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# WEED CONTROL IN MUSTARD

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Summary It is customary to establish both white and brown varieties of mustard as row crops, and the steerage hoe is usually all that is needed to control weeds in the crop. But the crop is fairly tolerant to a number of herbicides which can be used in special circumstances. For wild oat control benzoylprop-ethyl (1.1 l/ha) or barban (0.3 l/ha) may be applied during the growing season. Trifluralin (1.1 kg/ha) should be incorporated prior to sowing, and the following residual pre-emergence herbicides merit further study: propachlor (4.3 kg/ha), nitrofen (3.4 kg/ha), aziprotryne (3.3 kg/ha), alachlor (2.0 l/ha).

Résumé C'est la coutume d'établir la blanche aussi que la brune variéte de moutarde comme culture en rangées, et ordinairement on n'a que besoin de la bineuse pour régler les mauvaises herbes dans la culture. Mais la culture est assez tolérante de plusieurs herbicides qui peuvent être utilisés en des circonstances spéciales. Pour la réglement de la folle avoine, benzoylprop-ethyl (1.1 l/ha) ou barban (0.3 l/ha) peut être appliqué a la culture pendant la croissance. Trifluralin (1.1 kg/ha) peut être incorpore avant de semer, et les suivants méritent plus de recherche comme des herbicides residuelles de pré-émergence: propachlor (4.3 kg/ha), nitrofen (3.4 kg/ha), aziprotryne(3.3. kg/ha), alachlor(2.0 l/ha).

## INTRODUCTION

Mustard is sown in the eastern counties of England in March or April and harvested by combine harvester in late September; two species are grown, brown mustard (Brassica juncea) and white mustard (Sinapis alba).

The usual recommendation is to grow mustard as a row crop which can be steerage-hoed; in most situations this is an adequate method of weed control, for the vigour of a well-established crop of mustard smothers most weed competition. However, on land which is heavily infested with wild oats, some of these plants will survive to produce seed, and the commonly recommended chemicals have been tested in both brown and white mustard. Also a range of residual herbicides were tested in 1975 to find those suitable for general weed control in the crop.

## METHODS & MATERIALS

An 8 ft. plot sprayer, to cover 0.05 ha at one filling (at 1.100 l/ha) and mounted on a two-wheel tractor, was used to apply the herbicides, individual plot size being 10m. in length and spanning 5-6 rows (one drill-width) of crop. During the season any treatment effects on crop growth were noted, and the 4 inner rows were harvested by Claas Columbus combine to give yield and quality data.

Wild Oat Control For this the following chemicals have been tested:

1969

Barban @ 0.4 & 0.8 l/ha (brown mustard only)

1973

Barban @ 0.3 & 0.6 l/ha
Chlorfenprop-methyl @ 4.8 & 9.6 l/ha
Benzoylprop-ethyl @ 1.1 & 2.2 lb/ha
(on both white and brown mustard)

Data from these trials are summarised in Table 1.

Residual herbicides Two experiments were conducted in 1975:

1. Soil-incorporated treatments:

Trifluralin
Dinitramine
Carbetamide

2. Treatments applied pre- and post-crop emergence:

| | |
|---|---|
| Propachlor | Nitrofen |
| Benazolin | Oryzalin |
| Aziprotryne | Alachlor |

Results for these trials are shown in Tables 2 and 3.

## DISCUSSION

The three herbicides tested for wild oat control at the lower rate did not cause a severe loss of yield of mustard (see Table 1); chlorfenprop-methyl, however, did cause severe stunting of both varieties, and although they survived to give a reasonable yield, this treatment is not recommended. The seed yields for brown mustard, higher at the higher dosage rates, were strongly affected by bird and wind damage before harvest; it is possible that the stunting mentioned above resulted in a lower susceptibility, to seed loss through wind damage, but this was not visually notable in the field. Diallate was not tested on account of the difficulty of incorporation in a small trial, but in practice it is used by several mustard growers without apparent loss of yield (Regnault 1974).

Of the three incorporated residual herbicides (see Table 2) trifluralin appears to do minimal damage to either white or brown mustard; carbetamide caused unacceptable damage to the crop, and dinitramine was intermediate. Trifluralin was as effective a herbicide as the other two.

Both varieties of mustard proved more tolerant of pre-emergence treatment with the other chemicals (Table 3) than when they were applied post-emergence. Propachlor and nitrofen have become widely used in brassica crops, and used before crop emergence both appear to cause minimal check to either variety; but nitrofen applied after emergence caused considerable leaf yellowing in both varieties.

Benazolin was tested on the evidence of Canadian reports (Salam & Downey 1973) that it was selective in white mustard against wild mustard (Sinapis arvensis); in this trial brown mustard reacted quite severely, especially pre-emergence, by swelling and arching of the petioles, and seed yield was adversely affected. On its own this chemical did not appear to be a very effective herbicide at the rate applied; oryzalin also was rather ineffective.

Aziprotryne caused severe stunting in both varieties, but white mustard recovered well and yield was not affected. Alachlor, too, caused considerable damage originally, but both varieties survived to give reasonable yields. Both of these herbicides proved at least as effective as steerage hoeing in a dry season when most chemicals gave disappointingly poor weed control.

The cost of using a steerage hoe in the crop is still rather less than that of chemicals, and experiments over many years have failed to show any advantage in yield or quality of crop for growing it at cereal crop densities (involving narrow rows), and so in very few instances is there a need for the use of chemicals. However, occasionally the presence of wild oats may justify their use, and there may be cases where an expected infestation by a problem weed (e.g. cleavers, Galium aparine in white mustard) can be prevented by pre-emergence application of a residual herbicide; in such circumstances there may be an early check to crop growth, and seed yield will probably be lowered to some extent. With the exception of carbetamide the chemicals tested in these trials appear to be acceptable in both white and brown mustard.


## Acknowledgements

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## References


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Table 1

Control of wild oats in mustard

| Chemical & rate (l/ha) | White mustard (var. Kirby) | | Brown mustard (var. Stoke) | |
|---|---|---|---|---|
| | Seed yield | % large seed | Seed yield | % large seed |
| Chlorfenprop-methyl | | | | |
| 4.8 | 108 | 81 | 66 | 57 |
| 9.6 | 75 | 76 | 85 | 59 |
| Benzoylprop-ethyl | | | | |
| 1.1 | 102 | 67 | 78 | 62 |
| 2.2 | 97 | 77 | 95 | 66 |
| Barban | | | | |
| 0.3 | 100 | 76 | 88 | 58 |
| 0.6 | 89 | 79 | 85 | 49 |
| No treatment (control) | 100 (1.84 t/ha) | 78 | 100 (1.71 t/ha) | 64 |
| SE (controls) | ± 2.8 | ± 2.2 | ± 1.2 | ± 6.8 |

Table 2

Incorporated herbicides

| Variety & treatment rate (l/kg/ha) | | Young plant Loss (0-9 scales) | Young plant Vigour (0-9 scales) | Weeds % | Harvest % Seed yield | Harvest % large seed |
|---|---|---|---|---|---|---|
| KIRBY | | | | | | |
| Trifluralin | 0.7 kg | 0 | 9 | 10 | 90 | 83 |
| " | 1.1 kg | 0 | 8 | 5 | 98 | 84 |
| Dinitramine | 0.2 l | 1 | 7 | 20 | 87 | 86 |
| " | 0.4 l | 0 | 8 | 15 | 97 | 83 |
| Carbetamex | 1.2 kg | 1 | 8 | 15 | 87 | 86 |
| " | 2.3 kg | [illegible] | 4 | 20 | 74 | 83 |
| Steer-hoed (control) | | 0 | 9 | 5 | 100 (2.38 t/ha) | 81 |
| SE (control) | | | | | ± 1.9 | |
| STOKE | | | | | | |
| Trifluralin | 0.7 kg | 1 | 9 | 15 | 92 | 39 |
| " | 1.1 kg | 0 | 9 | 20 | 95 | 47 |
| Dinitramine | 0.2 l | 0 | 8 | 20 | 86 | 33 |
| " | 0.4 l | 1 | 9 | 15 | 92 | 23 |
| Carbetamex | 1.2 kg | 1 | 9 | 20 | 89 | 31 |
| " | 2.3 kg | 4 | 4 | 25 | 76 | 25 |
| Steer-hoed (control) | | 0 | 9 | 5 | 100 (1.85 t/ha) | 34 |
| SE (control) | | | | | ± 4.1 | |

Table 3

Residual herbicides

| Treatment & rate | | Kirby mustard: Young plant: Damage | Kirby mustard: Young plant: Vigour | Kirby mustard: Harvest: Weeds % | Kirby mustard: Harvest: Seed yield | Kirby mustard: Harvest: % large seed | Stoke mustard: Young plant: Damage | Stoke mustard: Young plant: Vigour | Stoke mustard: Harvest: Weeds % | Stoke mustard: Harvest: Seed yield | Stoke mustard: Harvest: % large seed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pre-emergence** | | | | | | | | | | | |
| Controls (steerage hoed) | | 0 | 9 | 10 | 100 (2.14 t/ha) | 73 | 0 | 9 | 10 | 100 (1.80 t/ha) | 26 |
| Propachlor | 4.4 kg | 1 | 8 | 10 | 96 | 72 | 0 | 8 | 15 | 91 | 33 |
| Nitrofen | 3.4 kg | 0 | 9 | 10 | 97 | 74 | 0 | 9 | 20 | 79 | 27 |
| Benazolin | 2.2 kg | 0 | 8 | 20 | 87 | 71 | 4 | 6 | 25 | 78 | 47 |
| Oryzalin | 0.6 kg | 0 | 9 | 20 | 96 | 77 | 0 | 9 | 25 | 83 | 33 |
| Aziprotryne | 3.3 kg | 2 | 6 | 5 | 100 | 73 | 5 | 7 | 10 | 83 | 24 |
| Alachlor | 2.0 l | 2 | 4 | 15 | 87 | 66 | 4 | 5 | 10 | 96 | 34 |
| **Post-emergence** | | | | | | | | | | | |
| Controls | | 0 | 8 | 15 | 100 (2.13 t/ha) | 81 | 1 | 9 | 10 | 100 (1.62 t/ha) | 21 |
| Propachlor | | 1 | 7 | 10 | 96 | 80 | 2 | 8 | 15 | 97 | 25 |
| Nitrofen | | 4 | 5 | 10 | 90 | 83 | 3 | 7 | 10 | 96 | 22 |
| Benazolin | | 1 | 8 | 15 | 95 | 77 | 1 | 8 | 20 | 87 | 29 |
| Oryzalin | | 1 | 8 | 15 | 85 | 77 | 1 | 9 | 15 | 100 | 21 |
| Aziprotryne | | 4 | 5 | 10 | 88 | 77 | 5 | 3 | 10 | 65 | 28 |
| Alachlor | | 1 | 7 | 10 | 96 | 82 | 3 | 8 | 5 | 106 | 22 |
| SE (controls) | | | | | ± 2.1 | | | | | ± 14.3 | |

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# CHEMICAL WEED CONTROL IN WINTER OIL SEED RAPE

## 1974/76 HARVEST YEARS

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Summary Selections of 6 herbicides were compared at several dose rates, combinations and dates of application in 20 experiments in 1974/76. Assessments of crop and weed development are presented, with yields from 14 sites. Yield responses of treated over untreated crops were generally large; up to 1,300%, but effects of treatments varied greatly with crop vigour, weed species, soil type and season. The results suggest that more precise determination of optimum treatment in relation to site is needed because of the large potential yield benefits.

Blackgrass and volunteer barley proved the most serious weeds although broad leaved weeds also markedly reduced yields at a few sites.

Dalapon was particularly active against monocotyledonous species and when applied early and at low dose showed negligible crop toxicity, but of the materials included at a reasonable number of sites, best results were obtained with carbetamide/dimefuron and propyzamide.

## INTRODUCTION

Determination of optimum herbicide treatments for differing weed and soil situations has become of major economic importance with the rapid expansion of the area of winter oil seed rape. Experience in the Eastern Region indicates that volunteer barley and blackgrass (*Alopecurus myosuroides*) cause most yield loss but that the pattern of, and degree of their competition varies significantly.

## METHODS AND MATERIALS

Randomised blocks with three or four replications and two untreated plots per block. Plot size 2.7 x 9.4 m. Spray applications applied with a modified van der Weij sprayer at 281 l/ha at 3.3 bar. Yields were determined by hand sampling of three $m^2$ quadrats per plot. Oil contents were determined by nuclear magnetic resonance (NMR) to the standard of the Soxhlet extraction method. Treatments are given in Table 1; site details in Table 2.

## RESULTS

In 1973/74 oil content tended to be a little higher on controls, in 1974/75 oil was lower where yields were much reduced by weed competition (H, treatments 0, 1 and 2; K, treatment 0). In 1975/76 oil content was lower on the controls at sites M & P but at sites L, N, R & S there were no differences between treatments.

