 7.1 | 9.2 | 9.2 | 9.3 | 9.3 |
| SE means | ± 0.48 | ± 1.34 | - | ± 0.54 | - | - | - |

Dominant weeds in the Hampshire trials were *Polygonum aviculare* (knotgrass) and *P. convolvulus* (black bindweed)

Table 3

**Effect of herbicides on the Crop**
(Damage score 0 = no damage, 10 = no crop)
(Crop density 0 = no crop, 10 = full crop)

| Site | Bridget's EHF | | | Bridget's EHF | | | West Stoke | | Essex | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date of scores | 22.5.67 | | | 10.6.68 | | | 27.5.69 | | 2.9.69 | |
| Treatment | Plants /ft$^2$ | Damage score | Yield % of control | Plants /ft$^2$ | Damage score | Yield % of control | Density score | Yield % of control | Height of crop (in) | Yield % of control |
| **Pre-emergence** | | | | | | | | | | |
| Simazine | 3.10 | 0.3 | 100.0 | 1.60 | 0.7 | 86.4 | 8.4 | 95.7 | 29.3 | 93.3 |
| Dinoseb/monolinuron | - | - | - | - | - | - | 8.7 | 103.5 | - | - |
| **Post-emergence** | | | | | | | | | | |
| 24 oz dinoseb acetate | 3.01 | 2.0 | 99.3 | 1.87 | 1.0 | 82.6 | - | - | - | - |
| 40 oz dinoseb acetate | 3.08 | 2.8 | 97.7 | 1.73 | 1.4 | 106.8 | 6.7 | 101.4 | 29.0 | 82.7 |
| Dinoseb amine | 3.17 | 5.0 | 93.1 | 1.45 | 2.5 | 67.4 | - | - | - | - |
| Dinoseb/monolinuron | - | - | - | - | - | - | 4.1 | 77.7 | 21.5 | 65.9 |
| Simazine | - | - | - | - | - | - | 6.9 | 86.2 | - | - |
| Harrowed once | - | - | - | - | - | - | 6.5 | 92.5 | - | - |
| Untreated | 3.10 | 0.0 | 100.0 | 1.60 | 0.0 | 100.0 | 8.4 | 100.0 | 31.7 | 100.0 |
| SE means | ±0.240 | ±0.33 | ±2.36% | ±0.142 | - | ±8.93% | ±0.31 | ±5.17% | - | ±4.72% |

## DISCUSSION

Simazine applied pre-emergence gave the most consistent control of weeds in these trials. It was particularly effective against the dominant weeds present, Polygonum aviculare (knotgrass) and P. convolvulus (black bindweed). Although Galium aparine (cleavers) was not well controlled it did not constitute a problem at harvest. The dinoseb/monolinuron mixture was less damaging to the crop than simazine but was less effective against P. convolvulus (black bindweed). Simazine applied post-emergence of the crop was less active against weeds and reduced crop yield.

Of the post-emergence chemicals the amine formulation of dinoseb produced considerably more crop damage than the acetate. For adequate weed control the acetate formulation required the higher dose of 40 oz per acre but it was noticeable with this herbicide that Polygonum spp. became more resistant after the two leaf stage of growth. The harrowing treatment tended to reduce crop density and weed control was relatively poor, with very high weed densities it seems unlikely that cultivation would prevent weeds causing trouble at harvest.

Although simazine applied pre-emergence gave adequate control of the weeds present there was no apparent improvement in yield over the unsprayed crop. Dinoseb/monolinuron pre-emergence was less toxic to the crop than simazine but its higher cost would tend to preclude its use in a relatively low value crop such as field beans. Dinoseb acetate offers an alternative as a post-emergence herbicide provided weeds are at an early stage of growth, but it requires high volume application and its efficiency may be affected by temperature and humidity conditions at the time of spraying.

# EXPERIMENTS ON THE CONTROL OF WEEDS IN FIELD BEANS WITH N-(1,1-DIMETHYLPROPYNYL)-3,5-DICHLOROBENZAMIDE (RH 315)

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Summary Control of Avena spp. and Alopecurus myosuroides in winter field beans following pre-emergent application of pronamide (RH 315) has been excellent. Broad leaved weed control where assessed was equal to or better than the standard simazine treatment. Where present, promising suppression of Agropyron repens was obtained. Results on weed control in spring beans have been good, but more variable. Little or no phyto-toxicity to the crop was observed at the lower doses. Where yields were assessed, they were all greater than the control, except at one site. Good control of Agropyron repens and Agrostis spp. has been observed in applications to stubble and fallow in the autumn.

## INTRODUCTION

N-(1,1-dimethylpropynyl)-3,5-dichlorobenzamide (RH 315) now known as pronamide is a residaul herbicide of low toxicity. Early screening work by Rohm and Haas in Philadelphia, U.S.A., showed the compound to be a selective broad spectrum herbicide for use in a range of crop situations with particular activity against grass weed species. de Sarjas and Perrot (1969) have shown that it is particularly selective on Compositae and Leguminosae whilst being toxic to the families Gramineae, Cruciferae, Caryophyllaceae, Polygonaceae and several others. Pronamide acts via the soil, its activity being related to soil moisture and temperature, falling off rapidly in warm dry conditions.

Trials were first carried out in the United Kingdom in the autumn of 1968 and were continued in 1969 and 1970. They were designed to examine the effectiveness of pronamide on perennial and annual grass weeds in several crops. This paper describes the trials carried out on field beans (Vicia faba), fallow and cereal stubbles. The results on lettuce and strawberries are to be found elsewhere at this Conference.

## METHOD AND MATERIALS

### Trials in field beans

These consisted of either replicated small plots or field strips which were not replicated (Table 1). For the small plot trials a minimum size of 50 $yd^2$ per plot was used and application was made using either a Van de Weij or an Oxford Precision Sprayer. Both were used at a pressure of 30 p.s.i. and 20 gal/ac, except on Site 8.

The field strips were applied by a standard tractor mounted sprayer. All applications were made shortly after the beans had been planted and before emergence.

Stubble/fallow trials

Three trials were carried out, two on a fallow and one on a stubble after harvest. Details of cultivations and following crops can be found in Table 3. The treatments were applied by Van de Weij at 20 gal/ac.

Assessments

All trials and strips were assessed as follows:-

Crop vigour - on a 1 - 10 grading where 10 = untreated.
Yield (% control) - a combine harvester was used. Results corrected to 85% dry matter.
Weed results - assessed visually and expressed as % untreated.

Formulation

Pronamide was applied as a 75% wettable powder in all cases.

Table 1

Crop, application and site details for all trials

| Site | Crop | Plot size $yd^2$ | No. of reps. | Water gal/ac | Date of application | Date of assessment | Soil type |
|---|---|---|---|---|---|---|---|
| 1 | Winter beans | 350 | 2 | 20 | 6.10.69 | 28.5.70 | silt loam |
| 2 | Winter beans | 50 | 3 | 20 | 22.10.69 | 18.5.70 | clay loam |
| 3 | Winter beans | 224 | 1 | 20 | 22.10.69 | 18.5.70 | sandy loam |
| 4 | Winter beans | 50 | 4 | 20 | 13.11.69 | 26.5.70 | clay loam |
| 5 | Winter beans | 50 | 4 | 20 | 11.11.69 | 10.7.70 | clay loam |
| 6 | Winter beans | 50 | 3 | 20 | 11.11.69 | 11.7.70 | clay loam |
| 7 | Spring beans | 224 | 1 | 20 | 14. 4.70 | 8.7.70 | clay loam |
| 8 | Spring beans | 200 | 3 | 38 | 20. 3.70 | 26.6.70 | silt loam |
| 9 | Spring beans | 110 | 2 | 20 | 8. 4.70 | 8.7.70 | sandy loam |
| 10 | Fallow | 50 | 4 | 20 | 10.11.69 | 25.4.70 | sandy loam |
| 11 | Fallow | 50 | 3 | 20 | 30. 9.69 | 19.5.70 | clay loam |
| 12 | Stubble | 50 | 3 | 20 | 17.10.69 | 16.7.70 | clay loam |

## RESULTS

Table 2

The effect of pronamide on field beans and weeds

| Site | Treatment in lb a.i./ac | | Crop vigour | Crop yield % control | Weed Control as % Untreated: Avena spp. | Alopecurus myosuroides | Agropyron repens | Broad leaved weeds |
|---|---|---|---|---|---|---|---|---|
| **Winter bean sites** | | | | | | | | |
| 1 | Pronamide | 1.5 | 8.5 | 132 | 93.5 | - | 69 | - |
| | Simazine | 0.75 | 9.0 | 133 | 70.5 | - | - | - |
| 2 | Pronamide | 1.0 | 10 | 159 | 100 | 100 | | 84 |
| | | 1.5 | 9.0 | 142 | 100 | 94 | | 83 |
| | | 2.0 | 8.0 | 146 | 100 | 100 | | 89 |
| | Simazine | 0.75 | 10 | 114 | 39 | 14 | | 43 |
| | Control | | 10 | 100 | - | - | | - |
| 3 | Pronamide | 1.0 | 9.5 | 155 | 98 | 100 | | 81 |
| | | 1.5 | 8.5 | 140 | 100 | 100 | | 90 |
| | | 2.0 | 8.5 | 140 | 100 | 100 | | 92 |
| | Simazine | 0.75 | 9.5 | 114 | 0 | 11 | | 68 |
| | Control | | 10 | 100 | - | - | | - |
| 4 | Pronamide | 1.0 | 9.0 | 96 | | | 22 | |
| | | 1.5 | 8.5 | 94 | | | 51 | |
| | | 2.0 | 8.0 | - | | | 68 | |
| | Simazine | 0.75 | 10 | 95 | | | 0 | |
| | Control | | 10 | | | | - | |
| 5 | Pronamide | 1.0 | 10 | | 93 | | | |
| | | 1.5 | 9.5 | | 98 | | | |
| | | 2.0 | 9.0 | | 96 | | | |
| | Simazine | 1.0 | 10 | | 14 | | | |
| | Control | | 10 | | | | | |
| 6 | Pronamide | 1.0 | 10 | | 83 | | | |
| | | 1.5 | 9.7 | | 87 | | | |
| | | 2.0 | 6.0 | | 94 | | | |
| | Simazine | 1.0 | 10 | | 50 | | | |
| | Control | | 10 | | | | | |
| **Spring bean sites** | | | | | | | | |
| 7 | Pronamide | 0.75 | 10 | 108 | 44 | | | 40 |
| | | 1.0 | 10 | 116 | 72 | | | 42 |
| | | 1.5 | 9.5 | 104 | 68 | | | 48 |
| | Simazine | 0.75 | 10 | 108 | 21 | | | 61 |
| | Control | | 10 | - | - | | | - |
| 8 | Pronamide | 1.5 | 9.5 | 126 | 100 | | | 82 |
| | Simazine | 0.75 | 9.5 | 102 | 40 | | | 86 |
| | Control | | 10 | 100 | - | | | - |
| 9 | Pronamide | 0.75 | 10 | | 35 | | | 54 |
| | | 1.5 | 9.0 | | 88 | | | 66 |
| | Simazine | 0.75 | 10 | | 14 | | | 69 |
| | Control | | 10 | | - | | | - |

Table 3

The effect of pronamide on weeds in fallow and cereal stubble

| | Site 10 pronamide lb a.i./ac | | | Site 11 pronamide lb a.i./ac | | Site 12 pronamide lb a.i./ac | | |
|---|---|---|---|---|---|---|---|---|
| Weed control | 1.5 | 2.0 | 4.0 | 1.0 | 2.0 | 0.75 | 1.5 | 3.0 |
| Agropyron repens | 98 | 95 | 94 | 42 | 73 | 38 | 85 | 94 |
| Agrostis spp. | 100 | 100 | 100 | - | - | - | - | - |
| Alopecurus myosuroides | 98 | 99 | 100 | - | - | - | - | - |
| Poa annua | 100 | 100 | 100 | 100 | 100 | 95 | 95 | 100 |
| Stellaria media | - | - | - | 94 | 100 | 78 | 95 | 100 |
| Veronica spp. | 92 | 98 | 100 | 85 | 95 | 80 | 82 | 100 |
| Galium aparine | 17 | 100 | 86 | 46 | 100 | - | - | - |
| Total broad leaf weed control | 84 | 84 | 95 | 75 | 89 | 61 | 81 | 84 |
| | Surface cultivated before spraying | | | No cultivation before spraying | | Surface cultivated before spraying | | |
| | Ploughed 12 weeks after spraying | | | Ploughed 4 weeks after spraying | | Ploughed 9 weeks after spraying | | |
| Following crop | Spring beans | | | Sugar beet | | Potatoes | | |

## DISCUSSION

### Field beans (Table 2)

Although no statistical analysis has been carried out it can be seen that treatments to winter beans were superior in effect to those applied to spring beans. In the winter sown crops, the control of Avena spp. and Alopecurus myosuroides was virtually complete. Agropyron repens only occurred in two trials at an acceptable level, both on winter beans. The higher doses of pronamide gave a useful suppression but below 1.5 lb a.i./ac the effect was only marginal, although there was a decrease in shoot length and vigour not indicated by the results in Table 2. Annual broad leaved weeds were well controlled in the winter applied trials. Members of the family Compositae were resistant to all doses of pronamide. Control of Stellaria media and Polygonum spp. was excellent, but Veronica spp. were only moderately susceptible. There was evidence at all sites assessed in July of recent germination of broad leaved weed seedlings which were not affected by the pronamide applications. This appears to agree with the results of de Sarjas and Perrot (1969) in which the chemical breaks down as soil temperatures rise. This is further reflected in the results obtained in spring planted beans. All three trials were drilled abnormally late and drilling was followed by dry warm conditions. At Site 8 in Berkshire, drilling was earlier and good control of both Avena spp. and broad leaved weeds was obtained. At the other spring bean sites, simazine gave better overall weed control although control of Avena spp. was somewhat better with pronamide.

All pronamide treatments above 1.0 lb a.i./ac caused a reduction in crop vigour and in some cases reduction of crop stand. The 1.0 lb a.i./ac treatment would appear, from these results, to be the optimum level for both efficient weed control and adequate crop safety in winter sown beans. The results indicate, however, that at this dose only a check to Agropyron repens will be obtained. From observations at Site 10, it would appear that Agrostis spp. are more susceptible to pronamide than Agropyron repens and this agrees with observations from the U.S.A.

Fallow and Stubble (Table 3)

The results show that good control of Agropyron repens and annual grass and broad leaved weeds can be obtained with pronamide when applied to fallow situations or on cereal stubble following harvest. Best results are obtained when ploughing is delayed following application. At Site 11 the field was ploughed four weeks after application, whereas at Sites 10 and 12, ploughing was delayed until after Christmas. At these latter sites, the fields were surface cultivated prior to application and this may be desirable for optimum results. The main resistant broad leaved weeds were Matricaria spp, Senecio vulgaris, Capsella bursa pastoris and Cirsium spp. Pronamide has considerable residual activity especially under cool moist conditions, and further work including trials on the effect on following crops will be required. Initial work shows that following autumn applications of pronamide early spring planted cereals cannot be grown. Doses as low as 1.0 lb a.i./ac to stubble in October caused severe damage to the crop stand of spring barley and moderate damage to spring wheat drilled in March. Potatoes, peas, beans, sugar beet and brassicas drilled in late March and April of the following spring showed no damage symptoms.

## Acknowledgments

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# THE SELECTIVE CONTROL OF ANNUAL AND PERENNIAL GRASS WEEDS IN FIELD BEANS (VICIA FABA L.) BY EPTC, CHLORPROPHAM AND SIMAZINE

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Summary In eight experiments carried out during 1969 and 1970 field beans suffered varying degrees of damage by pre-planting incorporated applications of EPTC and chlorpropham. In different experiments the extent of damage by EPTC was not directly related to the interval between application and planting, and the reasons for this are discussed. Chlorpropham was more damaging when incorporated before planting the beans than when applied to the soil surface after planting.

Control of Agropyron repens was poor with both EPTC and chlorpropham. Avena fatua was controlled moderately well by EPTC and better by simazine but the survivors were able to make vigorous growth. Simazine gave good control of dicotyledonous weeds, while chlorpropham and EPTC gave only partial control due to the presence of resistant species.

## INTRODUCTION

Field beans are being grown increasingly as a break crop where cereals are being grown more or less continuously. The effectiveness of the bean crop as a break between cereals may be reduced by inability to control grass weeds, notably Avena fatua and the rhizomatous grasses Agropyron repens and Agrostis gigantea. These can multiply rapidly in beans which are generally less competitive than cereals (Cussans, 1968), and so build up reserves of seed or rhizome to infest the cereals in the following years. They may also act as alternative hosts for cereal diseases.

Simazine has been accepted almost universally for weed control in field beans, but it is ineffective against rhizomatous grasses, and inconsistent in its control of A. fatua. Simazine has cost up to £3/ac and, in this low value crop, it is difficult to justify an additional cost for rhizomatous grass weed control. The requirement of the crop is for a weed control system that will control grass and dicotyledonous weeds, with priority for the former in many cases.

In a previous report (Holroyd and Wilson 1968) EPTC was shown to give good control of A. repens in field beans, but more work was needed to determine the necessary safe interval between spraying and planting to avoid damaging the crop. Further experiments, carried out during 1969 and 1970, are described here in which EPTC was applied at various intervals before planting.

EPTC has been shown to control certain broad leaved weeds (Bartlett and Marks 1966), but several species, notably Polygonum spp. are tolerant of this chemical. In some experiments reported here, chlorpropham was added to extend the range of susceptible species, and their control compared with that given by a standard simazine treatment.

Both EPTC and chlorpropham are active against graminaceous species, and control of both A. repens and A. fatua was examined in field beans in six experiments carried out during 1969 and 1970.

## METHOD AND MATERIALS

The experiments described are divided into two groups: two experiments carried out at Begbroke Hill on a sandy loam soil, and six experiments carried out elsewhere on a range of soil types.

Table 1

Details of Experiments at Begbroke Hill

| Experiment | Date of application | Method of incorporation | Date of planting | Rates of application lb/ac a.i. EPTC | Chlorpropham |
|---|---|---|---|---|---|
| 1969 | 27 March | Rotary cultivation | 27 March | 4,8 | 1 |
| 1970 | 21 March | Rotary cultivation | 4 April | 4,8 | 2,4 |
| | 26 March | " | " | 4,8 | |
| | 3 April | " | " | 4,8 | 2,4 |
| | 8 April | Nil | " | | 2,4 |
| | 17 April | Nil | " | | 2,4 |

The experiments were of randomised block design, and replicated three times (1969) and four times (1970). Plot size was 8 ft x 30 ft (1969) and 8 ft x 18 ft (1970). In both experiments e.c. formulations of the two herbicides were applied with an Oxford Precision Sprayer at 25 gal/ac. Those treatments which were incorporated were rotary cultivated to 2-3 in. within a few minutes of application. In the 1969 experiment, dinoseb amine 3 lb/ac was applied pre-emergence for the control of dicotyledonous weeds. In the 1970 experiment treatments were applied and incorporated at three different dates prior to planting; at each date untreated control plots were similarly rotary cultivated. Planting in this experiment was carried out with independent single row seeder units which were adjusted to plant the beans at depths of either 1, 2 or 3 in. Each plot consisted of six rows, two for each drilling depth, with guard rows sown at 2 in. Dicotyledonous weeds were counted in May after which the whole experiment was sprayed with dinoseb acetate 2.5 lb/ac a.i.

In both experiments the beans were counted at intervals during emergence, and damage symptoms noted after they had emerged. In the 1970 experiment the beans on the untreated control plots and the chlorpropham plots were harvested and threshed for yield when mature.

Other Experiments (Table 2)

All experiments were of randomised block design, replicated three times with plots 12 ft x 40 ft (1969), or replicated four times with plots 15 ft x 40 ft (1970). Treatments were applied with an Oxford Precision Sprayer at 25 gal/ac and incorporated treatments were cultivated in within a few minutes of application. Both the crop and weeds were assessed by counting plants in random quadrats. Beans were counted on all sites, A. repens on four sites, A fatua on two sites and broad leaved weeds on three sites. Experiment 1970-E was sprayed with dinoseb acetate 2,5 lb/ac a.i. on 15th May after the weeds were counted.

Table 2

Details of other Experiments

| Experiment | Soil type | Dates of application | Method of incorporation | Date of planting | Rates of application lb/ac a.i. EPTC | Chlorpropham | Simazine |
|---|---|---|---|---|---|---|---|
| 1969 | Loam over limestone | 5 March | Rotary cultivation | 8 March | 4 | 1 | |
| | | 11 March | Nil | 8 March | | | $\frac{3}{4}$ |
| 1970-A | Clay loam over limestone | 16 March | Spring tine harrow | 17 March | 2,4 | 1,1½,2 | |
| | | 25 March | Nil | 17 March | | 1,1½,2 | [illegible] |
| 1970-B | Clay loam | 27 Feb. | Spring tine harrow | 26 Feb* | 2,4 | 1,1½,2 | |
| | | 17 March | Nil | 26 Feb* | | 1,1½,2 | $\frac{3}{4}$ |
| 1970-C | Loamy clay | 19 March | Spring tine harrow | 22 March | 2,4 | 1,1½,2 | |
| | | 25 March | Nil | 22 March | | 1,1½,2 | $\frac{3}{4}$ |
| 1970-D | Loam | 19 March | Spring tine harrow | 2 March* | 2,4 | 1,1½,2 | |
| | | 23 March | Nil | 2 March* | | 1,1½,2 | $\frac{3}{4}$ |
| 1970-E | Loamy clay | 19 March | Spring tine harrow | 20 March | 2,4 | 1,1½,2 | |
| | | 3 April | Nil | 20 March | | 1,1½,2 | $\frac{3}{4}$ |

*Beans ploughed in prior to first application.

RESULTS

Experiments at Bebroke Hill

Table 3

Numbers of beans emerged as a percentage of mean of all controls - 1969 and 1970

Days before (-) or after (+) planting

| | 1969 | 1970 | | | | |
|---|---|---|---|---|---|---|
| | 0 | -14 | -9 | -1 | +4 | +13 |
| EPTC 4 lb/ac* | 78 | 101 | 88 | 100 | | |
| 8 lb/ac* | 61 | 96 | 97 | 99 | | |
| Chlorpropham 1 lb/ac* | 98 | | | | | |
| 2 lb/ac* | | 92 | | 75 | | |
| 4 lb/ac* | | 59 | | 24 | | |
| Chlorpropham 2 lb/ac | | | | | 93 | 100 |
| 4 lb/ac | | | | | 102 | 90 |

*Incorporated treatments

In the 1970 experiment there were no differences in bean emergence between control plots rotary cultivated at different times, and control values have been pooled for Table 3.

In 1969, EPTC caused a marked reduction in the numbers of beans emerging when applied the same day as planting. In 1970 the final numbers emerging were only slightly reduced, but most treatments of EPTC caused a delay in emergence. This is shown in Table 4 where the percentage of emerged beans relative to the controls are compared at two dates of assessment - 28 April and 6 May. There was a delay in emergence with all treatments of EPTC with the exception of 4 lb/ac applied 14 days before planting. The deeper sown beans tended to suffer a greater delay. Soon after emergence symptoms of stunting and distortion became apparent on all EPTC treatments. These were most severe where the higher rate of 8 lb/ac had been used 9 and 1 days before planting. Affected plants appeared darker green than the controls with leaflets inrolled and adhering together.

Chlorpropham applied in 1970 produced a severe delay in emergence and reduction in final stand when incorporated before planting, but relatively little effect when applied to the surface after planting. Symptoms developed after emergence on all chlorpropham treatments, affected plants being generally stunted, and pale green and showing less distortion than with EPTC. These symptoms were generally more severe on the incorporated treatments.

Table 4

Number of beans emerged as a percentage of the mean of all controls - 1970

| | | | Assessed 28 April | | | Assessed 6 May | | |
|---|---|---|---|---|---|---|---|---|
| | | Days pre planting | Depth of planting 1 in. | 2in. | 3in. | Depth of planting 1in. | 2in. | 3in. |
| EPTC incorporated | 4 lb/ac | 14 | 103 | 92 | 101 | 104 | 99 | 102 |
| | 8 lb/ac | " | 95 | 73 | 72 | 98 | 101 | 90 |
| | 4 lb/ac | 9 | 83 | 64 | 78 | 73 | 78 | 95 |
| | 8 lb/ac | " | 81 | 69 | 70 | 100 | 93 | 97 |
| | 4 lb/ac | 1 | 82 | 84 | 88 | 90 | 102 | 106 |
| | 8 lb/ac | " | 96 | 62 | 57 | 114 | 94 | 91 |
| Chlorpropham incorporated | 2 lb/ac | 14 | 76 | 77 | 81 | 90 | 91 | 91 |
| | 4 lb/ac | " | 48 | 24 | 23 | 72 | 58 | 50 |
| | 2 lb/ac | 1 | 54 | 50 | 20 | 82 | 84 | 88 |
| | 4 lb/ac | " | 17 | 2 | 1 | 38 | 25 | 11 |
| | | Days post planting | | | | | | |
| Chlorpropham surface | 2 lb/ac | 4 | 89 | 86 | 86 | 89 | 93 | 96 |
| | 4 lb/ac | " | 100 | 98 | 80 | 100 | 106 | 102 |
| | 2 lb/ac | 13 | 111 | 88 | 95 | 112 | 93 | 99 |
| | 4 lb/ac | " | 104 | 92 | 93 | 93 | 89 | 88 |

In addition to the symptoms noted above, all plots treated with EPTC showed symptoms of severe scorching following the application of dinoseb acetate. The affected leaves blackened and died, but new growth appeared normal. Relatively little dinoseb damage was noted on the control or chlorpropham plots.

Further assessments of the EPTC plots are not presented because of this complication of dinoseb scorch.

Table 5

Yield of Beans cwt/ac 85% D.M.

| | | Days before (-) or after (+) planting | | | |
|---|---|---|---|---|---|
| | | -14 | -1 | +4 | +13 |
| Chlor- | 2 lb/ac* | 18.7 | 14.3 | | |
| propham | 4 " * | 13.7 | 7.3 | | |
| Chlor- | 2 lb/ac | | | 18.4 | 19.1 |
| propham | 4 " | | | 20.3 | 17.6 |
| Control mean | | | 16.4 | | |
| S.E. ± | | | 2.66 | | |

* Incorporated treatments

Table 5 shows the yield of beans obtained when the chlorpropham and control plots were harvested and threshed. Chlorpropham 4 lb/ac applied and incorporated one day before planting caused a significant reduction in yield. 2 lb/ac applied at the same time, and 4 lb/ac applied and incorporated 14 days before planting resulted in slight but non significant reductions in yield. All surface applications of chlorpropham, and 2 lb/ac applied and incorporated 14 days before planting were tolerated by the crop.

## Other Experiments

### Beans

Table 6

Percentage emergence of Beans

| | | 1969 | 1970 | | | | |
|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | E |
| EPTC | 2 lb/ac* | | 89 | 130 | 94 | 108 | 89 |
| | 4 " * | 92 | 82 | 90 | 104 | 109 | 94 |
| Chlor- | 1 lb/ac* | 96 | 82 | 112 | 94 | 90 | 99 |
| propham | 1½ " * | | 95 | 78 | 80 | 104 | 99 |
| | 2 " * | | 63 | 108 | 86 | 91 | 80 |
| Chlor- | 1 lb/ac | | 86 | 121 | 106 | 91 | 107 |
| propham | 1½ " | | 87 | 104 | 94 | 122 | 100 |
| | 2 " | | 84 | 104 | 101 | 106 | 107 |
| Simazine | ¾ lb/ac | 107 | 99 | 106 | 108 | 141 | 103 |
| Controls | | 100 | 100 | 100 | 100 | 100 | 100 |
| Controls density plants/yd$^2$ | | 23.3 | 32.6 | 24.2 | 30.1 | 23.9 | 42.2 |

* Incorporated treatments

There was little effect on the emergence of the beans at these sites. Slight reductions occurred where chlorpropham had been incorporated, and on these plots the beans became stunted and distorted after emergence. Slight stunting also occurred where EPTC 4 lb/ac had been applied. The low rates of EPTC, or chlorpropham applied to the soil surface after planting, were tolerated by the beans, with no signs of damage.

## Grass Weeds

Table 7

Shoots of A. repens and A. fatua as a percentage of controls

| | A. repens 1969 | A. repens 1970 A | A. repens 1970 B | A. repens 1970 E | A. fatua 1970 B | A. fatua 1970 C |
|---|---|---|---|---|---|---|
| EPTC 2 lb/ac* | | 70 | 35 | 68 | 49 | 45 |
| " 4 " * | 74 | 50 | 19 | 72 | 22 | 39 |
| Chlor- 1 lb/ac* | 31 | 68 | 14 | 70 | 60 | 94 |
| propham 1½ " * | | 52 | 28 | 43 | 53 | 79 |
| " 2 " * | | 67 | 18 | 45 | 61 | 85 |
| Chlor- 1 lb/ac | | 81 | 37 | 54 | 50 | 81 |
| propham 1½ " | | 77 | 29 | 76 | 104 | 83 |
| " 2 " | | 90 | 57 | 94 | 60 | 50 |
| Simazine ¾ lb/ac | 100 | 84 | 62 | 112 | 63 | 98 |
| Controls | 100 | 100 | 100 | 100 | 100 | 100 |
| Controls shoots/yd$^2$ | 5 | 266 | 32 | 18 | 227 | 39 |

* Incorporated treatments

Control of A. repens was generally poor at sites A and E with all treatments; this was very obvious at site A with a high shoot population. Control was better at site B where the high rates of EPTC and incorporated chlorpropham reduced shoots by over 80%

Control of A. fatua was moderately good with EPTC 4 lb/ac but poor with chlorpropham both incorporated and applied to the soil surface after planting. The control of A. fatua by simazine improved after counting, and the figures in Table 8 do not reflect the good results obtained at both sites. Counts were taken when the wild oats had reached the 1-1.5 leaf stage, appropriate for assessing the effects of EPTC and chlorpropham, but too early a growth stage for the full effects of simazine to be shown.

Table 8

Dicotyledonous weeds as a percentage of controls - 1970

| | Total dicots -14 | Total dicots -1 | Total dicots +4 | Total dicots +13 | Polygonum spp. -14 | Polygonum spp. -1 | Polygonum spp. +4 | Polygonum spp. +13 |
|---|---|---|---|---|---|---|---|---|
| | Days before (-) or after (+) planting | | | | | | | |
| EPTC 4 lb/ac* | 63 | 96 | | | 70 | 100 | | |
| " 8 " * | 59 | 135 | | | 73 | 236 | | |
| Chlor- 2 lb/ac* | 30 | 62 | | | 13 | 21 | | |
| propham 4 " * | 17 | 44 | | | 7 | 7 | | |
| Chlor- 2 lb/ac | | | 32 | 71 | | | 34 | 77 |
| propham 4 " | | | 31 | 48 | | | 42 | 66 |
| Controls | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| " Weeds/yd$^2$ | 139 | 67 | 90 | 90 | 83 | 32 | 47 | 47 |

*Incorporated treatments

Dicotyledonous Weeds

Simazine gave good control of dicotyledonous species at site C (Table 9). Control at site E was good except for surviving Atriplex patula and Galeopsis tetrahit. EPTC was generally poor and chlorpropham intermediate in control of dicotyledonous species. Table 8 shows results at Begbroke Hill where Polygonum species which were little reduced by EPTC were well controlled by chlorpropham.

Table 9

Dicotyledonous weeds as a percentage of controls - 1970

| | | Site | |
|---|---|---|---|
| | | C | E |
| EPTC | 2 lb/ac* | 77 | 86 |
| | 4 " * | 40 | 65 |
| Chlorpropham | 1 lb/ac* | 60 | 74 |
| | 1½ " * | 66 | 85 |
| | 2 " * | 47 | 84 |
| Chlorpropham | 1 lb/ac | 52 | 80 |
| | 1½ " | 33 | 45 |
| | 2 " | 40 | 32 |
| Simazine | ¾ lb/ac | 7 | 39 |
| Controls | | 100 | 100 |
| " weeds/yd$^2$ | | 135 | 422 |

* Incorporated treatments

## DISCUSSION

The severe damage sustained by the beans in the Begbroke experiments, where EPTC was applied at or near to the date of planting, demonstrates that the field bean has little inherent tolerance towards EPTC. Selectivity is dependent upon the disappearance of the chemical before the beans germinate and reach a susceptible stage. It is difficult to predict the interval necessary for this to occur. The beans may not germinate immediately they are sown, particularly those sown in early spring, so that even a short interval between spraying and sowing may be safe for the crop where soil temperatures are low. This appears to have been the case in the 1969, 1970-B and 1970-D experiments. Conversely when soil temperatures are high, the resulting rapid germination and early growth of the beans may necessitate a longer interval than 14 days as was the case in the 1970 Begbroke experiment.

Chlorpropham, when applied to the soil surface after planting, was tolerated to a much greater extent by the beans than when incorporated before planting. At Begbroke there was no evidence of additional depth protection by increasing sowing depth from one to three inches. The incorporated treatments caused increased damage when applied close to the date of planting.

Weed control was not satisfactory with either herbicide. Both EPTC and chlorpropham appear capable of partial control of A. fatua and the perennial grasses, but the degree of control was inadequate in these experiments. EPTC 4 lb/ac gave inferior control of A. repens to that usually achieved in potatoes, for which application is usually later than in these experiments. It is probable that under the cold conditions of early spring most of the EPTC had disappeared by the time the rhizome buds commenced growth and became susceptible. One of the difficulties of using incorporated herbicides in beans, which are commonly sown at this time, is that soil conditions may not allow efficient incorporation of a herbicide. In these experiments incorporation was by rotary cultivator or spring tine harrows (two passes at right angles), and the degree of incorporation appeared satisfactory. The control of wild oats by EPTC 4 lb/ac (the standard recommended dose) was generally better than that of couch. Even so, the control was insufficient, as the surviving wild oats were not suppressed by the beans and were able to tiller vigorously. Better control of wild oats was given by simazine, and at one site control by this chemical was very good.

Dicotyledonous species were controlled better by simazine than by either EPTC or chlorpropham. Mixtures of EPTC and chlorpropham were included in some of these experiments but the results have not been presented. There was no increase in selectivity and dicotyledonous weed control was inferior to that of simazine.