## TABLE 1
### TREATMENTS 1973/4

| Treat-ment | Herbicide | Rate ai kg/ha | Time applied | Treat-ments | Herbicide | Rate ai kg/ha | Time applied |
|---|---|---|---|---|---|---|---|
| 0 | Untreated | | | 5 | dalapon | 2.87 | Feb |
| 1 | dalapon | 1.43 | Oct | 6a | dalapon | 2.87 | Oct |
| 2a | dalapon | 1.43 | Oct | b | dalapon | 2.87 | Feb |
| b | dalapon | 1.43 | Feb | 7 | dalapon | 3.81 | Dec |
| 3 | dalapon | 2.87 | Oct | 8 | dalapon | 3.81 | Feb |
| 4a | dalapon | 2.87 | Oct | 9 | carbetamide | 2.24 | Feb |
| b | dalapon | 2.87 | Dec | | | | |

### TREATMENTS 1974/5

| Treat-ment | Herbicide | Rate ai kg/ha | Time applied | Treat-ments | Herbicide | Rate ai kg/ha | Time applied |
|---|---|---|---|---|---|---|---|
| 0 | Untreated | | | 8 | propyzamide | 0.71 | late |
| 1 | dalapon | 1.43 | early | 9 | propyzamide | 0.71 | |
| 2 | dalapon | 2.87 | early | | diuron | 0.11 | late |
| 3a | dalapon | 1.43 | early | 10a | dalapon | 1.43 | early |
| b | dalapon | 1.43 | late | b | benazolin* | 1.34 | late |
| 4 | dalapon | 2.87 | late | 11a | carbetamide | 1.36 | late |
| 5 | dalapon | 1.43 | | b | benazolin* | 1.34 | late |
| | carbetamide | 1.37 | late | 12a | propyzamide | 0.42 | late |
| 6 | dalapon | 1.43 | | b | benazolin* | 1.34 | late |
| | propyzamide | 0.43 | late | 13 | carbetamide | 1.50 | |
| 7. | carbetamide | 2.14 | late | | dimefuron | 0.75 | late |

* **benazolin not applied at sites F, H and K**

### TREATMENTS 1975/6

| Treat-ment | Herbicide | Rate ai kg/ha | Time applied | Treat-ments | Herbicide | Rate ai kg/ha | Time applied |
|---|---|---|---|---|---|---|---|
| 0 | Untreated | | | 9 | carbetamide | 2.28 | |
| 1 | dalapon | 1.43 | early | | dimefuron | 0.77 | late |
| 2 | dalapon | 1.43 | late | 10 | carbetamide | 1.55 | |
| 3a | dalapon | 1.43 | early | | dimefuron | 0.77 | early |
| b | dalapon | 1.43 | late | 11 | carbetamide | 1.55 | |
| 4 | dalapon | 2.87 | early | | dimefuron | 0.77 | late |
| 5 | dalapon | 2.87 | late | 12 | dalapon | 0.95 | |
| 6 | dalapon | 0.95 | | | propyzamide | 0.71 | early |
| | carbetamide | 2.28 | | 13 | dalapon | 0.95 | |
| | dimefuron | 0.77 | early | | propyzamide | 0.71 | late |
| 7 | dalapon | 0.95 | | 14d | dalapon | 0.95 | early |
| | carbetamide | 2.28 | | b | propyzamide | 0.71 | late |
| | dimefuron | 0.77 | late | 15 | propyzamide | 0.71 | early |
| 8 | carbetamide | 2.28 | | 16 | propyzamide | 0.71 | late |
| | dimefuron | 0.77 | early | | | | |

## TABLE 3 RESULTS OF 1973/4 EXPERIMENTS

| SITE "A" | | Rate ai kg/ha | Time applied | Vigour Score 16 Apr | | Yield t/ha (CV = 7.4%) |
|---|---|---|---|---|---|---|
| | | | | Crop | Grasses | |
| 0 | Untreated | - | - | 4 | 10 | 1.48 |
| 1 | Propyzamide | 0.56 | Oct 73 | 8 | 1 | 2.85 |
| 2 | Propyzamide | 0.56 | Feb 74 | 3 | 2 | 2.32 |
| 3 | Carbetamide | 2.35 | Oct 73 | 7 | 0 | 2.72 |
| 4 | Carbetamide | 2.35 | Feb 74 | 2 | 3 | 2.25 |
| 5 | Devrinol | 1.40 | Sep 73 | 5 | 3 | 2.38 |

TABLE 2 SITE DETAILS

| SITE | SOIL SERIES | SOWN | SPRAY DATES | | | NUMBER OF TRUE LEAVES ON CROP AT | | | DOMINANT WEED(S) | GENERAL VIGOUR OF CROP DURING SUMMER |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1st | 2nd | 3rd | 1st | 2nd | 3rd spray | | |
| A | Hanslope | 15/9/73 | 18/9 | 31/10 | 26/2 | pre-em | 4-5 | extending | barley & A.myosuroides | moderate |
| B | Wicken | 12/8/73 | 23/10 | 4/12 | 21/2 | 6 | 7-8 | extending | A. myosuroides | high |
| C | Wicken | 20/8/73 | 23/10 | 4/12 | 21/2 | 3-5 | 4-8 | extending | A. myosuroides | very high |
| D | Denchworth | 27/8/73 | 5/10 | 6/12 | 18/2 | 3-7 | 4-8 | extending | A. myosuroides | low - moderate |
| E | River Gravel | 28/8/74 | 24/10 | 3/12* | - | 3-4 | 4-7 | - | general | very poor |
| F | Hanslope | 22/8/74 | 26/9 | 26/11 | - | 3-7 | 3-8 | - | barley | very high |
| G | Charity | 4/9/74 | 14/10 | 5/12 | 19/12* | 3-4 | 5-7 | 5-7 | various | moderate - high |
| H | Hanslope | 30/8/74 | 26/10 | 26/11 | - | 1-3 | 2-6 | - | barley & A.myosuroides | moderate - high |
| I | Wicken | 20/8/74 | 24/10 | 3/12* | - | 3-5 | 4-7 | - | cereals | very high |
| J | Swaffham Prior | 20/9/74 | 7/11 | 6/12 | 9/1* | 2-4 | 4-6 | 4-7 | general | moderate - high |
| K | Denchworth | 20/8/74 | 31/10 | 29/11 | - | 3-7 | 3-7 | - | A. myosuroides | high |
| L | Thundridge | 22/8/75 | 3/10 | 21/11 | - | 2.25 | 5-7 | - | A. myosuroides | high |
| M | Wicken | 2/9/75 | 15/10 | 21/11 | - | 2.25 | 5-6 | - | A. myosuroides | moderate |
| N | Hanslope | 5/9/75 | 9/10 | 20/11 | - | 2.5 | 5.5-6.5 | - | A. myo' & V. persica | very high |
| O | Hanslope | 28/8/75 | 7/10 | 20/11 | - | 2.25 | 5-8.5 | - | A. myosuroides | very high |
| P | Swaffham Prior | 3/9/75 | 15/10 | 26/11 | - | 3 | 7 | - | general | poor |
| Q | Thundridge | 14/8/75 | 10/10 | 28/11 | - | 2-3.5 | 4-7 | - | barley | moderate - high |
| R | Moulton | 18/9/75 | 17/10 | 26/11 | - | 2 | 5-6 | - | V. persica & S. media | high |
| S | Hanslope | 9/9/75 | 13/10 | 26/11 | - | 2.5-3.5 | 4 | - | barley | very high |
| T | Denchworth | 23/8/75 | 16/10 | 26/11 | - | 2.5-3.5 | 4.5-6.5 | - | A. myosuroides | moderate - high |

TABLE 3 RESULTS OF 1973/4 EXPERIMENTS (continued) (for Key see Table 1)

| | Treatments:- | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SITE "B" | Vigour Scores* - | Crop | 4 | 8 | 8 | 8 | 8 | 4 | - | 8 | 5 | - |
| Meldreth, Cambs | (Apr) | A. myosuroides | 9 | 2 | 0 | 0 | 0 | 3 | - | 0 | 3 | - |
| cv. Victor | Yield t/ha (CV = 8.31%) | | 1.78 | 2.30 | 2.55 | 2.88 | 2.56 | 2.14 | - | 2.60 | 1.76 | - |
| SITE "C" | Vigour Scores* - | Crop | 9 | 10 | 8 | 8 | 4 | 7 | - | 5 | 6 | - |
| Orwell, Cambs | (Apr) | Barley | 9 | 0 | 0 | 0 | 2 | 2 | - | 1 | 2 | - |
| cv. Hektor | Yield t/ha (CV = 5.47%) | | 2.52 | 3.02 | 2.82 | 2.42 | 2.32 | 2.77 | - | 2.95 | 2.77 | - |
| SITE "D" | Vigour scores* - | Crop | 4 | 7 | 7 | 5 | 5 | 2 | 5 | 3 | 3 | 3 |
| Warboys, Hunts | (Apr) | A. myosuroides | 10 | 2 | 0 | 0 | 0 | 3 | 0 | 0 | 3 | 4 |
| cv. Victor | Yield t/ha (CV = 7.6%) | | 0.82 | 1.51 | 1.5 | 1.63 | 1.66 | 0.94 | 1.56 | 1.26 | | 1.47 |

* Vigour scores (0-10) (for crop 10 = best growth; for weeds 10 = no effect)

TABLE 4 RESULTS OF 1974/1975 EXPERIMENTS (for key see Table 1)

| Site | Assessment | | Month | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TREATMENTS:- | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| SITE "E" | Vigour scores* - | Crop | May | 3 | 4 | 6 | 7 | 6 | 6 | 6 | 6 | 6 | 7 | 6 | 5 | 6 | 6 |
| Barrington, Cambs. | | Grasses | Mar | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 5 | 1 | 4 |
| cv. Primor | | S. media | Mar | 10 | 9 | 4 | 3 | 4 | 3 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 1 |
| SITE "F" | Vigour scores* - | Crop | Mar | 3 | 9 | 9 | 9 | 3 | 3 | 3 | 4 | 4 | 3 | – | 3 | 4 | 3 |
| Elsworth, Cambs. | | | May | 7 | 9 | 9 | 9 | 8 | 8 | 8 | 7 | 8 | 8 | – | 7 | 8 | 8 |
| cv. Victor | | Barley | Jan | 8 | 1 | 0 | 1 | 7 | 6 | 6 | 8 | 7 | 6 | – | 8 | 6 | 7 |
| | | | Mar | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | – | 0 | 0 | 0 |
| | Yield - t/ha (CV = 9.4%) | | | 2.8 | 3.4 | 3.2 | 3.4 | 3.2 | 3.2 | 3.2 | 3.4 | 3.6 | 3.4 | – | 3.0 | 3.2 | 3.6 |
| SITE "G" | Vigour scores* - | Crop | June | 6 | 7 | 8 | 9 | 9 | 9 | 9 | 8 | 8 | 9 | 7 | 8 | 8 | 8 |
| Gaddesden, Herts. | | Grasses | Mar | 10 | 7 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 5 | 3 | 3 | 6 |
| cv. Rapol | | Mayweed | | 3 | 4 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 3 | 1 | 1 | 1 | 2 |
| | | S. media | | 3 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| | | Veronica arvensis | | 2 | 1 | 2 | 1 | 3 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| | Yield t/ha (CV = 22.7%) | | | 1.9 | 1.9 | 2.5 | 3.2 | 3.5 | 3.1 | 2.8 | 2.8 | 2.7 | 2.8 | 2.5 | 2.5 | 2.9 | 3.6 |
| SITE "H" | Vigour scores* - | Crop | Jan | 10 | 8 | 7 | 4 | 1 | 8 | 7 | 2 | 8 | 9 | – | 3 | 7 | 6 |
| Knapwell, Cambs. | | | Apr | 1 | 2 | 4 | 2 | 1 | 2 | 2 | 1 | 2 | 3 | – | 1 | 1 | 2 |
| cv. Primor | | | May | 2 | 5 | 5 | 7 | 4 | 7 | 6 | 3 | 7 | 7 | – | 4 | 6 | 5 |
| | | Barley | Jan | 10 | 7 | 2 | 3 | 5 | 6 | 4 | 5 | 5 | 4 | – | 5 | 4 | 5 |
| | | | May | 10 | 8 | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | – | 2 | 0 | 1 |
| | | A. fatua | Harvest | 7 | 7 | 7 | 3 | 6 | 3 | 0 | 1 | 0 | 0 | – | 3 | 1 | 1 |
| | Yield t/ha (CV = 26.9%) | | | 0.1 | 0.5 | 0.5 | 1.1 | 0.8 | 0.9 | 1.4 | 1.3 | 1.8 | 1.6 | – | 1.0 | 1.3 | 1.1 |
| SITE "I" | Vigour scores* - | Crop | May | 9 | 9 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 10 | 9 | 9 | 9 | 9 |
| Meldreth, Cambs. | | Grasses | Mar | 10 | 4 | 0 | 0 | 0 | 2 | 1 | 2 | 1 | 1 | 3 | 6 | 2 | 4 |
| cv. Rapol | | Veronica persica | | 5 | 6 | 6 | 6 | 6 | 5 | 3 | 3 | 2 | 2 | 4 | 3 | 4 | 0 |
| | | S. media | | 2 | 4 | 3 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Yield t/ha (CV = 20.7%) | | | 1.3 | 1.1 | 1.0 | 0.9 | 0.9 | 1.2 | 1.0 | 1.2 | 1.4 | 1.5 | 0.9 | 1.3 | 1.2 | 1.5 |
| SITE "J" | Vigour scores* - | Crop | May | 7 | 7 | 6 | 3 | 3 | 7 | 7 | 7 | 8 | 8 | 5 | 7 | 7 | 8 |
| Ousden, Suffolk. | | Mayweed | Mar | 5 | 4 | 4 | 4 | 3 | 5 | 4 | 5 | 4 | 2 | 3 | 2 | 3 | 1 |
| cv. Mogul | Yield t/ha (CV = 15.1%) | | | 1.6 | 1.6 | 1.6 | 1.1 | 1.4 | 1.6 | 2.1 | 1.8 | 2.3 | 2.0 | 1.5 | 2.0 | 2.0 | 2.2 |
| SITE "K" | Vigour scores* - | Crop | Mar | 1 | 2 | 5 | 4 | 2 | 2 | 2 | 1 | 1 | 1 | – | 1 | 2 | 1 |
| Warboys, Hunts. | | | May | 2 | 9 | 10 | 10 | 9 | 9 | 9 | 8 | 6 | 6 | – | 5 | 5 | 5 |
| cv. Rapol | | A.myosuroides | Jan | 10 | 3 | 2 | 2 | 5 | 8 | 6 | 9 | 7 | 8 | – | 9 | 8 | 9 |
| | | | Apr | 10 | 1 | 0 | 0 | 0 | 1 | 0 | 2 | 4 | 4 | – | 8 | 9 | 7 |
| | Yield t/ha (CV = 24.5%) | | | 0.6 | 2.5 | 2.8 | 2.9 | 2.5 | 2.1 | 3.0 | 1.8 | 1.7 | 1.7 | 2.4 | 1.4 | 1.6 | 2.0 |