The nearest approach to a complete weed control system, referred to in the introduction, would on the basis of these experiments appear to be simazine. However, simazine may not give consistent control of wild oats, and will not control the perennial grass weeds. Thus the problem with beans remains primarily one of controlling the perennial grass weeds, and awaits the introduction of a new herbicide for this purpose at an acceptable cost. Alternatively, a re-appraisal of the best method of growing beans in these weedy situations may be considered. These experiments cannot be said to have enhanced the possibilities for weed control in beans, but they have provided information on a number of treatments originally thought possible.

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# HERBICIDES FOR WEED CONTROL IN FLAX

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Summary In trials of pre- and post-emergence herbicides for weed control in flax, the pre-emergence treatments have in general proved more effective. The evidence to date suggests that the wettable powder 50% w/w formulation of linuron at 0.75 lb/ac, or 1.0 lb/ac on heavier soils, is safe and except in dry seasons gives satisfactory control of most species including *Polygonum persicaria* (redshank). Lenacil (80% w/w wettable powder) at 0.8 lb/ac did not give noticeably superior weed control to linuron at 0.75 lb/ac, however, the mixture of linuron + lenacil (0.5 + 0.4 lb/ac) gave generally comparable control to linuron at 0.75 lb/ac and may have an advantage with respect to crop safety as evidenced by the one trial in 1970.

## INTRODUCTION

Flax was for many years one of the main crops in Northern Ireland. The 1930-39 average annual acreage of 18,300 increased during the Second World War to a maximum of 124,500 acres in 1944 but during the 1950's declined again rapidly until by 1962 none was grown except for experimental purposes. As it was felt that recent technical developments with respect to drilling, harvesting and scutching of flax could make it a useful break and cash crop for the farmer, proposals were made in 1967 to examine the feasibility of re-introducing flax growing in Northern Ireland. The elucidation of safe and effective herbicides for weed control was inherent in the overall study.

In 1967 the majority of information available on herbicide usage in flax came from France as reported in the Compte Rendu, of the Association Generale des Producteurs de lin (1967) and from the Netherlands, Friederich (1968) at Wageningen. In Europe, although DNOC + MCPA was still used post-emergence, there was an emerging trend towards the use of the residual herbicides, in particular lenacil and linuron. Neenan (1967) had used linuron and lenacil at doses up to 1.0 and 1.6 lb/ac respectively at Oak Park (Irish Republic). In Northern Ireland the only local experience available was from the Plant Breeding Station, Loughgall, Co. Armagh, where linuron had been used at 0.8 lb/ac and where dicamba + MCPA had been used post-emergence at 9.6 oz/ac.

The weed which potentially presents the greatest problem to flax growing is *Polygonum persicaria* (redshank). It not only reduces yield but is also very difficult to clean out from the flax fibres during processing and can appear as a discolouration in the final linen product. Since this is probably the most abundant weed species in Northern Ireland it was given special attention. In 1968 an *ad hoc* recommendation was made to farmers who had agreed to grow flax for yield trial purposes, for linuron to be used at 0.75 lb/ac on the heavier soils and at 0.5 lb/ac on lighter soils. Lenacil was also used at up to 0.8 lb/ac.

Trials designed to amplify the information on the effectiveness of these two materials and to examine alternative chemicals with the aim of establishing satisfactory weed control recommendations for the flax crop, were carried out in 1968, 1969 and 1970.

## METHOD AND MATERIALS

In the trials at the Plant Breeding Station, Loughgall, Co. Armagh, and the Plant Testing Station, Crossnacreevy, Co. Down plots (3'9" x 30') were drilled with an Øjyord Norwegian experimental drill at 4½" spacing and at a rate equivalent to 85 lb of flax seed (var. Fibra) per acre.

A randomised block design was used each treatment being replicated four times in all the current series of trials. In 1968 and 1969 the plots were sprayed with a knapsack sprayer at 10 p.s.i. The volume of application was 40 gal/ac for the pre-emergence treatments and 25 gal/ac for the post-emergence applications. In 1970 an Oxford Precision Sprayer was used with '0' jets for the pre-emergence and '00' jets for the post-emergence treatments at 30 p.s.i.

The treatments compared in the two 1968 trials are given in Table 1. Two smaller field screening trials (not reported) were also carried out at the same sites in 1968. Those treatments showing most promise were selected for inclusion in the one trial carried out in 1969, details of which are given in Table 2. A limited number of these treatments were also tried out at four farm sites. These plots were of between 16 and 35 $yd^2$ in size, replicated four times in a randomised block design. Details are given in Table 3. In the 1969 trials the lenacil/linuron mixture was altered to increase the proportion of linuron compared with that used in the 1968 treatments. During 1970 a single trial of similar design to that adopted in 1968 and 1969 compared the treatments shown in Table 4.

Details of the formulations and chemical names not included in the tables are as follows:

Table 1

ioxynil + MCPA - ioxynil octanoate 20% w/v + MCPA 20% w/v both as esters
bromoxynil + MCPA - bromoxynil octanoate 20% w/v + MCPA 20% w/v both as esters

Table 4

G.36393 (2-methylthio-4-isopropylamino-6-(γ-methoxy-propylamino)-S-triazine) as 22.5% w/w, w.p. + simazine 5% w/w w.p.
Bayer 79758 (4-amino-3-methylthio-6-phenyl-1,2,4-triazin-5-one) as 70% w.p.

In each year of the trials weed counts were made on the basis of 20 x 6 $in^2$ quadrats per plot 4 - 6 weeks after spraying, and also scored 0 to 9 (9 = no weed control) for the degree of weed control apparent at the time of harvesting the crop. The plots were pulled by hand and fresh weight yields of flax recorded.

## RESULTS

In 1968 it was evident that the pre-emergence materials were in general superior to the post-emergence treatments. In the two trials (Table 1) the use of pre-emergence materials gave yields about 20% above the unweeded control plots whereas using the post-emergence materials the maximum benefit was about 10%. The handweeded control plot Site 2 gave a yield of only 9% above the unweeded treatment. At Site 2 the MCPA + dicamba (14.4 oz/ac) and the MCPA + ioxynil (0.25 + 0.25 lb/ac) showed yields below that of the unweeded control. Of the pre-emergence materials lenacil gave somewhat superior general weed control noticeably of Poa spp. and of Polygonum aviculare (knotgrass). None of the treatments gave outstanding control of Polygonum persicaria the best being lenacil at 1.6 lb/ac. In a small screening trial metobromuron gave very good control of Polygonum persicaria at 1.0 and 1.5 lb/ac.

In the 1969 trials (Tables 2 and 3) linuron at 0.5 lb/ac did not give adequate weed control either on the heavy soil at Loughgall or the lighter soils at the farm sites and this was reflected in the yields. On the fairly heavy soil the 1.0 lb/ac of linuron gave the best control of Polygonum persicaria. Lenacil at 1.2 and 1.6 lb/ac also gave increases in the degree of weed control and flax yields which were highly significant.

Metobromuron gave good results at Loughgall but on the farm sites although weed control at the 1.5 lb/ac dose was excellent, there was a consistent drop in yield as compared with the 1.0 lb/ac dose. There were in addition visible signs of a reduced stand of flax on these plots. In the 1969 season the dicamba + MCPA + mecoprop treatment had a visible stunting effect on the crop after application and led to the formation of distorted compound leaves in the crop. The yields with this treatment were lower relative to the pre-emergence materials.

The results for the 1970 trials are shown in Table 4. The early part of this season in May, immediately after spraying, was particularly dry and this is reflected in the poor weed control results. This season the stand of weeds on the trial area was very light, only 18 per 20 x 6 $in^2$ quadrats as compared with 210 in 1969 and 62 in 1968 on the unweeded plots. The best treatment for weed control was linuron at 1.0 lb either as wettable powder or emulsifiable concentrate. The e.c. formulation gave a decrease on yield applied both pre-and post-emergence and appears to be somewhat more active than the w.p. formulation. The G.36393 + simazine mixture affected yield at the higher dose. Nitrofen was not found selective at the doses used. 1 lb/ac applied post-emergence, killed out all the main growing points and led to multiple branching of the crop, whilst only giving moderate weed control.

## DISCUSSION

Results of these trials over three years and observations on the lenacil, linuron and the dicamba + MCPA + mecoprop treatments which have been used on farms, indicated considerable variation in performance attributable to seasonal factors. In farm use during 1968 and 1969 there was evidence of occasional damage from linuron and the dicamba + MCPA + mecoprop treatments. This was attributable in the main to overdosing when turning at headlands or to inadequate agitation of the wettable powder formulations. In 1968 and 1969 weed control was generally satisfactory with the linuron at more than 0.5 lb/ac. Below this dose there was inadequate control of Polygonum persicaria. In farm crops on the heavier soils when Polygonum persicaria was not adequately controlled it was necessary to spray again post-emergence with the dicamba + MCPA + mecoprop (9.6 oz/ac). This resulted in some stunting of the crop, which was particularly prevalent in 1969. Because of this evidence from the commercial use of this material on the flax crop and the evidence from the trials that a significant amount of competition from weeds (see handweeded control treatment - Table 1) was occurring prior to the time at which post-emergence application can be made (when the crop is 3 - 4 in tall) it would obviously be preferable to establish a satisfactory pre-emergence treatment for this crop.

The two pre-emergence chemicals with which most experience has been gained in Northern Ireland, lenacil and linuron, have both been shown to give poor control of *Polygonum persicaria* in a dry season such as 1970. The linuron and lenacil mixture (0.5 + 0.4 lb/ac) has given control about equivalent to linuron at 0.75 lb (Table 3). In 1970 the mixture did not give as good a weed control as linuron but the fact that this year when there was little weed competition, the yield was increased compared to the linuron treatments may imply a greater safety of the linuron - lenacil mixture on flax. In the current season all treatments relying on residual herbicide action gave poor weed control. Metobromuron, which had given good *Polygonum persicaria* control in 1968, led to visible thinning of the crop and yield depression on the farm sites in 1969 and does not appear to be a safe treatment for this crop. The Bayer 79758 material appears to be worthy of further consideration having also given encouraging results as a pre-emergence treatment in French trials (reported in the Compte Rendu, of the Association Generale des Producteurs de lin 1969).

Of the post-emergence treatments the linuron emulsifiable concentrate (0.75 lb/ac) and the nitrofen (1.0 lb/ac) were the most severe on the crop. The flax seemed to tolerate the 0.5 lb/ac dose of linuron (w.p.) very well at the 3 - 4 in stage although in an earlier observational trial on time of application, the flax appeared to be very sensitive to linuron immediately after emergence when the cotyledons presented a highly receptive surface for the spray.

## Acknowledgments

Thanks are due to the commercial companies for materials made available during these trials and to the Northern Ireland Agricultural Trust for their assistance with respect to the farm trial sites.

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## Table 1

**Weed control and flax yield - 1968**

Site 1 - Loughgall Plant Breeding Station
soil - medium loam
crop drilled 25.4.68
sprayed pre-emergence 3.5.68
sprayed post-emergence 11.6.68
(crop 3-4 inches high)

Site 2 - Crossnacreevy P. T. S.
soil - medium heavy loam
crop drilled 19.4.68
sprayed pre-emergence 24.4.68
sprayed post-emergence 10.6.68
(crop 3-4 inches high)

| Treatment | Formulation | Dose lb/ac a.i. | Site 1 Weed Control: All spp. % Kill | Site 1 Weed Control: All spp. Score | Site 1 Weed Control: Polyg. spp. % Kill | Site 1 Yield fresh wt.: lb/12 sq.yd | Site 1 Yield fresh wt.: %unsprayed control | Site 2 Weed Control: All spp. % Kill | Site 2 Weed Control: All spp. Score | Site 2 Weed Control: Polyg. spp. % Kill | Site 2 Yield fresh wt.: lb/12 sq.yd | Site 2 Yield fresh wt.: %unsprayed control |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PRE-EMERGENCE | | | | | | | | | | | | |
| 1. linuron | 50%w.p. | 0.5 | 77 | 6.3 | 71 | 58.6 | 116 | 56 | 5.3 | 47 | 28.1 | 109 |
| 2. linuron | 50%w.p. | 0.75 | 83 | 2.8 | 76 | 51.1 | 110 | 75 | 3.0 | 40 | 33.4 | 129 |
| 3. lenacil | 80%w.p. | 0.8 | 87 | 4.0 | 87 | 53.1 | 115 | 84 | 4.5 | 39 | 32.8 | 127 |
| 4. lenacil | 80%w.p. | 1.2 | 85 | 3.8 | 66 | 54.4 | 118 | 85 | 3.8 | 43 | 33.1 | 128 |
| 5. lenacil | 80%w.p. | 1.6 | 92 | 2.3 | 89 | 56.9 | 123 | 93 | 2.0 | 68 | 33.8 | 131 |
| 6. lenacil | 80%w.p. | 0.4 | | | | | | | | | | |
| + linuron | 50%w.p. | 0.25 | 72 | 5.6 | 43 | 50.0 | 108 | 83 | 5.5 | 58 | 33.1 | 128 |
| 7. lenacil | 80%w.p. | 0.8 | | | | | | | | | | |
| + linuron | 50%w.p. | 0.25 | 75 | 4.3 | 67 | 54.6 | 118 | 91 | 2.3 | 64 | 36.7 | 142 |
| 8. promotryne | 50%w.p. | 0.75 | | | | | | | | | | |
| + simazine | | total a.i. | 79 | 4.0 | 84 | 51.1 | 110 | 63 | 3.3 | 39 | 34.3 | 133 |
| POST-EMERGENCE | | | | | | | | | | | | |
| 9. MCPA | 3.4%e.c. | 0.34 a.e. | | | | | | | | | | |
| + DNOC | 13% e.c. | 1.3 | - | 5.3 | - | 47.9 | 104 | - | 5.0 | - | 26.8 | 104 |
| 10. MCPA + dicamba | - | 9.6 oz a.e. | - | 3.0 | - | 51.7 | 110 | - | 4.3 | - | 27.8 | 108 |
| 11. MCPA + dicamba | - | 14.4 oz a.e. | - | 3.5 | - | 48.8 | 105 | - | 4.3 | - | 24.3 | 94 |
| 12. MCPA | 20%e.c. | 0.25 | | | | | | | | | | |
| + ioxynil | 20%e.c. | 0.25 | - | 4.8 | - | 47.6 | 103 | - | 3.5 | - | 24.0 | 93 |
| 13. MCPA | 20%e.c. | 0.25 | | | | | | | | | | |
| + bromoxynil | 20%e.c. | 0.25 | - | 3.3 | - | 50.5 | 109 | - | 2.0 | - | 27.0 | 105 |
| 14. handweeded control | | * | - | - | - | - | - | - | 0.8 | - | 28.0 | 109 |
| 15. unweeded control | | - | (62) | 8.8 | (18) | 46.25 | 100 | (107) | | (24) | 25.8 | 100 |
| ( ) Weed count in 20x6in$^2$ quadrats | | | | | | S.E.$\pm$1.65 (D.F.39) | | | | | S.E.$\pm$1.86(D.F.43) | |

Site 1: Weed Count 11.6.68
Weed Score 29.8.68 0 to 9 (9=no weed control)
Harvested 29-30.8.68

Site 2: Weed Count 10.6.68
Weed Score 22.8.68
Harvested 22.8.68

* At Site 1 this treatment was ommitted.

**Table 2**

**Weed Control and Flax yield - Loughgall 1969**

| Treatment | Formulation | Dose lb/ac a.i. | Weed Control % kill (30.5.69) All species | Weed Control % kill (30.5.69) *Polygonum persicaria* | Flax fresh weight yield lbs. plot 12. sq.yds. | Flax fresh weight yield % of unsprayed control |
|---|---|---|---|---|---|---|
| PRE-EMERGENCE | | | | | | |
| 1. linuron | 50%w.p. | 0.5 | 45 | 13 | 35.2 | 99 |
| 2. linuron | 50%w.p. | 0.75 | 77 | 43 | 36.6 | 103 |
| 3. linuron | 50%w.p. | 1.0 | 98 | 95 | 55.0 | 154 |
| 4. lenacil | 80% w.p. | 0.8 | 92 | 83 | 42.1 | 118 |
| 5. lenacil | 80%w.p. | 1.2 | 94 | 72 | 58.6 | 164 |
| 6. lenacil | 80% w.p. | 1.6 | 97 | 92 | 60.2 | 169 |
| 7. lenacil + linuron | 80%w.p. 50%w.p. | 0.4 0.5 | 97 | 84 | 51.5 | 144 |
| 8. lenacil + linuron | 80%w.p. 50%w.p. | 0.4 0.75 | 98 | 95 | 55.1 | 154 |
| 9. metobromuron | 50%w.p. | 1.0 | 86 | 61 | 38.6 | 108 |
| 10. metobromuron | 50%w.p. | 1.5 | 90 | 69 | 35.7 | 100 |
| 11. metobromuron | 50%w.p. | 2.0 | 98 | 96 | 59.2 | 166 |
| POST-EMERGENCE | | | | | | |
| 12. dicamba + MCPA + mecoprop | - | 13 oz total a.e. | * | * | 50.5 | 141 |
| 13. dicamba + MCPA + mecoprop | - | 19.5 oz total a.e. | * | * | 35.6 | 99.7 |
| 14. unweeded control | | | (210) | (30) | 35.7 | 100 |

( ) No weeds 20x6 $in^2$ quadrats

S.E.Mean $\pm$ 5.57 D.F.(43)

* Only visual observations at harvest taken

| Soil type | Crop drilled | Sprayed pre-emergence | Sprayed post-emergence | Harvested |
|---|---|---|---|---|
| medium loam | 17.4.69 | 24.4.69 | 11.6.69 | 12.9.69 |

## Table 3

**Weed control and flax yield - Farm sites (1 - 4) 1969**

| Treatment | Formulation | Dose lb/ac a.i. | Weed Control % Kill, all spp. 1. | 2. | 3. | 4. | Flax fresh weight yield (A. % of unsprayed control. B. lb/plot) 1. A | 1. B | 2. A | 2. B | 3. A | 3. B | 4. A | 4. B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. linuron | 50% w.p. | 0.5 | 62 | 84 | 60 | 78 | 106 | 29.7 | 113 | 59.7 | 111 | 40.2 | 108 | 42.0 |
| 2. linuron | 50% w.p. | 0.75 | 90 | 97 | 79 | 79 | 118 | 33.2 | 123 | 64.0 | 103 | 37.2 | 115 | 44.7 |
| 3. lenacil | 50% w.p. | 0.8 | 75 | 98 | 75 | 63 | 104 | 29.2 | 116 | 60.6 | 112 | 40.6 | 105 | 40.8 |
| 4. lenacil + linuron | 80% w.p. 50% w.p. | 0.4 0.5 | 90 | 100 | 66 | 83 | 126 | 35.4 | 113 | 59.0 | 102 | 36.8 | 112 | 43.6 |
| 5. metobromuron | 50% w.p. | 1.0 | 89 | 96 | 68 | 68 | 105 | 30.0 | 121 | 63.0 | 121 | 43.7 | 113 | 44.1 |
| 6. metobromuron | 50% w.p. | 1.5 | 95 | 99 | 90 | 74 | 107 | 30.1 | 120 | 62.7 | 112 | 40.5 | 105 | 40.9 |
| 7. dicamba + MCPA + mecoprop | - | 13 oz total a.e. | - | - | - | - | — | — | 108 | 56.6 | 99 | 56.6 | 107 | 41.6 |
| 8. unsprayed control | - | - | (256) | (74) | (178) | (243) | 100 | 28.2 | 100 | 52.2 | 100 | 36.2 | 100 | 38.9 |
| ( ) Weed No. in 20 x 6 in$^2$ quadrats | | | | | | | S.E. Mean D.F.(21) | (±2.4) | | (±1.8) | | (±1.4) | | (±2.3) |

| Site Details | Date drilled | Sprayed pre-emergence | Weed Counts | Sprayed post-emergence | Harvested | Plot size sq. yds. |
|---|---|---|---|---|---|---|
| 1. Downpatrick | 7.4.69 | 9.4.69 | 24.5.69 | 5.6.69 | 20.8.69 | 16 |
| 2. Annaclone | 17.4.69 | 18.4.69 | 30.5.69 | 5.6.69 | 19.8.69 | 21 |
| 3. Dromara | 16.4.69 | 19.4.69 | 31.5.69 | 5.6.69 | 8.9.69 | 35 |
| 4. Castlewellan | 18.4.69 | 22.4.69 | 25.5.69 | 5.6.69 | 11.8.69 | 35 |

Table 4

**Weed control and flax yield - Loughgall 1970**

| Treatments | Formulation | Dose lb/ac a.i. | Weed Control: % Kill All species (9.6.70) | Weed Control: Weed score 0-9 (29.8.70) | Weed Control: % Kill *Polygonum persicaria* | Flax fresh weight yield: lbs plot 12 sq. yds | Flax fresh weight yield: % of unsprayed control |
|---|---|---|---|---|---|---|---|
| PRE-EMERGENCE | | | | | | | |
| 1. linuron | 50% w.p. | 0.75 | 61 | 2.5 | 29 | 29.9 | 104 |
| 2. linuron | 50% w.p. | 1.0 | 72 | 2.0 | 57 | 29.5 | 102 |
| 3. linuron | 20% e.c. | 1.0 | 68 | 2.8 | 71 | 26.3 | 91 |
| 4. linuron + lenacil | 50% w.p.<br>80% w.p. | 0.5<br>0.4 | 23 | 4.0 | -29 | 32.8 | 114 |
| 5. G.36393+simazine | 22.5%+5% w.p. | 0.5 | 17 | 5.5 | 7 | 29.2 | 101 |
| 6. G.36393+simazine | 22.5%+5% w.p. | 0.75 | -7 | 5.8 | 14 | 27.6 | 96 |
| 7. Bayer 79758 | 70% w.p. | 1.0 | 18 | 4.3 | 50 | 31.1 | 108 |
| 8. Bayer 79758 | 70% w.p. | 1.4 | 31 | 2.5 | 36 | 31.2 | 108 |
| 9. nitrofen | 25% e.c. | 2.0 | 21 | 4.0 | 36 | 27.2 | 94 |
| POST-EMERGENCE | | | | | | | |
| 10. linuron | 50% w.p. | 0.5 | - | 2.5 | - | 32.9 | 114 |
| 11. linuron | 50% w.p. | 0.75 | - | 2.8 | - | 28.2 | 98 |
| 12. linuron | 20% e.c. | 0.75 | - | 3.4 | - | 25.6 | 89 |
| 13. dicamba + MCPA + mecoprop | - | 13 oz a.e. | - | 4.5 | - | 28.8 | 100 |
| 14. nitrofen | 25% e.c. | 1.0 | - | 5.5 | - | 24.2 | 84 |
| unweeded control | ( ) weed count in 20x6 in² quadrats | | (18) | 8.8 | (3.5) | 28.9<br>S.E. ± 2.64 D.F.(43) | 100 |

| Soil type | Flax drilled | Sprayed pre-emergence | Sprayed post-emergence | Harvested |
|---|---|---|---|---|
| medium loam | 5.5.70 | 12.5.70 | 9.6.70 | 26-27.8.70 |

# EXPERIMENTS ON THE USE OF TCA IN POTATOES

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Summary The tolerance of potatoes towards TCA, and the effectiveness of TCA in controlling *Agropyron repens* were examined in experiments carried out during 1967 and 1968. Potatoes were unaffected by TCA at 30 lb/ac applied a fortnight before planting in 1967, but yields were reduced in each year, by lower rates applied nearer to the planting date. There were differences between varieties in the extent of foliar damage caused by TCA applied one day before planting, and the variety King Edward appeared relatively tolerant. At harvest the yields of all four varieties were reduced.

TCA was more effective in controlling *A. repens* in the wet spring of 1967 than in the drier conditions of 1968. In the former case good control was achieved without incorporation by cultivation at the time of spraying, while in 1968 control was improved by cultivation.

## INTRODUCTION

TCA has been recommended for controlling perennial grass weeds in potatoes for many years, but certain aspects of the recommendations (Fryer and Evans 1968) tend to deter farmers from making more widespread use of this chemical. Rates of 30 to 40 lb/ac are suggested (the higher rate for use on heavier soils), with a half dose split application for all except the most readily leached sandy soils. With each application cultivations are needed both before and after spraying so that an extensive cultivation programme becomes necessary. It is recommended that the minimum interval between spraying and planting the crop should be not less than 8 weeks.

The majority of the maincrop acreage of potatoes is planted during the month of April, from which it follows that TCA should be applied during February or earlier. At this time of the year the land is often too wet for cultivation. Applications made in the autumn before planting are likely to be less effective due to leaching of the chemical from the soil before the rhizomes become active in the spring.

Loustalot and Ferrer (1950) showed that TCA disappeared more rapidly as the temperature and moisture content of the soil increased, and was readily moved downwards in the soil with low amounts of rainfall. TCA persisted longer in a clay than in a sandy soil.

In this report experiments are described where TCA has been applied to the ploughed surface at various intervals before planting, and cultivations restricted to those necessary for seedbed preparation. These experiments were carried out during 1967 and 1968 and in each year, in separate experiments, the tolerance of potatoes towards TCA, and the effect of TCA upon *Agropyron repens* were examined.

Experiments in Sweden (Granstrom, 1960) have demonstrated that potato varieties differ in their susceptibility to TCA. The tolerance of four varieties towards TCA was examined in an experiment described below.

## METHODS AND MATERIALS

Effect of TCA on Potatoes

In each year the experiments were carried out on a sandy loam soil at the Weed Research Organization.

1967

TCA was applied to the ploughed surface at various intervals before planting potatoes (var. King Edward). A randomised block design with four replicates was used with plots of 40 ft x 7 ft 6 in. Two rows per plot of potatoes were used for assessments.

The chemical was applied with an Oxford Precision Sprayer at a volume rate of 40 gal/ac. A commercially available formulation of TCA containing 92% of the sodium salt was used.

No cultivations were carried out until the time of planting (April 13th) when the whole area was rotary cultivated to 8 in.

The emergence of the potatoes was assessed on 18th May. Some plants remained stunted, and only those above three inches high at this time were counted as tolerant plants.

The experiment was harvested on 21st September with a 2-row digger and the tubers were subsequently graded into ware, seed and discard fractions. A sample of 20 tubers from each plot was assessed for pigmentation, by scoring both for the area and for the intensity of pigment.

1968

The tolerance of four varieties of potato towards TCA was examined by applying TCA to the ploughed surface the day before planting. The experiment was a split plot randomised block design with four replicates. The main plots, 30 ft x 40 ft comprised the TCA treatments which were split for variety sub plots each 7 ft 6 in. x 40 ft.

TCA was applied on April 18th at a volume rate of 37 gal/ac using two passes of a tractor mounted sprayer for each plot. On the following day a seedbed was prepared by rotary cultivating to 8 in., and chitted seed of the four varieties King Edward, Majestic, Record and Pentland Dell was planted.

Emerged plants were counted at intervals during May and early June. In addition, plants showing symptoms of herbicide damage were counted.

The experiment was harvested on 9th - 11th September and the potatoes were subsequently graded for ware, seed and discard.

Application of TCA to Agropyron repens
1967

TCA was applied to ploughed land containing rhizomes of **A. repens** in two experiments, one (Expt. A) on a sandy loam subsequently planted to potatoes, and the other (Expt. B) on a limestone brash subsequently planted to oilseed rape. Both experiments were of a randomised block design with three replicates, and in each TCA was applied (in mid February and in mid March) at rates corresponding to those used in the 1967 crop tolerance experiment. Each experiment received a single cultivation at the time of planting on 27th April for potatoes and on 30th March for the oilseed rape experiment. The effect on A. repens was assessed by counting emerged shoots in random quadrats during May and early June.

1968

An experiment was designed to examine the effect of cultivating after spraying TCA and was carried out at the Weed Research Organization on a sandy loam containing A. repens. A randomised block design was used with three replicates and plots of 15 ft x 7 ft 6 in. TCA was applied on 27th February and 28th March and plots which were cultivated received a single pass of a spring tined harrow immediately after spraying. Shoots of A. repens were counted in random quadrats on 25th April. No crop was planted.

## RESULTS

### Effect of TCA on Potatoes

1967

Table 1

Effect of TCA on the early growth and yield of potatoes planted on 13th April

| Application date | (a) Potatoes > 3 in. high (nos/plot) TCA 15 lb/ac | (a) TCA 30 lb/ac | (b) Yield of Potatoes (tons/ac) TCA 15 lb/ac | (b) TCA 30 lb/ac |
|---|---|---|---|---|
| 22nd February | 14 | 12 | 16.5 | 15.7 |
| 20th March | 13 | 10 | 16.6 | 15.1 |
| 31st March | 13 | 10 | 16.3 | 16.2 |
| 7th April | 12 | 8 | 16.6 | 14.6 |
| Unsprayed | 16 | | 16.2 | |
| | S. E. ± 2.0 | | S. E. ± 0.49 | |

Table 1(a) indicates the number of potato shoots which had reached 3 in. high on 18th May. Final shoot emergence was not affected by any treatment. Stunting with delayed shoot growth was recorded where 30 lb/ac had been applied during March and early April, but by July no differences between treatments were visible. Final yield was not significantly affected by the treatments except where 30 lb/ac of TCA had been applied 6 days before planting when the yield was reduced by 1.6 tons/ac. (Table 1(b))

The scoring for pigmentation of the tubers indicated that although the area of pigment was not affected, tubers from the TCA treated plots tended to be a paler shade of pink, particularly when TCA had been applied near to the date of planting.

Table 2

Effect of TCA on the emergence and early growth of potatoes

Emerged potatoes - Nos/plot (deformed plants in brackets) 27th May

| Treatment | King Edward | Majestic | Pentland Dell | Record |
|---|---|---|---|---|
| TCA 5 lb/ac | 50 (0) | 60 (4) | 56 (0) | 46 (0) |
| TCA 10 lb/ac | 48 (0) | 62 (26) | 54 (2) | 37 (2) |
| TCA 20 lb/ac | 44 (4) | 55 (44) | 46 (12) | 16 (2) |
| Unsprayed | 50 (0) | 60 (0) | 58 (0) | 56 (0) |

The effect of TCA, applied the day before planting, was apparent at the time of emergence of the crop. Emergence of all varieties was delayed with Record showing the most and King Edward the least delay. Emerged plants showed varying degrees of deformity. In extreme cases the leaf tissue was much reduced with the terminal leaflet cupped with the apex curled under, and secondary leaflets reduced or missing, giving a 'skeleton' appearance to the plant. Majestic appeared most sensitive with severely deformed plants on all the TCA plots, while King Edward and Record only showed a few slightly deformed plants where the highest rate had been applied.

The effect of TCA was still evident at the time of flowering of the varieties Majestic and Record, when flowering was delayed on all treated plots and absent where the highest rate had been applied. Pentland Dell appeared stunted while King Edward were not visibly affected.

Table 3

Effect of TCA on the yield of potatoes (tons/ac)

| Treatment | King Edward | Majestic | Pentland Dell | Record |
|---|---|---|---|---|
| TCA 5 lb/ac | 11.6 | 13.0 | 10.1 | 11.4 |
| TCA 10 lb/ac | 9.4 | 12.3 | 8.5 | 11.6 |
| TCA 20 lb/ac | 8.5 | 9.0 | 9.5 | 10.1 |
| Unsprayed control | 13.2 | 12.4 | 10.5 | 13.6 |

S. E. Body of table $\pm$ 0.68

The highest rate of 20 lb/ac TCA reduced the yields of all four varieties by amounts ranging from 1.0 tons/ac (Pentland Dell) to 4.7 tons/ac (King Edward), when compared with the unsprayed control. The lowest rate of 5 lb/ac reduced the yields of King Edward and Record, which was surprising in view of the low numbers of deformed plants of these two varieties recorded earlier.

Effect of TCA on *A. repens*

1967

Table 4

*A. repens* - Emerged shoots/5 $yd^2$

| | Experiment A 15th June TCA | | | Experiment B 25th May TCA | |
|---|---|---|---|---|---|
| Application date | 15 lb/ac | 30 lb/ac | | 15 lb/ac | 30 lb/ac |
| 24th February | 63 | 39 | 16th February | 154 | 124 |
| 20th March | 16 | 12 | 16th March | 9 | 6 |
| Unsprayed | 221 | | Unsprayed | 322 | |

In each experiment control of *A. repens* was superior when TCA was applied in March to that following the February applications. At the time of each application the soil surface was wet and subsequent rainfall may have encouraged leaching of the chemical down to the rhizomes.

1968

Table 5

*A. repens* - Emerged shoots /5 $yd^2$ on 25th April

| Date of treatment | Cultivation alone | TCA 15 lb/ac Cult. | TCA 15 lb/ac No cultivation | TCA 30 lb/ac Cult. | TCA 30 lb/ac No cultivation | Control Untreated |
|---|---|---|---|---|---|---|
| 27th February | 463 | 132 | 258 | 171 | 230 | 308 |
| 28th March | 218 | 149 | 296 | 102 | 214 | |

Control of *A. repens* was relatively poor with all treatments. Application of TCA at each date was to a dry soil surface and there was little rain afterwards. Weed control was improved by cultivating after spraying. Cultivating alone in February resulted in more shoots probably due to fragmentation of the rhizomes inducing more buds to grow. With the later cultivation, in March, shoots already growing may have been destroyed.

## DISCUSSION

The differences in effect of TCA on *A. repens* between 1967 and 1968 can be related to the moisture status of the soil at the time of application and to the subsequent rainfall. 1967 was a wet spring (113 mm rainfall at Begbroke between mid February and mid April) with conditions likely to lead to a rapid leaching and breakdown of the chemical. In each experiment application in mid March gave better control of *A. repens* than that in mid February, and this accords with results obtained in the same year with TCA applied to field beans (Holroyd and Wilson, 1968). TCA applied in February may have largely disappeared from the soil before the rhizomes became sufficiently active to absorb the chemical. The spring of 1968 was dry (27 mm rainfall between mid February and mid April) with little or no rain to take the TCA down from the soil surface after spraying. The single cultivation improved the action of the chemical, but even so control was poor compared with the previous year.

In 1967 the potatoes tolerated 15 lb/ac of TCA when applied 6 days before planting but 30 lb/ac reduced yield at this date. In 1968 5 lb/ac applied one day before planting reduced yield by an average of 1 ton/ac. It would seem that there is little inherent tolerance of the potato towards TCA, and although there were marked differences between varieties in foliar damage symptoms, yields of all varieties were reduced by the presence of the chemical at the time of planting.

For selective action against A. repens TCA needs to be present in the vicinity of the rhizomes at the time of maximum bud activity, and the residues need to have dwindled by the time the potatoes are planted. The control of A. repens achieved in both experiments in 1967 indicates that in a wet year the highly soluble TCA is readily leached into the vicinity of the rhizomes without the need for additional cultivation. Potato yields did not suffer when TCA was applied at the end of March, 2 weeks before planting. It should be stressed that these experiments were carried out on a sandy loam soil and residues may have persisted longer on a heavier soil.

Cultivation after spraying seems more necessary under dry conditions. Cultivation will fragment the rhizomes and so stimulate more active buds which in turn should lead to increased uptake of the chemical. With no leaching the chemical may remain in a high concentration near the soil surface; cultivation may dilute this concentrated layer and so lessen the risk of subsequent crop damage.

Reduced doses of TCA applied relatively near to the time of planting have considerable practical advantages over techniques recommended earlier for commercial practice. It is, however, difficult to predict the behaviour of TCA applied in this way. These experiments indicate that TCA is safer and more effective under wet conditions, than under dry conditions. Under wet conditions cultivations to incorporate the TCA may be dispensed with.

## Acknowledgments

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# TRIALS WITH MIXTURES OF 2-TERTIARY BUTYL-1-4-(2,4 DICHLORO-5-ISOPROPYLOXYPHENYL)-Δ-1-3-4 OXADIAZOLIN 5-ONE, OR 17,623 RP, AND LINURON, AS POTATO HERBICIDES

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Summary. In 1969, trials showed that 17,623 RP applied pre-emergence controlled a wide range of annual weeds except Stellaria media, and did not damage potatoes. In 1970, mixtures of 17,623 RP with either linuron or CIPC were tested on a range of potato varieties and soils. 17,623 RP/linuron mixture was shown to be safe pre-emergence in potatoes, to be comparable in activity against broad leaf annual weeds to the 1:1 linuron/monolinuron mixture used as a standard, and additionally to be active against Avena fatua and Convolvulus arvensis. Mixtures containing 17,623 RP appear to have advantages over other potato herbicides, but further trials are needed to test them when weeds emerge early in the life of the crop.

## INTRODUCTION

The compound 2-tertiary butyl-1-4- (2,4 dichloro-5-isopropyloxyphenyl)-Δ-1-3-4 oxadiazolin-5-one, or 17,623 RP, was described in a report to the 3rd E.W.R.C. symposuim (Burgaud et al, 1969). Details were given of its pre-emergence activity against a wide range of annual broad leaf and grass weeds, and of the tolerance of a range of temperate and warm country crops.

In 1969, 17,623 RP was also tested on a range of row crops in the U.K. In these trials, it was confirmed that, when applied pre-weed and crop emergence the compound would control a range of important annual weeds, with the notable exception of Stellaria media. There was no phytotoxicity shown by the three potato varieties in the trials, judged on appearance and yield. In 1970, trials covering a range of varieties, soil types and weed situations were carried out in potatoes. Because of the importance of ensuring good control of Stellaria media, 17,623 RP was tested as a component of mixtures with linuron or CIPC. A 1:1 mixture of linuron and monolinuron was used as a standard.

## METHOD AND MATERIALS

The following compounds were used :-

| | |
|---|---|
| 17,623 RP + linuron. | Formulated as emulsifiable concentrates containing:<br>(a) 20% w/v 17,623 RP + 20% w/v linuron<br>(b) 20% w/v 17,623 RP + 10% w/v linuron |
| 17,623 RP + CIPC. | Tank mixture of emulsifiable concentrates. |
| linuron + monolinuron. | Formulated as a wettable powder containing 20% w/w of each active ingredient. |
| linuron. | Wettable powder containing 50% w/w active ingredient. |

The trials were of randomised block design, with three replicates. Plots were three rows wide and 25 ft. long. Applications were made as soon as possible after ridging, before the emergence of either the weeds or the crop, with a motorised small plot precision sprayer, at a volume rate of 40 g.p.a. The European Weed Research Council (E.W.R.C.) scoring system was used for the 1969 weed assessment (Table 2).

Details of the 1970 trials are given in Table 1.

Table 1

1970 Trials

| Location | Variety | | Soil type |
|---|---|---|---|
| Tilbury | Maris Peer | (MP) | Clay |
| Hatfield Broad Oak | King Edward | (KE) | Clay |
| S. Kyme | Ulster Prince | (UP) | Organic loamy sand |
| Beauchamp Roding | Red Craigs Royal | (RCR) | Clay |
| and | Maris Peer | (MP) | |
| Beck Row | Record | (R) | Sand |
| | King Edward | (KE) | |

The 1970 weed control assessments are based on 2 x $\frac{1}{2}$yd$^2$ quadrats per plot, and the E.W.R.C. scale was used for assessing crop appearance (Tables 3, 4, 5 and 6). Yield data is taken from 36' row lengths per plot and are given also for unsprayed and handweeded (H.W.C.) controls (Tables 3, 4, 5, 6).

Table 2

1969. Effect of 17,623 RP on weeds. Pre-emergence application
E.W.R.C. scale (1-9)

| 17,623 RP dose lb/acre | 1 | 1½ |
|---|---|---|
| Avena fatua | 1 | 1 |
| Chenopodium album | 2 | 1 |
| Matricaria recutita | 2 | 1 |
| Polygonum aviculare | 3 | 1 |
| Polygonum convolvulus | 2 | 1 |
| Raphanus raphanistrum | 1 | 1 |
| Stellaria media | 9 | 9 |

Table 3

1970. % weed control and tuber yield. (Tilbury and Hatfield)

| Herbicide dose lb/ac | 17,623 RP + linuron $\frac{3}{4}+\frac{3}{4}$ | 17,623 RP + linuron 1+1 | 17,623 RP + linuron $\frac{3}{4}+\frac{3}{8}$ | 17,623 RP + linuron $1+\frac{1}{2}$ | 17,623 RP + C.I.P.C. $1+\frac{1}{2}$ | linuron + monolinuron $\frac{3}{4}+\frac{3}{4}$ | linuron $1\frac{1}{2}$ | Control weeds yd$^2$ |
|---|---|---|---|---|---|---|---|---|
| *Polygonum aviculare* | 69 | 70 | 72 | 66 | 85 | 83 | 90 | 8 |
| *Atriplex patula* | 95 | 86 | 95 | 100 | 74 | 74 | 100 | 7 |
| Total weeds | 73 | 75 | 61 | 77 | 75 | 76 | 78 | 32 |
| Crop score | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| Tuber yield (tons/ac) M.P. | 3.05 | 3.15 | 3.45 | 3.50 | 3.70 | 3.50 | 3.95 | 2.90 unsprayed<br>3.60 HWC |
| K.E. | 11.25 | 12.75 | 12.35 | 12.00 | 11.95 | 11.90 | - | 12.7 weed free |

No significant differences between yields at P = 0.05
Coefficients of variation. M.P. - 19.4%. K.E. - 9.5%

Table 4

1970. % weed control and tuber yield (S. Kyme)

| Herbicide dose lb/ac | 17,623 RP + linuron $\frac{3}{4}+\frac{3}{4}$ | 17,623 RP + linuron 1+1 | 17,623 RP + linuron $\frac{3}{4}+\frac{3}{8}$ | 17,623 RP + linuron $1+\frac{1}{2}$ | linuron + monolinuron $\frac{1}{2}+\frac{1}{2}$ | Control weed yd$^2$ |
|---|---|---|---|---|---|---|
| *Chenopodium album* | 96 | 92 | 78 | 96 | 92 | 6 |
| *Matricaria matricoides* | 99 | 100 | 97 | 99 | 99 | 66 |
| *Stellaria media* | 97 | 99 | 84 | 97 | 99 | 67 |
| *Urtica urens* | 98 | 99 | 97 | 98 | 90 | 104 |
| Total weeds | 97 | 99 | 92 | 98 | 93 | 250 |
| Crop score | 1 | 1 | 1 | 1 | 1 | |
| Tuber yield (tons/ac) U.P. | 4.00 | 3.75 | 4.15 | 3.45 | 4.45 | 2.85 (unsprayed)<br>3.45 H.W.C. |

No significant differences between yields at P = 0.05
Coefficient of variation - 17.1%

Table 5

1970. % weed control and tuber yield (Beck Row)

| Herbicide dose lb/ac | | 17,623 RP + linuron | | | | 17,623 RP + C.I.P.C. | linuron + monolinuron | Control weeds $yd^2$ | |
|---|---|---|---|---|---|---|---|---|---|
| | | $\frac{3}{4}+\frac{3}{4}$ | 1+1 | $\frac{3}{4}+\frac{3}{8}$ | $1+\frac{1}{2}$ | $1+\frac{1}{2}$ | $\frac{1}{2}+\frac{1}{2}$ | | |
| Annagallis arvensis | | 100 | 100 | 100 | 100 | 100 | 99 | 9 | |
| Chenopodium album | | 90 | 58 | 72 | 73 | 81 | 82 | 10 | |
| Erysimum cheiranthoides | | 100 | 100 | 91 | 100 | 100 | 100 | 13 | |
| Polygonum persicaria | | 97 | 94 | 68 | 94 | 77 | 98 | 33 | |
| Solanum nigrum | | 89 | 87 | 66 | 85 | 83 | 86 | 124 | |
| Urtica urens | | 89 | 80 | 96 | 62 | 96 | 96 | 12 | |
| Total weeds | | 92 | 92 | 87 | 91 | 81 | 89 | 185 | |
| Crop score | | 1 | 1 | 1 | 1 | 1 | 1 | | |
| Tuber yield (tons/ac) | R.C.R. | 9.10 | 8.95 | 8.35 | 7.10 | 9.60 | 7.70 | 5.65 | 8.80 HWC |
| | M.P. | 7.25 | 6.95 | 8.00 | 7.70 | 7.65 | 7.62 | 6.70 | 7.90 HWC |
| | R. | 14.00 | 16.25 | 13.75 | 18.80 | 14.35 | 14.40 | 7.90 | 13.15 HWC |
| | K.E. | 16.30 | 11.80 | 12.20 | 13.80 | 14.00 | 14.75 | 8.35 | 13.80 HWC |

No significant difference between yields at P = 0.05
Coefficients of variation. RCR - 21.5%. MP - 19.6%. R - 32.8%. KE - 29.4%

Table 6

1970. % weed control and tuber yield (Beauchamp Roding)

| Herbicide dose lb/ac | | 17,623 RP + linuron | | | | 17,623 RP + C.I.P.C. | linuron + monolinuron | linuron | Control weeds $yd^2$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $\frac{3}{4}+\frac{3}{4}$ | 1+1 | $\frac{3}{4}+\frac{3}{8}$ | $1+\frac{1}{2}$ | $1+\frac{1}{2}$ | 1+1 | 2 | | |
| Avena fatua | | 81 | 73 | 74 | 72 | 87 | 50 | 48 | 9 | |
| Convolvulus arvensis | | 80 | 69 | 0 | 82 | 72 | 0 | 58 | 9 | |
| Total weeds | | 81 | 70 | 35 | 76 | 77 | 18 | 58 | 25 | |
| Crop score | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| Tuber yield (tons/ac) R.C.R. | | 7.10 | 7.80 | 6.00 | 7.50 | 6.60 | 7.80 | 5.90 | 7.0 | 5.65 HWC |
| M.P. | | 7.10 | 6.70 | 6.55 | 6.90 | 7.00 | 6.25 | 7.30 | 6.6 | 6.90 HWC |
| R. | | 12.70 | 13.75 | 11.70 | 11.15 | 11.80 | 13.65 | 11.10 | 12.0 | 10.15 HWC |
| K.E. | | 14.45 | 12.55 | 12.20 | 13.70 | 12.50 | 13.65 | 12.00 | 12.5 | 13.65 HWC |

No significant differences between yields at P = 0.05
Coefficients of variation. RCR - 15%. M.P. - 12.3%. R - 13.5%
K.E.- 18.2%

## DISCUSSION

In 1970, dry weather conditions in early summer brought about late emergence of annual weeds in these trials, and on the clay sites in particular, populations were low throughout. Some Stellaria media was present at practically every trial site; at two there was sufficient to show that the addition of 12-16 oz/acre of linuron, or of 8 oz/acre of C.I.P.C. could control S. media. Control of total populations of annual broad leaf weeds by 16 oz/acre of 17,623 RP + 8 oz/acre of linuron was equivalent to that of the 1:1 linuron/monolinuron mixture at 16-24 oz a.i./acre. However, on a mixed population of Avena fatua and Convolvulus arvensis on cloddy soil, with no rain for several weeks after spraying, the presence of 17,623 RP at 1 lb/ac gave 70%-80% control of both species.

Though no significant differences in yields were shown, it can be seen that the removal of large weed populations with mixtures containing 17,623 RP and with the linuron/monolinuron mixture used as a standard, produced tuber yields that were markedly greater than those from the unsprayed controls, and equivalent to those from the hand weeded plots.

The trials have shown, therefore, that 17,623 RP/linuron mixtures are safe for use pre-emergence in a range of potato varieties and on a range of soil types, have equivalent activity against broad leaf annual weeds as a linuron/monolinuron mixture, and additionally are active against Avena fatua and Convolvulus arvensis.

## References

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# FIELD TRIALS WITH 2-(4-CHLORO-6-ETHYLAMINO-S-TRIAZINE-2-YLAMINE)-2-METHYL-PROPIONITRILE (WL 19805) IN THE UNITED KINGDOM FOR WEED CONTROL IN POTATOES

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Summary WL. 19805*, 2-(4-Chloro-6-ethylamino-s-triazine-2-ylamine)-2-methyl-propionitrile, was evaluated for weed control pre- and post-crop-emergence in early and maincrop potatoes in England, Wales and Scotland over a three year period. Pre-emergence application of 1.5 lb/ac. a.i. in earlies and 1.5 - 2.0 lb/ac. a.i. in maincrop gave good control of a broad spectrum of annual broad leaved weeds and grasses. Treatments at twice these rates were tolerated by the crop. Early post-emergence applications at 1.5 and 2.0 lb/ac. a.i. generally gave satisfactory weed control but inferior to the pre-emergence application, particularly against *Polygonum aviculare*. The crop showed slight but temporary leaf symptoms although yields were not affected.

## INTRODUCTION

WL 19805, 2-(4-chloro-6-othylamine-s-triazine-2-ylamino)-2-methyl-propionitrile, was introduced by Chapman et al (1968) as a promising herbicide in potatoes. The relatively short persistence of the chemical in the soil was of particular interest for weed control in early potatoes because of the lack of residue problems for subsequent cropping.

Initially field experiments were carried out during 1967 in Europe and Japan. Rosher and Urbain (1969) reporting on a series of trials carried out in France found that WL 19805 at 1.5 - 2.0 kg/ha a.i. applied pre-emergence, or at crop emergence, gave good control of the majority of annual weeds for a period of 6-8 weeks with an adequate margin of crop safety.

Trials in the U.K. were laid down in 1968, 1969 and 1970 to evaluate WL 19805 for weed control and crop effect in early and maincrop varieties.

* Known also in the U.K. as DW 3418, in the U.S. as SD 15418 and in Europe and America as Bladex.

## METHODS AND MATERIALS

The following trials were laid down at sites in Wales, Scotland and England:

| | Replicated | | Farmer User | |
|---|---|---|---|---|
| | Early | Maincrop | Early | Maincrop |
| 1968 | - | 4 | - | - |
| 1969 | 3 | 3 | - | - |
| 1970 | 11 | 4 | 7 | 7 |

Early sites (Nos. 1-14) were located in Pembrokeshire, Kent, Fife and Dumbartonshire, while maincrop sites (Nos. 15-23) were spread from Kent to Perth. Soil types varied from light sands to sandy clay loams and with the exception of one black-fen organic matter contents ranged from 1.5% - 4.25% in England and Wales and from 3% - 7.5% in Scotland.

The main trials were laid out in randomised blocks replicated four times, with plot size of 12 yd. x 4 rows. Treatments were applied with a knapsack precision sprayer at a volume rate of 25 gal/ac. at 30 lb/in$^2$ pressure. Linuron and ametryne as commercial w.p. formulations were applied at recommended rates for soil type, as control treatments. WL 19805 was applied in all trials as a 50% w.p. and also in 1970 as a suspension concentrate containing 5.4 lb/gal. The rates used pre-emergence were 1.0 - 3.0 lb/ac a.i. on earlies and 1.5 - 4.0 lb/ac a.i. on maincrop, and post-emergence at 1.5 lb/ac a.i. on earlies and 2.0 lb/ac a.i. on maincrop at approximately 10% emergence of crop.

Mechanical analysis of the soils was carried out and rainfall for the 7 - 10 days before and following treatments was recorded.

The main weed control assessment was carried out at 6 - 8 weeks after spraying in the early potato trials and at 9 - 10 weeks in the maincrop trials. Crop damage was assessed at 2 - 4 weeks. Visual assessments were carried out by two persons and recorded on the European Weed Research Council (EWRC) Scale. Yield results in the early potato trials were obtained by hand lifting, the maincrop trials were harvested mechanically. Samples of the crop were taken for taint and residue analysis.

"Farmer user" trials were unreplicated with one acre plots sprayed by the farmer pre-crop-emergence or at crop emergence.

## RESULTS AND DISCUSSION

### Weed control

General weed control results and the individual weed responses are given in tables 1 and 2. In the 1968 trials sites 15 and 17 were dominated by an uneven distribution of perennial weeds and general weed control was poor. Trial site 16 was on black fen soil, resulting in poor control from all treatments. At these three sites, WL 19805 at 2 - 3 lb/ac a.i. reduced the weed cover as effectively as the standards, but ametryne was significantly better on the fen soil. The assessment at trial No. 18 was carried out at harvest and, whilst linuron was the best treatment, WL 19805 at 2 - 3 lb/ac a.i. was more effective than ametryne.

In the 1969 series on earlies, WL 19805 at 1.0 lb/ac a.i. was often not sufficiently persistent but 1.5 lb/ac a.i. gave very good control of annual weeds and was as effective as linuron at 0.75 - 1.0 lb/ac a.i. The WL 19805 was more

## Table 1: General Weed Control

EWRC Scale 1.0 = complete control 9.0 = no control

| Treatments lb/ac a.i. | Early Varieties | | | | | | | | | | | | | | | Main Crop | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site No. | 1* | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14* | Mean | 15* | 16* | 17* | 18* | 19 | 20 | 21 | 22 | 23 | Mean |
| **Pre-crop emergence** | | | | | | | | | | | | | | | | | | | | | | | | | |
| WL 19805 at 1.0 | 4.3 | 4.6 | 2.8 | 5.6 | 6.8 | 5.5 | 3.3 | 5.6 | 7.0 | 7.3 | 4.1 | 5.3 | 3.9 | - | 5.05 | - | - | - | - | - | 2.3 | 6.2 | - | - | 4.25 |
| " 1.5 | 2.1 | 2.6 | 2.3 | 4.3 | 5.0 | 4.0 | 2.3 | 3.5 | 5.5 | 5.8 | 2.1 | 3.6 | 2.5 | 2.0 | 3.37 | 5.8 | 8.7 | 7.2 | 6.7 | 6.4 | 1.5 | 4.7 | 3.4 | 5.0 | 4.61 |
| " 2.0 | 2.6 | 1.8 | 1.0 | 2.8 | 3.8 | 3.5 | 2.0 | 2.9 | 4.3 | 5.9 | 3.0 | 4.3 | 2.5 | 1.8 | 3.01 | 5.7 | 8.4 | 7.1 | 5.7 | 5.4 | 1.3 | 3.7 | 4.1 | 3.4 | 3.93 |
| " 2.5 | - | 1.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | 5.7 | 8.2 | 7.2 | 5.6 | - | 1.8 | 2.2 | - | - | 3.20 |
| " 3.0 | - | - | - | 2.0 | 2.8 | 2.0 | 1.3 | 1.9 | 3.0 | 5.1 | 1.8 | 4.3 | 1.7 | 1.3 | 2.47 | 7.5 | 7.9 | 7.1 | 5.5 | 4.0 | - | - | 2.1 | 3.1 | 3.38 |
| " 4.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3.1 | 1.7 | 2.40 |
| Linuron at 0.75 | - | 3.3 | 1.8 | - | 6.3 | - | 2.0 | 4.4 | 8.1 | - | - | - | - | - | 4.32 | - | - | - | - | - | - | - | - | - | - |
| " 1.0 | 1.6 | 1.8 | - | 4.1 | - | 7.0 | - | - | - | 5.8 | 3.0 | 4.9 | 3.0 | - | 3.9 | 7.9 | 8.3 | 6.6 | - | - | 1.8 | - | - | 3.7 | 2.75 |
| " 1.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 4.5 | 5.3 | 1.0 | 2.7 | 2.1 | - | 3.12 |
| **Post-crop emergence** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ametryne at 1.375 | 6.8 | - | - | - | - | - | - | - | - | - | - | - | - | 2.0 | 4.4 | - | - | - | - | - | - | - | - | - | - |
| " 1.875 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 6.3 | 7.5 | 5.4 | 6.5 | 6.1 | - | - | - | - | - |
| WL 19805 at 1.5 | - | - | - | 3.4 | 4.9 | 3.3 | 2.0 | 4.3 | 4.2 | 7.4 | 3.8 | 6.4 | 4.3 | - | 4.40 | - | - | - | - | - | - | - | - | - | - |
| " 2.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2.6 | 5.2 | 3.90 |
| S.E. of a Mean ± | - | - | - | 0.32 | 0.26 | 0.44 | 0.42 | 0.40 | 0.23 | 0.50 | 0.54 | 0.38 | 0.51 | - | - | - | - | - | - | - | - | - | - | - | - |
| L.S.D. between Two Treatment means | - | - | - | 0.96 | 0.79 | 1.3 | 1.26 | 1.2 | 0.72 | 1.5 | 1.6 | 1.1 | 1.5 | - | - | - | - | - | - | - | - | - | - | - | - |

* the treatment units at these sites were in kg/ha

The scores from sites 15 - 17 are omitted from the means owing to the disproportionate effects of perennial weeds effective against Poa annua and Fumaria officinalis but less effective against Polygonum aviculare.

Table 2

Summary of the control of individual weed species with WL 19805 at 2 lb/ac. a.i. pre-crop-emergence

EWRC Scale 1.0 = complete control 9.0 = no control

| Weed Species | No. Sites | Mean Control | Range of Control |
|---|---|---|---|
| Atriplex patula | 4 | 3.80 | 2.3 - 5.0 |
| Agropyron repens | 6 | 7.50 | 6.1 - 9.0 |
| Agrostis sp. | 4 | 8.70 | 8.5 - 9.0 |
| Avena fatua | 4 | 7.70 | 6.5 - 9.0 |
| Capsella bursa-pastoris | 3 | 2.30 | 1.0 - 4.0 |
| Chenopodium album | 12 | 3.00 | 1.0 - 5.0 |
| Fumaria officinalis | 10 | 4.10 | 1.0 - 7.0 |
| Galeopsis tetrahit | 3 | 3.00 | 2.0 - 4.0 |
| Galium aparine | 4 | 3.70 | 2.0 - 5.0 |
| Lamium purpureum | 3 | 3.70 | 2.3 - 5.0 |
| Matricaria sp. | 5 | 1.50 | 1.0 - 2.0 |
| Poa annua | 12 | 3.10 | 1.0 - 5.0 |
| Polygonum aviculare | 16 | 4.20 | 1.5 - 8.5 |
| Polygonum convolvulus | 7 | 3.00 | 2.0 - 4.0 |
| Polygonum persicaria | 13 | 3.80 | 1.25 - 8.7 |
| Senecio vulgaris | 6 | 2.30 | 1.0 - 3.5 |
| Sinapis arvensis | 2 | 1.20 | 1.0 - 1.5 |
| Stellaria media | 17 | 2.20 | 1.0 - 5.0 |
| Urtica urens | 5 | 2.30 | 1.0 - 3.5 |
| Veronica arvensis | 7 | 3.10 | 1.0 - 4.5 |
| Veronica hederifolia | 3 | 3.80 | 1.5 - 6.0 |

In the maincrop 1969 trials, 1.5 lb/ac a.i. of WL 19805 generally gave satisfactory weed control but was not as good as the standard linuron treatments. The 2.0 lb/ac a.i. rate was equal to the standard and markedly better when grassy weeds and Fumaria officinalis were present. Early crop competition contributed to the outstanding weed control scores at site 20.

The 1970 trials confirmed the 1969 results for WL 19805 applied pre-emergence, especially the control of grassy weeds including Lolium multiflorum. The post-crop-emergence treatments of WL 19805 generally gave satisfactory, but more variable results, and were significantly less effective than the pre-emergence application where weeds were advanced beyond the 4-leaf stage at treatment. At site 9, where the post-emergence treatment coincided with weed emergence it was significantly more effective than the pre-emergence treatment at the same rate which, in this trial, had been applied 10 - 14 days before crop emergence. It appears that application at or near weed emergence is more important than the stage of crop growth. Poa annua, other grassy weeds and Polygonum aviculare were controlled more effectively by the pre-emergence treatment, whereas Stellaria media, Galeopsis tetrahit, Polygonum persicaria and Polygonum convolvulus were generally controlled more effectively by the post-emergence treatment. Because of slow shoot development in maincrop varieties, 2.0 lb/ac a.i. of WL 19805 was generally required to give weed control equal to the standard treatments.

Results of the farmer user trials confirmed the weed control performance of WL 19805 applied pre-emergence, except in two trials where the treatment was applied in late May 1970. With weeds at the cotyledon to 4-leaf stages, very dry soil conditions and no rainfall for the three weeks after application, as expected, weed control was poor.

No differences in weed control or crop effect between the w.p. and the suspension concentrate formulation of WL 19805 were recorded.

Crop effect and yields

Results of crop damage are shown in table 3 and yields in table 4. Crop damage was confined throughout to slight and temporary leaf margin chlorosis and necrosis of the tips of lower leaves. This generally followed the post-emergence treatments of WL 19805 and, in some trials, the higher rates pre-emergence. These symptoms were more persistent in Red Craigs Royal than in the other varieties but no significant reduction in yield followed any of the WL 19805 treatments. It was noted that where 4.0 lb/ac a.i. was applied a temporary discolouration of the foliage occurred following heavy rain after five weeks drought, similar to effects observed with other potato herbicides. These trials have not yet been harvested.

Potato samples were tested for taint at the Fruit & Vegetable Preservation Research Association and Woodstock Agricultural Research Centre in 1970. No taints in canned new potatoes were detected from WL 19805 at doses of 3.0 lb/ac a.i. pre-emergence and 1.5 lb/ac a.i. post-emergence.

## Conclusions

WL 19805 is an effective herbicide for use in early and maincrop potatoes, with a wide spectrum of broad-leaf weed control and effective suppression of many grasses. It has short persistence which offers advantages in earlies without the risk of residues harmful to subsequent crops.

## Acknowledgments

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**Table 3: Crop Damage Results**

EWRC Scale 1.0 = no damage 9.0 = complete crop kill

| Treatments lb/ac a.i. | Early Varieties | | | | | | | | | | | | | | | Main Crop | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Mean | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | Mean |
| **Pre-Crop Emergence** | | | | | | | | | | | | | | | | | | | | | | | | | |
| WL 19805 at 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 | 1.0 | 1.0 | 1.0 | 1.1 | - | 1.08 | - | - | - | - | - | 1.0 | 1.0 | 1.0 | - | 1.0 |
| " 1.5 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.2 | 1.0 | 2.3 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.10 | 1.6 | 1.2 | 1.4 | 1.0 | 1.0 | 1.3 | 1.0 | 1.0 | 1.0 | 1.17 |
| " 2.0 | 1.0 | 1.2 | 2.0 | 1.0 | 1.0 | 1.0 | 1.2 | 2.1 | 2.3 | 1.0 | 1.0 | 1.0 | 1.2 | 1.0 | 1.28 | 1.6 | 1.8 | 1.5 | 1.0 | 1.0 | 1.8 | 1.0 | 1.0 | 1.0 | 1.30 |
| " 2.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1.4 | 1.9 | 1.2 | 1.0 | - | 2.5 | 1.0 | - | - | 1.47 |
| " 3.0 | - | - | - | 1.0 | 1.0 | 1.0 | 1.0 | 2.3 | 3.1 | 1.0 | 1.0 | 1.0 | 1.1 | 2.5 | 1.45 | 1.7 | 2.3 | 1.5 | 1.0 | 1.0 | - | - | 1.0 | 1.0 | 1.36 |
| " 4.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1.5 | 2.7 | 2.10 |
| Linuron at 0.75 | - | 1.0 | 1.0 | - | 1.0 | - | 1.0 | 1.0 | 1.8 | - | - | - | - | - | 1.13 | - | - | - | - | - | - | - | - | - | - |
| " 1.0 | 1.0 | 1.0 | - | 1.0 | - | 1.0 | - | - | - | 1.0 | 1.0 | 1.0 | 1.0 | - | 1.0 | 1.9 | 1.9 | 1.1 | - | - | 1.0 | - | - | 1.0 | 1.72 |
| " 1.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | - | 1.0 |
| **Post-Crop Emergence** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ametryne at 1.375 | 1.0 | - | - | - | - | - | - | - | - | - | - | - | - | 1.0 | 1.0 | - | - | - | - | - | - | - | - | - | - |
| " 1.875 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1.8 | 3.1 | 1.6 | - | 1.0 | - | - | - | - | 1.87 |
| WL 19805 at 1.5 | - | - | - | 1.0 | 1.0 | 1.0 | 1.0 | 2.3 | 2.3 | 1.0 | 1.0 | 1.0 | 1.1 | - | 1.27 | - | - | - | - | - | - | - | - | - | - |
| " 2.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1.5 | 1.5 | 1.50 |

### Table 4: Crop Yield as % of Standard Control

(Standard Control = 100)

| Treatments lb/Acre a.i. | Site 1 | 5 | 6 | 8 | 9 | 11 | 13 | 14 | Mean | 15 | 17 | 18 | 19 | 20 | 21 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pre-Crop Emergence** | | | | | | | | | | | | | | | | |
| WL 19805 at 1.0 | 100 | 108 | 87 | - | 153 | 124 | 95 | - | 111 | - | - | - | - | 108 | 90 | 99 |
| " 1.5 | 118 | 102 | 98 | 104 | 161 | 103 | 101 | 98 | 111 | 100 | 111 | 93 | 94 | 114 | 93 | 101 |
| " 2.0 | 100 | 102 | 106 | - | 144 | 89 | 90 | 96 | 104 | 93 | 107 | 96 | 105 | 107 | 96 | 101 |
| " 2.5 | - | - | - | - | - | - | - | - | - | 91 | 96 | 103 | - | 100 | 101 | 98 |
| " 3.0 | - | 99 | 106 | 94 | 161 | 100 | 107 | 95 | 109 | 91 | 1108 | 86 | 108 | - | - | 98 |
| Linuron at 0.75 | - | 100 | - | 100 | 100 | - | - | - | 100 | - | - | - | - | - | - | - |
| " 1.0 | 100 | - | 100 | - | - | 100 | 100 | - | 100 | 100 | 100 | - | - | 100 | - | 100 |
| " 1.5 | - | - | - | - | - | - | - | - | - | - | - | 100 | 100 | 103 | 100 | 101 |
| **Post-Crop Emergence** | | | | | | | | | | | | | | | | |
| Ametryne at 1.375 | 112 | - | - | - | - | - | - | 100 | 126 | - | - | - | - | - | - | - |
| " 1.875 | - | - | - | - | - | - | - | - | - | 93 | 93 | 103 | 90 | - | - | 95 |
| WL 19805 at 1.5 | - | 102 | 107 | 100 | 161 | 94 | 92 | - | 109 | - | - | - | - | - | - | - |
| Untreated Control | - | 95 | 103 | - | 84 | 91 | 77 | 71 | 87 | 93 | 51 | 47 | 69 | - | - | 65 |
| Actual Yields (Tons/Acre) of Commercial Control | 10.3 | 6.80 | 6.00 | 7.01 | 2.90 | 19.3 | 12.3 | 3.42 | | 21.9 | 10.9 | 15.8 | 12.3 | 14.6 | 13.9 | |
| S.E. of a Mean % ± | 7.95 | 7.23 | 7.15 | 7.25 | 11.1 | 5.61 | 6.35 | 5.9 | | 6.25 | 6.52 | 5.82 | 3.35 | - | - | |
| Least Significant Difference between Two Means | 11.7 | N.S. | N.S. | N.S. | 36.0 | 16.7 | 18.7 | 17.0 | | 17.9 | 18.7 | 16.7 | 9.7 | - | - | |

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# CONTROL OF AGROPYRON REPENS (L.) BEAUV. IN SUGAR BEET WITH TCA

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Summary In field experiments TCA applied at 10, 15 and 20 lb/ac controlled approximately 80%-90% of A.repens in sugar beet except at a few sites where only 60%-70% control was obtained with the 10 lb rate. Doses of 30 and 40 lb/ac controlled approximately 95%-100% of A.repens. The optimum time of application was March/early April. Crop phytotoxicity studies indicated that 20 lb/ac TCA can be applied 14 days before crop sowing without reducing final root yield although retardation of seedling growth may be obtained. Doses in excess of 20 lb/ac can cause crop damage. Crop phytotoxicity was more severe in 1967 than in '68 and '69 and apparently the effects of TCA are influenced by environmental conditions.

## INTRODUCTION

Agropyron repens is a prevalent grass weed in Ireland where it is often a problem in root crops including sugar beet. Recommended doses of aminotriazole, dalapon and TCA (sodium trichloracetate) applied in autumn give satisfactory control of A.repens but the relatively high cost of these herbicides limits their use in agricultural crops. Spring application of TCA, 30 lb/ac eight weeks before crop sowing, is recommended for a number of root crops (Fryer and Evans, 1968). Bylterud (1965) however, reported recommendations from some Scandinavian countries of 10 to 25 kg/ha TCA applied in winter or early spring. The investigations described here were commenced in 1966 to obtain information on the control of A.repens in sugar beet with relatively low doses of TCA applied in the spring.

## METHOD AND MATERIALS

Two series (Series 1 and 11) of experiments were carried out in 1967 and 1968. Experiments were conducted on sites where barley or wheat infested with A.repens were grown the previous year. The stubble was ploughed 7 to 9 inches deep in late autumn - early winter. TCA (sodium trichloracetate) was sprayed on the ploughed sod and no cultivations were carried out until three to four days before crop sowing. In Series 11 one cultivation approximately 4 to 5 inches deep was carried out before TCA application.