* Vigour scores (0-10) (for crop 10 = best growth; for weeds 10 = no effect)

TABLE 5 RESULTS OF 1975/76 EXPERIMENTS (for key see Table 1)

Vigour scores (0–10) (for crop 10 = best growth; for weeds 10 = no effect): Mean plant weights (g):
Weed populations/$m^2$ in brackets: Yield (t/ha), CV in brackets

| | | Treatments :— | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SITE "L" | Crop wt (g) | Dec | .33 | .39 | – | – | .31 | – | .21 | – | – | – | – | – | .28 | – | – | .37 | – |
| | Crop | Dec | 10 | 7 | 9 | 7 | 6 | 10 | 6 | 10 | 8 | 10 | 8 | 10 | 7 | 10 | 9 | 9 | 10 |
| Barley, | | Jan | 8 | 8 | 8 | 7 | 7 | 8 | 6 | 8 | 8 | 8 | 8 | 9 | 8 | 8 | 9 | 8 | 8 |
| Herts. | A. myosuroides | Dec | 8 | 1 | 6 | 1 | 0 | 8 | 1 | 9 | 1 | 7 | 1 | 8 | 1 | 9 | 3 | 3 | 7 |
| cv. | (2,177) | Jan | 9 | 0 | 5 | 0 | 0 | 7 | 0 | 5 | 2 | 4 | 2 | 5 | 0 | 6 | 1 | 1 | 4 |
| Expander | | Feb | 6 | 0 | 2 | 0 | 0 | 2 | 0 | 1 | 0 | 1 | 2 | 2 | 0 | 2 | 0 | 0 | 1 |
| | | Mar | 7 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| | Yield (10.8%) | | 2.1 | 2.9 | 2.6 | 2.6 | 2.8 | 2.9 | 2.8 | 2.8 | 3.0 | 2.9 | 2.7 | 2.8 | 3.0 | 2.9 | 2.9 | 2.8 | 2.8 |
| SITE "M" | Crop | Jan | 7 | 6 | 7 | 6 | 6 | 7 | 5 | 7 | 5 | 7 | 6 | 8 | 7 | 7 | 8 | 6 | 8 |
| | | Apr | 5 | 5 | 7 | 5 | 6 | 6 | 5 | 6 | 3 | 5 | 4 | 5 | 7 | 6 | 5 | 4 | 5 |
| Barrington, | Wheat and | Jan | 10 | 3 | 7 | 1 | 1 | 6 | 7 | 7 | 3 | 7 | 7 | 7 | 2 | 8 | 4 | 8 | 8 |
| Cambs. | A. myosuroides | Mar | 8 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 |
| cv. | (291) | Apr | 10 | 3 | 1 | 0 | 0 | 0 | 0 | 5 | 4 | 0 | 5 | 0 | 1 | 0 | 0 | 3 | 1 |
| Primor | Sinapis ar.(25) | Jan | 9 | 8 | 8 | 7 | 8 | 8 | 7 | 4 | 3 | 6 | 4 | 8 | 1 | 7 | 6 | 2 | 8 |
| | Yield | | Untreated 0.97, Treated 2.87, Between treatment comparisons not assessed (see text) | | | | | | | | | | | | | | | | |
| SITE "N" | Crop | Jan | 7 | 7 | 6 | 6 | 6 | 7 | 7 | 8 | 8 | 7 | 8 | 8 | 7 | 7 | 7 | 7 | 8 |
| | | Mar | 3 | 4 | 3 | 3 | 3 | 3 | 5 | 4 | 5 | 5 | 5 | 4 | 4 | 3 | 4 | 4 | 4 |
| Childerley, | Barley and | Jan | 9 | 2 | 8 | 4 | 1 | 8 | 5 | 7 | 7 | 8 | 7 | 7 | 4 | 6 | 4 | 6 | 7 |
| Cambs. | A. myo. (314) | Mar | 7 | 1 | 3 | 0 | 0 | 1 | 2 | 1 | 3 | 2 | 5 | 2 | 1 | 0 | 0 | 2 | 1 |
| cv. | V. persica | Jan | 10 | 10 | 10 | 10 | 10 | 10 | 0 | 10 | 0 | 9 | 0 | 10 | 5 | 10 | 10 | 9 | 10 |
| Primor | (623) | Mar | 6 | 6 | 7 | 7 | 9 | 8 | 0 | 1 | 0 | 0 | 0 | 0 | 4 | 4 | 3 | 6 | 4 |
| | Yield (11.9%) | | 2.8 | 3.5 | 3.5 | 2.8 | 3.1 | 3.4 | 3.2 | 3.2 | 3.0 | 3.3 | 3.2 | 3.3 | 3.5 | 3.4 | 3.6 | 3.4 | 3.2 |
| SITE "O" | Crop | Dec | 9 | 8 | 8 | 7 | 5 | 9 | 5 | 9 | 8 | 9 | 8 | 9 | 7 | 9 | 8 | 9 | 9 |
| | | Mar | 6 | 8 | 5 | 7 | 9 | 5 | 6 | 6 | 7 | 7 | 7 | 8 | 8 | 7 | 8 | 6 | 8 |
| Elsworth, | A. myosuroides | Dec | 10 | 4 | 10 | 5 | 2 | 10 | 3 | 10 | 10 | 9 | 10 | 10 | 5 | 10 | 7 | 8 | 10 |
| Cambs. | (108) | Feb | 8 | 2 | 3 | 0 | 1 | 3 | 1 | 2 | 5 | 1 | 6 | 2 | 1 | 3 | 1 | 3 | 2 |
| cv. Rapora | | Mar | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 1 | 0 | 1 | 0 | 0 | 0 |
| SITE "P" | Crop | Jan | 7 | 6 | 7 | 6 | 5 | 7 | 3 | 7 | 3 | 6 | 5 | 7 | 4 | 7 | 6 | 4 | 6 |
| | | Apr | 3 | 5 | 4 | 5 | 4 | 5 | 3 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 3 |
| Shelford, | Cereals and | Jan | 10 | 2 | 9 | 2 | 1 | 9 | 1 | 5 | 1 | 5 | 1 | 6 | 1 | 5 | 2 | 1 | 6 |
| Cambs. | A. fatua(186) | Feb | 4 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| cv. | All Weeds | Feb | 4 | 1 | 3 | 1 | 0 | 3 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| Expander | Yield | | Untreated 0.43, Treated 1.53 Between treatment comparisons not assessed (see text) | | | | | | | | | | | | | | | | |

TABLE 5 (continued) RESULTS OF 1975/76 EXPERIMENTS (for key see Table 1)

Vigour scores (0-10)(for crop 10 = best growth; for weeds 10 = no effect): **Mean plant weights (g):**
Weed populations/$m^2$ in brackets: Yield (t/ha), CV in brackets

| | Treatments:- | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SITE "Q" | Crop | Apr | 1 | 3 | 2 | 5 | 4 | 1 | 5 | 3 | 4 | 4 | 3 | 4 | 5 | 4 | 4 | 6 | 3 |
| Streatley, | Barley | Dec | 9 | 5 | 8 | 5 | 2 | 9 | 3 | 9 | 6 | 9 | 9 | 9 | 5 | 9 | 6 | 5 | 9 |
| Beds. | (143) | Mar | 8 | 1 | 5 | 0 | 0 | 2 | 1 | 1 | 4 | 0 | 8 | 1 | 0 | 1 | 0 | 0 | 0 |
| SITE "R" | Crop wt (g) | Dec | .35 | .42 | - | - | .32 | - | .18 | - | .34 | - | - | - | .21 | - | - | .33 | - |
| | Crop | Jan | 10 | 10 | 10 | 9 | 10 | 10 | 7 | 9 | 7 | 9 | 8 | 9 | 8 | 9 | 9 | 7 | 9 |
| Thriplow, | | Mar | 3 | 5 | 3 | 4 | 5 | 3 | 8 | 8 | 7 | 6 | 7 | 7 | 7 | 5 | 5 | 7 | 4 |
| Cambs. | S. media | Dec | 10 | 10 | 10 | 10 | 10 | 10 | 2 | 10 | 2 | 10 | 4 | 10 | 3 | 10 | 10 | 2 | 10 |
| cv. | (500) | Jan | 9 | 8 | 8 | 5 | 4 | 7 | 1 | 5 | 1 | 7 | 3 | 7 | 0 | 5 | 4 | 1 | 6 |
| Expander | V. persica | Dec | 10 | 10 | 10 | 10 | 10 | 10 | 0 | 10 | 0 | 10 | 0 | 10 | 4 | 10 | 10 | 4 | 10 |
| | (1,563) | Mar | 10 | 9 | 10 | 9 | 10 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 4 | 1 | 7 |
| | Wheat | Jan | 10 | 4 | 7 | 0 | 0 | 4 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Yield (13.1%) | | 0.9 | 1.3 | 1.2 | 1.1 | 1.2 | 1.0 | 1.6 | 1.8 | 1.8 | 1.6 | 1.7 | 1.5 | 1.7 | 1.6 | 1.5 | 1.8 | 1.5 |
| SITE "S" | Crop wt (g) | Dec | 1.08 | .98 | - | - | 1.08 | - | .80 | - | 1.12 | - | - | - | 1.08 | - | - | 1.04 | - |
| | Crop | Feb | 7 | 8 | 6 | 7 | 7 | 6 | 6 | 7 | 8 | 8 | 7 | 7 | 8 | 6 | 8 | 8 | 8 |
| Turvey, | Barley | Dec | 10 | 4 | 10 | 2 | 0 | 10 | 1 | 9 | 1 | 9 | 4 | 9 | 1 | 9 | 5 | 2 | 9 |
| Beds. | (116) | Feb | 2 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| cv. | | Mar | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rapora | **S. media** | Dec | 10 | 7 | 10 | 5 | 3 | 10 | 0 | 10 | 0 | 10 | 0 | 9 | 2 | 8 | 8 | 1 | 9 |
| | (11) | Feb | 8 | 7 | 7 | 5 | 5 | 8 | 0 | 6 | 0 | 5 | 0 | 4 | 2 | 3 | 1 | 4 | 4 |
| | Yield (10.1%) | | 3.8 | 4.0 | 3.7 | 4.0 | 4.1 | 3.9 | 4.2 | 4.1 | 4.1 | 3.8 | 3.9 | 3.8 | 4.1 | 4.3 | 4.1 | 4.3 | 3.9 |
| SITE "T" | Crop | Dec | 7 | 7 | 7 | 6 | 6 | 7 | 4 | 8 | 6 | 7 | 7 | 7 | 5 | 7 | 6 | 5 | 8 |
| | | Apr | 1 | 6 | 4 | 6 | 7 | 5 | 5 | 6 | 5 | 7 | 4 | 5 | 6 | 7 | 6 | 4 | 7 |
| Warboys, | A. mysuroides | Dec | 10 | 7 | 10 | 6 | 4 | 9 | 3 | 9 | 5 | 8 | 8 | 8 | 5 | 9 | 6 | 8 | 9 |
| Hunts. | (886) | Jan | 10 | 5 | 8 | 4 | 3 | 6 | 2 | 7 | 4 | 6 | 9 | 7 | 4 | 6 | 4 | 6 | 6 |
| cv. | | Feb | 10 | 4 | 6 | 2 | 2 | 4 | 2 | 5 | 3 | 5 | 8 | 5 | 3 | 4 | 3 | 4 | 4 |
| Rapora | | Mar | 9 | 4 | 3 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 7 | 2 | 2 | 1 | 0 | 3 | 1 |
| | | Apr | 10 | 6 | 6 | 2 | 3 | 2 | 5 | 1 | 5 | 2 | 9 | 3 | 2 | 2 | 1 | 6 | 2 |
| | A. fatua | Dec | 10 | 9 | 10 | 7 | 6 | 10 | 7 | 9 | 8 | 9 | 10 | 9 | 6 | 8 | 7 | 8 | 9 |
| | | Feb | 10 | 5 | 2 | 0 | 1 | 2 | 3 | 1 | 5 | 1 | 7 | 1 | 2 | 1 | 1 | 5 | 2 |
| | | Mar | 8 | 5 | 0 | 0 | 1 | 0 | 3 | 0 | 3 | 0 | 7 | 0 | 1 | 0 | 0 | 4 | 1 |

Site details, including visual scorings of crop and weeds, and yields, are presented in Tables 3, 4 and 5. Yields were not taken at certain sites due to treatment effects being masked by bird damage or other special problems.

## DISCUSSION

The critical importance of herbicides to the winter oil seed rape crop is well demonstrated by the high magnitude of many of the yield responses recorded (sites D. H. K. L. M. N. P. R). Yet the crop's extreme sensitivity to weed competition contrasts strangely with its remarkable powers of recovery from early checks in many circumstances; for instance, from weeds at sites B and F, after bird grazing and after bad winter weather checks.

Thus low weed populations which during the early winter would visually seem incapable of offering detectable competition may later dominate the crop (G, J, P). Similarly substantial differences in yield between treatments (excluding dalapon) recorded at several sites confirm the crops potential sensitivity to comparatively small differences in degree of weed control (G, H, J). Yet, at other sites, early major checks to growth have not been appreciably reflected in yields whether the early competition has been removed (F) or not and major differences in weed control between treatment (F, R) were not reflected in yields.

The necessity for controlling weeds at any site can not yet be predicted in terms of weed population and crop vigour at spraying time because the pattern of subsequent development of these factors varies too much. The experiments suggest that even where weed populations are low it is always wise to spray.

A wide contrast in interaction between weeds, herbicides and crop development are highlighted by sites L and T. The former had an extremely high blackgrass population, the latter a moderate one. At L all herbicides were particularly effective, whilst at T none gave full control.

Another interesting contrast occurred between neighbouring sites F and H. Both initially had very high infestation of volunteer barley. At F the volunteer barley came into ear and died and an initial crop vigour improvement from early barley control by dalapon was soon compensated for by all other treatments. At H the first flush was killed by early treatment but a second dense germination followed so that although the early dalapon gave an initial advantage in crop growth the situation was reversed in comparison with the later treatments well before harvest.

At Q the volunteer barley so dominated the crop in the combine swathe that it failed to recover even after the earlier spray (a situation seen frequently in field crops in 1975/6).

The value of dalapon for winter oil seed rape was much questioned after the experiences of the 1974/75 season when much flower distortion (I) occurred with occasional serious foliar check (with or without (J) flower distortion). There was also evidence of dalapon allowing more development of Cylindrosporium on the crop (Jones et al). The higher damage that season was attributed to the very wet soils through winter yet was not detectable at the very waterlogged site (E). Dalapon checks were often reflected in yields that season, even being below the control (I, J) where the grass weed population was low. Dalapon is certainly the quickest acting material, of those tested against grasses, and would seem of potential value at a situation as Q if applied very early, at low dose. It could then be followed by one of the other materials eg propyzamide or carbetamide plus dimefuron, which in 1975/76 were at some sites noticeably less effective against grass weeds when applied in Oct compared with Nov/Dec (N, O, T). The evidence certainly shows that dalapon damage risk increases with dosage and delay in application.

Dalapon has shown an appreciable effect on chickweed (C) but the results of site (R) are difficult to explain in that this material gave yield responses which approached, much more closely than could have been expected, those from treatments which were very effective on all weeds; there was very little grass weed at this site while speedwell was dense and chickweed very thick. Perhaps this is yet another instance of the complex pattern of rape and weed dominance and that the marginal effect of dalapon on the weed flora was fortunately just enough to swing the balance in favour of the crop.

In 1975/76, early applied dalapon mixtures were quicker acting than the constituents alone to an unexpected degree; they also gave some appreciable crop check (L, R) although these were not reflected in yield. For adequate safety it would seem that in mixtures, the doses of the constituents should be appreciably reduced to ensure crop safety.

It is of note that dimefuron was extremely effective against speedwell, that benazolin was extremely effective against chickweed and that dalapon can be very effective against grasses at low (safe) doses. There would seem to be a strong case for taking a less blunderbuss approach against weeds in the crop than in the past by selecting the chemicals most appropriate to the needs of each field. There might be a case for as little as 0.7 kg/ha of dalapon when the grass weeds were only just fully established (avoiding the losses of Q), followed by say 1.4 kg/ha of dalapon where a further grass flush occurred, separately or with the most appropriate broad leaved herbicide.

Fuller details of the results of these experiments were given in Experiments and Development in the Eastern Region for the appropriate years. (Finch and Proctor, 1974, 1975, 1976).

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# WEED CONTROL IN RAPESEED WITH BENAZOLIN ESTER/ 3,6 DICHLOROPICOLINIC ACID MIXTURES

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Summary Extensive field trials in the United Kingdom and continental Europe during the years 1974-76 have examined mixtures of benazolin ester and 3,6 dichloropicolinic acid for wide spectrum post-emergence broad-leaved weed control in rapeseed. The potential for such mixtures has been greatly enhanced by the discovery that benazolin, which used alone has excellent activity against *Stellaria media*, *Galium aparine* and *Sinapis arvensis*, synergises 3,6 dichloropicolinic acid, thereby increasing its effect on other important weeds such as *Matricaria* spp and *Anthemis* spp.

The results reported demonstrate that, under a range of climatic and cultural conditions, combinations of the two herbicides at rates of benazolin ester, 250-375 g a.i./ha, and 3,6 dichloropicolinic acid, 50-80 g a.i./ha, provide extremely effective broad-leaved weed control whilst maintaining a good margin of crop safety.

Trials investigating the addition of grass herbicides to the benazolin ester/3,6 dichloropicolinic acid mixtures to achieve volunteer cereal, grass and broad-leaved weed control are also reported.

Résumé Cette expérimentation de plein champ conduite sur colza en Grande-Bretagne et en Europe entre 1974 et 1976 a eu pour but d'évaluer l'activité antidicotylédone de mélanges de bénazoline ester et d'acide 3,6 dichloropicolinique appliqués en post-levée. L'intérêt porté a ces mélanges fut exalté par le fait que la bénazoline, active contre *Stellaria media*, *Galium aparine* et *Sinapis arvensis*, synergisait l'acide 3,6 dichloropicolinique, accroîssant ainsi son activité herbicide vis à vis d'autres adventices telles que *Matricaria* spp et *Anthemis* spp.

Les résultats obtenus sous des conditions climatiques et culturales tres diverses, montrent que les combinaisons de ces deux herbicides aux doses de 250 à 375 g/ha de bénazoline ester et de 50 à 80 g/ha d'acide 3,6 dichloropicolinique, ont fait preuve d'une excellente efficacité antidicotyledone et d'une selectivité satisfaisante vis à vis du colza.

On a également rapporté ici les résultats des essais de mélanges de bénazoline ester/acide 3,6 dichloropicolinique et d'herbicides antigraminées dont le but etait d'essayer de détruire les flores mixtes de dicotyledones et de graminées adventices.

## INTRODUCTION

The biological properties of benazolin, 4 chloro-2-oxobenzothiazolin-3-ylacetic acid, and its potential uses as a herbicide in agriculture have already been described in detail elsewhere, Leafe et al (1964)[1], and Lush et al (1965)[2], (1966)[3], (1968)[4]. It has a narrow but valuable spectrum of post-emergence activity when used at rates between 150 and 300 g a.i./ha, controlling weeds such as *Stellaria media* and *Galium aparine* whilst showing very good selectivity in small grain cereals, rapeseed and legume crops such as clovers. As a consequence benazolin is already used commercially in many European countries either alone in rapeseed, or in admixture with other herbicides in cereals, clover and grassland crops. Investigational work in the United Kingdom has demonstrated the marked safening effect on rape of benazolin ethyl ester over its alkali metal salts.

During the last few years there has been a significant increase in the rapeseed hectarage in Europe, production in the major countries rising from 1.8 million tonnes in 1970 to 2.3 million tonnes in 1973, and in 1976 still increasing. Although in the later stages of its development the crop effectively smothers weeds, during its establishment the autumn sown crop in particular can suffer drastically from weed competition with a consequent yield reduction. The main weed problems identified are graminaceous species such as volunteer cereals, *Avena fatua*, *Alopecurus* spp and *Lolium* spp, and broad-leaved weeds such as *Matricaria* spp, *Stellaria media* and *Galium aparine*.

In 1974 the opportunity arose to investigate the herbicidal potential of mixtures of benazolin ester and 3,6 dichloropicolinic acid, a new herbicide from Dow Chemical Company. 3,6 dichloropicolinic acid, tested under the code number Dowco 290, has similar herbicidal properties to picloram, being particularly active against members of the Compositae without having the persistency problems associated with the latter herbicide. It also has good selectivity in cereals and rapeseed.

A programme of field trials was initiated with benazolin ester/3,6 dichloropicolinic acid mixtures in autumn 1974 in the United Kingdom, France and Sweden, and development continued during the following two years. Additionally investigational work has been carried out with these mixtures, either in tank mixture or in sequential application, with herbicides effective on grasses such as dalapon, carbetamide and propyzamide. This paper reports results from the three countries mentioned above, although trials are also in progress in all the major rapeseed producing countries in West and East Europe.

## METHOD AND MATERIALS

For the first season's trials, autumn 1974-summer 1975, tank mix combinations of the two products were used, with benazolin ester formulated as a 25% a.i. w.p. and 3,6 dichloropicolinic acid as a 30% a.i. diethanolamine salt. For the following season, autumn 1975-summer 1976, two wettable powder mixed product formulations were prepared. In United Kingdom and French trials the formulation comprised 30% a.i. benazolin ester and 5% a.i. 3,6 dichloropicolinic acid, and in Swedish trials a 25% a.i. + 8% a.i. mixture.

Eleven trials in autumn sown rape were conducted in the United Kingdom in 1974-75, seven of these being logarithmic dose to establish effective combination rates and investigate synergistic ratios, followed in 1975-76 by eleven finite dose trials (7 observation and 4 yield) and 35 grower trials. Rates in United Kingdom trials ranged from 1.0 kg/ha of formulated product (ie. 300 g a.i./ha benazolin ester + 50 g a.i./ha 3,6 dichloropicolinic acid) to 2.3 kg/ha, the latter rate being chosen because 700 g a.i./ha benazolin ester is normally required for *Sinapis arvensis* control. Yield trials also included a 4.7 kg/ha rate for crop safety determination. For situations where graminaceous species occurred, propyzamide 50% a.i. w.p. from Rohm and Haas at 350-700 g a.i./ha, dalapon 85% a.i. Na salt at 2,000-2,800 g a.i./ha, or carbetamide 70% a.i. w.p. from May and Baker at 1,050-2,100 g a.i./ha were used, either in tank mixture or in sequential application, with benazolin ester/3,6 dichloropicolinic acid. Treatment application in replicated trials was by the Lenton small plot pusher sprayer, Lush and Mayes (1972)[5]. Plot size in observation trials was 10 x 2.7 m with threefold replication, and in yield trials 40 x 3 m, replicated six times. Yields were estimated by combine harvester, with crops cut and swathed prior to threshing. Plot size of grower trials was 1 ha., unreplicated, and treatments applied by conventional farm spraying machinery.

In France 25 trials, and in Sweden some 40 trials were carried out over the two year period in spring and autumn sown rape, all treatments being at finite dose. Experimental techniques were essentially the same as those used in the United Kingdom, varying only in the application equipment used, and in assessment methods. Assessment techniques employed in each country were in accordance with the requirements of the relevant Registration Authority. Rates of use also varied to some extent, and there was no grass herbicide requirement for Sweden.

The majority of the United Kingdom and French trials were carried out on the low erucic acid varieties Primor and Rapora, and in Sweden on the variety Sinus.

## RESULTS

### Establishment of synergism and optimum rates of benazolin ester/ 3,6 dichloropicolinic acid mixtures in 1974-75

As would be anticipated from a knowledge of the herbicidal properties of the two compounds, the effect of combining benazolin ester and 3,6 dichloropicolinic acid was to achieve control of *Matricaria* spp, *Stellaria media* and *Galium aparine*. However a completely unexpected result was that benazolin ester synergises 3,6 dichloropicolinic acid thereby increasing its activity on mayweeds.

Combinations of the two herbicides in the rate range 300 g a.i./ha benazolin ester and 30-50 g a.i./ha 3,6 dichloropicolinic acid achieved a standard of mayweed control equal or better than that obtained with 100 g a.i./ha 3,6 dichloropicolinic acid used alone (Table 1), which incidentally gave no control of either *Stellaria media* or *Galium aparine*. Benazolin ester 300 g a.i./ha had little or no effect on mayweeds, and lower rates of 3,6 dichloropicolinic acid viz. 30-50 g a.i./ha gave a poor standard of control.

On the basis of the very good effects on *Stellaria media* and *Galium aparine* achieved by 300 g a.i./ha benazolin ester and its valuable synergising effect on 3,6 dichloropicolinic acid against mayweeds, particularly when used in mixture with 50 g a.i./ha of the latter herbicide, a combination of the two herbicides in the ratio 6:1, utilising 300 g a.i./ha benazolin ester and 50 g a.i./ha 3,6 dichloropicolinic acid was selected as the optimum treatment to take forward for further development in United Kingdom and France.

Results in Sweden showed the necessity for a slightly modified mixture to provide consistently good *Matricaria* control under the more stringent climatic conditions prevailing in that country, whilst retaining the good effects on *Stellaria media* and *Galium aparine*. The optimum ratio of the two herbicides was found to be approximately 3:1, employing rates of 250 g a.i./ha + 80 g a.i./ha, and this combination was taken into large scale development trials in 1975-76.

An excellent crop safety margin was observed with these mixtures in all three countries.

Table 1

United Kingdom 1974-75 trials: Results from logarithmic trials in autumn sown rapeseed at three locations demonstrating the synergising effect of benazolin ester on 3,6 dichloropicolinic acid against *Matricaria* spp

| Treatment | Site location / Rate g a.i./ha | Shardlow Derbys: *Matricaria* spp | Shardlow Derbys: *Stellaria media* | Lockington Notts: *Matricaria* spp | Lockington Notts: *Stellaria media* | Newbold on Stour, Warks: *Stellaria media* | Newbold on Stour, Warks: *Galium aparine* |
|---|---|---|---|---|---|---|---|
| Benazolin ester + 3,6 dichloropicolinic acid | 300 + 30 | 6 | 10 | 7 | 10 | 10 | 10 |
| | 300 + 40 | 7 | 10 | 8 | 10 | 10 | 10 |
| | 300 + 50 | 9 | 10 | 9 | 10 | 10 | 10 |
| | 500 + 40 | - | - | - | - | 10 | 10 |
| | 500 + 50 | - | - | - | - | 10 | 10 |
| Benazolin ester | 300 | 2 | 10 | 0 | 10 | 10 | 10 |
| | 500 | - | - | - | - | 10 | 10 |
| 3,6 dichloropicolinic acid | 30 | 0 | 0 | 3 | 0 | 0 | 0 |
| | 40 | 0 | 0 | 4 | 1 | 0 | 0 |
| | 50 | 0 | 0 | 7 | 5 | 0 | 0 |
| | 100 | 8 | 0 | 7 | - | 0 | 0 |

| | Shardlow | Lockington | Newbold on Stour |
|---|---|---|---|
| Variety | Primor | Primor | Rapol |
| Sowing date | 3.9.74. | Early Sept' 74 | Early Sept' 74 |
| Application date | 21.10.74. | 5.2.75. | 18.3.75. |
| Crop stage | 3-4 leaves | 5-7 leaves | 4-5 leaves |
| Weed stage | *Matricaria* spp sd - yp; *Stellaria media* sd - yp | *Matricaria* spp sd - yp; *Stellaria media* yp | *Stellaria media* yp - mp; *Galium aparine* yp - mp |
| Assessment date | 18.3.75. | 19.3.75. | 9.4.75. |

Weed stage key: sd - seedling
yp - young plant
mp - mature plant

Assessment key: 0 = no weed control
7 = commercially acceptable weed control
10 = 100% weed control

### Efficacy of optimum mixtures in 1975-76

In United Kingdom trials weed control was extremely good (Table 2) confirming the evidence from the previous year's trials. Grass weeds were well controlled irrespective of the herbicide used for grass weed control, but they had no enhancing effect on the important broad-leaved species when tank mixed with benazolin ester/3,6 dichloropicolinic acid.