In Series 1, TCA was applied with a propane pressurised sprayer at a volume rate equivalent to 50 gal water/ac. Each plot measured 36ft long and 12 ft wide. Experiments were of randomised block design with six replications. Unsprayed areas 3 ft and 6ft wide were left between adjacent plots and blocks respectively. Control of A.repens, crop vigour and seedling number were determined at the time of crop singling. In 1967 control of A.repens was also assessed at the end of September. An area consisting of approximately 135 square ft was harvested from each plot where root yields and sugar per cent were recorded.

In Series 11 plot size measured 21ft wide extending the length of the field. TCA was applied in 50 gal water per acre with a tractor-mounted sprayer. Crop vigour and control of A.repens was visually assessed at singling.

Experiments were carried out in 1968 and 1969 on weed free sites to determine the effects of dosage rate and time of application of TCA on emergence, growth and final yield of sugar beet. Experimental method and materials were the same as described for Series 1 except that the TCA was soil incorporated 3-4 inches deep with a rotary cultivator on the day of spraying.

In spring 1970 the influence of the time of application of TCA on the control of A.repens was investigated in a small plot field trial. In early March, thirty rhizomes, each 12 inches long were planted three inches deep in plots 12ft long and 4ft wide. TCA was applied at 15 and 30 lb/ac on March 2nd, March 23rd, April 10th, April 23rd, and May 21st in 50 gal water/ac and soil incorporated 3 inches deep by hand forking. Each treatment was replicated three times. Counts of emerged shoots and fresh weight of shoots and rhizome/roots were determined on July 20th. Aerial shoots of A.repens which were visible on April 23rd and May 21st were not destroyed or buried after TCA application.

## RESULTS

### Effect on A.repens

The doses of TCA shown in Table 1 were applied at 42, 28 and 14 days before crop sowing, but as time of treatment did not influence the percentage control of A.repens to any appreciable extent only the results from 42, and 14 days are shown. The percentage control of A.repens was generally higher in 1967 than in '68. This was also apparent in Series 11 experiments (Table 2 and Table 3). Counts of emerged shoots at harvest (Table 1) show that the effect of TCA lasted throughout the season. However, at site 4, Series 11 1967, there was a marked increase of A.repens during the growing season in the 10 lb treatment. This was especially true where the TCA was applied 6 weeks before crop sowing, and indicates a temporary suppression of A.repens by the 10 lb dose.

The shoots of A.repens present in TCA treated areas were generally less vigorous than in the untreated controls and consequently the growth or new rhizomes of affected plants was reduced.

The effect of time of application of 15 and 30 lb/ac TCA compared with the untreated control on stem number, fresh weight of leaf/stem and fresh weight of rhizome/roots is shown in Table 4. Stem number and fresh weight of leaf/stem and rhizome/roots were reduced greatly when TCA was applied on March 2nd, March 23rd, and April 10th. Stem number increased, and fresh weight of leaf/stem and rhizome/roots were reduced by 15 lb applied on April 30th. Each dose applied on May 21st increased stem number by approximately 20%. However, fresh weight of stem/leaf and rhizome/roots was reduced by the higher dose.

### Effect on beet

In trial Series 1 1967, TCA at 40 lb/ac applied 28 and 14 days before crop sowing, reduced crop seedling number. A 20% reduction was obtained at site 7, Series 11 1967, with the 20 lb dose applied 21 days before crop sowing. TCA had no

Table 1

Effect of TCA on *A.repens* (Series 1 1967 and 1968)

| Rate of TCA (lb/ac) | Time of treatment (days before crop sown) | % Control *A.repens* 1967 At singling | 1967 At Harvest | 1968 At singling |
|---|---|---|---|---|
| 10 | 42 | 89 | 87 | 77 |
| | 14 | 85 | 89 | 81 |
| 15 | 42 | -- | -- | 87 |
| | 14 | -- | -- | 89 |
| 20 | 42 | 98 | 97 | 87 |
| | 14 | 95 | 98 | 93 |
| 30 | 42 | 97 | 96 | 89 |
| | 14 | 96 | 98 | 95 |
| 40 | 42 | 100 | 100 | -- |
| | 14 | 96 | 99 | -- |

Table 2

Effect of TCA on *A.repens* (Series 11 1967)

| Treatment TCA, lb/ac | Time of treatment (days before crop sown) | % Control *A.repens* Site 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 10 | 21 | 85 | 87 | 85 | 87 | 90 | 82 | 87 |
| | 42 | 85 | 85 | 86 | 86 | 90 | 87 | 83 |
| 15 | 21 | - | - | - | 95 | 93 | 95 | - |
| | 42 | - | - | - | - | - | - | - |
| 20 | 21 | 95 | 95 | 92 | - | - | - | 95 |
| | 42 | 92 | 95 | 90 | 93 | 95 | 96 | 95 |

effect on crop seedling number in any trial in 1968 and '69.

Visual assessment of crop seedling vigour showed that TCA retarded the early growth of crop plants (Table 3 and Table 5). The degree of retardation varied with TCA dose, time of application, site and year. The cotyledons of affected plants were characteristically brittle. This was also observed in some TCA treated plants where no reduction in vigour was evident.

In Series 1, 1967 root number and yield of the untreated control were lower than the TCA treated plots. It is assumed that TCA at 10 lb/ac applied 42 days before crop sowing had no effect on the crop other than indirectly from weed control and this treatment is taken as a control for treatment comparison.

Table 3

Effect of TCA on A. repens and crop vigour (Series 11, 1968)

| Site | Time of treatment (days before crop sown) | Treatment (TCA, lb/ac) | [1] % control A. repens | [2] Crop vigour % |
|---|---|---|---|---|
| 1 | 25 | 10 | 70 | 90 |
| | | 15 | 85 | 90 |
| 2 | 32 | 10 | 90 | 100 |
| | | 15 | 90 | 100 |
| 3 | 36 | 10 | 90 | 100 |
| | | 15 | 90 | 100 |
| 4 | 42 | 10 | 90 | 100 |
| | | 15 | 95 | 100 |
| 5 | 35 | 10 | 90 | 100 |
| | | 15 | 90 | 90 |
| 6 | 32 | 10 | 85 | 100 |
| | | 20 | - | 100 |
| 7 | 45 | 10 | 60 | 100 |
| | | 15 | 85 | 90 |
| 8 | 51 | 10 | 40 | 100 |
| | | 20 | 70 | 100 |
| 9 | 42 | 10 | 70 | 100 |
| | | 20 | 90 | 100 |
| 10 | 56 | 10 | 60 | 100 |
| | | 20 | 90 | 80 |
| 11 | 65 | 10 | 70 | 100 |
| | | 15 | 80 | 100 |
| 12 | 78 | 10 | 60 | 100 |
| | | 20 | 80 | 100 |

1 Expressed to nearest 5%

2 Visual assessment

Table 4

Effect of time of application of TCA on A.repens (1970)

| Treatment TCA, lb/ac) | Time of treatment (date) | No of shoots | Fresh wt stems/leaves (g) | Fresh wt rhizomes/roots (g) |
|---|---|---|---|---|
| 15 | 2/3/70 | 46 | 21.0 | 112.0 |
| | 23/3/70 | 44 | 21.0 | 168.0 |
| | 10/4/70 | 39 | 10.5 | 45.5 |
| | 30/4/70 | 356 | 392.0 | 826.0 |
| | 21/5/70 | 493 | 567.0 | 1169.0 |
| 30 | 2/3/70 | 22 | 10.9 | 63.0 |
| | 23/3/70 | 20 | 10.5 | 73.5 |
| | 10/4/70 | 6 | 7.0 | 28.0 |
| | 30/4/70 | 239 | 280.0 | 578.0 |
| | 21/5/70 | 495 | 322.0 | 665.0 |
| 0.0 (Untreated) | --- | 330 | 563.0 | 1358.0 |

Table 5

Effect of TCA on sugar beet (Series 1)

| Treatment (TCA, lb/ac) | Time of treatment (days before crop sown) | Root yield (tons/ac) | | | No of roots (000's/ac) | | | Crop vigour % | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1967 | '68 | '69 | 1967 | '68 | '69 | 1967 | '68 | '69 |
| 10 | 42 | 17.38 | 20.35 | 18.03 | 24.96 | 25.12 | 23.60 | 100 | 100 | 100 |
| 10 | 28 | 17.69 | 20.47 | 18.57 | 24.16 | 25.92 | 24.08 | 100 | 100 | 100 |
| 10 | 14 | 17.29 | 19.24 | 18.80 | 22.88 | 26.16 | 22.64 | 90 | 90 | 90 |
| 20 | 42 | 17.07 | 20.20 | 19.03 | 22.24 | 25.36 | 22.88 | 100 | 100 | 100 |
| 20 | 28 | 17.62 | 18.89 | 17.67 | 24.64 | 27.28 | 24.32 | 90 | 100 | 90 |
| 20 | 14 | 16.81 | 20.82 | 18.60 | 22.56 | 24.88 | 23.04 | 80 | 90 | 90 |
| 30 | 42 | 16.50 | 20.64 | 18.07 | 24.48 | 26.40 | 23.52 | 90 | 100 | 90 |
| 30 | 28 | 16.17 | 19.89 | 18.78 | 22.19 | 26.72 | 25.36 | 80 | 90 | 80 |
| 30 | 14 | 16.62 | 20.89 | 18.82 | 22.61 | 27.36 | 22.56 | 70 | 90 | 80 |
| 40 | 42 | 16.88 | 19.43 | 18.78 | 22.13 | 26.72 | 25.52 | 80 | 100 | 90 |
| 40 | 28 | 15.57 | 19.89 | 18.82 | 20.21 | 26.40 | 20.80 | 70 | 90 | 80 |
| 40 | 14 | 16.21 | 19.92 | 18.10 | 21.49 | 27.04 | 22.16 | 60 | 80 | 80 |
| 0.0 | -- | 15.07 | 20.61 | 18.07 | 21.71 | 24.32 | 23.44 | 100 | 100 | 100 |
| F Test | | *** | N.S. | N.S. | ** | N.S. | N.S. | | | |
| S.E. | | ±0.46 | ±0.62 | ±0.74 | ±1.03 | ±0.75 | ±1.10 | | | |

The number of roots/ac was not affected by TCA except in Series 1, 1967 where root number was reduced significantly ($P < 0.05$) by 40 lb/ac applied 28 and 14 days before crop sowing. Yield of roots was also reduced significantly ($P < 0.05$) by these treatments and by 30 lb/ac applied 28 days before crop sowing. Yield was not affected by any treatment in 1968 and 1969. Sugar % was not affected in any trial.

## DISCUSSION

The results of the investigations reported here showed that relatively low doses of TCA applied in the spring controlled a high percentage of A.repens. This agrees with the findings reported by Bylterud (1965), Hackansson (1968) and Holroyd and Wilson (1968). Sufficient specific information is not available to explain the relatively low percentage control obtained at some sites in 1968. However, time of application of TCA, amount of rainfall after treatment, soil temperature and soil type may have influenced the results.

The time of application trial in 1970 showed that March/early April is the optimum treatment time for TCA although it is well established that good control of A.repens may also be obtained in summer and autumn where the aerial shoots are destroyed (Hackansson 1969, Ramand et al, 1968). Unpublished results indicate that low doses of TCA applied in early February give inadequate control of A.repens when rainfall is high and soil leaching of the herbicide is excessive. Excessive leaching of TCA may have occurred at some sites in 1968 when the average rainfall in March and April was approximately 2.5 times greater than that of the corresponding months in 1967.

The low number and yield of roots in the untreated control in Series 1, 1967 are interesting. The A.repens was undisturbed until the aerial shoots were destroyed by hand hoeing and mechanical inter-row cultivation at singling. Despite three additional subsequent inter-row cultivations A.repens established in the untreated controls, and it is likely that competition between crop and weed for light and nutrients together with the low number of crop plants after singling reduced the yield of roots. A.repens interfered with manual singling and mechanical inter-row hoeing; this resulted in excessive removal of crop plants.

Crop phytotoxicity studies in 1967-69 showed that 20 lb/ac TCA may be applied approximately 14 days before crop sowing without a reduction in plant population and field yield. The results in 1967, however, indicate that doses in excess of 20 lb can cause crop damage under certain environmental conditions and thus an interval of 28 days TCA application and crop sowing is desirable. Possible interactions between TCA and other herbicides for the control of annual weeds could also increase crop damage and studies on this aspect are in progress.

## Acknowledgments

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# A PROGRAMME FOR THE CONTROL OF ANNUAL BROAD-LEAVED WEEDS IN SUGAR BEET

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Summary The rapid acceptance of herbicides in the sugar beet crop over the past few years is a reflection of the declining availability and increased cost of hand labour. As the trend to total mechanisation increases there is a demand for herbicides capable of giving season long weed control. No single herbicide marketed at present meets this requirement under varying conditions and a programmed approach involving two herbicides has been examined.

Results from two years work (1968 & 1969) on mineral soils have confirmed the complementary nature of lenacil (pre-emergence) and phenmedipham (post-emergence) in such a programme. This paper indicates that very good weed control can be obtained from the pre-emergence use of 3/4 or recommended dose of lenacil followed by 4/5 or recommended dose of phenmedipham post-emergence. The use of lower doses may be possible under some circumstances but reliability is reduced.

## INTRODUCTION

Sugar beet is an important crop in many farming systems. In order to offset the declining availability and increasing expense of hand labour it is necessary to rely more and more on mechanisation. A variety which can be drilled satisfactorily at wide spacing in the row to produce an acceptable plant population and profitable yield is a first essential. Herbicides are also needed to give adequate season long weed control. Despite the wide range of materials now available no single herbicide has the necessary properties of activity and selectivity to achieve the required standard of results under widely varying conditions. Therefore a programme involving two or more herbicides is suggested and an obvious first line of approach is to consider the application of pre and post-emergence sprays.

During the development of lenacil and phenmedipham it became obvious that these materials were complementary. Both control many broad-leaved weeds important in the sugar beet crop but there are important differences in activity on certain species as indicated in table 1. It was therefore decided to examine a programme of weed control involving both chemicals. This paper summarises the results obtained over two years, 1968 and 1969.

Table 1

Susceptibility of certain weeds to lenacil & phenmedipham

| Weed | Lenacil | Phenmedipham |
| --- | --- | --- |
| Anchusa arvensis | Intermediate | Susceptible |
| Polygonum aviculare | Susceptible | Some susceptibility at cotyledon stage |
| Matricaria/Tripleurospermum spp. | Susceptible | Sometimes controlled when very small |
| Urtica urens | Intermediate | Susceptible |
| Veronica hederifolia | Resistant | Susceptible |
| Other Veronica spp. | Intermediate | Susceptible |
| Viola tricolor | Resistant | Susceptible |

## METHODS AND MATERIALS

All experiments were carried out on commercial crops grown on mineral soils in East Anglia, East and West Midlands and Lincolnshire. A minimum seed spacing of 5" within the row was intended throughout. Plots were 10 yards x 3 or 4 rows and each treatment was replicated four times in a randomised layout. The standard commercial formulations were used and applied through a Drake and Fletcher knapsack sprayer operating at a pressure of 35 p.s.i. (2$^{1}$/2 atmos.) and giving an output of 20 gal/ac. The recommended dose of lenacil (pre-emergence) varied according to soil type between 1 and 2$^{1}$/2 lbs Venzar$^{R}$ (80% lenacil) per acre. The recommended dose of phenmedipham (post-emergence) was constant at 5 pints Betanal$^{R}$ (15.9% phenmedipham) per acre. Assessments of weed control were carried out at various times during the season by quadrat counts and visual assessments.

### 1968 Trials

Seven trials were laid down in 1968. The treatments used are presented in the table of results (table 6). Details of application and weeds present in unsprayed areas at the time of phenmedipham application are given in tables 2 and 3 respectively.

Table 2

Application details 1968 Trials

| Site | Soil Type (New Jersey) Scale | Variety | Date Drilled '68 | Date sprayed 1968 | | Stage of crop at phenmedipham application |
| --- | --- | --- | --- | --- | --- | --- |
| | | | | lenacil | phenmedipham | |
| 1. Lincs. | SCL | Not recorded | 4/4 | 8/4 | 6/5 | 2-3 L |
| 2. Lincs. | LVFS | Not recorded | 7/4 | 11/4 | 6/5 | 2-4 L |
| 3. Suffolk | ZyL | Sharpes Klein E | 8/4 | 10/4 | 18/5 | Cot-2 L |
| 4. Berks. | SL | Amono | 10/4 | 10/4 | 6/5 | Cot-2 L |
| 5. Norfolk | VFSL | Sharpes Monogerm | 27/3 | 4/4 | 21/5 | Cot-2 L |
| 6. Staffs. | LFS | Sharpes Monogerm | 27/3 | 4/4 | 21/5 | 2-4 L |
| 7. Hereford | CSL | Anglo Maribo Poly | 8/4 | 9/4 | 1/5 | Early-late Cot |

Cot = Cotyledon L = True Leaves

Table 3

Main weed species and stages at phenmedipham application, 1968 trials

| Weed | Sites 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Stellaria media | - | Cot-½" | ½"-1½" | ½"-1½" | - | 1½"-2½" | ½"-1" |
| Polygonum convolvulus | Cot-1L | 1L | Cot-2L | Cot-1L | - | 2L | Cot |
| Polygonum aviculare | - | - | Cot-2L | Cot-1L | Cot | 1-3L | Cot-2L |
| Chenopodium album | Cot | 2L | 2-4L | 2L | Cot-2L | 4-6L | - |
| Matricaria/Tripleurospermum spp. | - | - | 1½" | ½"-1" | Cot-½" | - | Cot-1" |
| Veronica persica | - | - | Cot | - | - | - | Cot-2L |
| Veronica hederifolia | Cot-1L | - | - | - | - | 4L | Cot |
| Urtica urens | - | - | 2L | - | - | 4-6L | - |
| Raphanus raphanistrum | - | - | Cot-2L | 2L | - | - | - |
| Fumaria officinalis | 1L | - | - | - | - | 4L | Cot-4L |
| Senecio vulgaris | - | - | - | - | Cot-2L | 4L | - |

Cot = Cotyledon L = True Leaves

In addition to the species recorded in table 3 the following weeds were recorded once only: Polygonum persicaria, Polygonum lapathifolium, Galium aparine, Viola tricolor, Anagallis arvensis, Capsella bursa-pastoris, Anchusa arvensis, Thlaspi arvense.

## 1969 Trials

In 1969 it was decided to lay down six trials to examine a wider range of treatments than those tested in 1968. Actual treatments are presented in the tables of results (tables 7 & 8). Tables 4 and 5 give details of application and weeds present at the time of phenmedipham application respectively.

Table 4

Application details 1969 trials

| Site | Soil Type (New Jersey Scale) | Variety | Date Drilled '69 | Date sprayed: lenacil | phenmedipham: Phen alone | After 1/2 lenacil | After 3/4 lenacil | After full lenacil | After phen. repeat dose | Crop stage at 1st phenmedipham application |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Herts | SL | Sharpes Klein E | 3/4 | 5/4 | 30/4 | 5/5 | 19/5 | 19/5 | 6/6 | Cot |
| 2. Suffolk | LVFS | Bush Mono | 11/4 | 14/4 | 8/5 | 14/5 | 14/5 | 14/5 | 29/5 | 2-4L |
| 3. Somerset | VFSL | M 31 Amono | 16/4 | 23/4 | 14/5 | 13/5 | 14/5 | 14/5 | 23/5 | Cot-2L |
| 4. Notts | FSL | Amono | 17/4 | 19/4 | 21/5 | 3/6 | 11/6 | not req. | 11/6 | Cot-2L |
| 5. Lincs. | FSL | Monotri | 12/5 | 12/5 | 5/6 | 10/6 | 20/6 | 20/6 | 10/6 | Cot-2L |
| 6. Oxon | Zyl | Monotri | 4/4 | 10/4 | 1/5 | 1/5 | 1/5 | 1/5 | 29/5 | Cot-2L |

Cot = Cotyledon L = True Leaves

Table 5

Main weed species and stages at 1st phenmedipham application 1969

| Weed | Sites 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Stellaria media | Cot-½" | ½"-1" | ½" | ½"-1" | 1"-1½" | - |
| Polygonum convolvulus | Cot-1L | - | Cot | Cot-2L | 1L | Cot-1L |
| Polygonum aviculare | Cot-1L | - | Cot-2L | Cot-2L | 1L | Cot-1L |
| Chenopodium album | Cot-2L | Cot | Cot | 2L | - | - |
| Matricaria/Tripleurospermum spp. | 1" | ½" | 1" | ½"-1" | 1"-1½" | - |
| Galium aparine | - | - | 2-4L | - | - | Cot |
| Veronica persica | Cot-2L | Cot | 2L | - | Cot-2L | - |
| Veronica hederifolia | - | - | 2L | - | - | Cot-2L |
| Viola arvensis | Cot | - | - | - | - | Cot-2L |
| Sonchus oleraceus | - | - | 2L | 2L | - | - |
| Poa annua | - | - | 1L | 2L | 4L | 2-4L |

Cot = Cotyledon   L = True leaves

The following weeds were recorded once only. Polygonum persicaria, Lamium purpureum, Spergula arvensis, Urtica urens, Raphanus raphanistrum, Silene alba, Anagallis arvensis, Atriplex patula.

## RESULTS

### 1968 Results

(1) Effect on crop

No crop damage was recorded on five sites. A slight reduction in vigour occurred with treatments 3 and 4 on two sites (sites 5 and 7) but the crop quickly recovered.

(2) Effect on weeds

Data for the final weed control assessments made 8-10 weeks after drilling are given in table 6. (Rec. = recommended.)

Table 6

Mean % Weed Control. Final assessment 1968

| Treatment: Pre-emergence | Post-emergence | Sites 1 | 2 | 3 | 4 | 5 | 6 | 7 | Mean |
|---|---|---|---|---|---|---|---|---|---|
| 1. ½ rec. dose lenacil | Unsprayed | 85 | 75 | 60 | 60 | 65 | 85 | 40 | 67 |
| 2. ⅔ rec. dose lenacil | Unsprayed | 85 | 85 | 60 | 60 | 70 | 85 | 65 | 73 |
| 3. ½ rec. dose lenacil | Rec. dose phenmedipham | 100 | 95 | 80 | 60 | 100 | 90 | 75 | 86 |
| 4. ⅔ rec. dose lenacil | Rec. dose phenmedipham | 100 | 95 | 90 | 80 | 95 | 100 | 95 | 93 |
| 5. Unsprayed | Rec. dose phenmedipham | 100 | 95 | 90 | 85 | 100 | 100 | 95 | 95 |
| 6. Unsprayed | Unsprayed | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

A four sites reduced doses of lenacil alone did not give a commercially acceptable control of those weeds normally regarded as susceptible, notably Polygonum aviculare, Polygonum convolvulus, Chenopodium album and Raphanus raphanistrum. On the remaining sites better results were obtained but known resistant weeds e.g. Veronica hederifolia and Anchusa arvensis survived. Phenmedipham alone at recommended rate gave 90% weed control or better on six of the seven sites. Each dose of lenacil followed by phenmedipham gave very good results and treatment 4 (2/3 dose lenacil followed by recommended dose phenmedipham) gave 95-100% weed control on five of the seven sites. Galium aparine was resistant to all treatments.

## 1969 results

### (1) Effect on crop

Plant counts of total seedlings on 10 yards/plot were made on all sites except site 6 and are given in table 7. At site 6 poor seedbed conditions and leather-jacket damage made counts unreliable.

Table 7

Mean plant counts on sites 1-5

| Treatment: Pre-emergence | Treatment: Post-emergence | Sites: 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1. Rec. dose lenacil | Unsprayed | 42 | 34 | 41 | 52 | 47 |
| 2. 3/4 rec. dose lenacil | Unsprayed | 52 | 39 | 43 | 58 | 50 |
| 3. 1/2 rec. dose lenacil | Unsprayed | 47 | 35 | 41 | 59 | 53 |
| 4. Rec. dose lenacil | Rec. dose phenmedipham | 42 | 36 | 14 | 51 | 49 |
| 5. 3/4 rec. dose lenacil | Rec. dose phenmedipham | 45 | 34 | 17 | 61 | 48 |
| 6. 1/2 rec. dose lenacil | Rec. dose phenmedipham | 43 | 38 | 29 | 62 | 46 |
| 7. Rec. dose lenacil | 4/5 rec. dose phenmedipham | 48 | 38 | 26 | 54 | 47 |
| 8. 3/4 rec. dose lenacil | 4/5 rec. dose phenmedipham | 40 | 35 | 34 | 51 | 47 |
| 9. 1/2 rec. dose lenacil | 4/5 rec. dose phenmedipham | 46 | 33 | 41 | 63 | 50 |
| 10. Rec. dose lenacil | 3/5 rec. dose phenmedipham | 43 | 38 | 29 | 59 | 47 |
| 11. 3/4 rec. dose lenacil | 3/5 rec. dose phenmedipham | 40 | 37 | 34 | 69 | 48 |
| 12. 1/2 rec. dose lenacil | 3/5 rec. dose phenmedipham | 39 | 36 | 40 | 53 | 48 |
| 13. Unsprayed | Rec. dose phenmedipham | 43 | 35 | 44 | 59 | 48 |
| 14. Unsprayed | Rec. dose phenmedipham + Rec. dose phenmedipham 10 days later | 40 | 36 | 43 | 59 | 49 |
| 15. Unsprayed | Unsprayed | 38 | 35 | 41 | 59 | 45 |

Loss of plants was recorded on one site only (site 3) where there was severe reduction in seedling numbers with treatments 4 and 5 (recommended and 3/4 dose lenacil followed by recommended rate phenmedipham). Moderately severe losses occurred with treatments 6, 7, 8, 10 and 11 on the same site.

Crop growth was affected on one site only, again site 3. Here all treatments reduced vigour to varying extents although plants recovered later in the season. Yields were not taken but loss of plants (table 7) coupled with loss of vigour is likely to have had a serious effect on yield with all treatments using $^3/4$ or recommended rate lenacil followed by phenmedipham even at the lowest dose at this site.

(2) Effect on weeds

Table 8 gives the final assessments of weed control which were made just before the crop met across the rows.

Table 8

Mean % Weed Control. Final assessment 1969

| | Treatment: Pre-emergence | Treatment: Post-emergence | Sites 1 | 2 | 3 | 4 | 5 | 6 | Mean |
|---|---|---|---|---|---|---|---|---|---|
| 1. | Rec. dose lenacil | Unsprayed | 50 | 64 | 95 | 79 | 64 | 50 | 67 |
| 2. | $^3/4$ rec. dose lenacil | Unsprayed | 50 | 48 | 85 | 59 | 50 | 30 | 54 |
| 3. | $^1/2$ rec. dose lenacil | Unsprayed | 10 | 14 | 80 | 55 | 32 | 0 | 32 |
| 4. | Rec. dose lenacil | Rec. dose phenmedipham | 97 | 98 | 98 | 88 | 78 | 90 | 92 |
| 5. | $^3/4$ rec. dose lenacil | Rec. dose phenmedipham | 95 | 85 | 98 | 89 | 75 | 90 | 89 |
| 6. | $^1/2$ rec. dose lenacil | Rec. dose phenmedipham | 75 | 78 | 90 | 71 | 64 | 75 | 77 |
| 7. | Rec. dose lenacil | $^4/5$ rec. dose phenmedipham | 95 | 98 | 97 | 80 | 75 | 80 | 88 |
| 8. | $^3/4$ rec. dose lenacil | $^4/5$ rec. dose phenmedipham | 93 | 80 | 98 | 89 | 75 | 80 | 86 |
| 9. | $^1/2$ rec. dose lenacil | $^4/5$ rec. dose phenmedipham | 75 | 70 | 93 | 68 | 62 | 70 | 73 |
| 10. | Rec. dose lenacil | $^3/5$ rec. dose phenmedipham | 85 | 83 | 98 | 73 | 65 | 75 | 80 |
| 11. | $^3/4$ rec. dose lenacil | $^3/5$ rec. dose phenmedipham | 85 | 70 | 99 | 66 | 62 | 60 | 75 |
| 12. | $^1/2$ rec. dose lenacil | $^3/5$ rec. dose phenmedipham | 50 | 60 | 94 | 63 | 50 | 70 | 65 |
| 13. | Unsprayed | Rec. dose phenmedipham | 40 | 58 | 70 | 54 | 19 | 60 | 50 |
| 14. | Unsprayed | Rec. dose phenmedipham + Rec. dose phenmedipham 10 days later | 97 | 68 | 70 | 70 | 58 | 70 | 74 |
| 15. | Unsprayed | Unsprayed | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Rec. = Recommended rate

Lenacil alone at lower doses gave inadequate weed control on most sites due to the occurrence of resistant or partially resistant species and to prolonged weed emergence. Phenmedipham alone was inadequate for the same reasons. Best results were achieved with combinations of $^3/4$ or recommended dose lenacil followed by $^4/5$ or recommended dose phenmedipham. (Treatments 4, 5, 7 and 8).

## DISCUSSION

The results presented in tables 6 and 8 show that lenacil alone and phenmedipham alone did not always give the high standard of results essential to a mechanised system of growing sugar beet. This is partly due to the occurrence of weeds resistant to each material. The complementary nature of these two chemicals was confirmed in 1968 and 1969. *Polygonum aviculare*, *Matricaria/Tripleurospermum* spp., *Veronica* spp., *Viola tricolor*, *Urtica urens* and *Anchusa arvensis* were important weeds in this context.

Best overall results were obtained from using recommended or $^3/_4$ dose lenacil pre-emergence followed by recommended for $^4/_5$ dose phenmedipham post-emergence (1969 Treatments 4, 5, 7 and 8). Although programmes combining lower doses of each herbicide also gave very good weed control at some sites they were not sufficiently reliable (1969 Treatments 6, 9, 10 and 11). In some cases e.g. where moisture was freely available and weed emergence was not prolonged, lenacil alone at reduced doses gave acceptable weed control. Similarly phenmedipham alone gave adequate weed control where an appropriate weed flora and suitable weather conditions coincided.

Growers relying entirely on herbicides for weed control must plan for reliability since correction of inadequacies may prove impractical without recourse to handwork. Therefore, of the programmes tested in 1969 treatments 4, 5, 7 and 8 appear to offer the best approach.

In addition to achieving broader spectrum and longer lasting weed control from programmes combining the use of two herbicides than from either alone the pre-emergence use of lenacil lengthens the period over which phenmedipham can be applied successfully (see dates of application in table 4). The greater flexibility resulting is an important practical consideration in the use of a post-emergence material dependent on weather conditions and critical weed size at application.

Although this paper deals with the control of broad-leaved weeds it is worth recording that treatments 4, 5, 7 and 8 also gave very good control of *Poa annua* which is frequently an important constituent of the weed flora in beet fields.

Throughout this work crop safety was good on all sites except site 3 in 1969 (variety Amono). Here most combinations of herbicides are likely to have caused yield reductions although yields were not actually taken (see table 7).

Following the work reported in this paper a Ministry approved recommendation has been obtained for the use of a programme of weed control on mineral soils involving recommended or $^3/_4$ dose lenacil followed by recommended or $^4/_5$ dose phenmedipham. Owing to the results obtained on site 3 in 1969 it was considered prudent to exclude the variety Amono until further work clarified its response to such a programme.


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# EXPERIMENTS TO IMPROVE THE HERBICIDAL ACTIVITY OF PHENMEDIPHAM BY THE PRIOR USE OF OTHER HERBICIDES 1968-1970

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Summary In twenty field trials, which included peats, the degree of weed control obtained by a single application of phenmedipham was greatly improved by the prior use of a pre-emergence application of propham, or a contact pre-emergence application of a paraquat/diquat mixture. A reduction in the rate of propham hardly affected the efficiency of the combined treatment and incorporation of propham pre-drilling improved only the control of wild oats. Phenmedipham at $\frac{2}{3}$ of the recommended rate gave poorer weed control, though this was less marked when propham had been applied previously. Weed competition seriously reduced crop yield.

## INTRODUCTION

In farming it is difficult to ensure that phenmedipham is always applied at the right time. Under favourable growing conditions some weeds may rapidly grow past the susceptible stage for this herbicide (Holmes 1968), which can make the timing of the spray difficult, and in practice wet soil conditions can make application at the correct time impossible. Because it has only contact action as many as 2 or 3 applications may be necessary where there is a prolonged period of weed emergence and this is relatively expensive.

The object of these trials was to find if another herbicide, cheap enough to be sprayed overall if necessary, could be used to reduce the number or vigour of the weeds sufficiently for a single delayed post emergence application of phenmedipham to result in an effective degree of control.

The experiments examined the possible use of either a contact pre-emergence herbicide (paraquat/diquat mixture) or a cheap residual herbicide (propham) for this purpose.

Applying phenmedipham at a very early stage may check the development of the crop (Holmes, 1968) and the use of the paraquat/diquat mixture pre-emergence would avoid this. Combined applications of straight propham pre-emergence and phenmedipham post emergence may be useful against species such as <u>Chenopodium album</u> and <u>Sinapis arvensis</u> which are resistant to the former herbicide are very susceptible to the latter - while annual grass weeds and <u>Polygonum avicalare</u> which are not killed by phenmedipham (Eddowes and Caldwell 1968, Edwards 1968) are generally susceptible to propham. Some species are moderately resistant to both herbicides, but it seemed probable that propham might stunt and delay the growth of many weeds so that they would be more susceptible to the phenmedipham over a longer period. This would make the timing of the post-emergence spray much easier and may give better final weed control.

## METHODS AND MATERIALS

All trials were situated in commercial crops of sugar beet and the ten treatments were replicated three times at each site. As there will be need in the future for adequate weed control in crops planted to a stand the intention was to have the trials on sites where the seed was spaced at 5 or 6 inches apart in the row. This was not always possible and close spaced brairds had surplus beet removed by hand, without disturbance of the soil, to simulate 'planting to a stand'.

Propham was used as a 50% wp, well creamed before mixing. The full dose rate was adjusted to the soil texture:- 2 lb ai/ac on light soils 3 lb ai/ac on medium soils, and 4 lb ai/ac on heavy soils and highly organic fen peats. In some treatments in 1968 on the mineral soils the propham was incorporated before drilling the sugar beet, but normally it was applied on the surface within three days of drilling.

Paraquat/diquat mixture was applied at the rate of 3 pints/ac of the commercial product ('Preeglone extra') shortly before crop emergence, or in a few cases when a small percentage of the crop had emerged.

The phenmedipham was applied at 1.5 lb ai/ac in all trials, though in 1969 and 1970 1 lb ai/ac was also included at some sites. In the first year a single application was compared with two applications, but subsequently phenmedipham was applied as required by the weed situation.