Table 2

United Kingdom 1975-76 trials: Mean results from replicated trials in autumn sown rapeseed at five locations

| Treatment | Rate g a.i./ha | Matricaria spp | Stellaria media | Grasses[1.] |
|---|---|---|---|---|
| Benazolin ester + 3,6 dichloropicolinic acid | 300 + 50 | 8.5 | 10 | 0 |
| | 400 + 66.5 | 8.4 | 10 | 0 |
| | 700 + 116.5 | 9.6 | 10 | 0 |
| Benazolin ester + 3,6 dichloropicolinic acid + propyzamide | 300 + 50 + 350 | 8.5 | 10 | 8.4 |
| | 300 + 50 + 700 | 8.2 | 10 | 10 |
| Propyzamide | 350 | 0 | 4.4 | 8.4 |
| | 700 | 0 | 8.5 | 10 |

Assessment key: 0 = no weed control
7 = commercially acceptable weed control
10 = 100% weed control

1. Grass weeds including volunteer cereals and *Avena fatua*.

Yields (Table 3) were also very satisfactory. Although transient crop effects, such as stunting and slight lamina distortion were observed in the early spring following autumn application, they had no effect on final yield.

Table 3

United Kingdom 1975-76 trials: Yield results in autumn sown rapeseed at three locations, expressed as a % of untreated control

| Location / Treatment | Rate g a.i./ha | Clipston Notts | Keyworth I Notts | Keyworth II Notts |
|---|---|---|---|---|
| Benazolin ester + 3,6 dichloropicolinic acid | 375 + 62.5 | 109.1 | 108.8 | 106.4 |
| | 700 + 117 | 105 | 106.1 | 105 |
| | 1400 + 234 | 103.7 | 106.7 | 110.6 |
| Benazolin ester + 3,6 dichloropicolinic acid + propyzamide | 375 + 62.5 + 350 | 105.2 | 98.7 | - |
| | 700 + 117 + 350 | 104.2 | 99.5 | - |
| Yield of untreated in kg/ha | | 3468 | 2905 | 2793 |
| % standard error | | 7.0 | 6.0 | 9.6 |
| Variety | | Primor | Rapora | Rapora |
| Application date | | 18.11.75. | 16.12.75. | 26.2.76. |
| Growth stage | | 4-6 leaves | 3-6 leaves | 6-8 leaves |
| Harvest date | | 21.7.76. | 17.7.76. | 14/15.7.76. |

Results of French trials (Table 4) indicate that a rate of 375 g a.i./ha + 62.5 g a.i./ha of the mixture is required for consistently good *Matricaria* and *Stellaria media* control, whereas a rate of 300 g a.i./ha + 50 g a.i./ha was sufficient when tank mixed with propyzamide or carbetamide. In Sweden, 250 g a.i./ha + 80 g a.i./ha of the mixture gave very good weed control and yield results. (Tables 5a and 5b).

Table 4

France 1975-76 trials: Mean % weed control[1.] following autumn treatment in 10 autumn sown rapeseed trials

| Treatment | Rate g a.i./ha | *Matricaria* spp | *Stellaria media* | Grasses[2.] |
|---|---|---|---|---|
| Benazolin ester + 3,6 dichloropicolinic acid | 300 + 50 | 75.5 | 84.6 | 18.2 |
| | 375 + 62.5 | 90.3 | 84.5 | 23.8 |
| | 450 + 75 | 91.5 | 89.3 | 14.8 |
| | 600 + 100 | 93.8 | 91.1 | 28.0 |
| Benazolin ester + 3,6 dichloropicolinic acid | | | | |
| + propyzamide | 300 + 50 + 400 | 91.8 | 89.8 | 81.4 |
| | 600 + 100 + 800 | 96.0 | 92.6 | 91.0 |
| + carbetamide | 300 + 50 + 2100 | 92.5 | 80.7 | 90.5 |
| + dalapon | 300 + 50 + 2000 | 94.5 | 97.0 | 93.7 |
| Propyzamide | 400 | 18.5 | 66.5 | 85.8 |
| | 500 | 19.3 | 68.3 | 89.4 |
| Propyzamide + diuron | 500 + 160 | 50.8 | 95.0 | 93.1 |
| Untreated (number of weeds/m$^2$) | | 25.8 | 25.6 | 51.9 |
| Number of trials | | 4 | 8 | 7 |

Application dates: October to December 1975
Assessment dates: December 1975 to April 1976
1. Assessment based on CEB 0-10 scale
2. Grass weeds include volunteer cereals, *Alopecurus agrestis*, *Lolium rigidum* and *Poa annua*.

Table 5a

Sweden: Mean % Weed control results from 20 trials carried out in autumn sown rapeseed and turnip rape crops 1974-75 and 1975-76 following treatment with benazolin ester/3,6 dichloropicolinic acid mixtures*

| Weed species | % Weed** control | Wt g/m$^2$ in untreated control | Number of trials |
|---|---|---|---|
| *Matricaria inodora* | 95 | 93 | 18 |
| *Matricaria chamomilla* | 100 | 71 | 1 |
| *Centaurea cyanus* | 100 | 194 | 2 |
| *Stellaria media* | 97 | 213 | 17 |
| *Galium aparine* | 87 | 81 | 2 |
| *Lamium* spp | 76 | 59 | 6 |
| *Myosotis arvensis* | 73 | 39 | 2 |
| *Veronica* spp | 53 | 21 | 3 |
| *Capsella bursa pastoris* | 45 | 86 | 7 |
| *Viola arvensis* | 29 | 31 | 6 |
| All broad-leaved spp | 83 | 396 | 20 |

* 1974-75 10 trials treated with a 250 g a.i./ha + 60 g a.i./ha mixture
1975-76 10 trials treated with a 250 g a.i./ha + 80 g a.i./ha mixture
Total number of trials: 20 (12 in rapeseed and 8 in turnip rape)
Time of application: September 25th to October 28th
Crop stage: at least 4 true leaves

** Assessment date: May - June in the year following treatment

Table 5b

Sweden: Mean yield results from 10 trials treated with benazolin ester/3,6 dichloropicolinic acid mixtures in 1974-75

| Treatment | Rate g a.i./ha | Yield kg/ha | Chlorophyll ppm | Oil % |
|---|---|---|---|---|
| Benazolin ester + 3,6 dichloropicolinic acid | 250 + 60 | 2610 | 14 | 42.4 |
| Untreated | | 2320 | 16 | 41.5 |
| LSD 5% | | ±113 | ±3 | ±1.3 |
| Number of trials | | 10[1.] | 5 | 5 |

1. 6 trials in rapeseed and 4 in turnip rape

## DISCUSSION

The totally unexpected synergising effect of benazolin ester on 3,6 dichloropicolinic acid against mayweeds has provided the basis for valuable herbicidal mixtures for wide spectrum broad-leaved weed control in rapeseed. In over 125 trials carried out over a two year period in United Kingdom, France and Sweden, mixtures of these two herbicides have consistently exhibited excellent post-emergence activity on the important broad-leaved weeds occurring in the rapeseed crop. A 6:1 ratio of benazolin ester/3,6 dichloropicolinic acid, employing 300 g a.i./ha + 50 g a.i./ha in the United Kingdom, and 375 g a.i./ha + 62.5 g a.i./ha in France, has given excellent control of Matricaria spp, and Stellaria media, a good suppression of Galium aparine and other weeds such as Veronica spp and Lamium spp, whilst conferring a very good margin of crop safety. Under the more stringent climatic conditions prevailing in Sweden a combination of the two herbicides in approximately 3:1 ratio, utilising 250 g a.i./ha + 80 g a.i./ha, has achieved equally good results on these weeds, and also on Centaurea cyanus and Lapsana communis.

For situations where grass and broad-leaved weeds occur together, there is considerable potential for benazolin ester/3,6 dichloropicolinic acid mixtures to be used in conjunction with herbicides effective on grass weeds. Dalapon Na salt at 2,000-2,800 g a.i./ha can be used as a separate treatment either before or after the combination mixture. However, propyzamide at 400-700 g a.i./ha or carbetamide at 1,050-2,100 g a.i./ha can be used either in tank mixture or in sequential application.

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# TRIALS WITH BROMOXYNIL/MCPA AND ASULAM IN LINSEED (OILSEED FLAX)

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Summary Mixtures of bromoxynil and MCPA esters were investigated for broad-leaved weed control in linseed in Western Canada during 1965-67, and a 1:1 mixture of them was marketed in that country in 1967. Asulam plus a surfactant controlled wild oats at a dose tolerated by linseed in glasshouse studies during 1965-70. This finding was confirmed by field work in Canada during 1971-73, and further work showed that a mixture of bromoxynil/MCPA esters with asulam plus surfactant gave control of both wild oat and the majority of broad-leaved weeds.

Increase in the U.K. linseed acreage encouraged experiments in this country to confirm our Canadian experience. Bromoxynil/MCPA esters, and asulam plus surfactant, separately or as a mixture were shown to be effective herbicides in linseed under U.K. conditions.

Résumé De 1965 a 1967, dans l'ouest du Canada, des melanges d'ester de bromoxynil et de MCPA ont été essayés pour lutte contre les adventices dans de lin. Par la suite un mélange dans les proportions (1/1) a été vendu sur le marché dans ce pays en 1967. De 1965 a 1970, l'asulam avec un mouillant se montrait efficace contre la "folle avoine" en serre à dose non nocive pour le lin. Ceci a été confirmé par la suite en culture plein champ de Canada de 1971 a 1973 et plus tard on se rendit compte qu'un mélange d'ester de bromoxynil/MCPA et d'asulam (avec un mouillant) était efficace à la fois contre la "folle avoine" et contre la majorité des autres adventices.

L'augmentation de la surface en lin au Royaume-Uni encouragea les essais dans ce pays pour confirmer notre experience canadienne. Les esters de bromoxynil/MCPA, et l'asulam (avec son additif), utilisées séparément ou en mélange, se sont montrés des herbicides éfficaces au Royaume-Uni.

## INTRODUCTION

The use of a 1:1 mixture of bromoxynil/MCPA esters for broad-leaved weed control in linseed was investigated in Western Canada during 1965-67 (Molberg 1965), and a product already in use for weed control in cereals, 'Buctril M', was recommended there in 1966. Meanwhile, glasshouse studies with asulam during 1965-70, (Hibbitt et al 1974), showed that the addition of a surfactant enhanced control of wild oat at rates tolerated by the linseed; during 1971-73, this activity was confirmed in the field in Western Canada. Also, mixtures of asulam with surfactant plus MCPA were examined with the object of achieving wild oat and broad-leaved weed control with one application. The poor results with this mixture on the widespread *Polygonaceae* led to the development of tank mixtures of bromoxynil/MCPA plus formulated asulam with surfactant ('Asulox F').

In the U.K., the increase in the acreage of linseed, often grown instead of spring rape as a cereal break crop, led, in 1975, to 4 replicated trials in which were examined bromoxynil/MCPA, asulam plus surfactant, and mixtures of the two, for use in linseed under U.K. conditions, using application rates recommended in Canada. The Canadian formulation of asulam containing the surfactant needed for wild oat control was not, however, used in these trials, it being thought preferable to tank mix a surfactant that was very widely available with the formulation of asulam currently marketed for control of docks and bracken, rather than introduce an additional asulam formulation.

## METHODS AND MATERIALS

| | |
|---|---|
| U.K. and Canada | Randomised blocks 3-4 replicates. |
| Plot sizes: | Weed control trials 2.5m x 10m or 4m x 10m.<br>Yield and tolerance trials 2.5m to 5m by 50m to 100m. |
| Application: | Motorised precision small plot sprayer. Volume 50-100 l/ha (Canada) 200 l/ha (U.K.). |
| Timing: | Linseed between 2.5 and 15cm high. Wild oats 1-6 leaves.<br>Broad-leaved weeds - seedlings to young plant. |
| Assessments: | Weed control. Standard weed counts or European Weed Research Council (EWRC) Scores. |
| | Crop effect: Routine observations using EWRC scores. |
| | Yields: Taken with small plot combine harvester, and expressed at a calculated base level moisture content with the percentage impurities ('dockage') removed. |
| Formulations: | |
| Canada: | E.C. containing 20% w/v bromoxynil, as octanoate.<br>E.C. containing 20% w/v MCPA as iso-octyl ester.<br>Aqueous solution containing 80% w/v MCPA as amine salt.<br>Aqueous solution containing 40% w/v asulam as Na Salt and also containing a non-ionic surfactant. |
| Canada and U.K.: | E.C. containing 20% w/v bromoxynil, as octanoate and 20% w/v MCPA as iso-octyl ester.<br>Aqueous solution containing 40% w/v asulam as Na Salt. |
| U.K.: | Alkyl phenol ethylene oxide condensate ("Agral")*.<br>E.C. containing 40% w/v chlorpropham.<br>E.C. containing 20% w/v ioxynil + 20% w/v bromoxynil as octanoate.<br>Aqueous solution containing 25% w/v MCPA as Na salt. |

## RESULTS

Tables 1-4 - Broad-leaved weed and wild oat control in Western Canada.
" 2&5 - Yields, Western Canada.
Table 6 - Broad-leaved weed control, U.K.
" 7 - Wild oat control, effect on yield U.K.
" 8 - Crop effect in the absence of weeds, U.K.