On the black fen sites in 1968 propham was compared with proprietary mixtures of propham/medinoterb acetate (12 lb/ac of 'Murbetex Organic') and propham/chlorpropham/fenuron (10 pints/ac of 'Herbon Gold'). The herbicides were applied overall at 20 gals/acre by an Oxford Precision Sprayer boom using 00 jets and a pressure of 32 lbs/in. The plot size was 1/250 ac.

Visual assessments were made of beet and weed vigour before the application of the phenmedipham, and quadrat counts were made of weed numbers about 2 weeks after the phenmedipham had been applied - usually 3 one ft square quadrats per plot. Counts of beet seedlings were made at the same time. Where possible the two centre rows of each plot were lifted in the autumn, topped and weighed, and sub-sampled for dirt tare and sugar content.

The trials were carried out on twenty sites in the years 1968 to 1970. In each year there were two sites on black fen soils, with organic matter contents between 24% and 33.5%. The remaining trials were on mineral soils with textures which varied from sandy loam to clay with organic matter contents between 1.7% and 6.3%.

The main weeds present were <u>Polygonum convolvulus</u> (15 trials), <u>Stellaria media</u> (17 trials), <u>Polygonum avicalare</u> (16 trials), <u>Tripleurospermum maritimum spp inodorum</u> (11 trials), <u>Veronica spp</u> (14 trials) and <u>Chenopodium album</u> (15 trials).

RESULTS

(Herbicide rates are given under 'Methods and Materials')

Table 1

1968

(a) Mineral Soils

| Treatment | Dates applied | weeds/ft² Site 1 (Counted 23/5) | weeds/ft² Site 2 (Counted 14/5) |
|---|---|---|---|
| A. Control (unweeded) | - | 6.4 | 22.4 |
| B. Phenmedipham | 2/5-7/5 | 1.1 | 0.9 |
| C. Phenmedipham | 25-26/4 & 14-16/5 | 0.4 | 0.3 |
| D. Paraquat/diquat and phenmedipham | 17/4-24/4 14/5-20/5 | 1.4 | 12.5 |
| *E. Propham (full rate) and phenmedipham | 11/3-9/4 2/5-7/5 | 0.9 | 0.0 |
| *F. Propham (¾ rate) and phenmedipham | 11/3-9/4 2/5-7/5 | 0.7 | 0.1 |
| *G. Propham (½ rate) and phenmedipham | 11/3-9/4 2/5-7/5 | 0.5 | 0.0 |
| *H. Propham (full rate) and phenmedipham | 27/3-11/4 2/5-7/5 | 0.4 | 0.1 |
| *I. Propham (¾ rate) and phenmedipham | 27/3-11/4 2/5-7/5 | 0.7 | 0.0 |
| *J. Propham (½ rate) and phenmedipham | 27/3-11/4 2/5-7/5 | 0.3 | 0.1 |

* pre sowing + post sowing. On treatment D site 2 the phenmedipham subsequently removed almost all these weeds.

Table 2

(b) Black fen soils

| Treatment | Dates applied | weeds/ft² Site 5 (Counted 28/5) | weeds/ft² Site 6 (Counted 28/5) |
|---|---|---|---|
| K. Control (unweeded) | - | 5.4 | 11.4 |
| L. Phenmedipham | 7/5 | 0.2 | 4.1 |
| M. Phenmedipham | 26/4 & 15/5 | 0.8 | 2.5 |
| N. Paraquat, diquat and phenmedipham | 17/4 15/5 | 5.3 | 3.2 |
| O. Propham, Chlorpropham, Fenuron mixture (full rate) and phenmedipham | 28/3 3-7/5 | 0.2 | 4.2 |
| P. Propham, Chlorpropham, Fenuron mixture (⅔ rate) and phenmedipham | 28/3 3-7/5 | 0.2 | 2.7 |
| Q. Propham, Medinoterb mixture (full rate) and phenmedipham | 28/3 3-7/5 | 0.3 | 2.8 |
| R. Propham, Medinoterb mixture (⅔ rate) and phenmedipham | 28/3 3-7/5 | 0.3 | 3.1 |
| S. Propham (full rate) and phenmedipham | 28/3 3-7/5 | 0.1 | 4.6 |
| T. Propham (⅔ rate) and phenmedipham | 28/3 3-7/5 | 0.2 | 3.1 |

After the first year treatments were modified in the light of experience. The incorporation of propham before drilling was discontinued because it only appeared necessary where *Avena fatua* were the main weed. For other species there appeared to be a better control from the post drilling surface application (Table 1). On the black fen sites propham compared well in the first year with the two mixtures of propham/chlorpropham/fenuron and propham/medinoterb acetate (Table 2) and so in the two subsequent years propham was the only residual herbicide used in the trials. Where phenmedipham followed full, half or three quarter rates of propham on the mineral soils in 1968 (Table 1) there was so little difference in the ultimate control of weeds that only full and half rates of propham were included in 1969 and 1970.

It was often very noticeable that pre-treatment with propham led to a reduction in annual grass weeds (*Poa annua*, *Avena fatua*, *Alopecurus myosuroides*, and self sown *Lolium multiflorum*). Site 4 in 1968 had to be abandoned because of the high number of *Avena fatua* (220/yd$^2$) counts were made on 16 May and showed the expected improvement in control (from 48% up to 73%) following incorporation of increasing rates of propham. There was still a significant control of wild oats from the post drilling application of between 32% and 49%. The paraquat/diquat mixture removed almost half the wild oats and even the phenmedipham showed considerable activity against *Avena fatua* though assessments were difficult following the use of this herbicide because plants were scorched, but not necessarily killed.

The effects of the treatments on plant population and yields in 1968 are shown in Table 3.

Table 3

| | Plant Population (000/Acre) | | | Sugar (cwt/acre) | | |
|---|---|---|---|---|---|---|
| Treatment | Site 1 | Site 2 | Site 3 | Site 1 | Site 2 | Site 3 |
| A | 30.2 | 26.4 | 33.2 | 52.8 | 57.6 | 62.2 |
| B | 33.2 | 24.2 | 32.9 | 59.5 | 60.7 | 66.0 |
| C | 32.7 | 28.3 | 31.9 | 63.5 | 63.0 | 68.9 |
| D | - | 25.4 | 32.7 | - | 65.3 | 63.2 |
| E | 32.5 | 27.1 | 36.5 | 59.1 | 66.4 | 72.6 |
| F | 34.3 | 24.9 | 36.1 | 57.2 | 64.7 | 73.7 |
| G | 30.2 | 25.7 | 37.5 | 54.8 | 57.7 | 65.7 |
| H | 30.7 | 25.4 | 32.4 | 57.1 | 61.0 | 70.9 |
| I | 31.1 | 24.4 | 36.3 | 55.5 | 63.6 | 75.1 |
| J | 32.5 | 22.7 | 35.8 | 55.4 | 64.8 | 72.9 |
| SE$\pm$ | 1.50 | 2.35 | 1.94 | 2.75 | 3.14 | 3.32 |

Table 4

1969 & 1970

| Treatments | Dates applied 1969 | Dates applied 1970 |
|---|---|---|
| A. Control (unweeded until late Summer) | - | - |
| B. Control (handweeded) | 22/5-6/6 | 15/5-28/5 |
| C. Phenmedipham (full rate) | 8/5-20/5 | 7/5-20/5 |
| D. Phenmedipham (⅔ rate) | 8/5-20/5 | 7/5-20/5 |
| E. Propham (full rate) and | 3/4-18/4 | 20/4-27/4 |
| phenmedipham (full rate) | 12/5-27/5 | 7/5-20/5 |
| F. Propham (full rate) and | 3/4-18/4 | 20/4-27/4 |
| phenmedipham (⅔ rate) | 12/5-27/5 | 7/5-20/5 |
| G. Propham (half rate) and | 3/4-18/4 | 20/4-27/4 |
| phenmedipham (full rate) | 12/5-27/5 | 7/5-20/5 |
| H. Propham (half rate) and | 3/4-18/4 | 20/4-27/4 |
| phenmedipham (⅔ rate) | 12/5-27/5 | 7/5-20/5 |
| I. Paraquat/diquat mixture and | 3/4-18/4 | 18/4-4/5 |
| phenmedipham | 12/5-27/5 | 7/5-20/5 |
| J. Propham (full rate) | 3/4-18/4 | 20/4-27/4 |

Table 5

Weed Seedlings/$ft^2$

1969

| Treatment | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Site 7 | Mean as % of Control |
|---|---|---|---|---|---|---|---|---|
| A) B) | 10.0 | 22.8 | 94.1 | 14.1 | 32.4 | 17.0 | 4.0 | 100 |
| C | 1.0 | 6.1 | 6.5 | 3.1 | 3.5 | 4.1 | 0.3 | 12.7 |
| D | 2.0 | 8.0 | 10.8 | 2.8 | 3.8 | 8.1 | 1.8 | 19.2 |
| E | 0.3 | 3.9 | 0.9 | 1.5 | 2.3 | 2.1 | 0.4 | 5.9 |
| F | 1.8 | 5.3 | 1.1 | 1.1 | 1.9 | 2.6 | 1.4 | 7.8 |
| G | 0.8 | 3.3 | 0.1 | 1.8 | 2.2 | 1.8 | 1.3 | 5.8 |
| H | 1.3 | 2.2 | 0.9 | 1.3 | 2.9 | 4.3 | 2.0 | 7.7 |
| I | 0.7 | 2.1 | 0.3 | 1.2 | 1.1 | 3.1 | 1.2 | 5.0 |
| J | 10.7 | 12.1 | 73.7 | 7.5 | 11.5 | 9.1 | 3.2 | 65.7 |

Table 6

Weed Seedlings/$ft^2$

1970

| Treatment | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Mean as % of control |
|---|---|---|---|---|---|---|---|
| A) B) | 8.6 | 10.6 | 1.6 | 8.6 | 2.1 | 10.8 | 100 |
| C | 1.0 | 0.1 | 0.3 | 0.4 | 0.2 | 1.8 | 9.0 |
| D | 3.1 | 0.2 | 0.7 | 0.9 | 0.4 | 2.3 | 18.0 |
| E | 1.0 | 0.1 | 0.5 | 0.5 | 0.3 | 0.9 | 7.8 |
| F | 1.3 | 0.2 | 0.2 | 0.7 | 0.6 | 1.3 | 10.2 |
| G | 1.4 | 0.1 | 0.5 | 0.3 | 0.2 | 0.8 | 7.8 |
| H | 2.2 | 0.2 | 0.3 | 0.6 | 0.4 | 2.2 | 13.9 |
| I | 0.7 | 0.1 | 0.5 | 0.1 | 0.2 | 1.4 | 7.1 |
| J | 3.4 | 4.7 | 0.4 | 5.4 | 0.9 | 5.1 | 47.0 |

Table 7

1969

| Treatment | Plant Population (000/acre) Site 2 | Site 3 | Site 4 | Site 5 | Site 7 | Mean as % of control | Sugar (cwt/acre) Site 2 | Site 3 | Site 4 | Site 5 | Site 7 | Mean as % of control |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 37.0 | 42.9 | 36.5 | 34.4 | 30.5 | 100 | 78.1 | 59.6 | 52.6 | 38.8 | 75.6 | 100 |
| B | 35.3 | 39.4 | 34.1 | 35.6 | 37.3 | 100 | 83.6 | 77.3 | 74.4 | 70.4 | 80.8 | 127 |
| C | 38.5 | 40.3 | 37.3 | 35.3 | 32.7 | 101 | 77.5 | 75.0 | 71.8 | 58.0 | 72.8 | 117 |
| D | 38.5 | 41.7 | 35.1 | 36.1 | 35.1 | 103 | 77.9 | 82.0 | 75.5 | 59.7 | 77.8 | 122 |
| E | 41.4 | 42.6 | 33.2 | 36.5 | 31.0 | 102 | 79.1 | 78.0 | 73.3 | 65.3 | 71.9 | 121 |
| F | 41.9 | 42.9 | 31.0 | 35.6 | 31.9 | 101 | 79.6 | 77.1 | 76.5 | 68.8 | 79.2 | 125 |
| G | 39.0 | 44.3 | 33.4 | 41.6 | 33.4 | 105 | 81.2 | 79.3 | 74.8 | 62.5 | 77.4 | 123 |
| H | 38.0 | 41.5 | 33.9 | 35.6 | 31.9 | 100 | 77.3 | 79.8 | 73.8 | 66.3 | 75.3 | 122 |
| I | 35.6 | 40.6 | 31.7 | 27.8 | 30.7 | 92 | 76.6 | 74.9 | 73.4 | 56.9 | 72.9 | 116 |
| J | 38.5 | 42.2 | 40.9 | 31.2 | 34.4 | 103 | 79.8 | 70.9 | 61.2 | 60.1 | 71.6 | 113 |
| SE± | 2.70 | 1.11 | 2.05 | 1.98 | 1.17 | | 3.39 | 2.09 | 2.90 | 4.60 | 2.65 | |

Propham was applied alone in 1969 and 1970 (treatment J) mainly to make possible a better assessment of its herbicidal action. On some sites it was very effective, but even where it only killed a small percentage of the weeds it nearly always checked resistant species, thus keeping them at a stage where they were susceptible to phenmedipham for a longer period. This resulted in weed control markedly superior to that obtained from phenmedipham used alone.

The timing of the paraquat/diquat application proved very difficult, particularly in the last two seasons when drilling was generally delayed and weed emergence was slow. In some instances applications would not have been commercially acceptable because of lack of weed or because too many beet plants had emerged. This treatment was effective where weeds resistant to phenmedipham emerged before the beet, and in fact killed many germinating seedlings not visible at the time of spraying. The results showed that the highest yields came from handweeded plots and the lowest from the unweeded control plots (Tables 3 and 7); the depression in yields, particularly in the 1969 trials, was roughly proportional to the degree of weed infestation.

Where herbicides had been used yields were much higher than the unweeded control but marginally lower than the handweeded treatment (Table 7). This could have been due either to competition from the few remaining weeds, or possibly to slight toxicity from the herbicides. (All trials were tractor hoed in June). There was some indication in the 1968 series that the early removal of weeds was desirable (Table 3). Neither the transient check in vigour noted from propham at some sites, nor the slight reduction in plant numbers resulting from late applications of paraquat/diquat, (Tables 3 and 7), appeared to have any serious effect on yields.

## DISCUSSION

The commercial acceptability of a herbicide for sugar beet is closely bound up with the availability of hand labour on any farm and is not necessarily a matter of trying to achieve 100% weed control regardless of cost. In spite of the shortage of labour it is still necessary for the majority of beet crops, even after the use of herbicides, to receive at least one final hand trimming operation to remove perennial weeds and resistant annuals. Where adequate hand labour is available the degree of weed control on some of the sites from propham used alone would probably suffice for at least part of the acreage.

This series of trials suggests that there are many situations where an acceptable degree of weed control can be obtained for crops 'planted to a stand' by using propham followed by phenmedipham, particularly where annual grasses are a problem. This combination may not be suitable where resistant weeds such as _Matricaria_ spp predominate on farms where labour is extremely short but it should be noted that none of the plots treated with propham and phenmedipham became infested with weeds to the point where yields were seriously affected. It also appears a safe and reliable technique for crops drilled on wide spacings where damage to crop seedlings is least tolerable.

Incorporation of the propham only appears necessary where _Avena fatua_ is common. Surface applications of propham can be lost in dry windy weather and on some sites this herbicide was noticeably more effective when some rain followed application.

Phenmedipham was very successful when used alone, but in this trial series care was taken to apply the material before any weed species had reached a resistant stage. A reduction in the rate was not advisable unless weeds were small or resistant species were absent. In the majority of trials the pre-treatment with propham led to an appreciable overall improvement in weed control and it appeared quite feasible to reduce the rate by up to a half and still retain some considerable benefit from its use.

The use of a contact pre-emergence spray of paraquat/diquat is difficult to time correctly but it can be a useful treatment where there is a flush of weeds emerging before the beet. This situation sometimes arises where, because of adverse weather conditions, a pre-emergence spray has not been applied, or has been made partially ineffective.


## Acknowledgements

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# WEED CONTROL IN SUGAR BEET USING DI-ALLATE FOLLOWED BY PYRAZONE OR LENACIL

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**Summary** An examination has been made of di-allate followed by pyrazone or lenacil at full and reduced rates for control of *Avena fatua* and broad-leaved weeds. The di-allate was soil incorporated pre-drilling and the pyrazone and lenacil applied post-drilling.

The di-allate/pyrazone combinations were generally safe to the crop and a reduction of the full dose of one or both of the herbicides gave acceptable control of all weed species present on most occasions.

Occasionally the di-allate/lenacil treatments caused damage to the sugar beet seedlings, but weed control was slightly surperior to that of the di-allate/pyrazone combinations. The results indicated that where di-allate and lenacil are to be used together on sugar beet then the recommended dose of each ought to be reduced by one-third.

## INTRODUCTION

The importance of *Avena fatua* as a weed of arable cropping has increased in recent years (Hammerton, 1968) and it has spread to a wide range of soil types on which sugar beet is grown (Turner, 1967). Consequently, beet growers requiring a high level of control of this species and annual broad-leaved weeds need to use two herbicides to control both weed types. Propham, the only available material for use on sugar beet that may control *A.fatua* and broad-leaved species, unfortunately does not always control *A.fatua* satisfactorily and the number of susceptible broad-leaved weeds it controls is relatively restricted (Murant, 1958 a & b). Therefore, a great deal of interest has been shown by growers in the use of di-allate for control of *A. fatua* followed by either pyrazone or lenacil against annual broad-leaved weeds.

A trials series lasting four years was started in 1966 to examine the tolerance of beet and the susceptibility of weeds to applications of these herbicides. In each experiment the commercially recommended rate of each chemical was applied alone as separate treatments. In addition, applications of di-allate followed by either pyrazone or lenacil were examined in all combinations of their recommended dosages and two-thirds of this rate. The di-allate in all cases was soil incorporated pre-drilling and the pyrazone or lenacil was surface applied as soon after sowing as possible. A 'split' application was used because it was felt that the majority of farmers still preferred the economy of band-spraying where possible. In the absence of suitable machinery for herbicide band application and incorporation this 'split' technique was the only means of economising under the recommendations in force for these products in 1966. In addition, it has been shown that the selectivity of lenacil towards sugar beet is reduced when soil-incorporated pre-drilling (Bray, 1970) and therefore would not be suitable as a 'tank mix' with di-allate for the purposes of the experiment described here.

In each of the three years 1966 to 1968 experiments on three sites were carried out and in 1969 two trials were used to complete the series of investigations. The location of these sites together with relevant details are listed in Table 1.

Table 1

Site details

| Year and location | Soil types* | Drilled | Sprayed | Rain after spraying (in) 1 week | Rain after spraying (in) 4 weeks |
|---|---|---|---|---|---|
| 1966 | | | | | |
| A. Paston, Norfolk | FSL | 22 March | 22 March | 0.48 | 2.26 |
| B. Morley, Norfolk | SL | 23 March | 23 March | 0.77 | 2.57 |
| C. Woolpit, Suffolk | SCL | 1 April | 1 & 4 April | 0.33 | 1.37 |
| 1967 | | | | | |
| D. East Ruston, Norfolk | VFSL | 19 April | 19 April | 0.59 | 2.40 |
| E. Drinkstone, Suffolk | SCL | 20 April | 20 April | 0.54 | 1.17 |
| F. Groton, Suffolk | SCL | 3 April | 3 April | 0.54 | 2.16 |
| 1968 | | | | | |
| G. Paston, Norfolk | FSL | 1 April | 1 April | 0.29 | 0.80 |
| H. Morley, Norfolk | SL | 12 April | 11 & 18 April | 0.30 | 2.40 |
| I. Clopton, Suffolk | CL | 4 April | 30 March & 10 April | 0.05 | 2.12 |
| 1969 | | | | | |
| J. Hethel, Norfolk | SL | 26 April | 14 & 30 April | 0.41 | 2.62 |
| K. Rougham, Suffolk | L | 18 April | 17 & 21 April | 0.35 | 2.16 |

* Soil type symbols: SL = sandy loam; FSL = fine sandy loam; VFSL = very fine sandy loam; SCL = sandy clay loam; CL = clay loam; L = loam.

## METHOD AND MATERIALS

The investigations were undertaken on commercial crops of sugar beet. Treatments were fully randomised and replicated four times. The plot size used for spraying was 1/200 ac.

Chemicals were applied overall in a water volume of 50 gal/ac. This was done with an Oxford Precision Sprayer fitted with Birchmeier Helico Sapphire 1.6-673a-1.3 nozzles operating at a pressure of 25 or 30 lb/in $^2$.

The di-allate used was a 40% emulsifiable concentrate and the pyrazone and lenacil were formulated as 80% wettable powders.

To incorporate the di-allate into the soil the implements normally employed for final seedbed preparation on the farm were used. The type of implement varied considerably but they all appeared to give adequate admixture.

**Records**

(i) Pre-singling: Twelve or twenty-four random quadrat (4 x 18in) counts were taken on each plot, the numbers of beet and the dominant weed species being recorded individually. In addition visual assessments of crop and weed vigour were taken on a scale 0-10.

(ii) Post-singling: A mid-season count of the beet in the centre two rows of each plot was made for the measurement of final population, together with a visual score for vigour.

(iii) Yield: Where possible the same beet that had been counted in mid-season were hand lifted, washed, weighed and then analysed for sugar content.

With the exception of Site I which had two untreated control treatments all experiments had three controls in each replicate.

Table 2

Summary of pre-singling assessments on sugar beet, 1966-1969

| Treatment<br>1 = recommended rate<br>⅔ = ⅔ rec rate | 1966 A | 1966 B | 1966 C | 1967 D | 1967 E | 1967 F | 1968 G | 1968 H | 1968 I | 1969 J | 1969 K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Seedling counts as % controls | | | | | | | | | | |
| Di-allate 1 | 88 | 96 | 96 | 94 | 97 | 102 | 102 | 91 | 97 | 103 | 90 |
| Pyrazone 1 | 88 | 104 | 88 | 79 | 96 | 86 | 97 | 107 | 99 | 102 | 97 |
| Lenacil 1 | 98 | 104 | 69* | 77 | 99 | 86 | 93 | 98 | 96 | 91 | 90 |
| Di-allate/pyrazone | | | | | | | | | | | |
| ⅔ + ⅔ | 107 | 107 | 94 | 92 | 104 | 117 | 101 | 100 | 97 | 101 | 107 |
| 1 + ⅔ | 119* | 113 | 103 | 93 | 99 | 82 | 105 | 94 | 96 | 94 | 87 |
| ⅔ + 1 | 110 | 109 | 89 | 72 | 103 | 78 | 107 | 102 | 92 | 91 | 105 |
| 1 + 1 | 107* | 103* | 74* | 80* | 103* | 81* | 98 | 99 | 94 | 92 | 101 |
| Di-allate/lenacil | | | | | | | | | | | |
| ⅔ + ⅔ | 96 | 121 | 74* | 82 | 99 | 76* | 107 | 87 | 98 | 90 | 105 |
| 1 + ⅔ | 95 | 111 | 68* | 71 | 104 | 78* | 89 | 89 | 90 | 87 | 94 |
| ⅔ + 1 | 94* | 90* | 66* | 68* | 99 | 51* | 110 | 96 | 100 | 95 | 86 |
| 1 + 1 | 84* | 97* | 62* | 48* | 101 | 47* | 92 | 75 | 97 | 87* | 89 |
| Untreated controls | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| (Population, thousands/acre) | (116) | ( 94) | (108) | (112) | (163) | ( 46) | (172) | (132) | (115) | ( 54) | ( 85) |
| Sig. diff (P = 0.05) between herbicide treatments | 18 | NS | 13 | 23 | NS | 28 | NS | 14 | NS | 11 | NS |
| (between herbicide treatments & controls) | (21) | | (15) | (27) | | (35) | | (17) | | (13) | |
| % S E | 12.9 | 14.9 | 10.7 | 19.6 | 9.0 | 23.6 | 10.1 | 10.5 | 9.5 | 8.5 | 13.1 |

* treatments showing a 30% or greater reduction in vigour compared with the controls

## RESULTS

**Effect on sugar beet:** Pre-singling assessments on the crop clearly show (Table 2) on most occasions a reasonable tolerance by the beet seedlings towards the three herbicides applied alone. This did not occur with lenacil on site C (sandy clay loam, 1966), or with lenacil and pyrazone on site D (very fine sandy loam, 1967). In general the di-allate/pyrazone combinations did not greatly affect the sugar beet seedlings although noticeable effects on seedling numbers and/or vigour were observed when the full rate of pyrazone followed di-allate at sites D and F (sandy clay loam, 1967) and where the recommended rate of both di-allate and pyrazone were used together at site C. The results with the di-allate/lenacil combinations were not so encouraging. When these two herbicides were used together, marked and sometimes serious, reductions in seedling numbers and/or vigour were found following all combinations on sites C and F; whenever the full rate of either were used at site D; and where the recommended dose of each were used together at sites A (fine sandy loam, 1966), H(sandy loam, 1968) and J(sandy loam, 1969).

Most of the sites were drilled using a seed spacing of between 2 and 3in. Therefore singling was necessary on all sites with the exception of F where even after a spacing of 2in beet seedling emergence was so low that there were only 45,600/ac plants on the untreated plots. An attempt was made to leave a uniform final population but this was not possible on the trial or the surrounding crop where the final beet population only averaged 17,600/ac. Only on site D did a herbicide treatment give a significantly (P = 0.05) lower final beet population compared with the untreated controls, when full doses of di-allate and lenacil used in combination gave 5,800 fewer plants per acre. On average, the di-allate/lenacil treatments had 1,600 fewer plants per acre compared with the di-allate/pyrazone combinations.

Yield assessments were taken at sites A,B,C,D,E,G,H,J and K. No significant differences were found between any of the treatments in terms of yield of washed roots, their sugar content, and yield of sugar. Only on three of the nine centres harvested did the di-allate/lenacil combinations outyield the di-allate/pyrazone treatments which had an overall sugar yield advantage of 0.7 cwt/ac.

<u>Effect on weeds:</u> A summary of the pre-singling assessments on <u>Avena fatua</u> is shown in Table 3. On two of the sites selected in 1968 (H and I) no A. <u>fatua</u> were

Table 3

<u>Summary of pre-singling assessments on Avena fatua, 1966-1969</u>

| Treatment<br>1 = recommended rate<br>$\frac{2}{3}$ = $\frac{2}{3}$ rec rate | 1966 A | 1966 B | 1966 C | 1967 D | 1967 E | 1967 F | 1968 G | 1969 J | 1969 K |
|---|---|---|---|---|---|---|---|---|---|
| | Seedling counts as % controls | | | | | | | | |
| Di-allate 1 | 2 | 43* | 5 | 1 | 31 | 15 | 0 | 2 | 21 |
| Pyrazone 1 | 100 | 96* | 68* | 69 | 152 | 27 | 235* | 110 | 71* |
| Lenacil 1 | 52 | 68 | 57* | 24 | 49 | 25 | 64* | 50* | 69* |
| Di-allate/pyrazone | | | | | | | | | |
| $\frac{2}{3}$ + $\frac{2}{3}$ | 1 | 30* | 17 | 5 | 22 | 13 | 0 | 2 | 10 |
| 1 + $\frac{2}{3}$ | 1 | 30 | 16 | 1 | 19 | 7 | 0 | 3 | 9 |
| $\frac{2}{3}$ + 1 | 1 | 26 | 16 | 3 | 10 | 4 | 21 | 4 | 12 |
| 1 + 1 | 0 | 21 | 11 | 0 | 9 | 6 | 0 | 0 | 11 |
| Di-allate/lenacil | | | | | | | | | |
| $\frac{2}{3}$ + $\frac{2}{3}$ | 2 | 70* | 7 | 1 | 7 | 2 | 0 | 0 | 6 |
| 1 + $\frac{2}{3}$ | 1 | 43 | 8 | 1 | 6 | 5 | 0 | 4 | 4 |
| $\frac{2}{3}$ + 1 | 0 | 38 | 13 | 1 | 13 | 3 | 21 | 2 | 6 |
| 1 + 1 | 1 | 36 | 8 | 2 | 3 | 2 | 0 | 2 | 4 |
| Untreated controls | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| (population, thousands /ac.) | (261) | (44) | (808) | (194) | (121) | (179) | (9) | (119) | (249) |

* treatments not showing a 70% or greater reduction in vigour compared with the controls when assessed on sites B,C,G,J and K.

encountered, and on the other site in that year (G) and on site B in 1966 the populations observed were relatively low. On average, pyrazone had little effect on A. fatua, whereas the effect from lenacil was always marked but never reached a level that would be accepted by growers as an adequate control. With the exception of site B all di-allate/pyrazone and di-allate/lenacil treatments gave good control of A. fatua and those treatments using the full rate of di-allate were generally superior in this respect. At site B the general level of control by the herbicide combinations was low but when vigour of the remaining plants was taken into account only those treatments using two-thirds of the recommended dose of each chemical did not give satisfactory results.

Effect on annual broad-leaved weeds: A summary of the pre-singling assessments on broad-leaved weeds is shown in Table 4. In general, the control of broad-leaved weeds was marginally better from lenacil alone compared with pyrazone alone. However, each herbicide gave acceptable results when used alone at all centres with the exception of pyrazone in 1968 at sites G and I. The results with di-allate alone indicate that it's activity is not just confined to A. fatua because in some of the experiments it had a marked effect on some broad-leaved weeds, particularly Veronica spp. Generally, all herbicide combinations gave acceptable to excellent control.

Table 4

Summary of pre-singling assessments on all annual broad-leaved weeds, 1966-1969

| Treatment (1 = recommended rate; ⅔ = ⅔ rec rate) | | | 1966 A | 1966 B | 1966 C | 1967 D | 1967 E | 1967 F | 1968 G | 1968 H | 1968 I | 1969 J | 1969 K |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Seedling counts as % controls | | | | | | | | | | |
| Di-allate | | 1 | 188 | 85* | 64* | 67 | 49 | 84 | 73* | 32* | 73 | 91 | 74* |
| Pyrazone | | 1 | 13 | 7 | 6 | 4 | 11 | 2 | 41* | 6 | 70 | 5 | 20 |
| Lenacil | | 1 | 6 | 8* | 13 | 4 | 15 | 0 | 29* | 3 | 28 | 5 | 25 |
| Di-allate/pyrazone | | | | | | | | | | | | | |
| ⅔ | + | ⅔ | 16 | 10 | 9 | 8 | 13 | 13 | 41* | 8 | 51 | 17 | 37 |
| 1 | + | ⅔ | 15 | 9 | 4 | 9 | 7 | 5 | 23 | 7 | 49 | 14 | 28 |
| ⅔ | + | 1 | 9 | 4 | 4 | 3 | 5 | 1 | 46* | 6 | 62 | 7 | 19 |
| 1 | + | 1 | 4 | 5 | 5 | 6 | 5 | 5 | 10 | 2 | 37 | 8 | 19 |
| Di-allate/lenacil | | | | | | | | | | | | | |
| ⅔ | + | ⅔ | 3 | 5 | 4 | 5 | 5 | 1 | 30* | 3 | 27 | 5 | 10 |
| 1 | + | ⅔ | 9 | 4 | 6 | 2 | 7 | 0 | 11 | 0 | 15 | 7 | 10 |
| ⅔ | + | 1 | 5 | 2 | 5 | 0 | 4 | 1 | 14 | 1 | 16 | 4 | 8 |
| 1 | + | 1 | 6 | 1 | 5 | 0 | 5 | 0 | 11 | 0 | 13 | 3 | 8 |
| Untreated controls | | | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| (Population, thousands /ac.) | | | (503) | (994) | (561) | (455) | (668) | (271) | (203) | (362) | (1674) | (597) | (463) |

* treatments not showing a 70% or greater reduction in vigour compared with the controls when assessed on sites B, C, G, H and K.

The exception to this were all di-allate/pyrazone treatments at site I, those di-allate/pyrazone combinations using a two-thirds dose of di-allate at site G and those using a two-thirds rate of pyrazone at site K, and the di-allate/lenacil treatments using two-thirds of each herbicide at sites G and I.

Pyrazone alone at the recommended rate gave good control of Matricaria spp., *Veronica* spp., *Stellaria media* and *Polygonum aviculare* whereas lenacil at its recommended dosage gave good control of *Matricaria* spp., *S. media*, *P. aviculare*, *Veronica* spp., and *Anagallis arvensis*. Pyrazone gave better control than lenacil of *Veronica* spp. whereas lenacil was better on *S. media*, *P. aviculare*, and *A. arvensis*. *P. convolvulus* was only moderately susceptible to each herbicide.

## DISCUSSION

This series of trials has given useful additional information on the use of the three herbicides alone on a number of soil types, over a number of seasons, and at their commercially recommended dosages. Di-allate was safe and gave good control of *A. fatua* and *Veronica* spp. Pyrazone and lenacil were safe on most sites and they usually gave acceptable control of annual broad-leaved weed species Generally, lenacil was slightly more damaging to the beet seedlings but gave better weed control than pyrazone.

The herbicide combinations gave good control of both broad-leaved weeds and *A. fatua* with the exception of broad-leaved weeds on two sites in 1968, and *A. fatua* in one experiment in 1966. Although the counts on this trial in 1966 (site B) indicated poor control of *A. fatua*, visually the results were acceptable. The inadequate control of broad-leaved weeds on the two sites (G & I) in 1968 was almost certainly a result of low rainfall after application of the herbicides. Unfortunately, the damage effects on the beet seedlings were not always acceptable. The di-allate/pyrazone treatments rarely affected the crop any more than was recorded from the use of either herbicide alone at it's recommended rate and therefore crop safety with these combinations was generally satisfactory. In the case of the di-allate/lenacil applications, serious damage in terms of beet seedling numbers together with loss in vigour occurred on three of the eleven experiments, one in 1966 and two in 1967. On nearly every occasion the di-allate/pyrazone treatments were safer than di-allate/lenacil.

In conclusion, if di-allate followed by pyrazone or lenacil treatments are to be used in sugar beet then some reduction in the rates of use of each herbicide should be made in the interests of savings in costs and safety of the crop.

With di-allate followed by pyrazone a reduction of the recommended rate of each by one-third (giving 1.0 lb a.i./ac di-allate) gave acceptable results on most occasions, but in 1968 a full dose of di-allate (1.5 lb) was superior. The full dose of each chemical was never unduly damaging to the crop.

In the case of di-allate followed by lenacil the results obtained in the series of experiments described here would suggest that a reduction in the rate of each herbicide to two-thirds of that normally recommended should always be used to ensure adequate safety to the sugar beet. At these levels weed control was very good on most occasions.

Some growers are turning away from band-spraying to overall application of their pre-emergence herbicide. If, in addition to broad-leaved weeds there is also a problem with *A. fatua* then it would be advantageous to be able to apply both chemicals together overall and soil incorporate pre-drilling. It has already been noted that soil incorporation of lenacil would not be recommended (Bray, 1970) but di-allate mixed with pyrazone could be an alternative. Trials in addition to those reported here (Lush, 1970) have been undertaken with 'tank mixes' of di-allate and pyrazone when it was found that similar reductions in dosages could be made on medium loams, silts and heavy soils.

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# A COMPARISON OF THE EFFECTS OF LENACIL, A PROPHAM/CHLORPROPHAM/ FENURON MIXTURE AND A PHENMEDIPHAM/BARBAN MIXTURE FOR WEED CONTROL IN SUGAR BEET ON A PEAT SOIL

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**Summary** In an experiment on a fenland soil (18% organic matter) lenacil mixed into approximately the top 2 in. of soil at doses of 1.5 and 3.0 lb a.i./ac gave excellent control of both broad-leaved weeds (Chenopodium album, Stellaria media, Polygonum persicaria, P.convolvulus and Matricaria spp.) and Poa annua in sugar beet with little or no damage to the crop. Mixing the lenacil in the soil by rotary cultivation gave better control than mixing it in with reciprocating harrows. A propham/chlorpropham/ fenuron mixture (Herbon Gold) applied pre-emergence at 1.25 gal product/ac was less effective. However, a mixture of phenmedipham and barban applied at 1.25 + 0.62 lb a.i./ac post-emergence gave excellent selective control of the broad-leaved weeds and moderate control of the Poa annua.

## INTRODUCTION

A number of workers have already investigated the behaviour of lenacil as a pre-emergence herbicide for the control of weeds in sugar beet on soils of low organic matter (Bray & Cussans, 1968; Cussans, 1964; Caldwell & Eddowes, 1966; Forrest, Bagnall & Makepeace, 1966; Holmes, 1966; Marks, 1966). However, relatively little work has been done with lenacil on the more highly organic soils, possibly due to its apparent lack of activity, as illustrated by the experiments of Thomas & Mitchell (1967). In more recent work (Ramand, 1969; Ramand, Forbes & Holroyd, 1970) it was found that although this herbicide was inactive when applied to the surface of peat soils (organic matter greater than 17%), excellent weed control was obtained if it was mixed with the top two inches of soil.

The present experiment at the Ministry of Agriculture, Fisheries and Food's Arthur Rickwood Experimental Husbandry Farm compares the effectiveness of lenacil/ cultivation combination treatments for the control of annual weeds in sugar beet, with that of a widely used pre-emergence herbicide and another post-emergence treatment.

## METHOD AND MATERIALS

Lenacil was applied as a wettable powder at doses of 1.5 and 3 lb a.i. in 40 gal water/ac to the surface of separate plots on 8th April, 1969. The herbicide was incorporated to a depth of about 2 in. with either a rotary cultivator (Cadet) or reciprocating harrow, and rolled. Pelleted monogerm sugar beet seed (variety Amono)

*Now at Pan Britannica Industries Limited, Waltham Cross, Hertfordshire.

was then drilled 6 in. apart on 20 in. rows. Three days after sowing a proprietary propham/chlorpropham/fenuron mixture (Herbon Gold) was sprayed on to separate plots at 1.25 gal (product)in 40 gal water/ac. A post-emergence application of a mixture of phenmedipham/barban was superimposed as a split plot treatment at 1.25/0.62 lb a.i. in 21 gal water/ac on the 19th May when the weeds (mainly Poa annua, Chenopodium album, Polygonum convolvulus, P. persicaria. Stellaria media and Matricaria spp.) were at about the first true leaf stage of growth. The soil was a peat (18% organic matter) overlying silt and the experimental design was of randomised block split plot type with four replicates. The main plot size was 3 x 30 yards and sub-plot 3 x 15 yards. Weed counts were taken on 15th May and 5th June respectively. that is, before and after the application of the phenmedipham/barban mixture. Weeds were assessed by counting the numbers present in ten one foot square quadrats on each sub-plot. The beets were harvested on 8th and 9th October, 1969 and the clean weight, sugar production and numbers of roots harvested per acre were recorded.

## RESULTS

Table 1

First assessment of Poa annua (counts in ten 1 $ft^2$ quadrats/plot) 5 weeks after initial treatment and 4 days before application of phenmedipham/barban mixture

a) propham/chlorpropham/fenuron mixture

| Treatment | Mean |
|---|---|
| Control | 303 |
| Mixture | 186 |
| | S.E. ± 31 |

b) lenacil

| lenacil lb a.i./ac | Rotary Cultivator | | Reciprocating Harrow | | Mean |
|---|---|---|---|---|---|
| 1.5 | 97 | | 148 | | 124 |
| 3.0 | 97 | | 107 | | 101 |
| | | S.E. ± 31 | | S.E. | ± 22 |
| Mean | 97 | | 128 | | |
| | | S.E. ± 22 | | | |

Table 1 shows significant differences between the control, carbamate/urea mixture and lenacil plots, thus indicating the effectiveness of the treatments on germinating Poa annua seedlings. There was no difference between the 1.5 and 3.0 lb/ac doses of lenacil in control of this grass when incorporation was by rotary cultivator.

Table 2

Second assessment of Poa annua (counts in ten 1 $ft^2$ quadrats/plot) 17 days after application of phenmedipham/barban mixture

a) propham/chlorpropham/fenuron mixture

| Treatment | Without phenmedipham/barban | With phenmedipham/barban | Mean |
|---|---|---|---|
| Control | 317 | 145 | 231 |
| Carbamate/urea | 148 | 47 | 98 |
| | S.E. ± 40 | | S.E. ± 28 |
| Mean | 233 | 96 | |
| | S.E. ± 28 | | |

b) lenacil treatments without phenmedipham/barban

| lenacil lb a.i./ac | Rotary Cultivator | Reciprocating Harrow | Mean |
|---|---|---|---|
| 1.5 | 21 | 26 | 24 |
| 3.0 | 1 | 24 | 13 |
| | S.E. ± 9.0 | | S.E. ± 6.4 |
| Mean | 11 | 25 | |
| | S.E. ± 6.4 | | |

Table 2a shows the means of the treated and untreated phenmedipham/barban mixture to be significantly different, thus suggesting the usefulness of such a post-emergence treatment where Poa annua is present. Table 2b indicates the effects of lenacil plus cultivation on Poa annua eight weeks after application. Lenacil at 3 lb/ac when mixed with a rotary cultivator gave almost complete control of Poa annua; a negligible number of weeds survived any of the treatments involving both lenacil and the phenmedipham/barban mixture.

Table 3

First assessment of broad-leaved weeds, before treatment with phenmedipham/barban mixture (total count of Chenopodium Album, Stellaria media, Polygonum persicaria, P.convolvulus and Matricaria spp. in ten 1 $ft^2$ quadrats/plot

a) propham/chlorpropham/fenuron mixture

| Treatment | Mean |
|---|---|
| Control | 87 |
| Mixture | 51 |
| S.E. | ± 6.8 |

b) lenacil

| lenacil lb a.i./ac | Rotary Cultivator | | Reciprocating Harrow | | Mean |
|---|---|---|---|---|---|
| 1.5 | 26 | | 33 | | 29 |
| 3.0 | 19 | | 27 | | 23 |
| | | S.E. ± 6.8 | | S.E. ± | 4.8 |
| Mean | 22 | | 30 | | |
| | | S.E. ± 4.8 | | | |

Table 3a shows significant reduction in weeds between the control and the carbamate/urea mixture treatment, while Table 3b shows that this mixture was inferior to both rates of lenacil. There was little or no differences in the performance of the two incorporation machines used, as judged by weed numbers in the lenacil-treated plots.

Table 4

Second assessment of broad-leaved weeds 17 days after application of phenmedipham/barban mixture (species as Table 3; ten 1 $ft^2$ quadrats/plot)

a) propham/chlorpropham/fenuron mixture (statistical analysis on counts transformed to log (x+1): entries in count columns obtained by de-transforming means)

| Treatment | Without phenmedipham/barban | | With phenmedipham/barban | | Mean | |
|---|---|---|---|---|---|---|
| | Transformed count | Count | Transformed count | Count | Transformed count | Count |
| Control | 1.91 | 82 | 0.46 | 3 | 1.19 | 15 |
| Mixture | 1.73 | 54 | 0.18 | 1 | 0.95 | 9 |
| | | S.E. ± 0.17 | | S.E. ± | 0.12 | |
| Mean | 1.82 | 66 | 0.32 | 2 | | |
| | | S.E. ± 0.12 | | | | |

S.E.'s apply to transformed data only.

b) **lenacil treatments without phenmedipham/barban**

| lenacil lb a.i./ac | Rotary Cultivator | | Reciprocating Harrow | | Mean |
|---|---|---|---|---|---|
| 1.5 | 8 | | 16 | | 12 |
| 3.0 | 3 | | 10 | | 6 |
| | | S.E. ± 4.2 | | S.E. ± | 2.9 |
| Mean | 5 | | 13 | | |
| | | S.E. ± 2.9 | | | |

Table 4a shows significant differences according to whether or not phenmedipham/barban mixture was applied on both control and carbamate/urea mixture plots. Lenacil alone (Table 4b) gave excellent control of all the broad-leaved weed species present. The data for the plots receiving both lenacil and phenmedipham/barban treatments, were not included in the analysis because of the relatively few weeds surviving in the plots.

Table 5

Effects on sugar beet population, yield and sugar production

NP = no post-emergence treatment, P = phenmedipham/barban applied post-emergence

| | Plant population at harvest (1000/ac) | | Clean beet ton/ac | | Sugar (cwt/ac) | |
|---|---|---|---|---|---|---|
| | NP | P | NP | P | NP | P |
| Control | 26.2 | 33.9 | 10.6 | 12.3 | 38.9 | 45.6 |
| Propham/chlorpropham/fenuron | 29.9 | 36.8 | 12.6 | 13.8 | 46.8 | 50.2 |
| Lenacil 1.5 lb/ac, harrowed | 34.7 | 33.3 | 14.4 | 15.1 | 52.7 | 55.4 |
| Lenacil 3.0 lb/ac, harrowed | 32.8 | 32.1 | 14.8 | 14.9 | 53.7 | 53.6 |
| Lenacil 1.5 lb/ac, rotovated | 34.7 | 35.3 | 17.7 | 14.6 | 62.7 | 52.6 |
| Lenacil 3.0 lb/ac, rotovated | 32.0 | 28.8 | 13.9 | 14.0 | 51.9 | 51.1 |
| S.E. horizontal comparisons | ± 1.12 | | ±0.56 | | ± 1.68 | |
| S.E. vertical comparisons | ± 1.39 | | ±0.67 | | ± 2.08 | |
| Mean | 31.7 | 33.4 | 14.0 | 14.1 | 51.1 | 51.4 |
| S.E. | ± 0.46 | | ± 0.23 | | ± 0.69 | |

The results in Table 5 show that the superimposed post-emergence application of phenmedipham/barban mixture apart from increasing the yield and sugar production of the control and the carbamate/urea mixture treatment was of little benefit to the lenacil treatments. The very high yield in the 1.5 lb/ac lenacil rotary cultivated treatment is unexplained. The low yield in the hand weeded control plots may have been due to delay in removing the weeds, due to labour shortage, at the critical stage of beet development.

## DISCUSSION

The most striking features of the experiment are the high degree of control of both annual grass and broad-leaved weeds and the remarkable tolerance of the sugar beet plants to lenacil even at 3 lb a.i./ac on a peat soil (18% organic matter). Although 2.9 in. of rain fell within ten days of lenacil application and the experimental area was flooded, only the beet plants in the 3.0 lb/ac plots showed slight chlorosis. The affected plants recovered rapidly and by the eighth week were indistinguishable from those in other treatments. Between the two assessment dates (15.5.69 and 5.6.69) the annual grass and broad-leaved weed populations in the control and carbamate/urea mixture treatments were unchanged; however, where a mixture of phenmedipham/barban was superimposed, there were significant reductions in both broad-leaved and annual grass weeds. During the same period lenacil cultivation combination treatments improved control of each type of weed, culminating in 92% and 96% control of *Poa annua*, and 87% and 93% control of the broad-leaved weeds at the 1.5 and 3 lb/ac doses respectively. Where the phenmedipham/barban mixture was superimposed on the lenacil-treated plots, weed control was almost complete.

The excellent weed control given by lenacil eight weeks after treatment suggested that enough residue was present in the soil to control later germinating weed seedlings. Weeds which escaped the initial effect of lenacil germinated but eventually died off at the seedling stage of growth. This suggested root uptake of the herbicide, as reported by Bray and Cussans (1968). The implication of the present results is that a superimposed post-emergence treatment would not justify the extra cost but in the event of a weed control failure with lenacil. Table 5 suggests that a superimposed post-emergence treatment of phenmedipham/barban would have relatively little effect on the beet. In the case of the control and carbamate/urea mixture, the superimposed post-emergence treatment was effective in controlling Poa annua and broad-leaved species and consequently enhanced both yield of beet and sugar production. A lower dose of the phenmedipham/barban mixture would have been more economic and might still have proved worthwhile.

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# THE EFFECTS OF BAND INCORPORATION OF LENACIL ON SUGAR BEET IN HIGHLY ORGANIC SOILS

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Summary Details are given of two experiments in which lenacil was incorporated pre-drilling in 11 and 15 in. bands on sugar beet in peat soils. In experiment 1 lenacil was used at doses of 1.6, 2.4 and 3.2 lb a.i./ac on a peat containing 56.7% organic matter and mixed to a depth of about 1½ to 2 in. with a Standen inter-row hoe. Its activity was compared with a mixture of paraquat at 0.2 lb a.i. plus CIPC/IPC/fenuron (Herbon Gold) at 0.56 gal/ac applied pre-emergence. In experiment 2 lenacil was used at 2.4 lb a.i./ac incorporated with a Howard (Rotacadet) rotavator fitted with guards for band incorporation and its performance compared with IPC/medinoterb acetate (Murbetex Organic) at 21 lb product/ac and an IPC/CIPC/fenuron mixture (Herbon Gold) at 1.3 gal/ac on a peat containing 41.8% organic matter. In each experiment the weed control given by lenacil at 2.4 lb/ac was greater than that given by the other doses of lenacil and herbicides. Neither beet seed germination nor growth of the beet seedlings was affected at any of the lenacil doses used.

## INTRODUCTION

Weed control in peat soils poses special problems. The activity of pre-emergence herbicides on these highly organic soils is greatly reduced by adsorption. In addition, soil-acting herbicides are lost by wind erosion, volatilisation and leaching. Consequently very few of the chemicals in present use can be relied upon to give satisfactory weed control. Recent work by Ramand (1969) has shown lenacil to be quite active on peat soils when thoroughly mixed to a depth of about 2 in. and, overall application on sugar beet was found to have given excellent weed control without affecting yield (Ramand, Forbes and Holroyd, 1970). The high cost of overall lenacil treatment undoubtedly limits the use of the herbicide in the sugar beet crop and for this reason, further work has been explored using band application as a means of reducing cost. This paper reports the results of two experiments carried out on highly organic soils on two farms.

## MATERIALS AND METHODS

### Experiment I

Lenacil was applied at 1.6, 2.4 and 3.2 lb a.i./ac in 50 gal water on to the bare soil surface of a prepared seedbed in 15 in. bands and incorporated with a Standen inter-row hoe to a depth of about 2 in. Five rows of rubbed and graded multigerm seed (variety Anglo Maribo) were drilled at a spacing of $1\frac{1}{2}$ in. the same day along the length of separate plots on 30 in. rows. Spraying, incorporation and drilling was done on the 18th April, 1970. On 21st April, when the weeds were visible but before the beet **seedlings** emerged, a mixture of paraquat at 0.25 lb a.i. plus IPC/CIPC/fenuron (Herbon Gold) at 0.56 gal in 50 gal water per acre was also band sprayed on to separate plots. The experimental design was a randomised block with four replicates. Plot size was $4\frac{1}{2}$ x 20 yards. The soil was a peat containing 56.7% organic matter.

On the 14th May the dominant weeds present along the treated band on the three centre rows were assessed by counting the plants present in ten 6 x 18 in. quadrats in each plot. The numbers of beet plants present were also recorded and a score of growth and vigour recorded. An attempt to determine chemical effects on the developing beet plants was made by harvesting 50 plants at random in each plot. Four samples at approximately weekly intervals were taken and the dry weight recorded. Beet yield was not obtained.

Experiment 2

Lenacil was applied at 2.4 lb a.i. in 20 gal water per acre on to 11 in. bands of a prepared seedbed and incorporated to a depth of about 2 in. with a Howard (Rotacadet) rotavator. The simultaneous operation was carried out by a spray boom situated in front of the tractor and fitted with fan jets and chemical/soil incorporation done at the rear. The guards and rotor blades of the rotavator were set to mix 11 in. bands on 22 in. rows. Sugar beet (variety Monotri) seeds were drilled immediately after incorporation of the herbicide with a precision seeder unit at 8 in. spacing and left unsingled. A CIPC/IPC/fenuron mixture (Herbon Gold) at 1.3 gal/ac and IPC/medinoterb acetate (Murbetex Organic) at 21 lb product/ac respectively were applied post-drilling in 30 gal water/ac on 7 in. bands on to separate plots. The chemical treatments and drilling were done on 20th April, 1970. Plot size was 3 x 100 yd and organic matter content was 41.8%. The experimental design was a randomised block with four replicates.

On 15th May, the weeds present along the treated bands of the two centre rows were assessed by counting the numbers in ten 18 x 6 in. quadrats/plot. A record of established beet plants in 100 ft lengths per plot was also taken. No final yield data was obtained.

Fig. 1

**Weed free bands showing unaffected sugar beet plants in rows where lenacil was incorporated at 2.4 lb a.i./ac with a Standen inter-row hoe.**

## RESULTS

Experiment 1

### Table 1

Weed counts in ten 1 $ft^2$ quadrats/plot

Treatment means of principal weed species

| Herbicides | Senecio vulgaris | Polygonum persicaria | Chenopodium album | Matricaria spp. | Urtica urens | Stellaria media | Poa annua |
|---|---|---|---|---|---|---|---|
| Lenacil at 1.6 lb a.i./ac | 29.50 | 32.00 | 12.00 | 4.75 | 50.50 | 41.25 | 22.50 |
| Lenacil at 2.4 lb a.i./ac | 0.75 | 13.50 | 6.50 | 0.00 | 15.75 | 2.50 | 3.00 |
| Lenacil at 3.2 lb a.i./ac | 3.75 | 23.00 | 14.00 | 4.00 | 20.50 | 12.75 | 1.75 |
| Paraquat at 0.25 lb a.i. + Herbon Gold at 0.56 gal/ac | 21.25 | 31.25 | 16.00 | 0.50 | 34.00 | 17.25 | 20.00 |
| Control | 233.75 | 28.50 | 26.75 | 232.25 | 98.00 | 96.25 | 89.00 |
| S.E. | ± 23.15 | ± 7.92 | ± 3.28 | ± 6.55 | ± 8.66 | ±10.31 | ± 5.37 |

The results show that lenacil at 2.4 and 3.2 lb a.i./ac gave significant reductions of Poa annua, Senecio vulgaris, Chenopodium album, Matricaria spp., Urtica urens and Stellaria media compared with check plots. The 2.4 lb/ac treatment of lenacil appeared to be the most effective for weed control.

Table 2

Mean dry weight of 50 plants/plot (g)

| Harvest Date | Control | Paraquat 0.25 lb a.i. + Herbon Gold 0.56 gal | Lenacil lb a.i./ac | | |
|---|---|---|---|---|---|
| | | | 1.6 | 2.4 | 3.2 |
| 14.5.70. | 9.45 | 9.21 | 8.41 | 8.18 | 8.22 |
| 19.5.70. | 17.89 | 16.63 | 18.37 | 16.36 | 16.33 |
| 26.5.70. | 56.00 | 62.12 | 51.41 | 75.81 | 56.13 |
| 4.6.70. | 136.20 | 231.22 | 168.68 | 289.32 | 242.24 |

The results of the mean dry weight of the four samples of sugar beet plants taken at approximately weekly intervals indicated no apparent check with lenacil even at 3.2 lb/ac. A reduction in the final sample weights of the control and 1.6 lb/ac lenacil treatments was due mainly to weed competition. In the other treatments, weed control was almost complete.

Experiment 2

Table 3

Mean weed counts in ten 6 x 18 in. quadrats/plot 25 days after treatment

| | Weeds | | | | |
|---|---|---|---|---|---|
| Treatment | Poa annua | Chenopodium album | Polygonum persicaria | Stellaria media | Urtica urens |
| Lenacil | 13.8 | 6.0 | 6.3 | 5.3 | 13.3 |
| Carbamate/urea (Herbon Gold) | 36.7 | 26.5 | 20.5 | 18.5 | 28.0 |
| Carbamate/phenol (Murbetex Organic) | 21.0 | 19.5 | 26.0 | 24.5 | 31.5 |
| Control | 64.3 | 71.1 | 30.0 | 59.0 | 63.7 |
| L.S.D.(P = 0.05) | 15.2 | 21.6 | 9.3 | 15.2 | 14.3 |

The results show that apart from the effect of Murbetex Organic on Polygonum persicaria, all other treatments differ significantly from controls. Lenacil gave a greater degree of weed reduction of all the principal weed species compared to the other two proprietary herbicide mixtures used.

## DISCUSSION

The substantial control of annual broad-leaved weeds and Poa annua provided by lenacil on highly organic soils appears to be consistent with previous work (Ramand, Holroyd & Forbes, 1970). The results obtained by lenacil may be attributed to the following factors:- a) the chemical being put in the zone of the germinating weed seeds and in the vicinity of available sub-surface moisture, and b) protection by the soil against wind erosion. In contrast, the carbamate/urea/paraquat and IPC/medinoterb acetate mixtures applied separately on to the soil surface and left undisturbed were vulnerable to 'wind blow' and relied on subsequent rainfall for the downward movement into the zone of the germinating weed seeds. But, the dry late spring encountered this year may have severely restricted the activity of these surface-applied chemicals as they were either left lying on the soil surface or blown away.

Although the peat soils in both experiments at the time of treatment were extremely wet and caused some difficulty in incorporating the lenacil, the results, nevertheless, were superior to those from the other herbicides used. The 2.4 lb a.i./ac of lenacil gave the greatest degree of weed control (Fig.1) and the highest plant dry weights on the 5th and 7th weeks after drilling. This indicated that neither beet germination nor plant development were affected as shown in Table 2. The 1.6 lb a.i./ac lenacil dose, on the other hand, was inadequate in these very highly organic soils and gave poor weed control and a low beet plant dry weight, due to weed competition. Where drilling was done to a stand of 8 in. in experiment 2, the plant population ranged from 98 to 112 per 100 ft length in both the controls and treated plots, thus suggesting that the slight variation in plant numbers may have been due to factors other than chemical effects.

Apart from the wet weather in the early spring, no other difficulty was experienced in the incorporation of lenacil, either by the Standen inter-row hoe or Rotacadet on 11 or 15 in. bands. Generally, the weed reduction in experiment 1 was much more satisfactory where incorporation was by the Standen inter-row hoe than by the Rotacadet. The excellent weed control may have depended on the efficiency of chemical/soil mix, thus suggesting the importance of a thorough mix for good weed control where lenacil is used in peat soils.

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# POSSIBILITIES OF INCREASING THE EFFECTIVENESS OF POST-EMERGENCE HERBICIDES USED IN SUGAR BEETS BY HIGHLY REFINED NON-PHYTOTOXIC PARAFFINIC OIL

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Summary The use of the new adjuvant oil 11E may contribute to the improvement of the new post-emergence weed control techniques. Indeed the addition of the oil reinforces the herbicidal action and makes it possible to treat the more developed weeds and to destroy the kinds of weed which were resistant or not sensitive at all. This improves the efficiency of the treatment irrespective of the nature of the soil and climatic conditions. The use of 11E has increased the activity of herbicides that previously were used only in the pre-emergence applications. It allows, in most cases, reduction of the dosages and consequently less risks of build up of residues for following sensitive crops particularly in the case of persistent herbicides.

## INTRODUCTION

Dr. George Jones and co-workers of the Department of Agronomy at the University of Guelph, Ontario, Canada were the first to investigate the concept of using highly refined paraffinic oils as carriers for herbicides in post-emergence applications. Their initial work was done in 1963 using atrazine with highly paraffinic oils as a post-emergence spray on field corn. Subsequent work done in 1964 in which Superior Spray Oil 11E* was one of the principal oils, confirmed that this oil improves the performance of atrazine as a post-emergence foliar spray under normal growing conditions. In 1965 an experimental label was approved by the Ontario Department of Agriculture recommending the use of oil "to increase the post-emergence activity of atrazine and to extend the period of application".

In the U.S.A. application of oil with atrazine was introduced in 1966 on a limited scale. This followed a year of extensive testing at state and federal institutions throughout the U.S.A. representing a broad spectrum of field and environmental conditions. In subsequent years the use of phytobland oils with other herbicides on other crops such as soybeans, sorghum, sugar cane, sugar beets, cotton, rice and vegetable crops has been under intensive investigation.

Based on the favorable results which were observed in North America, Seppic undertook to study the possibility of using this same Superior Spray Oil 11E for post-emergence weed control with phenmedipham* on sugar beets under European climatic conditions. Field testing of the above combination under French conditions resulted in its authorization for sale in France in November 1968 as an adjuvant to be used in the herbicidal mixture.

## CHARACTERISTICS AND SCOPE OF ACTION OF SPRAY OIL 11E

Superior Spray Oil 11E is a highly refined paraffinic oil containing an emulsifier specifically designed to provide emulsification in water up to 1200 ppm hardness with cold water (5°C) which is so often typical of ground water used at the time of spraying. Initially ten oils, five paraffinic and five naphtenic, were tested for

* trade mark: Sunoco Superior Spray Oil 11E

* trade mark: Betanal

their effectiveness with atrazine. The paraffinic oil exhibited viscosities from 60 to 210 SUS at 38°C and UR values ranging from 91 to 93. The naphthenic oils are of similar viscosities but have UR values ranging from 73 to 75. Based on field test data comparing the performance of these oils, Superior Spray Oil 11E was selected as being the most consistently effective supplementary carrier for atrazine.

Principal Characteristics of the Base Oil used to Formulate 11E

1. Viscosity 100 SUS at 38°C

2. Distillation range at 10 mmHg
   50% point 243°C
   10-90% Range °C 51.6°C

3. Unsulfonated residue over 90%, which makes it very adequate for use on vegetables.

4. Typical composition is such that:
   67% of the carbon atoms are in paraffin chains
   29% of the carbon atoms are in naphthenic rings
   4% of the carbon atoms are in aromatic rings

5. Superior Spray Oils plus their emulsifier system are tolerance exempt when used under the conditions listed in the Federal Register, i.e., "when applied to growing crops in accordance with good agricultural practices..."

6. Emulsion with water: quick-breaking type
   This means that the oil is temporarily dispersed in the water phase, and upon standing or lack of agitation the oil separates to a cream layer at the surface. The purpose of the quick-breaking oil is to assure the maximum deposit of the oil herbicide mixture upon the foliar surface. The advantages of 11E as an additive for herbicidal sprays include:

   a. an improved spray suspension for better field distribution and uniformity of weed killing
   b. a longer uptake or contact period for assimilation of the herbicide through the foliage
   c. the retardation of water evaporation for hydrophilic routes into the plant
   d. an improved resistance to the mechanical action of rain

7. Molecular weight: 360

METHOD AND MATERIALS

1 TESTS IN FRANCE

On sugar beet
- oil used alone

In 1968, treatments of 2,5 to 40 l./ha of 11E oil alone did not cause any damage to sugar beets when treated at the 2-true leaf stage. In 1969, tests with logarithmic volume have confirmed the tolerance of the young beets up to the dosage of 125 l./ha, i.e., 25 times the normal dosage of 5 l./ha. However when very high dosages of oil were used, a slowing down in the growth could be observed. Presumably, excessive deposits of the oil on the leaves reduced phytosynthetic processes of the plant. This phenomenon could be seen at the same time on the beet crop as well as upon the weeds. This metabolic effect varied in degree of action with the weed species and their stages of growth. Growth depression was only of a temporary nature and did not delay the maturity of the crop.

- oil + phenmedipham

These tests were designed to study the herbicide in combination with oil 11E. The treatments were made by means of a spray apparatus with constant pressure delivering 1000 1. water/ha under 3 $kg/cm^2$ pressure.

Dosages of the products studied
phenmedipham 0.5 - 1-2 kg/ha alone or in mixture with oil 11E at 2.5 - 5 - 7.5 and 10 1./ha

Vegetative stages considered for the treatments
sugar beets = at least 2 true leaves
weeds = a maximum of 4 true leaves

No pre-emergence treatment was made in order to obtain a normal emergence of the weeds.

Results

In 1969 the tests confirmed the observations of 1968, and in 1970 the behavior of the weeds which received a pre-planting treatment with incorporation and then a post-emergence treatment with or without oil 11E were studied.

It could be seen very clearly that the dosage of 5 1./ha oil 11E is necessary and sufficient. This finding was confirmed in several previous tests. It is, therefore, not necessary to exceed this dosage in order to obtain commercial herbicidal efficiency. The various herbicide mixtures which were studied lead us to the following conclusions:

With the mixture phenmedipham + oil 11E, in some cases, certain grassy weeds, Avena fatua and Alopecurus myosuroïdes, were severely stunted or destroyed, when the mixture was applied not later than the 3-leaf stage. This was something new because it is known that the phenmedipham shows little activity on the grasses. This was verified in 1969 in thickly infested fields previously treated pre-emergence with pyrazon*. These field plots showed at the moment of the post-emergence treatment, a regrowth of rape seed and Avena fatua.

The annual broad leaved weeds usually well controlled by the phenmedipham at the recommended stages of growth are more rapidly destroyed upon the addition of oil. However, certain very resistant weeds such as Amaranthus retroflexus or Mercurialis annua must always be treated at the cotyledon stage for effective control.

Moreover it has been possible to destroy up to 70% or to stunt certain weeds, such as Sinapis arvensis, Chenopodium album, Matricaria sp., at a very advanced stage (average height 30 cm).

In this way it was possible for a grower to control a dense population of these weeds when the beets had developed 6 to 8 leaves. The efficiency of the 11E phenmedipham combination after a precipitation of 30 mm water an hour after the application was also improved.

Summarizing, the addition of oil 11E in a phenmedipham solution shows clearly that one may expect a more flexible use of the weed control product without reducing the security margin and also a weed foliar destruction between 80 and 95% as compared to 75% when used alone.

In 1970, several trials on small plots and applications on more than 350 hectares have confirmed the interest in the successive technical treatments of pre-emergence and post-emergence in commercial practice.

* trade mark: Pyramine

Consequently, the following programme has been applied on beets placed from 8 to 22 cm on the row:

1. pre-emergence: 600 to 640 g lenacil/ha incorporated before sowing
2. post-emergence: 0.7 to 1 kg phenmedipham/ha plus 5 to 6 l./ha of 11E oil.

- oil + pyrazon or lenacil

The oil 11E makes these 2 herbicides with essentially radicular activity (root-action) active in post-emergence treatments. It has been found that up to 85% weed control was obtained in the best cases. However, unlike the oil phenmedipham treatments, these combinations have been erratic in their post-emergence control of weeds. This is attributed to a greater dependence upon favorable climatic factors. These 2 products must be used with certain combinations such as phenmedipham + lenacil + oil 11E which are now under study.

## II TESTS IN GERMANY

During the Second International Meeting on Selective Weed Control in Beet Crops at Rotterdam March 1970, Fischer (1970) published the results of his tests with Sun Oil 11E in mixture to find an oily adjuvant. Fischer obtained the best results with 11E which is a very tolerant product for the beets.

Out of 40 adjuvants tested in Germany with new herbicides it was found that Spray Oil 11E provided the best action against weeds with good compatibility to beets (Fischer 1970).

The following table shows the improved action of BAS 3501 H and BAS 3800 H + Spray Oil 11E in comparison with BAS 3501 H and BAS 3800 H alone, especially under dry weather conditions.

Table 1
Percentage Weed Control

| Weeds | Treatment | | | |
|---|---|---|---|---|
| | BAS 3501 H 1,8 kg/ha | BAS 3501 H 1,8 kg/ha + oil 11E 4,0 l./ha | BAS 3800 H 2,0 kg/ha | BAS 3800 H 2,0 kg/ha + oil 11E 4,0 l./ha |
| Amaranthus retr. | 70 | 95 | 50 | 70 |
| Galinsoga parv. | 70 | 95 | 60 | 90 |
| Galium aparine | 70 | 90 | 55 | 80 |
| Polygonum con. | 85 | 100 | 70 | 90 |
| Matricaria cham. | 80 | 100 | 60 | 90 |
| Alopecurus myos. | 70 | 90 | 65 | 85 |
| Poa annua | 80 | 100 | 70 | 95 |
| Poa trivialis | 70 | 95 | 65 | 90 |
| Echinochloa c.g. | 65 | 85 | 60 | 80 |

The 11E was introduced to the Federal Republic of Germany in January 1969. The Institute for Sugar Beets Research of Göttingen included the oil 11E in a first series of tests in 1969. These tests will be made over a period of 3 years. Other tests have been made simultaneously by different official Plant Protection Services. Some large sugar mills in Germany have given us their help in arranging for orientation tests. The organizations of the cooperative society at Worms and Regensburg and the "Association of Frankish Sugar Beet Growers" at Würzburg have also helped us in the introduction tests of the 11E. In general the results have been good, but treatments at high temperatures have also caused phytotoxicity. The increase of the herbicidal action on grassy weeds could be determined in 2 specific cases. Herbicide dose rates to give results, comparable to the ones obtained with the normal rate of use, could be determined.