### Table 1

**Weed control with bromoxynil/MCPA mixtures in linseed, Western Canada 1966**

| Treatment g/a.i./ha | | % weed control | | | | Number of sites | |
|---|---|---|---|---|---|---|---|
| Bromoxynil | MCPA | Polygonum convolvulus No. | Polygonum convolvulus Bulk | Polygonum scabrum No. | Polygonum scabrum Bulk | P. convolvulus | P. scabrum |
| 280 | - | 83 | 95 | 93 | 92 | 3 | 3 |
| 350 | - | 91 | 95 | 55 | 92 | 5 | 3 |
| 420 | - | 89 | 98 | 90 | 94 | 5 | 4 |
| 210 | 210 | 72 | 94 | 78 | 92 | 3 | 3 |
| 280 | 280 | 84 | 96 | 87 | 91 | 5 | 4 |
| 350 | 350 | 89 | 98 | 92 | 95 | 5 | 3 |
| - | 350 | 3 | 17 | 41 | 60 | 3 | 3 |

No. = Plant number Bulk = Plant number x mean height

### Table 2

**Weed control and linseed yields with asulam ± wetter and MCPA, Western Canada 1971**

| asulam g/a.i./ha | MCPA g/a.i./ha | wetter | % control of Avena fatua (wild oats) mean of 8 sites | % control of Avena fatua (bulk*) mean of 5 sites | mean of 9 sites | Flax yields $g/m^2$ mean of 4 sites | Flax yields $g/m^2$ mean of 7 sites |
|---|---|---|---|---|---|---|---|
| 840 | - | - | 66.4 d | 53.0 d | - | 46.6 d | - |
| 840 | - | + | 91.6 a | 89.8 abc | - | 60.5 a | - |
| 840 | 210 | + | 87.9 ab | 91.8 ab | - | 54.8 ab | - |
| 1120 | - | - | 75.5 c | 73.2 c | 68.4 b | 55.1 ab | 46.6 b |
| 1120 | - | + | 92.9 a | 93.9 a | 84.4 a | 61.0 a | 52.5 ab |
| 1120 | 210 | - | 81.2 bc | 73.5 bc | 70.7 b | 50.8 cd | 46.6 b |
| 1120 | 210 | + | 92.5 a | 94.1 a | 85.6 a | 55.1 ab | 49.7 ab |
| 2240 | - | + | - | - | 89.8 a | - | 47.8 b |
| 2240 | 420 | + | - | - | 88.4 a | - | 49.7 ab |
| | control | | 0 e | 0 e | 0 c | 35.3 e | 41.7 c |

Means followed by the same letter are not significantly different at the 0.1% level.
*Bulk = Plant number x mean height.

## Table 3

% control of wild oats and broad-leaved weeds in linseed
asulam, asulam + MCPA, asulam + bromoxynil/MCPA
Western Canada 1972

| Treatment g/a.i./ha | Avenua fatua | | Polygonum convolvulus | | Amaranthus retroflexus | |
|---|---|---|---|---|---|---|
| | No. | bulk | No. | bulk | No. | bulk |
| Asulam 1120 | 90 | 95 | 80 | 86 | 0 | 38 |
| Asulam 1120 + | | | | | | |
| MCPA amine 280 | 85 | 95 | 49 | 92 | 18 | 71 |
| MCPA Na. 280 | 81 | 91 | 40 | 91 | 18 | 73 |
| Brom/MCPA 280 + 280 | 93 | 95 | 99 | 99 | 100 | 100 |
| Brom/MCPA 140 + 140 | 85 | 94 | 86 | 98 | 82 | 96 |
| MCPA amine alone 280 | - | - | 29 | 78 | 0 | 53 |

## Table 4

% control of wild oats and broad-leaved weeds with asulam/
bromoxynil/MCPA mixtures, in linseed, Western Canada 1973

| g/a.i./ha | | | A. fatua | P. convolvulus | | P. Scabrum | | Capsella bursa-pastoris | |
|---|---|---|---|---|---|---|---|---|---|
| Asulam | Bromoxynil | MCPA | Bulk only | No. | Bulk | No. | Bulk | No. | Bulk |
| 1120 | - | - | 93 | 49 | 88 | 62 | 86 | 45 | 56 |
| - | 280 | 280 | 9 | 86 | 96 | 93 | 96 | 90 | 96 |
| 1120 | 280 | 280 | 92 | 91 | 99 | 99 | 99 | 96 | 99 |
| 1120 | 210 | 210 | 94 | 85 | 98 | 100 | 100 | 93 | 98 |
| 1120 | 140 | 140 | 97 | 90 | 98 | 97 | 99 | 87 | 94 |
| 1120 | - | 280 | 91 | 39 | 80 | 57 | 84 | 50 | 60 |
| Growth stage at spraying | | | 2-6 leaves | seedling - 4 leaves | | 2-5 leaves | | seedling - 6 leaves | |

Tables 3 & 4. No = plant number. Bulk = plant no x mean height.

## Table 5

### Linseed yields with asulam/bromoxynil, MCPA mixtures, Western Canada 1973

| Treatment g/a.i./ha | | | Yield of clean linseed at 10% moisture $(g/m^2)$ | | | | |
|---|---|---|---|---|---|---|---|
| | | | Site no. | | | | |
| sulam | bromoxynil | MCPA | S3 | S12 | S4 | S14 | S1 |
| 1120 | - | - | 70.2 b | 109.1 ab | 179.6 c | 117.0 a | 160.6 c |
| - | 280 | 280 | 58.5 b | 89.9 ab | 96.4 a | 131.6 b | 102.7 |
| 1120 | 280 | 280 | 99.7 c | 144.8 c | 192.7 c | 130.7 b | 166.1 c |
| 1120 | 210 | 210 | 94.5 c | 131.6 c | 177.5 c | 129.6 c | 162.6 c |
| 1120 | 140 | 140 | 92.7 c | 125.2 bc | 172.7 bc | 126.1 ab | 185.2 c |
| 1120 | - | 280 | 68.4 b | 127.8 bc | 147.3 b | 114.7 a | 131.3 b |
| Untreated control | | | 24.0 a | 78.7 a | 103.3 a | 121.1 ab | 83.3 a |
| Weeds present ($nos/m^2$ in controls) | | | | | | | |
| Avena fatua | | | 31 | 44 | 19 | - | 42 |
| Polygonum convolvulus | | | - | - | - | - | 91 |
| Capsella bursa-pastoris | | | 44 | 13 | - | 69 | - |
| Chenopodium album | | | 10 | 10 | - | - | - |
| Polygonum scabrum | | | 24 | - | 8 | - | - |
| Stellaria media | | | 28 | - | - | - | - |
| Tripleurospermum maritimum | | | - | 13 | - | - | - |
| Lappula echinata | | | - | - | 10 | - | - |
| Setaria viridis | | | - | - | 54 | - | - |

Means followed by the same letter are not significantly different at the 5% level.

## Table 6

### Control of broad-leaved weeds - U.K. 1975

| Product | Dose g/ha | Mean EWRC scores | | | | |
|---|---|---|---|---|---|---|
| | | Chenopodium album | Polygonum aviculare | Tripleurospermum maritimum | Veronica persica | Viola arvensis |
| ost-emergence | | | | | | |
| Bromoxynil + MCPA | 280 280 | 1.7 | 3.0 | 2.0 | 4.5 | 1.0 |
| Bromoxynil + MCPA + Chlorpropham | 280 280 1120 | 1.0 | 1.3 | 1.0 | 2.3 | 3.0 |
| Bromoxynil + MCPA + Asulam | 280 280 1120 | 1.3 | 4.0 | 1.0 | 6.0 | 4.0 |
| Asulam | 1120 | 6.0 | 8.0 | 5.3 | 2.3 | 5.7 |
| MCPA | 1750 | 4.0 | 3.0 | 4.3 | 1.0 | 2.3 |

Treatments containing asulam had the surfactant "Agral" added to give 0.2% v/v in the final spray.

Table 7

Suffolk. Visual crop effect and % control of wild oat

Yield as % control - U.K. 1975

| Material | Dose g/ha | Crop effect-EWRC score + 8 days | + 22 days | Wild oat % control | Yields as % of control |
|---|---|---|---|---|---|
| Bromoxynil + MCPA + Asulam | 280 280 1120 | 2 | 1.3 | 93 | 135 |
| Bromoxynil + MCPA Asulam + Chlorpropham | 280 280 1120 | 2 | 3.3 | 95 | 127 |
| MCPA + Asulam | 1750 1120 | 4 | 4.4 | 86 | 171 |
| Ioxynil + Bromoxynil + Asulam | 210 210 1120 | 5.3 | 4.7 | 87 | 125 |
| Asulam | 1120 | 1 | 1 | 87 | 194 |
| Control | | | | panicles per $m^2$ 76 | control yield 1.14 tonnes/ ha (9.9 cwt/ac) |
| | | | | growth stage at spraying 2-6 leaves | |

Treatments containing asulam had the surfactant "Agral" added to give 0.2% v/v in the final spray.

Table 8

Visual crop effect (Mean EWRC Scores) and Yield site 2 only)

as percentage of control - U.K. 1975

| Material | Dose g/ha | Mean E.W.R.C. score: Site 1 +19 days | Site 2 +5 days | Site 2 +19 days | Site 4* +8 days | Site 4* +22 days | Site 4* +58 days | Site 2. Weedfree. Yield as % control |
|---|---|---|---|---|---|---|---|---|
| Bromoxynil + MCPA | 280+ 280 | 3.0 | 2.0 | 1.3 | 1.7 | 1.7 | 1.0 | 96 |
| Bromoxynil + Ioxynil + Chlorpropham | 280+ 280+ 1120 | 7.3 | 2.3 | 1.7 | 3.0 | 3.7 | 4.7 | 80 |
| Bromoxynil + MCPA + Asulam | 280+ 280+ 1120 | 3.7 | 1.3 | 1.0 | 1.7 | 2.3 | 1.3 | 82 |
| Asulam | 1120 | 3.3 | 1.7 | 1.0 | 1.0 | 1.7 | 1.0 | 86 |
| MCPA | 1750 | 3.3 | 4.7 | 2.7 | 3.0 | 3.7 | 3.7 | 94 |
| Ioxynil + Bromoxynil | 280+ 280 | - | - | - | 2.3 | 2.7 | 2.7 | control 1.004 tonnes/ha (8.0 cwt/ac) |
| Crop size at spraying | | 15 cm | 15 cm | | 12 cm | | | |

* At site 4, 11.2 kg/ha TCA were applied pre-emergence.
Treatments containing asulam had the surfactant "Agral" added to give 0.2% in the final spray.

## DISCUSSION

The 1:1 mixture of bromoxynil + MCPA esters marketed for cereal weed control in Canada in 1965 effectively controlled broad-leaved weeds in linseed there (Table 1), and was subsequently marketed for this use. The development of asulam for wild oat control in linseed was possible because of the significant increase in wild oat control when a suitable surfactant was added, thus lowering the effective necessary dose of active asulam (Table 2). The addition of MCPA to supplement the limited broad-leaved weed control by asulam, however, did not control the important and widespread polygonaceous weeds, and in consequence mixtures of asulam + surfactant, with bromoxynil/MCPA, were examined (Tables 3, 4 & 5). Results with these mixtures showed excellent control of both wild oat and common annual broad-leaved weeds, with significant yield increases over those from unsprayed controls or from the mixture components used separately. As a result of this work, the mixture of bromoxynil/MCPA with asulam is registered, as are the separate components, with the Federal Government for use in linseed.

The acreage of linseed being grown in the U.K. had markedly increased by 1975, partly because of its possible advantage over spring rape as an oilseed break crop for cereals. Accordingly bromoxynil/MCPA esters, asulam, and mixtures of the two were examined in the U.K. crops at the rates already shown to be suitable in Canada. The formulation of asulam containing surfactant, developed in Canada for wild oat control, was not used; instead commercial asulam plus a commercial wetter were tank mixed. Laboratory tests established that 0.2% of "Agral", the product used, would give equivalent effect to that of the surfactant contained in the Canadian formulation.

The U.K. results, in 1975, confirmed the control, by bromoxynil/MCPA of a range of broad-leaved weeds (Table 6) though weed susceptibilities to this mixture were already well known because of its established use in cereals. Tolerance of linseed to bromoxynil/MCPA, to asulam + surfactant, and to mixtures of the two was satisfactory (Table 8). The crop showed slight signs of wilting a few days after spraying, and this effect was exacerbated by drought stress at site 1: however, the crop recovered from this effect, and there was negligible effect on yield in a weedfree crop. Control of wild oat by asulam + surfactant, was excellent, and dramatic yield increases were obtained by spraying when the wild oat was at the 2-4 leaf stage. The addition of chlorpropham to bromoxynil/MCPA, to give chickweed control, caused unacceptable damage to the crop, as did a mixture of ioxynil + bromoxynil. Crop wilt after 1.75 kg/ha MCPA was much more severe than after bromoxynil/MCPA. Bromoxynil/MCPA, and asulam are both valuable materials for post-emergence weed control in linseed in the U.K.