III TESTS IN BELGIUM

The first introduction of Spray Oil 11E in Belgium dates from July 1968. On basis of the most promising information from tests effected in France the I.B.A.B. (Belgian Institute for the Amelioration of the Beets) made later orientation test with 11E in mixture with phenmedipham on sugar beets sown in July at the same time as rye grass. The purpose was to determine the selectivity and the anti-grassy weeds action. The improvement of the action against grassy weeds obtained by using 5-6 l./oil to the phenmedipham was of special interest to us. As a result of the favorable weed control obtained, a large test and demonstration programme was started in 1969. Through the cooperation of I.B.A.B. about 100 ha of sugar beets were treated with 11E chiefly in mixture with phenmedipham. These tests were divided among all the Belgian sugar manufacturers. In addition to these demonstration tests, a large experimental output test was carried through by I.B.A.B. in collaboration with the Station of Phytopharmacy at Gembloux.

IV TESTS IN THE UNITED STATES (USDA REGISTRATION NUMBER 862-9)

The use of non-phytotoxic oils such as Superior Spray Oil 11E are standard recommendations in the United States and Canada for post-emergence applications in corn, sorghum, sugar cane, and Florida turf. The standard rate of oil ranges from 1-2 US. gallon/acre with the principal herbicide atrazine at a maximum suggested use of 2 pounds actual per acre. The suggested rate of the oil atrazine in a broadcast application is 20-40 U.S. gallon/acre of solution.

Field evaluation of 11E is continuing in the major agricultural research stations of the corn, sorghum, cotton and sugar beet belts to develop improved post-emergence weed control where continued use of single chemicals are developing ecological changes that are creating new problems such as fall Panicum (Panicum dichotomoflorum) and yellow nutsedge (Cyperus esculentus).

The future research for post-emergence sprays is definitely directed at chemical combinations to control resistant weed problems, or as a supplement to the pre-plant or pre-emergence treatments.

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# A NEW IMIDAZOLIDINONE FOR WEED CONTROL IN SUGAR AND FODDER BEETS WITH SPECIAL ACTION AGAINST ALOPECURUS MYOSUROIDES

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Summary Imidazolidin-2-on-1-carboxylic acid isobutylamide is a new chemical for weed control in sugar beet. Application is made pre-emergence at 4.6 - 6.8 kg/ha (6 - 8 kg/ha of the 80% wettable powder, BAY 6199 H). It controls broad-leaved weeds and grasses without incorporation into the soil. The safety margin is wide, as shown by glasshouse and field trials.

## INTRODUCTION

Chemical weed control in sugar beet is now widely accepted and in most European Countries more than 90% of the total acreage is treated (Durgeat, 1970). For the control of broad-leaved weeds pyrazon, and, under certain conditions, lenacil are being used. Both products are applied pre-sowing or pre-emergence, whereas phenmedipham is used post-emergence. Triallate, applied pre-sowing and incorporated has been widely accepted for the control of grass weeds. As its effect against broad-leaved weeds is not adequate, it is usually used in combination with a post-drilling residual herbicide. This method is, in comparison with pre-emergence herbicides, more laborious and costly. Broad-leaved weeds have been successfully controlled for a much longer time than grass weeds, particularly in cereals, and as a result the grass weeds have increased in their importance. Pfeiffer reported in detail on this aspect in 1968. For the control of grass weeds in cereals, several compounds have been developed in recent years (chlorotoluron, methabenzthiazuron, metoxuron, terbutryne); they are sufficiently tolerated by the crop and, besides grasses, also control broad-leaved weeds. Wild oats (Avena fatua, Avena strigosa, Avena ludoviciana) hold a special position with respect to their response to the materials already mentioned, and will not be considered in the context of this paper.

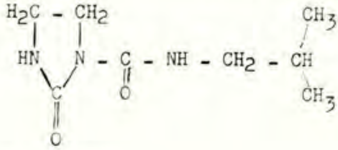
We now would like to describe BAY 6199 H which controls broad-leaved and grass weeds in sugar beet, when applied pre-emergence, without the need for incorporation.

## CHEMICAL AND PHYSICAL DATA

During our investigation on the herbicidal properties of Imidazolidinone we found compounds which were well tolerated by sugar beet and showed a good effect on weeds. Out of a series of compounds we selected the Imidazolidin-2-on-1-carboxylic acid isobutylamide for larger scale evaluation.

Chemical name: Imidazolidin-2-on-1-carboxylic acid isobutylamide

Structural formula:




Suggested common name: Imizolamid

Emperical formula: $C_8H_{15}N_3O_2$

Molecular weight: 185.2

Melting point: 95° - 96° C

Solubility: In water at 20°C. 5.5 g/100 ccm, also soluble in organic solvents like acetone, dimethylformamide and chlorobenzene

Formulation: in the field, an 80% w.p. formulation with good suspension properties was used, under code number BAY 6199 H

Toxicological data: the following data were obtained by the Institute for Toxicology, Farbenfabriken Bayer AG, Elberfeld:

| | | | ♂ | ♀ |
|---|---|---|---|---|
| $LD_{50}$ | rat | per os | > 2500 mg/kg | ~2500 mg/kg |
| | mice | " " | > 2500 mg/kg | > 2500 mg/kg |
| | rabbits | " " | > 500 mg/kg | > 500 mg/kg |
| | rat | i.p. | ~900 mg/kg | ~900 mg/kg |

Cutaneous toxicity tests were done on rats, using the "collar" method. No changes were observed following the application of 500 mg/kg (25% in water) during a 7-day observation period. In the LIM-test no accumulation was noticeable.

## CROP TOLERANCE

Sugar beet seed (Erta E calibriert) was sown in the glasshouse and covered with sand. A suspension of the product was watered or sprayed pre-emergence. The symptoms of phytotoxicity were scored visually. There were no differences in response between the two methods of application, probably due to the high water solubility of the compound. From a great number of tests, average values were obtained, expressed in "degree of damage", as follows

| | kg/ha | degree of damage in % |
|---|---|---|
| Imizolamid | 20 | 76 |
| | 10 | 40 |
| | 5 | 4 |
| | 2.5 | 0 |
| | 1.25 | 0 |

The results indicate good crop tolerance even under severe conditions when seeds were only covered by sand.

Additional data on tolerance were obtained in the so-called hydrotest. Plastic flower pots (Ø 12 cm), filled with washed gravel, were planted with 7 day old sugar beet seedlings, 3 per pot. The pots were placed in plastic saucers and watered with 200 ml of a 0.3% Bayfolan[R] nutrient solution. Every 2 days the solution was made up to 200 ml and, with the help of a funnel in the pot, distributed, so that the solution did not contact the foliage. After 7 days different amounts of Imizolamid were added to the nutrient solution and applied as described before. 14 days later the young beet plants were cut and weighed (3 per pot, four pots per concentration). Temperature during the trial was 18°C. The following average weights were recorded:

| Product | mg per pot | fresh weight in g |
|---|---|---|
| Imizolamid | 2 | 4.7 |
| | 1.6 | 7.3 |
| | 1.2 | 8.7 |
| | 0.8 | 9.8 |
| | 0.4 | 12.2 |
| Comparison | 1 | 0.7 |
| | 0.8 | 2.5 |
| | 0.6 | 6.0 |
| | 0.4 | 9.4 |
| | 0.2 | 10.5 |
| Check | - | 7.9 |

This test confirmed the good tolerance of sugar beet to Imizolamid and justified further work on its behaviour under field conditions.

Two year's trial results are now available, the majority of which were obtained in 1970. Phytotoxicity was assessed in two ways. One was based on scoring the symptoms logarithmically (Bolle 1964) using a scale from 1 - 9. The other consisted of counting the numbers of emerged plants over a distance of 8 x 10 m per treatment. There was a considerable variation in the trials with respect of type of seed drills and sowing depth, as well as soil and climatic conditions. As it was possible to work with absolute figures we have expressed the emergence in each individual treatment relative to control = 100. As averages would not be meaningful we have, in the following table, compared the results on a different basis, as percentages, according to the relative degree of emergence.

Table 1

Degree of emergence of sugar beet as influenced by treatment with Imizolamid, given in % (check = 100) from 40 trials

| | | % emergence (check = 100) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 110 | 100-110 | 95-99 | 90-94 | 80-89 | 80 |
| Product | kg/ha | distribution among emergence groups (%) | | | | | |
| Imizolamid | 4.8 | 5 | 62.5 | 12.5 | 12.5 | 5 | 2.5 |
| | 6.4 | 7.5 | 37.5 | 15 | 20 | 20 | 0 |
| | 9.6 | 7.5 | 30 | 15 | 7.5 | 25 | 15 |
| Comparison | 3.2 | 10 | 47.5 | 20 | 15 | 5 | 2.5 |

The figures show that in the majority of the trials emergence figures at 4.8 kg/ha were good or better than those obtained with the product used for comparison. At 6.4 kg/ha the picture is less favourable, and 9.6 kg/ha (which is twice the basic rate) caused unacceptable damage.

Damage takes the form of growth retardation, but sometimes we also observed paler foliage and leaf necrosis. Total damage was scored according to BOLLE and results are summarized in table 2.

Table 2

Damage in sugar beet observed after treatment with Imizolamid (check = 100% no damage), from 40 trials

| Product | kg/ha | Damage in % | no damage | up to 5% | 6 - 10% | 10% |
|---|---|---|---|---|---|---|
| | | Score | 1 | 2 and 3 | 4 | 5 |
| | | distribution among damage groups (%) | | | | |
| Imizolamid | 4.8 | | 80 | 20 | | |
| | 6.4 | | 60 | 37.5 | 2.5 | |
| | 9.6 | | 42.5 | 25 | 15 | 17.5 |
| Comparison | 3.2 | | 70 | 25 | 2.5 | 2.5 |

These data also demonstrate good crop tolerance, particularly when considering that affected plants grow out of the damage within 2 - 3 weeks.

Unfortunately, information on yield is not yet available from 1970 trials. In the two trials which were taken to yield in1969 there was no indication of a depressing effect on either top or root yield and even at 12 kg/ha yields were similar to those obtained in the plots receiving the standard treatment used as comparison. We quote these data with some reservation until further yield figures, to be obtained this year, are available.

## WEED CONTROL

Initially, the herbicidal effect was assessed in the glasshouse, and it became obvious, that Imizolamid had an effect against both broad-leaved and grass weeds.

Table 3 summarizes the results of 12 glasshouse trials giving the percent weed control against various species, compared to the effect on sugar beet, at rates from 1.25 to 20 kg/ha. 80 - 100% control of broad-leaved weeds was obtained at 2.5 - 5 kg/ha and these rates were also safe to the crop. The effect against grasses was satisfactory, Poa annua being particularly susceptible.

Weed scores are also available from a number of field trials. Table 4 lists the species in terms of frequency on a percentage basis as experienced in our work. They differ from those published by HANF (1957) but there is good agreement as far as major groups of weeds are concerned. Average values based on scores (BOLLE 1964) are given for 3 rates. We believe the results to be significant for those weeds, which occur in 20% or more of the trials - the other species we consider as of secondary importance. Results are graded in 3 groups - i.e. group 1: 90 -100% control (scores 4 - 1), group 2: 75 - 89% control (scores 4.1 - 6) and group 3:

below 75% (scores 6.1 - 9). Effectiveness against weeds in group 1 can be considered to be very good whilst weeds in group 2 can probably be controlled satisfactorily under practical conditions.

In general, 4.8 kg/ha seem to give good weed control, including 80% control of Alopecurus myosuroides. Where blackgrass is the predominant weed it is advisable to increase rates to 6.4 kg/ha. It is an advantage that control of this grass weed can be achieved with Imizolamid without the need for soil incorporation. The effect against Fumaria officinalis, Veronica spp. and Viola spp. is particularly useful, as these weeds have increased in the last few years. The product is weaker against Galium aparine and Polygonum spp., but increasing the rate to 6.4 kg/ha will probably give satisfactory results against the latter.

We believe that Imizolamid will be a useful sugar beet herbicide and we shall continue work with related compounds and product combinations which will be reported later.

Acknowledgements

Thanks are due to all colleagues who have contributed to the work reported here.

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Table 3

Control of various weed-species in sugar beet by Imizolamid (glasshouse tests)

| Imizolamid kg/ha | Beet-damage in % | GASP | URTU | STEM | MATC | SINA | AMAR | LOLP | ECHC | POAA |
|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 76 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 10 | 40 | 100 | 100 | 96 | 100 | 100 | 100 | 86 | 74 | 100 |
| 5 | 4 | 100 | 100 | 94 | 100 | 100 | 90 | 78 | 60 | 100 |
| 2.5 | 0 | 100 | 98 | 82 | 86 | 88 | 80 | 68 | 50 | 80 |
| 1.25 | 0 | 76 | 80 | 64 | 70 | 84 | 60 | 48 | 40 | 62 |

GASP = Galinsoga parviflora

URTU = Urtica urens

STEM = Stellaria media

MATC = Matricaria recutita

SINA = Sinapis arvensis

AMAR = Amaranthus retroflexus

LOLP = Lolium perenne

ECHC = Echinochloa crus-galli

POAA = Poa annua

Table 4

Frequency of different weed-species and their control in sugar beet by Imizolumid

| | Frequency % | Weed control kg/ha: 4.8 | 6.4 | 9.6 |
|---|---|---|---|---|
| Stellaria media | 58 | 5,6 | 3,7 | 2,6 |
| Chenopodium album | 55 | 3,7 | 2,4 | 1,8 |
| Polygonum convolvulus | 35 | 6,2 | 5,7 | 4,8 |
| Matricaria spp. | 35 | 3,2 | 2,4 | 1,9 |
| Lamium spp. | 30 | 3,4 | 3,0 | 2,4 |
| Alopecurus myosuroides | 30 | 4,7 | 3,3 | 2,5 |
| Thlaspi arvense | 25 | 2,7 | 2,0 | 1,2 |
| Sinapis arvensis | 25 | 2,9 | 2,3 | 2,0 |
| Poa annua | 20 | 1,4 | 1,0 | 1,0 |
| Polygonum aviculare | 20 | 4,9 | 4,3 | 3,5 |
| Fumaria officinalis | 20 | 4,1 | 3,3 | 3,1 |
| Polygonum persicaria | 12 | 5,8 | 4,6 | 4,0 |
| Veronica heder efolia | 12 | 4,5 | 2,7 | 1,5 |
| Veronica arvensis | 10 | 2,5 | 1,7 | 1,1 |
| Galium aparine | 10 | 6,7 | 6,1 | 4,7 |
| Viola arvensis | 8 | 5,0 | 3,7 | 2,8 |
| Senecio vulgaris | 8 | 3,0 | 2,3 | 1,5 |
| Atriplex patula | 5 | 3,4 | 2,2 | 1,8 |
| Galeopsis spp. | 5 | 4,6 | 4,2 | 2,7 |
| Raphanus raphanistrum | 5 | 2,0 | 1,5 | 1,0 |
| Galinsoga spp. | 5 | 2,0 | 1,5 | 1,0 |
| Myosotis arvensis | 3 | 3,5 | 2,7 | 1,5 |
| Vicia spp. | 3 | 7,0 | 4,4 | 4,2 |

group 1: 90-100 % control (scores 4-1)

group 2: 75- 89 % control (scores 4,1-6)

group 3: below 75 % (scores 6,1-9)

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# TRIALS WITH MIXTURES OF AZIPROTRYNE AND SIMAZINE FOR WEED CONTROL IN PEAS

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Summary A mixture of aziprotryne 1.79 lb/ac and simazine 0.13 lb/ac was tested in 1969/1970 as a pre- and post-emergence herbicide treatment in peas. The mixture was as selective as aziprotryne alone, and had no adverse effect on yields. Weed control was generally improved by using the mixture with better pre-emergence control of *Polygonum aviculare*, *Polygonum convolvulus* and *Veronica persica* and better post-emergence control of *Aethusa cynapium*.

## INTRODUCTION

The use of aziprotryne as a herbicide for peas was first reported by Marks and Smith (1968). It was shown that aziprotryne was selective in peas when applied pre- or post-emergence on a wide range of soils including very light sands. Aziprotryne controlled many annual weeds when applied before weed emergence, or after emergence provided weeds had less than three leaves. The control of *Polygonum aviculare*, *Polygonum convolvulus*, *Veronica persica*, *Sinapis arvensis* and *Lamium amplexicaule* with pre-emergence applications was variable.

In 1968 preliminary investigations were commenced with mixtures of aziprotryne with other herbicides to obtain reliable control of these weeds and of a broader weed spectrum. The trials indicated that the addition of 0.06-0.19 lb/ac simazine to 1.79 lb/ac aziprotryne improved pre- and post-emergence weed control without adverse effect on the crop. Work by Wettasinghe (1968) showed peas to be tolerant of up to 0.25 lb/ac simazine.

Following these preliminary investigations, three logarithmic and eleven replicated plot trials were carried out with aziprotryne / simazine mixtures in 1969 and 1970. These trials were carried out on light and very light soils to ascertain whether the mixture of aziprotryne with simazine was as selective as aziprotryne alone.

## MATERIALS AND METHODS

A 65% wettable powder of aziprotryne and a 50% wettable of simazine were used in all trials. Mixtures of aziprotryne with simazine were prepared by mixing the wettable powders in the proportions of the two active ingredients shown in the results. Apart from the logarithmic trials, all trials were of a randomised block design with three replicates. In the replicated plot trials aziprotryne was used according to commercial recommendations and the mixtures of aziprotryne with simazine were applied at the same time as aziprotryne alone. In the 1970 logarithmic trials a series of applications was made to ascertain crop tolerance to mixtures of aziprotryne with simazine before, during and after crop emergence. All treatments were applied with a precision plot sprayer in 25 gal water/ac.

Weed control and crop vigour assessments were made in the replicated plot trials about 4 weeks after post-emergence treatments were applied. Estimates of yield were obtained from all the 1969 trials and four of the 1970 trials by cutting an area of 12 $yd^2$ per plot. The cut haulm was vined and samples of peas from plots subjected to a tenderometer test. In addition samples from the aziprotryne plus simazine treatments were submitted for processing and taint testing.

## RESULTS

The results of the logarithmic trials are given in Table 1. These results with the aziprotryne / simazine mixture show a high degree of selectivity which was of the same order as that with aziprotryne alone at all stages of crop growth tested. Good crop tolerance was also shown in the yield trials the results of which are given in Table 2. No significant differences occurred in the yield trials except in trial 3/69 where 1.79 lb/ac aziprotryne + 0.13 lb/ac simazine gave a significant increase in crop yield.

The mean percentage control of all weeds in the 1969 and 1970 trials is given in Table 3.

Table 1

Results of Logarithmic Trials 1969-1970

| Trial Reference | Treatment: Compound | Treatment: Dose lb/ac | Crop Stage | Weed Stage | Selectivity Factor* |
|---|---|---|---|---|---|
| 1/69 | Aziprotryne | 6.0-0.5 | Pre-em.<br>3-4 lf. | Pre-em.<br>Cot-2 lf. | 2.7<br>2.0 |
| | Aziprotryne + simazine | 1.79+ 0.56-0.47 | Pre-em.<br>3-4 lf. | Pre-em.<br>Cot-2 lf | 6.3<br>5.0 |
| 1/70 | Aziprotryne | 7.8-0.65 | Post plant<br>Pre-em.<br>90% em.<br>3 lf. | Pre-em.<br>Pre-em.<br>Cot.<br>1 lf. | 5.0<br>4.2<br>2.0<br>2.5 |
| | Aziprotryne + simazine | 7.2-0.6+ 0.48-0.4 | Post plant<br>Pre-em.<br>90% em.<br>3 lf. | Pre-em.<br>Pre-em.<br>Cot.<br>1 lf. | 3.1<br>4.9<br>2.7<br>2.0 |
| 2/70 | Aziprotryne | 7.8-0.65 | Post plant<br>Pre-em.<br>2% em.<br>1-2 lf. | Pre-em.<br>Pre-em.<br>Cot.<br>1 lf. | 2.6<br>2.6<br>2.4<br>3.0 |
| | Aziprotryne + simazine | 7.2-0.6 0.48-0.4 | Post plant<br>Pre-em.<br>2% em.<br>1-2 lf. | Pre-em.<br>Pre-em.<br>Cot.<br>1 lf. | 2.9<br>3.7<br>3.5<br>2.7 |

* Selectivity factor = dose at which crop damage occurred divided by dose necessary to give 90% weed control.

em. = emergence  cot. = cotyledon  lf. = leaf

Table 2

Effect of mixtures of aziprotryne with simazine on crop yield

| Trial Reference Soil Type and Crop Variety | Treatment Compound | Dose lb/ac | Crop Stage at Application | Yield in cwt/ac | Tenderometer Reading |
|---|---|---|---|---|---|
| 2/69 Coarse sandy loam Sprite | Aziprotryne | 1.79 | 4 lf. | 40.82 | 93 |
| | Aziprotryne + simazine | 1.79+0.13 | Pre-em. | 43.06 | 93 |
| | | 1.79+0.13 | 4 lf. | 40.81 | 94 |
| | | 3.58+0.25 | 4 lf. | 46.27 | 93 |
| 3/69 Sandy loam Feltham First | Aziprotryne | 1.79 | 4-5 lf. | 29.25 | 169 |
| | Aziprotryne + simazine | 1.79+0.13 | Pre-em. | 36.90 | 144 |
| | | 1.79+0.13 | 4-5 lf. | 41.83 | 144 |
| | | 3.58+0.25 | 4-5 lf. | 29.25 | 168 |
| 4/69 Sandy loam Sprite | Aziprotryne | 1.79 | 5-6 lf. | 28.20 | 116 |
| | Aziprotryne + simazine | 1.79+0.13 | Pre-em. | 32.10 | 114 |
| | | 1.79+0.13 | 5-6 lf. | 30.31 | 114 |
| | | 3.58+0.25 | 5-6 lf. | 25.73 | 110 |
| 5/69 Sandy loam Kelvedon Wonder | Aziprotryne | 1.79 | 3 lf. | 38.47 | 96 |
| | Aziprotryne + simazine | 1.79+0.13 | Pre-em. | 43.01 | 96 |
| | | 1.79+0.13 | 3 lf. | 35.47 | 94 |
| | | 3.58+0.25 | 3 lf. | 25.63 | 96 |
| 3/70 Loamy coarse sand Freezer 69 | Aziprotryne | 1.95 | Pre-em. | 26.38 | 92 |
| | | 1.95 | 3 lf. | 35.39 | 93 |
| | Aziprotryne + simazine | 1.79+0.13 | Pre-em. | 31.50 | 95 |
| | | 1.79+0.13 | 3 lf. | 33.01 | 91 |
| | | 3.58+0.25 | 3 lf. | 35.71 | 93 |
| 4/70 Loamy coarse sand Freezer 69 | Aziprotryne | 1.95 | Pre-em. | 15.70 | 101 |
| | | 1.95 | 4 lf. | 14.83 | 101 |
| | Aziprotryne + simazine | 1.79+0.13 | Pre-em. | 14.04 | 103 |
| | | 1.79+0.13 | 4 lf. | 14.62 | 101 |
| | | 3.58+0.25 | 4 lf. | 15.01 | 100 |
| 5/70 Sandy loam Dark Skinned Perfection | Aziprotryne | 1.95 | Pre-em. | 12.89 | 98 |
| | | 1.95 | 1-2 lf. | 10.73 | 96 |
| | Aziprotryne + simazine | 1.79+0.13 | Pre-em. | 11.84 | 99 |
| | | 1.79+0.13 | 1-2 lf. | 10.37 | 97 |
| | | 3.58+0.25 | 1-2 lf. | 9.97 | 95 |
| 6/70 Loamy coarse sand Sprite | Aziprotryne | 1.95 | Pre-em. | 25.56 | 111 |
| | | 1.95 | 3-4 lf. | 21.31 | 116 |
| | Aziprotryne + simazine | 1.79+0.13 | Pre-em. | 21.96 | 106 |
| | | 1.79+0.13 | 3-4 lf. | 25.81 | 112 |
| | | 3.58+0.25 | 3-4 lf. | 25.27 | 109 |

Table 3

Mean Percentage Weed Control 1969-1970

| Weed Stage at Application | Treatments in lb/ac Aziprotryne 1.79/1.95* | Aziprotryne + simazine 1.79+0.13 |
|---|---|---|
| Pre-emergence | 72 | 80 |
| Post-emergence | 65 | 73 |

* 1.79 lb/ac used in 1969 and 1.95 lb/ac in 1970.

## DISCUSSION

The mean weed control results for all trials show an improvement in weed control from the addition of simazine. The apparently low weed control resulting from post-emergence applications was largely due to the 1970 results. In that year abnormally dry conditions persisted during and after the applications were made in mid May. This resulted in 'hard' leaves and low soil moisture conditions which limited the foliar and root uptake of aziprotryne and the root uptake of simazine by the weeds. The addition of 0.13 lb/ac simazine to 1.79 lb/ac aziprotryne gave increased control of Polygonum aviculare, Polygonum convolvulus, Veronica persica and Lyopsis arvensis with pre-emergence applications and with post-emergence applications the control of Aethusa cynapium was also increased.

The logarithmic trials which were carried out on a sandy loam soil show that mixtures of aziprotryne with simazine had a similar selectivity to that with aziprotryne alone. In the yield trials on light and very light soils post-emergence applications of 1.58 lb/ac aziprotryne plus 0.25 lb/ac simazine did not cause significant reductions in yields, and yields after pre- and post-emergence applications of 1.79 lb/ac aziprotryne plus 0.13 lb/ac simazine were in all cases approximately equal to those obtained with 1.79 or 1.95 lb/ac aziprotryne alone. Crop maturity as measured by tenderometer assessment was also unaffected by the mixture.

Taint test results from 1969 and 1970 indicate that applications of up to 3.58 lb/ac aziprotryne + 0.25 lb/ac simazine do not give rise to taint in canned or frozen peas.

From these trials it is concluded that the addition of 0.13 lb/ac simazine to 1.79 lb/ac aziprotryne does not have any adverse effect on crop tolerance and improves the control of certain weed species which are less effectively controlled by aziprotryne alone.

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# THE PRE- AND POST-EMERGENCE USE OF 2-(4-CHLORO-6-ETHYLAMINO-S-TRIAZINE)-2-METHYL-PROPIONITRILE (WL 19805) IN PEAS

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**Summary** WL 19805*, 2-(4-chloro-6-ethylamino-S-triazine)-2-methyl-propionitrile, was extensively tested in pea crops in England, Ireland and Scotland over a period of two years. Field trials, under a wide range of soil and climatic conditions, showed that pre-emergence treatments of 1.5 - 2.0 lb/ac a.i. gave excellent control of annual weeds until harvest. Post-emergence applications of 1.5 lb/ac a.i. gave promising results in England and Ireland except under very dry conditions, when a few species tended to become resistant. Under Scottish conditions post-emergence treatments were variable and only an application of 2.0 lbs/ac a.i. gave results comparable to dinoseb amine at commercially recommended rates. Yields of vining and dried peas were not affected at high rates of application, except on light soils with low organic matter when heavy rain fell soon after treatment. No taints were detected in quick frozen or canning peas.

## INTRODUCTION

At the Ninth British Weed Control Conference in 1968, Chapman et al. introduced a group of triazine herbicides of which one, WL 19805, showed good selectivity in peas. In 1969, trials were carried out in the U.K., Ireland, Spain, Holland, France and Germany. In 1970, further experiments were carried out in Europe and the U.K. with special emphasis on obtaining yield data from pre and post-emergence treatments in vining peas, and tests for taint in quick frozen and canning peas.

## METHODS AND MATERIALS

In 1969, 13 pre-emergence and 2 post-emergence trials were carried out on dried and vining peas and 5 were harvested. Sixteen experiments were laid down in 1970 of which 13 on vining peas and 2 on dried peas were harvested. Pre and post-emergence treatments were applied also on fifty log. plots.

*Also known in the U.K. as DW 3418, in the U.S.A. as SD 15418, and in Europe and America as Bladex.
+Now with I.C.A.M.

The sites covered a wide range of environmental conditions, being located as far apart as Carlow, Kent and Perthshire with most of the trials in East Anglia. Soil types varied in organic matter from 1% to 15%, and in clay from 5% to 40%. Weather conditions between the two years were markedly different, 1969 being wet and cold generally, whilst in 1970 a cold wet spring was followed by a prolonged dry period. Rainfall was recorded for 7 days before and after each application and mechanical analyses of the soils were carried out.

The experimental design was randomized blocks with 4 replicates. WL 19805 was applied pre-emergence at doses of 1.0 to 4.0 lb/ac a.i. and post-emergence from 0.75 to 2.0 lb/ac a.i. Treatments were applied to plots 2 yds x 10 yds in a volume of 25 gal/ac at 30 p.s.i. pressure using an Oxford Precision sprayer with Allman jets. Log. plots were sprayed within the dose range 0.14 to 6.0 lb/ac a.i. Pre-emergence treatments were sprayed at varying times from immediately after drilling until just prior to emergence; post-emergence treatments were applied to the peas between the early seedling stage and the commencement of flowering.

Two different formulations of WL 19805 were tested, a 50% w.p. and a suspension concentrate containing 5.4 lb/gal.

In most trials commercially recommended rates of prometryne (pre-emergence) and dinoseb amine (post-emergence) were applied as standard comparative treatments.

In 1969, yields of vining peas were determined by the total weight of haulm and pods, and of dried peas by threshing in a combine harvester. In the 1970 series, the crop was either hand-pulled or cut with tractor mounted mower at optimum tenderometer readings for quick freezing or canning and transported in bags to miniature viners.

Weed control inspections were carried out about 4 weeks after spraying to assess initial results and again before harvest to ascertain the persistence of the herbicides. Visual assessments were made for percentage overall weed cover and for the predominant individual species on the European Weed Research Council (EWRC) scale. Crop phytotoxicity was also recorded on the EWRC scale.

## RESULTS

### i) Weed Control

The susceptibility of different weed species to varying doses of WL 19805 is given in Table 1 on the EWRC scale; a score of 5.0 or less indicates satisfactory control. Pre-emergence applications of WL 19805 at 1.5 lb/ac a.i. gave a mean score for overall weed control of 3.6 at the final assessment 6-8 weeks after treatment. This is equivalent to a 93% reduction in weed cover and was superior to prometryne which scored 5.0 (85% weed reduction). All annual weeds were satisfactorily controlled with the possible exception of Galium aparine on which the data is limited to 2 trials. Rainfall within a few days of spraying improved weed control, particularly of Polygonum aviculare. Perennial weeds were checked but not killed. The Scottish results (Table 2) were generally not quite as good as those in England and Ireland; the reason for this may be the relatively high organic matter of Scottish soils, none of which was below 3%, coupled with lower soil and air temperatures leading to lower transpiration rates and hence to less uptake of soil acting herbicides. On heavy soils in both England and Scotland, WL 19805 2.0 lb/ac a.i. was required to give effective weed control.