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# EFFECT OF THE ADDITION OF R-25788 SAFENER TO EPTC FOR THE CONTROL OF AGROPYRON REPENS AND ANNUAL WEEDS IN FORAGE MAIZE. 1974-1976

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Summary The results of experiments carried out over three years with pre-planting incorporated applications of EPTC + R-25788 safener, prior to drilling maize, are reported.

In 1974, 4.6 Kg/ha EPTC gave excellent control of Agropyron repens and annual weeds, but twice this rate showed symptoms of damage to the crop. The addition of 0.4 Kg/ha R-25788 safener gave the maize complete protection from damage by EPTC @ 4.6 Kg/ha, and 0.8 Kg/ha R-25788 safener allowed EPTC @ 9.2 Kg/ha to be applied without any crop damage. R-25788 did not effect the degree or range of weed control.

In 1975 and 1976 4.6 Kg/ha EPTC with 0.4 Kg/ha R-25788 formulated by Stauffer Chemical Company as 'Eradicane' (R) gave excellent control of Agropyron repens and annual weeds resulting in substantially increased crop yield. No crop damage was recorded from this mixture.

The preparation of a deep seed bed is shown to be necessary in order to obtain satisfactory crop emergence and efficient herbicidal activity. An average yield increase of 18.7 t/ha from the EPTC + R-25788 mixture resulted.

## INTRODUCTION

The dry 1976 growing season has highlighted the need for the British live-stock farmer to supplement his grass with a more drought resistance forage crop. Maize, which is rich in starch, is ideal for this purpose and it has now become increasingly important as an alternative to grass with concentrates, for winter feeding of livestock. Traditional maize varieties were poorly suited to the UK since insufficient hours of sunshine were frequently received to allow full ripening. However, plant breeders are now producing maize varieties specifically designed for UK conditions, which together with the greater mechanisation of the crop, has resulted in forage maize becoming a permanent feature of many rotations.

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Atrazine has been used for weed control in maize for many years, but at the recommended rates (4.5 Kg/ha applied twice) to give control of Agropyron repens, toxic residues are left in the soil which may prevent any crop except maize being grown in the 18 months following the second application. This practice upsets the farm rotation, and, combined with the wide rows necessary with maize, allows the build up of troublesome perennial weeds in addition to soil pests and diseases, such as Fusarium stalk rot. Furthermore, in the event of very wet autumns, harvesting may leave the land in poor condition with a loss of structure and this may extend over two years before normal winter cultivations can improve the situation. There is therefore, a need for a herbicide capable of giving good control of Agropyron repens in maize, without leaving toxic residues.

EPTC as "Eptam" (R) has been used for many years to control Agropyron repens and annual weeds in potatoes. The material is volatile and must be incorporated into the soil prior to planting, but gives very effective control of the weeds. EPTC remains effective for 9-10 weeks, by which time the crop should have formed a canopy, before it is degraded leaving no toxic residues to the following crop. Its use in other crops has been limited since few will tolerate the rates of application necessary for acceptable weed control. One such crop is maize which is severely stunted by EPTC at rates above 4.0 Kg/ha. In recent years, however, materials have emerged which can protect maize from this EPTC damage.

In 1969 Hoffman reported that a seed treatment of 1,8 Naphthalic anhydride can protect maize from EPTC damage. However in 1970 Stauffer Chemical Company discovered a more effective safener. This material, coded R-25788, (N,N-diallyl-dichloroacetamide) was shown to perform equally well as a seed treatment or when combined with EPTC and incorporated into soil. Workers in Canada found that R-25788 also reduced the phytotoxicity of several herbicides, especially barban, sulfallate and alachlor, proving that the protective action was not confined to EPTC or to the thiocarbamate group of herbicides. (Chang, Bandeen and Stevenson 1973).

Although early work suggested that R-25788 acts by preventing root uptake of EPTC, more recent work has shown these findings to be incorrect. Instead the safener appears to interfere with the metabolism of EPTC. Lay, Hubbell and Casida (1975) found that when EPTC is taken up by maize roots, it is initially oxidised to form thiocarbamate sulphoxides. In the absence of a safener, these sulphoxides take part in further metabolic reactions which lead to inhibition of plant growth, e.g. they may break down co enzyme A which plays an important role in the synthesis of fatty acids. However, Lay et Al noted that R-25788 increased considerably the levels of glutathione and glutathione S-transferase in maize seedlings. The increased amounts of these materials, they concluded, play a major role in protecting maize from EPTC damage, since they readily react with thiocarbamate sulphoxides, converting them to non-damaging metabolites.

This paper describes trials carried out during 1974-76 to evaluate EPTC + R-25788 for the control of Agropyron repens and annual weeds in maize in the UK.

## METHOD AND MATERIALS

The herbicide formulation used in all experiments described was 4.6 Kg EPTC + 0.4 Kg R-25788 per 6.3 l/ha, formulated by Stauffer Chemical Company as an emulsifiable concentrate under the trade name 'Eradicane'.

All trials were carried out on commercial crops and contained 3 or 4 replicates designed in randomised blocks. Plots were 4.6 x 7.3 m and the treatments were applied using an Oxford Precision Sprayer fitted with Allman '00' jets, spraying

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at 2.1 bars and travelling at 3.2 km/hr. Water volume was 225 l/ha throughout and all treatments were incorporated within 10 minutes of spraying by a tractor mounted Howard Rotavator 150 cm wide, set to a working depth of 10 cm.

There was no commercial comparison made as the only recommended alternative treatment is atrazine @ 4.5 Kg/ha applied twice, and the co-operating farmers were unable to fit a second maize crop (to clear atrazine residues) into their rotations. Other site details are given in Table 1.

The emergence assessments were made by counting emerged plants along 5 x 0.9 m lengths of row per plot. These results were averaged and are presented as thousands of plants per hectare (000's/ha).

Vigour was assessed on a 0-10 visual scoring scale, where 0 = dead and 10 denotes the absence of any phytotoxic symptoms.

Yield was obtained from weighing whole plants cut at ground level from 2 x 2.7 m strips of row per plot. No attempt was made to separate green matter from the cobs. Weights were averaged and are presented in tonnes per hectare (t/ha).

Agropyron repens and annual weed control were both assessed on 0-10 visual scoring scales, where 0 = no control compared to the untreated areas, and 10 denotes the absence of the weed from the treatment.

Table 1

Site Details

1974

| Trial Reference | A | B | C | D |
|---|---|---|---|---|
| Location | Chigwell, Essex | Fyfield, Essex | Bungay, Suffolk | Southwold, Suffolk |
| Soil type | Heavy loam | Heavy loam | Light loam | Light loam |
| Crop variety | DeKalb 202 | DeKalb 202 | Fronica | Caldera 535 |
| No. replicates | 4 | 4 | 4 | 4 |
| Spraying date | 6/5/74 | 7/5/74 | 14/5/74 | 14/5/74 |
| Drilling date | 7/5/74 | 15/5/74 | 15/5/74 | 18/5/74 |
| Weed spectrum in order of importance | Agropyron repens<br>Polygonum persicaria<br>Chenopodium album<br>Polygonum convolvulus | Convolvulus arvensis<br>Polygonum convolvulus<br>Sinapis arvensis | Urtica dioica<br>Solanum nigrum | Agropyron repens<br>Chenopodium album |
| Date of weed assessment | 14/6/74 | 14/6/74 | 11/6/74 | 4/7/74 |
| Date of harvest | Not harvested | 18/10/74 | 17/10/74 | 17/10/74 |

1975

| Trial Ref. | E | F | G |
| --- | --- | --- | --- |
| Location | Towcester, Northants | North Walsham, Norfolk | Bawdeswell, Norfolk |
| Soil type | Clay | Fine sandy loam | Coarse sandy loam |
| Crop variety | DeKalb 202 | Caldera 535 | Caldera 535 |
| Spraying date | 7/5/75 | 16/5/75 | 23/5/75 |
| Drilling date | 21/5/75 | 16/5/75 | 24/5/75 |
| Weed spectrum | Agropyron repens<br>Polygonum convolvulus<br>Polygonum arvensis<br>Stellaria media<br>Poa annua | Brassica nigra<br>Fumaria officinalis<br>Polygonum convolvulus<br>Chenopodium album<br>Agropyron repens<br>Capsella bursa-pastoris | Agropyron repens<br>Chenopodium album<br>Solanum nigrum<br>Matricaria matricarioides<br>Polygonum arvensis<br>Polygonum persicaria |
| Date of weed assessment | 11/7/75 | 1/7/75 | 1/7/75 |
| Date of harvest | 3/10/75 | 13/10/75 | 6/10/75 |

1976

| Trial Ref. | H | J | K |
| --- | --- | --- | --- |
| Location | Towcester, Northants | Icklingham, Suffolk | Bawdeswell, Norfolk |
| Soil type | Clay loam | Loamy fine sand | Coarse sandy loam |
| Crop variety | DeKalb 202 | Caldera 535 | Caldera 535 |
| Spraying date | 7/5/76 | 17/5/76 | 19/5/76 |
| Drilling date | | 18/5/76 | 24/5/76 |
| Weed spectrum in order of importance | Agropyron repens<br>Convolvulus arvensis | Reseda lutea<br>Agropyron repens<br>Solanum nigrum<br>Polygonum convolvulus | Agropyron repens<br>Chenopodium album |
| Date of weed assessment | 25/6/76 | 18/6/76 | 24/6/76 |
| Date of harvest | 10/9/76 | 16/9/76 | Not yet harvested |

## RESULTS

The effects of treatment on crop emergence, vigour and yield are given in Table 2, for the years 1974, 5 and 6. The control of Agropyron repens and annual weeds are recorded in Table 3.

### Emergence and Vigour

In 1974 none of the treatments had any effect upon emergence, but the beneficial effect of the safener R-25788 on crop vigour was clearly apparent, in spite of the dry conditions. These conditions made it very difficult for farmers on heavy soils to achieve a good seed bed, and this is reflected in the low emergence figures quoted for sites A and B. In 1975, these conditions were repeated, and again a heavy soil (site E) proved difficult to work without losing excessive amounts of moisture, and eventually gave a low crop emergence. Site H may well have given a similar low emergence in 1976, had it not been for thundery rain falling soon after drilling.

The low emergence on the heavy soil sites was never compensated in either 1974 or 1975 by subsequent growth, again due to the dry conditions. Vigour was reduced and finally a poor yield was obtained from these sites, (Site A was never harvested due to the stunted, patchy crop). This was a reflection of the growth of these particular crops and no correlation could be established between chemical treatment and crop health.

### Yield

It became evident during the years over which these trials were conducted that yield was found to be largely dependant on two factors;

1. The provision of good conditions for germination and early crop growth.
2. The maintenance of a weed free crop during the first 10-12 weeks of growth.

However these two factors were found to be inter-related, each acting as a major constraint under certain conditions (see Table 4).

Where the seedbed was good, moist and fine, yield was substantially increased by the excellent control of Agropyron repens and annual weeds given by EPTC + R-25788. However, where poor dry and cloddy seed beds were produced, yield from all treatments was found to be reduced roughly to the level of untreated areas i.e. weed control had little effect and the condition of the seed bed was the most important factor in determining final yield.

Table 4
The effect of the seed bed condition on the interaction between crop emergence, yield and weed control

| | Untreated | EPTC @ 4.6 Kg/ha + R-25788 @ 0.4 Kg/ha | Untreated | EPTC @ 4.6 Kg/ha + R-25788 @ 0.4Kg/ha |
|---|---|---|---|---|
| Average Emergence 000's/ha | 102.3 | 110.1 | 50.1 | 43.9 |
| Average Yield t/ha | 23.5 | 42.2 | 32.2 | 32.9 |
| Couch control | 0 | 9.0 | 0 | 7.6 |

Table 2

The effect of EPTC ± R-25788 on the Emergence, Vigour and Yield of maize

| 1974 | Site | A | | B | | C | | D | |
|---|---|---|---|---|---|---|---|---|---|
| Herbicide | Dose Kg/ha | Emergence 000's/ha | Vigour | Emergence 000's/ha | Vigour | Emergence 000's/ha | Vigour | Emergence 000's/ha | Vigour |
| Nil | - | 37.6 | 6.5 | 73.6 | 8.8 | 114.9 | 10.0 | 96.9 | 10.0 |
| EPTC | 4.6 | 41.3 | 7.0 | 55.6 | 7.0 | 109.5 | 9.0 | 111.2 | 7.8 |
| EPTC | 9.2 | 32.4 | 7.8 | 60.0 | 6.0 | 107.7 | 7.0 | 79.8 | 4.0 |
| EPTC + R-25788 | 4.6 0.4 | 34.1 | 7.5 | 69.9 | 7.5 | 109.5 | 10.0 | 86.0 | 10.0 |
| EPTC + R-25788 | 9.2 0.8 | 43.0 | 8.3 | 68.2 | 7.0 | 105.8 | 10.0 | 91.4 | 10.0 |

| 1975 | Site | E | | F | | G | |
|---|---|---|---|---|---|---|---|
| Herbicide | Dose Kg/ha | Emergence 000's/ha | Vigour | Emergence 000's/ha | Vigour | Emergence 000's/ha | Vigour |
| Nil | - | 39.2 | 10.0 | 89.9 | 10.0 | 86.2 | 10.0 |
| EPTC + R-25788 | 4.6 0.4 | 27.7 | 7.7 | 94.4 | 10.0 | 101.6 | 10.0 |
| EPTC + R-25788 | 9.2 0.8 | 31.6 | 9.0 | 89.9 | 10.0 | 103.3 | 10.0 |

| 1976 | Site | H | | I | | K | |
|---|---|---|---|---|---|---|---|
| Herbicide | Dose Kg/ha | Emergence 000's/ha | Vigour | Emergence 000's/ha | Vigour | Emergence 000's/ha | Vigour |
| Nil | - | 131.0 | 5.0 | 79.3 | 5.7 | 117.6 | 8.0 |
| EPTC + R-25788 | 4.6 0.4 | 111.9 | 8.0 | 101.3 | 9.3 | 132.0 | 9.0 |
| EPTC + R-25788 | 9.2 0.8 | 121.6 | 7.3 | 91.9 | 10.0 | 124.3 | 8.3 |