Table 1

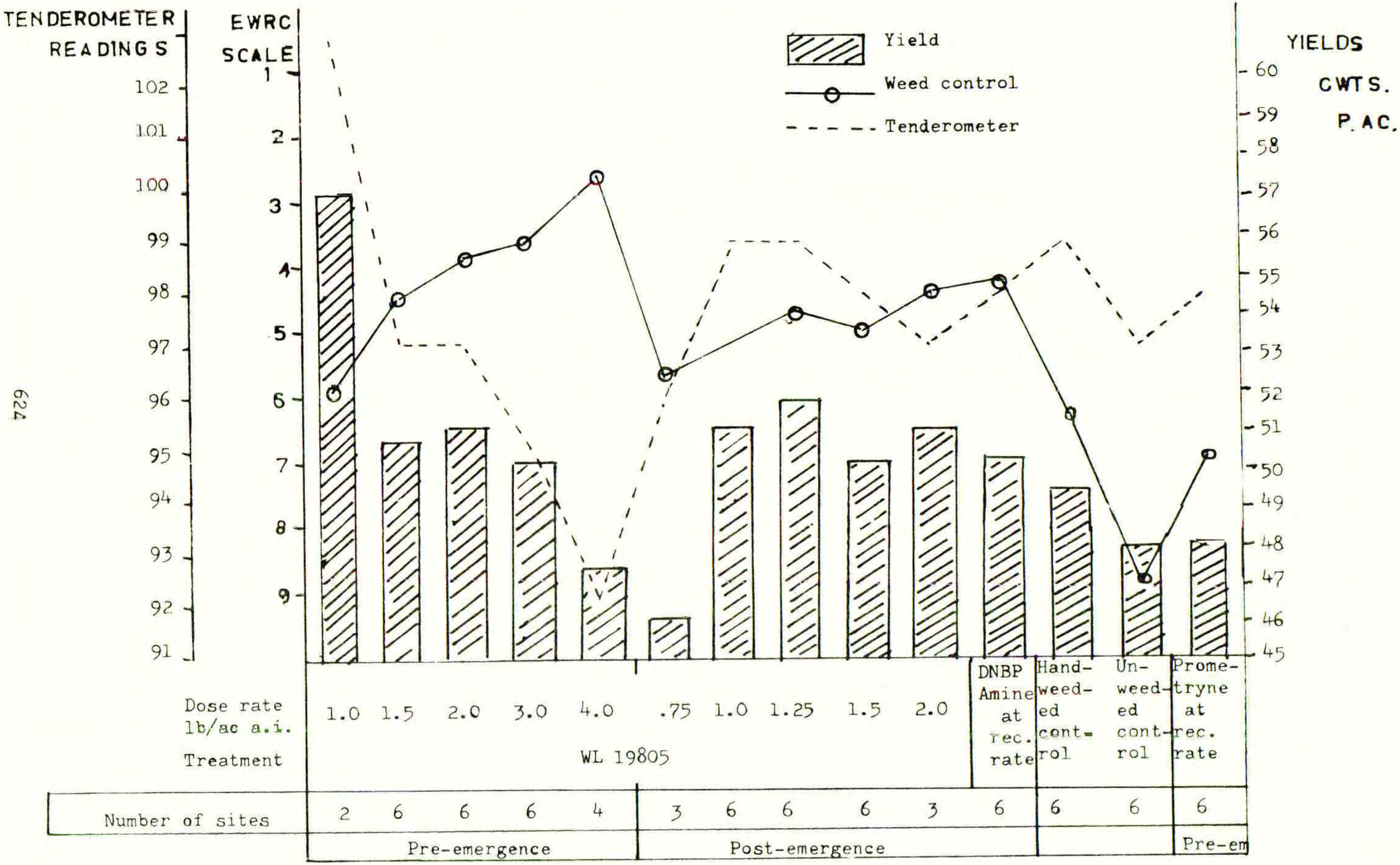
Mean weed control scores

EWRC Scale 1.0 = complete control 9.0 = no control ( ) number of trials assessed

| Weed Species | Pre-emergence Dose WL 19805 lbs/ac a.i. 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | Prome-tryne | Post-emergence Dose WL 19805 lbs/ac a.i. 0.75 | 1.0 | 1.25 | 1.5 | 2.0 | Dinoseb amine |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Agrostis* spp. | 7.1(2) | 5.9(4) | 5.3(4) | 5.3(4) | 4.6(2) | 5.4(2) | | 7.0(2) | | 6.7(4) | 7.0(1) | 6.6(2) |
| *Anagalis arvensis* | | 1.2(4) | 1.2(4) | 1.0(4) | 1.0(4) | 2.3(4) | | 2.2(4) | 2.3(4) | 2.0(4) | 2.7(2) | 1.9(4) |
| *Atriplex* spp. | | 2.1(6) | 2.5(6) | 2.3(6) | 1.7(6) | 2.8(6) | 6.6(2) | 4.0(6) | 3.5(6) | 4.2(6) | 3.0(4) | 3.0(6) |
| *Chenopodium* spp. | 3.3(7) | 2.9(17) | 2.3(15) | 2.0(17) | 1.9(8) | 2.2(11) | 4.8(5) | 4.8(11) | 5.2(10) | 4.1(15 | 4.4(6) | 2.8(10) |
| *Cirsium arvensis* | | 5.3(3) | 5.0(2) | 3.6(3) | 2.1(2) | 3.9(3) | 7.0(1) | | 4.5(2) | 5.0(2) | | 5.0(2) |
| *Fumaria officinalis* | | 5.0(4) | 3.9(4) | 3.9(4) | | 4.0(4) | | 3.8(5) | 3.6(5) | 3.9(6) | 3.9(4) | 2.2(5) |
| *Galium aparine* | | 7.0(2) | 5.0(1) | 6.0(1) | 3.0(1) | 7.0(2) | | 5.0(1) | | 4.3(1) | 1.8(1) | 3.0(1) |
| *Matricaria, Anthemis* and *Tripleurospermum* spp. | 1.2(2) | 1.1(8) | 1.0(8) | 1.0(9) | 1.0(6) | 2.8(8) | 3.5(2) | 2.9(9) | 3.0(9) | 3.0(9) | 2.4(6) | 2.8(7) |
| *Papaver Rhoeas* | | 1.3(4) | 1.1(4) | 1.1(4) | 1.0(4) | 1.6(4) | | | | | | |
| *Poa annua* | 2.8(4) | 1.4(7) | 1.3(7) | 1.1(7) | 1.0(3) | 1.7(3) | 5.7(2) | 3.3(3) | | 3.2(7) | | 6.0(3) |
| *Polygonum aviculare* | 5.1(5) | 4.2(15) | 3.2(14) | 2.8(16) | 2.3(9) | 5.3(11) | 6.5(3) | 6.4(12) | 6.6(10) | 5.2(14) | 5.2(9) | 5.6(10) |
| *Polygonum convolvulus* | | 3.9(8) | 2.8(8) | 2.4(9) | 2.6(8) | 4.7(7) | 1.9(2) | 2.3(9) | 2.1(8) | 2.6(9) | 2.0(7) | 2.4(8) |
| *Polygonum persicaria* | 2.9(6) | 2.7(10) | 1.6(8) | 1.3(9) | 1.2(2) | 4.6(4) | 2.5(2) | 2.3(5) | 3.1(3) | 1.8(9) | 1.1(3) | 2.0(3) |
| *Senecio vulgaris* | | 2.4(4) | 1.2(4) | 1.0(4) | 1.0(4) | 1.0(2) | | | 3.9(2) | 2.2(4) | 2.4(2) | 3.0(20) |
| *Sinapis arvensis* | | 1.1(6) | 1.1(5) | 1.4(6) | 2.1(4) | 5.0(2) | 2.0(3) | 1.7(6) | 2.0(5) | 1.8(5) | 1.3(3) | 2.0(5) |
| *Stellaria media* | 3.2(6) | 1.9(16) | 1.8(16) | 1.7(17) | 1.5(10) | 3.2(11) | 2.9(3) | 2.6(12) | 2.4(10) | 2.3(16) | 2.5(9) | 3.6(10) |
| *Urtica urens* | | 3.8(5) | 1.2(4) | 2.6(5) | 1.6(4) | 3.9(5) | 5.3(1) | 2.0(4) | 2.7(4) | 2.6(4) | 1.0(3) | 4.9(4) |
| *Veronica hederifolia* | 2.0(1) | 1.9(9) | 1.7(9) | 1.5(9) | 1.4(8) | 3.0(8) | | | | | | |
| Overall weed control | 4.7(11) | 3.6(26) | 2.7(25) | 2.4(27) | 2.1(15) | 5.0(21) | 5.7(5) | 5.1(16) | 5.1(14) | 4.6(21) | 4.6(11) | 4.8(15) |

Table 2

Scottish Results - Pea yields in relation to weed control and tenderometer readings



Post-emergence treatments gave slightly inferior results to pre-emergence, although WL 19805 at 1.5 lb/ac a.i. achieved marginally better overall weed control in England and Ireland than dinoseb amine. In Scotland, the majority of the post-emergence treatments were applied during periods of low rainfall and WL 19805 at doses of less than 2 lbs/ac a.i. did not give as good weed control as dinsoseb amine. Unless there was adequate rainfall soon after spraying, Polygonum aviculare, Chenopodium and Atriplex spp. were not satisfactorily controlled. In all experiments carried out under dry conditions, herbicidal activity was slow and the majority of weeds did not die until about 3 weeks after treatment. Early application to weeds up to 2 inches in height achieved better control than later applications, especially in the case of Polygonum aviculare which became resistant in the young plant stage. Perennial weeds were checked, many species severely.

Soil type had some effect on the degree of weed control, while 1.5 lb/ac a.i. was adequate on most sites 2.0 lb/ac a.i. was needed on the heavier soils for satisfactory results. Limited data on light sands suggests that a pre-emergence rate of 1.0 lb/ac a.i. will give effective control.

In the log. trials, WL 19805 w.p. formulation gave marginally better weed control than the suspension concentrate.

ii) Crop selectivity

All varieties of peas exhibited good tolerance to pre-emergence treatments of WL 19805 at a dose of 1.5 lb/ac a.i. When heavy rain fell soon after application, slight temporary symptoms of chlorosis of the lower leaves occurred at some sites, particularly on light soils. This did not affect the subsequent growth of the crop except in one trial carried out in 1969 on a medium silt which was waterlogged for about 2 weeks following spraying; prometryne caused similar symptoms on this site.

Post-emergence treatments gave slightly more initial crop effect than pre-emergence, especially on light sands and when heavy rain fell soon after application. Symptoms, mostly in the form of leaf margin chlorosis, were only temporary however, with the exception of one trial in Ireland on a soil containing 49% sand, and then the crop made a complete recovery 2-3 weeks later. Dinoseb amine caused slightly greater temporary symptoms than WL 19805 at 1.5 lb/ac a.i.

Table 3 shows that at the rates required for acceptable weed control (i.e. 1.5 lb/ac a.i. either pre or post-emergence), WL 19805 caused less temporary symptoms than prometryne or dinoseb amine. There were no differences in crop selectivity between the w.p. and suspension concentrate formulations.

iii) Crop yields

Table 4 gives the yields expressed as a percentage of the control. Trials Nos. 1-6 were carried out in England in 1969 and the remainder in England and Scotland in 1970. Yields in Trials Nos. 1 and 2 are expressed in terms of total weight of crop. Trials Nos. 3 and 4 as the weight of shelled green peas. Trials Nos. 5, 7 and 8 as dried peas and Trial No. 6 as the weight of peas in the pod. In the remaining trials, yields are expressed in terms of the weight of vined peas. The control plots were hand weeded where necessary.

Table 3

Temporary crop symptoms

EWRC scale 1.0 = no damage 9.0 = complete crop kill

| Treatments per ac. | Time of application | Number of Trials | Mean score (EWRC scale) |
|---|---|---|---|
| WL 19805 1.0 lb | pre-emergence | 5 | 1.1 |
| " 1.5 lb | " | 25 | 1.1 |
| " 2.0 lb | " | 26 | 1.5 |
| " 3.0 lb | " | 27 | 1.8 |
| " 4.0 lb | " | 19 | 2.6 |
| Prometryne | " | 23 | 1.5 |
| WL 19805 1.0 lb | post-emergence | 16 | 2.0 |
| " 1.25 lb | " | 13 | 1.9 |
| " 1.5 lb | " | 16 | 2.1 |
| " 2.0 lb | " | 11 | 3.4 |
| Dinoseb amine | " | 14 | 2.2 |

Pre-emergence treatments of WL 19805 gave statistically significant increases over the controls in 4 trials (Nos. 7, 11, 18 and 21). There were no significant reductions in yield, except at two sites on sandy soils with low organic matter where heavy rain fell soon after application. In Trial No. 10 there was a 22% reduction from a pre-emergence dose of 3 lb/ac a.i. as a result of 0.4 inches of rain during the week following treatment on a soil containing 1.06% organic matter and 69% sand; however, a lower dose of 1.5 lb/ac a.i. gave an increase in yield of 7%. In Trial No. 19 on a soil containing 3.5% organic matter and 51% sand there was a significant yield reduction at the 4 lb/ac a.i. rate pre-emergence, but not at lower doses.

Post-emergence treatments of WL 19805 gave significant increases in yield over the controls in 4 trials (Nos. 10, 11, 18 and 21). There were no significant yield reductions except in Trial No. 12 on variety Gregory's Surprise where the treatments were applied very late when the peas were 10-12 inches high and starting to flower.

In the 1970 series, the mean yields of vined peas in 13 experiments expressed as a percent of the hand weeded controls together with mean tenderometer readings (T.R.) for quick frozen peas were as follows:

Table 4

Crop yields as percentages

| Treatment per ac a.i. (Trial No. / Variety) | 1 DSP | 2 DSP | 3 Jade | 4 DSP | 5 DSP | 6 Sprite | 7 Maro | 8 Maro | 9 Jade | 10 Scout | 11 Pugit | 12 Gregory | 13 Selway | 14 Sprite | 15 Jade | 16 Early Freezer | 17 Jade | 18 Jade | 19 Sprite | 20 Sprite | 21 DSP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Control % | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Control cwt/ac | * | * | * | * | * | * | 7.8 | 46.6 | 28.6 | 41.4 | 51.6 | 35.5 | 34.9 | 32.0 | 67.1 | 64.9 | 44.5 | 44.4 | 38.2 | 44.5 | 50.1 |
| **Pre-emergence** | | | | | | | | | | | | | | | | | | | | | |
| WL 19805 1.0 lbs | 106 | | | | | | | | | | | | | | | 104 | | | | 103.5 | |
| " 1.5 " | | | 120 | | 103 | 114 | 123 | 103 | 107 | 107 | 110 | 109 | 100 | 108 | 107 | 94 | 99 | 136 | 108 | 102.9 | 102 |
| " 2.0 " | 107 | 106 | | 105 | | 106 | 123 | 108 | | | | | | | | 92 | 97 | 134 | 106 | 106.4 | 110 |
| " 3.0 " | 106 | 97 | 130 | 101 | 99 | | 133 | 106 | 121 | 78 | 99 | 94 | 99 | 93 | 101 | 95 | 100 | 141 | 97 | 105.6 | 95 |
| " 4.0 " | | 82 | | 95 | | | 147 | 104 | | | | | | | | | 89 | 138 | 82 | | 114 |
| Prometryne | 100 | 100 | 105 | | 94 | | 104 | 99 | 125 | 115 | 97 | 96 | 105 | 109 | 92 | 88 | 93 | 118 | 109 | 97.7 | 104 |
| **Post-emergence** | | | | | | | | | | | | | | | | | | | | | |
| WL 19805 0.75 lbs | | | | | | | | | | 117 | 100 | | | | | | | 107 | 108 | 92.7 | |
| " 1.0 " | | | | | | | 118 | 105 | 117 | | | 84 | 98 | 92 | 81 | 96 | 95 | 127 | 114 | 100.7 | 112 |
| " 1.25 " | | | | | | | | | | | | | | | | 93 | 104 | 124 | 114 | 103.6 | 115 |
| " 1.5 " | | | | | | | 132 | 108 | | 113 | 108 | | | | | 94 | 94 | 127 | 110 | 104.6 | 103 |
| " 2.0 " | 105 | | | | | | 116 | 103 | 105 | | | | 91 | 103 | 95 | 90 | 97 | | | | 100 |
| Dinoseb amine | | | | 100 | | | | | 104 | 111 | 109 | 96 | 99 | 101 | 90 | 96 | 102 | 118 | 118 | 100.0 | 103 |
| Aziprotryne | | | | | | | 71 | 104 | | | | | | | | | | | | | |
| L.S.D. P = 0.05 | | | | | | | 36 | NS | 23 | 13 | 6 | 14 | NS | 13 | 15 | 12 | NS | 15 | 16 | NS | 11 |
| S.E. ± | | | | | | | 14 | 25 | 8 | 5 | 2 | 5 | 8 | 4 | 6 | 4 | 6 | 5 | 6 | 6 | 4 |

* Figures for whole crop, unthreshed weights and shelled sub samples omitted.

Table 5

Mean yields and tenderometer readings

| Treatments per ac a.i. | Time of application | No. of trials | Yields % | T.R. |
|---|---|---|---|---|
| Control | | 13 | 100 | 104 |
| WL 19805 1.5 lbs | pre-emergence | 12 | 104 | 104 |
| " 3.0 " | " | 13 | 100 | 104 |
| " 4.0 " | " | 5 | 99 | 96 |
| Prometryne | " | 13 | 102 | 104 |
| WL 19805 0.75 lbs | post-emergence | 6 | 98 | 97 |
| " 1.0 " | " | 11 | 99 | 107 |
| " 1.5 " | " | 8 | 104 | 97 |
| " 2.0 " | " | 8 | 99 | 104 |
| Dinoseb amine | " | 13 | 102 | 105 |

Yields were not affected by any of the treatments, nor were there any significant differences in maturity as measured by tenderometer readings, except in Trial No. 21 in which dinoseb amine treatment was significantly lower than the control. In Scotland, the range of tenderometer readings for all treatments was between 92 and 103, and good weed control was associated with low tenderometer readings in all trials.

iv) Taint analysis

Vined pea samples were tested for taint at The Fruit and Vegetable Preservation Research Association. In 1969 and 1970, no taints in quick frozen or canning peas were detected from WL 19805 at doses of 1.5 and 3.0 lb/ac a.i. pre-emergence or 1.0 and 2.0 lb/ac a.i. post-emergence.

DISCUSSION

The results of 31 trials carried out over a period of two years show that WL 19805 is a very effective herbicide in peas. Pre-emergence applications of 1.5 lb/ac a.i. on light and medium soils and 2.0 lb/ac a.i. on heavy soils gave commercially acceptable control of all common annual weeds until harvest. In a few trials, *Polygonum aviculare* was moderately resistant, but providing rain fell within one week of spraying, satisfactory control was achieved. In England and Ireland, post-emergence treatments at 1.5 lb/ac a.i. were slightly less effective than pre-emergence, particularly under dry conditions against *Polygonum aviculare*, *Chenopodium* and *Atriplex* spp. However, both pre and post-emergence treatments gave better overall weed control than the standard herbicides (prometryne and dinoseb amine) used in comparison. In Scotland WL 19805 pre-emergence gave considerably better overall weed control than recommended rates of prometryne, but none of the post-emergence treatments were as effective as dinoseb amine.

Some slight temporary chlorosis of the crop leaves was observed and this was more apparent following post-emergence treatments on light soils when heavy rain fell soon after application. However, the crop made a full recovery subsequently and yields were not affected, except at one site where the treatments were applied very late when the peas were flowering. At the rates required to give satisfactory weed control, both prometryne pre-emergence and dinoseb amine post-emergence had in fact a slightly greater crop effect than WL 19805.

All varieties exhibited good tolerance to WL 19805 and on medium and heavy soils yields were not affected by more than twice the pre-emergence rates of application required to give acceptable weed control. Post-emergence treatments also gave good results, although the margin of selectivity was not quite as great as for pre-emergence applications. The selective mechanism for post-emergence treatments is not yet fully understood but there is some evidence that it is correlated with the amount of wax on the peas, damage being greatest on Gregory's Surprise and on areas of any variety which suffered mechanical damage.

No taint differences in quick frozen or canning peas were detected, nor were any residues of WL 19805 or its metabolites found in the peas or haulm after application of twice normal doses.

WL 19805 can safely be recommended therefore for pre-emergence use at 1.5 lb/ac a.i. on medium soils and at 2.0 lb/ac a.i. on heavy soils but further work is required on light soils to confirm crop tolerance under conditions of heavy rainfall following application. Post-emergence treatments at 1.5 lb/ac a.i. gave slightly inferior results but tentative recommendations can be made for medium and heavy soils in England and Ireland where growers have been unable to apply pre-emergence treatments.

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# HERBICIDE EVALUATION IN PEAS 1969-70

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Summary The performance of six pre- and three post-emergence herbicides was assessed in eight trials carried out in vining peas. Pre-emergence applications of aziprotryne at 1.78 and 1.95 lb/ac were not as effective as prometryne, but the addition of simazine at 0.13 lb/ac to aziprotryne improved weed control considerably. A chlorpropham, monolinuron, fenuron mixture gave effective weed control and resulted in satisfactory yields of peas. Two instances of irregular crop emergence caused by the material indicated that care is required concerning dose rates on free-draining soils. DW 3418 appears to be a promising pre-emergence material on the basis of this work, but terbacil proved too damaging to the crop under certain conditions. The addition of 0.13 lb/ac of simazine to aziprotryne improved the effectiveness of post-emergence applications, but it did not allow applications to be made later than the two leaf stage of weed growth without reliability being adversely affected.

## INTRODUCTION

The constant danger of crop rejection caused by contamination of vined green peas with weed fragments necessitates efficient weed control, and for many years the P.G.R.O. has undertaken herbicide evaluation in this crop. The development of the dinitro-phenols was a tremendous step forward and the introduction of prometryne as a pre-emergence herbicide (King 1966) has also proved of considerable benefit to the industry. The problems of dependence upon suitable weather conditions for satisfactory control, high mammalian toxicity and the need for high volume application make the replacement of the dinitro-phenols desirable. Prometryne has the drawbacks of poor control of Sinapis arvensis and other Brassica weeds and the need for adequate soil moisture after the application. Eight trials were carried out in 1969 and 1970 comparing the more promising pre- and post-emergence materials selected from preliminary logarithmic trials, to dinoseb-amine and prometryne.

Work carried out in 1968 with aziprotryne indicated that selectivity in peas was good, but high rates appeared to be required for satisfactory weed control. In these trials aziprotryne was tested both pre- and post-emergence and the addition of a small quantity of simazine was evaluated in an attempt to improve the weed control particularly of those species which were sometimes resistant to aziprotryne.

## METHOD AND MATERIALS

Randomised block design with three or four-fold replication was used, plots being 0.0025 acre in area. Applications were made with a modified Oxford Precision Sprayer at a volume of 50 gal/ac. Dose rates are given in active ingredient. In 1969 assessments for effects on the crop, overall weed control and control of individual species were carried out, while in 1970 additional weed counts were undertaken. The trials were carried out in vining peas sited on the Thornhaugh trial ground and in commercial crops. The peas were cut by hand and threshed with a plot viner. Yields of shelled peas were recorded and the maturity measured by means of the tenderometer. Soil samples were mechanically analysed and the details are shown below:-

| | Site | Location | Silt % | Clay % | Organic matter % | Classification |
|---|---|---|---|---|---|---|
| 1969 | A | Thornhaugh | 5 | 12 | 2.9 | F.S.L. |
| | B | Grantham | 13 | 15 | 3.1 | F.S.L. |
| | C | Hubberts Bridge | 17 | 23 | 3.0 | Zy L. |
| | D | Turves | 18 | 20 | 8.4 | Org F.S.L. |
| | E | Thornhaugh | 5 | 12 | 2.9 | F.S.L. |
| 1970 | F | Thornhaugh | 14 | 20 | 2.3 | F.S.L. |
| | G | Hubberts Bridge | 12 | 10 | 2.6 | L.V.F.S. |
| | H | Lobthorpe | 14 | 16 | 4.9 | ZyL. |

The stages of crop and weed development at the time of pre- and post-emergence applications are shown below:-

| | Pre-emergence (Weeks after drilling approx.) | Post-emergence (Number of true leaves) Crop | Post-emergence (Number of true leaves) Weeds |
|---|---|---|---|
| Site A | 2 | 3 | 1-3 |
| B | 1 | 3 | 1-2 |
| C | 2 | 4 | 2-4 |
| D | 1 | 3 | 1-3 |
| E | 3 days | ≠ | ≠ |
| F | 3 | 1 | 1* |
| G | 2 | 3 | 1-2 |
| H | 1 | 3 | 1-2 |

* Dinoseb-amine applied when weeds were at 2-4 leaf stage.

≠ Very early post-emergence weeds cotyledon -1 leaf stage, crop 2 leaves.

Early post-emergence weeds 1-2 leaf stage, crop 3 leaves.

Late post-emergence weeds 4-6 leaf stage, crop 4 leaves.

Some weed emergence had taken place at all sites except site A. At sites B, C and H the seed was sown very shallowly.

## RESULTS

### 1969 trials

The pre-emergence applications of terbacil caused severe crop damage at site B which was shallowly drilled and where heavy rain fell soon after application. Less severe effects also resulted from the high doses at sites A and C.

Other effects on development noted were irregular emergence and delayed development of a proportion of the crop caused by the three rates of the chlorpropham, monolinuron, fenuron mixture, and moderately severe chlorosis of the lower leaves by the high rate of prometryne at site E. The high rate of aziprotryne, with an without the addition of simazine, affected the crop at all sites causing slight stunting. The other aziprotryne treatments also caused slight effects on crop growth at site B, while dinoseb-amine caused moderately severe scorch. All visible effects on the crop were outgrown by harvest except the terbacil damage at site B, where the crop was completely destroyed. The assessments for overall weed control appear in Table 1 and 2. Assessments for the control of fourteen weed species were made, but are not presented.

Table 1

Weed control and yield data

| Material | lb/ac | Application | Weed control ø Site A | B | C | D | Yield as % of untreated Site A | B | C | D |
|---|---|---|---|---|---|---|---|---|---|---|
| Aziprotryne | 1.78 | Pre | 6 | 7 | 8 | 7 | 103 | 95 | 95 | 111 |
| Aziprotryne | 1.78 | Post | 7 | 5 | 8 | 4 | 98 | 105 | 107 | 114 |
| Aziprotryne | 3.60 | Post | 9 | 9 | 10 | 7 | 100 | 96 | 88 | 119 |
| Aziprotryne plus Simazine | 1.78+0.13 | Pre | 7 | 7 | 9 | 7 | 105 | 87* | 84 | 111 |
| Aziprotryne plus Simazine | 1.78+0.13 | Post | 8 | 8 | 9 | 6 | 99 | 92 | 97 | 124 |
| Aziprotryne plus Simazine | 3.60+0.25 | Post | 9 | 9 | 10 | 7 | 80 | 92 | 82 | 114 |
| Terbacil | ∤ | Pre | 7 | 9 | 9 | 8 | 102 | 0* | 112 | 115 |
| Terbacil | ∤ | Pre | 9 | 9 | 10 | 9 | 96 | 0* | 76* | 122 |
| Prometryne | ∤ | Pre | 8 | 8 | 9 | 8 | 104 | 106 | 86 | 113 |
| Dinoseb-amine | 1.85 | Post | 5 | 10 | 9 | 9 | 107 | 93 | 112 | 114 |
| Untreated | | | | | | | (60.5) | (44.6) | (38.6) | (42.4) |
| Significance @ P = 0.05 | | | | | | | N.S. | YES | YES | N.S. |
| S.E. as % of gen. mean | | | | | | | 10.4 | 6.7 | 11.5 | 14.9 |

ø Weed score:- 10 = complete control, 0 = No control
∤ Terbacil dose rates:- 0.13 & 0.25 at site A, 0.25 & 0.50 at sites B & D and 0.19 & 0.38 at site C. Prometryne dose rates were 1.5 at sites B, C & D and 1.25 at site A.
() Figures in brackets cwt/ac

The pre-emergence application of aziprotryne was less effective than prometryne at all sites and while the addition of simazine slightly improved the weed control the mixture still did not give comparable control to prometryne. The post-emergence application at 1.78 lb/ac was less effective than the pre-emergence application at two of the sites and better at site A, where greater control of Polygonum convolvulus, Stellariamedia and Fumaria officinalis was achieved. Aziprotryne gave better control of Polygonum aviculare at all four sites when used pre-emergence rather than post-emergence although control was not as good as that from prometryne. The addition of simazine to the post-emergence treatment again improved weed control and this was noticeable in respect of Polygonum aviculare, Polygonum convolvulus and Galium aparine. The mixture of aziprotryne at 1.78 lb/ac and simazine at 0.13 lb/ac post-emergence compared favourably with pre-emergence prometryne, but dinoseb-amine post-emergence was superior at three of the sites. The pre-emergence terbacil applications gave good weed control at all sites, even at the low dose rates and these treatments gave better control of Galium aparine and Aethusa cynapium than prometryne.

The importance of weed stage in relation to the control from post-emergence applications of aziprotryne can be seen from Table 2 where applications made to weeds up to the time they had no more than three true leaves gave excellent control, but the late application, made at the normal stage of weed growth for dinoseb-amine, gave very poor control. The pre-emergence applications of the chlorpropham, monolinuron, fenuron mixture gave acceptable weed control, there being no noticeable difference between the lowest and highest rates.

Each dose rate of terbacil significantly reduced yield compared to the untreated control at site B and the high rate significantly reduced yield at site C. The pre-emergence application of aziprotryne at 1.78 lb/ac plus simazine at 0.13 lb/ac also significantly reduced yield at site B and the yield was also rather low at site C. The shallow drilling at sites B and C probably accounted for the effect on yields at these sites.

Table 2

Weed control assessments and yield data at site E

| Material | lb/ac | Application | Weed control ø | Yield as % of untreated | Maturity (T.R.)⊕ |
|---|---|---|---|---|---|
| Aziprotryne | 1.78 | Very early post | 9 | 87 | 147 |
| Aziprotryne | 1.78 | Early post | 9 | 86 | 142 |
| Aziprotryne | 1.78 | Late post | 5 | 95 | 142 |
| Dinoseb-amine | 1.85 | Late post | 9 | 96 | 150 |
| Chlorpropham plus monolinuron plus fenuron | 1.0+ 0.13+0.13 | Pre | 8 | 97 | 144 |
| Chlorpropham plus monolinuron plus fenuron | 1.5+ 0.2+0.2 | Pre | 8 | 89 | 147 |
| Chlorpropham plus monolinuron plus fenuron | 2.0+ 0.25+0.25 | Pre | 8 | 84 | 144 |
| Prometryne | 1.25 | Pre | 8 | 93 | 143 |
| Prometryne | 2.50 | Pre | 8 | 85 | 135 |
| Untreated | | | | 100 (40.4) | 160 |
| Significance @ P = 0.05 | | | | N.S. | N.S. |
| S.E. as % of gen. mean | | | | 9.7 | 11.1 |

ø Weed score: 10 = complete control, 0 = no control
⊕ T.R. = Tenderometer reading. () Figure in brackets cwt/ac.

The aziprotryne at 1.78 lb/ac plus simazine at 0.13 lb/ac post-emergence treatment generally gave acceptable yields, but the double rate of this treatment resulted in low yields at site A and C although these were not significantly lower than the untreated. There were no significant effects on maturity, as measured by the tenderometer, from any treatment at the four sites.

At site E (Table 2) all the yields from the treatments were lower than the untreated although this was not statistically significant and could possibly be a maturity effect since the untreated had the highest tenderometer reading. The two earliest post-emergence applications of aziprotryne gave rather low yields compared to the dinoseb-amine yield and there was a suggestion that the two highest rates of the chlorpropham, monolinuron, fenuron mixture were reducing yield. The high rate of prometryne also gave a low yield, but in this case the tenderometer reading was also rather low.

1970 trials

The most noticeable effects on crop development were recorded at site G where the double rate of aziprotryne plus simazine, applied post-emergence, caused stunting and necrosis of the lower leaves. The post-emergence applications of aziprotryne at 1.78 lb/ac plus simazine at 0.125 lb/ac and aziprotryne at 1.95 lb/ac also caused slight stunting, but all these effects had been outgrown by harvest. At site H the post-emergence applications of aziprotryne plus simazine at both dose rates caused a temporary paling in the colour of the crop with some stunting. Very slight chlorosis was noted on the pre-emergence prometryne treated plots at site F, while a slightly uneven emergence and early development occurred on plots treated with the high rate of the chlorpropham, monolinuron, fenuron mixture. These effects were quickly outgrown. The results of overall weed control and yield data are shown in Table 3.

At site F all the pre- and post-emergence treatments gave acceptable overall weed control although dinoseb-amine failed to control Polygonum aviculare and Poa annua satisfactorily.

The pre-emergence applications of the chlorpropham, monolinuron, fenuron mixture and prometryne did not give very satisfactory control of Aethusa cynapium which also tolerated the post-emergence application of aziprotryne at 1.95 lb/ac. At site G the pre-emergence treatments gave good weed control with the exception of aziprotryne at 1.95 lb/ac which did not control Urtica urens, Poa annua and Veronica spp. The post-emergence applications of aziprotryne at 1.95 lb/ac and the low rate of the aziprotryne plus simazine mixture were not very satisfactory against Polygonum aviculare, Poa annua and Veronica spp, while dinoseb-amine gave poor control of these weeds and also Urtica urens. Conditions were very dry when the pre-emergence treatments were applied at site H and the resulting weed control was disappointing. Under these conditions 2-(4-chloro-6-ethylamino-S-triazine-2-ylamino)-2-methyl-propionitrile (DW 3418) and the mixture of chlorpropham, monolinuron and fenuron performed slightly better than prometryne; aziprotryne at 1.95 lb/ac gave very poor control, but with simazine gave improved control. The post-emergence aziprotryne treatments did not compare favourably with dinoseb-amine particularly with respect to the control of polygonous weeds.

There were no significant differences between the yields obtained from the various treatments at any site and the slight differences in maturity recorded (as measured by the tenderometer) also failed to reach statistical significance.

Table 3

Weed control and yield data

| Material | lb/ac | Application | % weed control ø Site F | G | H | Yield as % of untreated Site F | G | H |
|---|---|---|---|---|---|---|---|---|
| DW 3418 ⊕ | 1.0 | Pre | 92 | 98 | 50 | 90 | 98 | 102 |
| DW 3418 ⊕ | 2.0 | Pre | 99 | 98 | 37 | 97 | 88 | 127 |
| Chlorpropham plus monolinuron plus fenuron | 1.0+ 0.13+ 0.13 | Pre | 90 | 91 | 75 | 104 | 99 | 89 |
| Chlorpropham plus monolinuron plus fenuron | 2.0+ 0.25+ 0.25 | Pre | 91 | 95 | 50 | 91 | 89 | 106 |
| Aziprotryne | 1.95 | Pre | 99 | 72 | 12 | 102 | 99 | 118 |
| Aziprotryne plus simazine | 1.78+ 0.13 | Pre | 99 | 96 | 37 | 102 | 105 | 110 |
| Aziprotryne | 1.95 | Post | 96 | 70 | 62 | 95 | 95 | 77 |
| Aziprotryne plus simazine | 1.78+ 0.13 | Post | 98 | 73 | 75 | 109 | 97 | 117 |
| Aziprotryne plus simazine | 3.6+ 0.25 | Post | 100 | 96 | 87 | 111 | 97 | 111 |
| Prometryne | 1.25 | Pre | 95 | 97 | 25 | 125 | 91 | 106 |
| Dinoseb-amine | 1.85 | Post | 78 | 46 | 100 | 95 | 107 | 134 |
| Untreated | | | | | | 100 (21.0) | 100 (39.0) | 100 (22.6) |
| Significance @ P = 0.05 | | | | | | N.S. | N.S. | N.S. |
| S.E. as % of gen. mean | | | | | | 14.0 | 11.5 | 23.3 |

ø determined by three, 3 sq ft weed counts per plot.
⊕ 2-(4-chloro-6-ethylamino-s-triazine-2-ylamino)-2-methyl-propionitrile.
() Figures in brackets cwt/ac.

## DISCUSSION

The results of the trials reported in this paper, together with unpublished data, suggest that aziprotryne is a safe herbicide for pre- or post-emergence use in peas. At rates up to 1.95 lb/ac pre-emergence applications were generally slightly less effective against weeds than commercial rates of prometryne, but crop safety on free-draining sandy soils may be better. Post-emergence applications only seem to compare favourably to dinoseb-amine if they are applied at a very early stage of weed development and for consistent results the weeds should have fewer than two true leaves. The work carried out indicates that it is safe to apply aziprotryne to peas at any growth stage from shortly after emergence to shortly before flowering. The addition to aziprotryne of simazine at 0.13 lb/ac improved the weed control from both pre- and post-emergence applications and in 1970 aziprotryne at 1.78 lb/ac plus simazine at 0.13 lb/ac performed better than aziprotryne at 1.95 lb/ac. Improved control of the more difficult weeds such as Polygonum aviculare was achieved, but the addition of simazine did not appear to improve general control sufficiently to give comparable results post-emergence to dinoseb amine unless it was applied at an early stage of weed growth.

Pre-emergence results from the mixture did, however, compare favourably with prometryne in 1970. Post-emergence applications of aziprotryne do not appear to require such high temperatures or dry conditions as dinoseb-amine to be effective.

Terbacil does not seem to possess sufficient selectivity for general use in peas. The crop damage which resulted where the crop was shallowly sown suggests that there is little inherent selectivity once depth protection is removed.

The pre-emergence mixture of chlorpropham, monolinuron and fenuron gave effective weed control in these trials and satisfactory yields. At site E in 1969 and at site F in 1970 crop emergence was rather irregular and a proportion of plants were retarded for some time. This indicates the danger which exists when using chlorpropham in peas and under certain conditions effects on emergence may result. These appear to be more likely to occur on free-draining soils, but under heavy rainfall conditions this effect could occur on heavier soils. At normal application rates yield reductions due to this effect have not been recorded.

The pre-emergence applications of DW 3418 performed well in the 1970 trials and unpublished data has shown good crop tolerance and weed control to early post-emergence applications. Used pre-emergence it controlled Aethusa cynapium which is tolerant to prometryne, but in some cases was slightly less effective against Polygonum aviculare.

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