Table 3
The effect of EPTC ± R-25788 on
control of Agropyron repens and Annual Weeds

1974

| Herbicide | Dose Kg/ha | Yield t/ha A | Yield t/ha B | Yield t/ha C | Yield t/ha D | Control of annual weeds A | B | C | D | Control of Agropyron repens A | B | C | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nil | - | | 43.3 | 48.3 | 20.5 | 0 | 0 | 0 | 0 | C | - | - | 0 |
| EPTC | 4.6 | | 38.3 | 60.3 | 50.5 | 4.0 | 4.3 | 10.0 | 10.0 | 8.0 | - | - | 9.8 |
| EPTC | 9.2 | | 39.3 | 53.0 | 28.8 | 7.7 | 5.7 | 10.0 | 10.0 | 9.5 | - | - | 10.0 |
| EPTC + R-25788 | 4.6 0.4 | | 42.8 | 63.0 | 50.5 | 4.5 | 3.7 | 10.0 | 10.0 | 8.5 | - | - | 10.0 |
| EPTC + R-25788 | 9.2 0.8 | | 37.0 | 61.0 | 61.3 | 7.9 | 5.0 | 10.0 | 10.0 | 9.3 | - | - | 10.0 |

1975

| Herbicide | Dose Kg/ha | Yield t/ha E | Yield t/ha F | Yield t/ha G | Control of annual weeds E | F | G | Control of Agropyron repens E | F | G |
|---|---|---|---|---|---|---|---|---|---|---|
| Nil | - | 21.0 | 16.0 | 26.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| EPTC + R-25788 | 4.6 0.4 | 23.0 | 36.5 | 51.5 | 9.4 | 9.8 | 8.5 | 6.7 | 9.3 | 10.1 |
| EPTC + R-25788 | 9.2 0.8 | 18.5 | 38.0 | 53.0 | 9.4 | 10.0 | 9.5 | 9.3 | 9.7 | 10.0 |

1976

| Herbicide | Dose Kg/ha | Yield t/ha H | Yield t/ha J | Yield t/ha K | Control of annual weeds H | J | K | Control of Agropyron repens H | J | K |
|---|---|---|---|---|---|---|---|---|---|---|
| Nil | - | 13.8 | 15.8 | | - | 0 | 0 | 0 | 0 | 0 |
| EPTC + R-25788 | 4.6 0.4 | 30.1 | 21.6 | - | - | 9.3 | 10.0 | 7.3 | 8.3 | 9.3 |
| EPTC + R-25788 | 9.2 0.8 | 29.5 | 26.4 | - | - | 9.8 | 10.0 | 9.3 | 8.3 | 9.3 |

### Annual Weed Control

Good control of annual weeds was obtained in 1974 except where resistant weeds were encountered. At site C heavy infestations of Urtica dioica and Solanum nigrum were well controlled by EPTC + R-25788.

In 1975 the herbicide/safener combinations gave good control of annual weeds at both light soil type sites F, and G.

This patternwas repeated in 1976 on the two sites where annual weeds occurred.

### Perennial Grass Weed Control

Agropyron repens was well controlled by EPTC @ 4.6 Kg/ha ± R-25788 @ 0.4 Kg/ha. In poor seed beds, inefficient incorporation reduced control to 76%, although where a good tilth was obtained the complete mixing of the herbicide in the top 10-12.5 cm of soil increased the control to 90% as shown in Table 4. This indicates that where EPTC + R-25788 was incorporated into reasonably good seed beds 4.6 Kg/ha + 0.4 Kg/ha respectively, was close to being an optimum dose.

## DISCUSSION

The discovery of R-25788 by the Stauffer Chemical Company has, for the first time resulted in a safener being used commercially to prevent herbicide damage. This concept could open a new avenue to research workers and provide more specific herbicide/safener mixtures in the future. The above trials in 1975-76 confirmed the safety of the EPTC + R-25788 mixture to maize (forage and grain) and sweetcorn, and proved that weed species that had been previously shown to be susceptible to EPTC were also equally susceptible to EPTC + R-25788 i.e. no susceptible weed species has been protected from ETPC by the safener effect of R-25788.

As with all soil incorporated chemicals, thorough mixing between the chemical and soil recommended by the manufacturer is essential for good weed control. The tools most suited to the incorporation of EPTC +R-25788 are the rotary cultivator and tandem disc harrows.


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# WEED CONTROL AND YIELD RESPONSE IN WINTER RAPE WITH CARBETAMIDE AND DIMEFURON

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Summary 2:1 and 3:1 ratio mixtures of carbetamide with 0.75 kg a.i./ha dimefuron have been evaluated as post-emergence treatments in both replicated and user trials in winter oil-seed rape. Excellent crop tolerance, yield responses and annual broad-leaved weed control, including *Lamium* spp., mayweeds, *Stellaria media* and *Veronica* spp., have been achieved with both mixtures. Control of annual grass weeds has, however, been more reliable with the higher rate of carbetamide (2.25 kg a.i./ha).

Résumé Les associations de 0.75 kg m.a./ha dimefuron + 1.5 kg m.a./ha carbetamide et de 0.75 kg m.a./ha dimefuron + 2.25 m.a./ha carbetamide étaient utilisées en post-levée sur le colza d'hiver dans des essais repliqués et en plein champs. La culture supportait tres bien les traitiments, les rendements augmentaient, et *Lamium* spp, les matricaires, *Stellaria media* et *Veronica* spp et des autres adventices dicotyledonés annuelles étaient tres sensibles.

L'efficacité herbicide sur les graminées annuelles était plus sûr à la dose élevée de la carbetamide (2.25 kg m.a./ha).

## INTRODUCTION

Since the publication on the herbicidal activity and tolerance of carbetamide/ dimefuron mixtures in winter rape (Burgaud et al, 1974), several series of experiments have been undertaken to evaluate the potential of such mixtures under U.K. conditions. This paper is concerned with the latter stages of development of a post-emergence formulation of the mixture to complement the use of carbetamide in winter rape.

## METHODS AND MATERIALS

This work was initiated in the winter of 1974/75, when 8 replicated experiments were laid down in commercial crops, to compare the activity and tolerance of a 2:1 ratio wettable powder formulation to carbetamide/dimefuron (1.5 + 0.75 kg a.i./ha respectively) with similar formulations of either carbetamide (2.1 kg a.i./ha) or propyzamide (0.7 kg a.i./ha) alone, together with an unsprayed control. The plots were 4 x 50 m in size, duplicated and the volume rate using the 'Colwood' small plot sprayer was 411 litres/ha. Owing to extremely wet weather, spraying could not be started until early December 1974 and spraying of sites continued, as and when possible, until mid-January 1975.

As a result of the above tests, it was decided that for reliability, dimefuron (0.75 kg a.i./ha) should be considered as an additive to somewhere near the full commercial dose of carbetamide alone (2.1 kg a.i./ha). A 3:1 ratio wettable powder formulation (applying 2.25 + 0.75 kg a.i.) was, therefore, included in a series of 18 user trials laid down in the late autumn of 1975. In these tests, this higher ratio formulation was compared with the original 2:1 ratio, carbetamide alone and the co-operating farmer's own standard, if different. Plots were unreplicated, ranged from 1.0 to 2.5 ha in size and were sprayed with farmers' own equipment. Volume rate ranged from 200 - 500 litres/ha. With one exception (mid-January), time of application range from mid-October to mid-December. 15 of these sites were taken through to harvest.

In all the above work, yield determinations have been made by using the farmer's own equipment both to cut and thresh conditioned swaths. All weed assessments have been made using quadrats of 0.5 $m^2$, counting weed numbers and employing the proposed EWRC scoring system to record crop condition.

## RESULTS

Tables 1 and 2 summarise the results of the 1974/75 experiments, tables 3 and 4 the user trials in 1975/76. Collectively they give a clear picture of the advantage to be gained from adding dimefuron to carbetamide. In none of the work undertaken with such mixtures has any sign of intolerance been observed in treated crops.

TABLE 1 - PERCENTAGE CONTROL OF WEED NOS. IN REPLICATED TRIALS - 1974/75

| | HERBICIDE DOSE a.i./ha | | | | | |
|---|---|---|---|---|---|---|
| Species | Carbetamide 2.1 kg mean % control (No. of sites) | Range % Control | Carbetamide + Dimefuron 1.5+0.75 kg mean % control (No. of sites) | Range % Control | Propyzamide 0.7 kg mean % control (No. of sites) | Range % Control |
| Volunteer barley | 100 (2) | 100 | 100 (2) | 100 | 98.7 (2) | 95-100 |
| Alopecurus myosuroides | 97.9 (3) | 82-100 | 87.5 (3) | 73-100 | 100 (3) | 100 |
| Poa spp | 95.3 (6) | 70-100 | 87.2 (6) | 20-100 | 96.3 (6) | 54-100 |
| Stellaria media | 73.0 (7) | 56-100 | 95.3 (7) | 87-100 | 89.6 (7) | 52-100 |
| Tripleurospermum maritimum ssp inodora | 19.4 (4) | 0-84 | 83.3 (4) | 53-100 | 8.2 (4) | 0-32 |
| Veronica spp | 50.0 (2) | 0-100 | 99.5 (2) | 98-100 | 98.2 (2) | 93-100 |
| Cerastium vulgatum | 100 (1) | 100 | 100 (1) | 100 | 100 (1) | 100 |
| Myosotis arvensis | 70.0 (1) | 70 | 84.0 (1) | 84 | 73.0 (1) | 73 |
| Lamium purpureum | 3.0 (1) | 3 | 100 (1) | 100 | 14.0 (1) | 14 |

Figures for weed control were obtained from transformed (angular transformation) percentages and then de-transformed to obtain the mean values indicated in the table.

TABLE 2 - YIELDS OF CLEANED SEED AS PERCENTAGE OF UNSPRAYED CONTROL - REPLICATED TRIALS 1974/75
(Highest yield at each site underlined)

| Location | Variety | HERBICIDE DOSE kg a.i./ha<br>Propyzamide 0.7 | Carbetamide + Dimefuron 1.5 + 0.75 (2:1 ratio) | Carbetamide 2.1 | Unsprayed Control (Yield tonnes/ha = 100) | Statistical significance | Major Weeds Nos/m$^2$ at spraying |
|---|---|---|---|---|---|---|---|
| Hambledon, Hants | Rapol | 107.0 | 123.0 | 126.0 | 2.37 | N.S. | Alopecurus myosuroides (150), Myosotis arvensis (19) |
| Ham Street, Kent | Sollerngold | 106.0 | 138.0* | 94.0 | 1.53 | 0.05 | Stellaria media (20), Tripleurospermum maritimum (19) |
| Cottisford, Bucks | Rapora | 168.3 | 191.4 | 160.5 | 1.86 | - | Lamium purpureum (58) Veronica spp (29) |
| Stratton Audley, Oxon | Primor | 118.0 | 119.0 | 130.0 | 2.85 | N.S. | Alopecurus myosuroides (33) |
| Wollaston, Northants | Rapol | 239.6*** | 210.7*** | 221.5*** | 1.24 | .001 | V. Barley (137), T. maritimum (122) |
| Sherston, Wilts (A) | Victor | 309.0** | 314.0** | 299.0*** | 1.08 | .01 | S. media (24), Poa spp (150) |
| Sherston, Wilts (b) | Victor | 295.0 | 298.0 | 268.0 | 0.88 | N.S. | Poa spp (50) A. myosuroides (140), V. Barley (31) |
| Bubbenhall, Warws. | Lesira | 122.9 | 1128.4 | 92.3 | 2.16 | N.S. | S. media (12), Poa spp (125), V. Barley (30), T. maritimum (16) |

*** Statistically significant difference from control at 0.1% level
** " " " " " " 1% "
* " " " " " " 5% "

TABLE 3 - PERCENTAGE CONTROL OF WEEDS NOS. - USER TRIALS - 1975/76

HERBICIDE DOSE a.i./ha

| Species | Carbetamide 2.1 kg mean % control (No.of sites) | Range % Control | Carbetamide + Dimefuron 1.5 + 0.75 kg mean % control (No.of sites) | Range % Control | Carbetamide + Dimefuron 2.25 + 0.75 kg mean % control (No.of sites) | Range % Control | Propyzamide 0.7 kg mean % control (No.of sites) | Range % Control |
|---|---|---|---|---|---|---|---|---|
| Volunteer Barley | 99.9 (16) | 89-100 | 99.5 (16) | 52-100 | 99.9 (16) | 83-100 | 100 (5) | 100 |
| Volunteer Wheat | 98.6 ( 6) | 82-100 | 100 ( 5) | 100 | 100 ( 6) | 100 | - | - |
| Avena spp | 99.7 ( 7) | 87-100 | 99.8 ( 7) | 89-100 | 99.8 ( 7) | 96-100 | 100 (1) | 100 |
| Alopecurus myosuroides | 99.8 ( 6) | 98-100 | 98.3 ( 5) | 90-100 | 100 (7) | 100 | 91.0 (1) | 91 |
| Poa spp | 99.9 (12) | 95-100 | 99.8 (12) | 86-100 | 99.8 (12) | 96-100 | 100 (1) | 100 |
| Stellaria media | 40.1 (19) | 0-100 | 97.5 (17) | 75-100 | 98.4 (18) | 59-100 | 94.5 (5) | 77-100 |
| Matricaria, Tripleurospermum + Anthemis spp | 32.9 (12) | 0-97 | 91.1 (12) | 74-100 | 96.2 (12) | 84-100 | 0 (1) | 0 |
| Veronica spp | 41.5 ( 8) | 0-100 | 99.9 ( 8) | 94-100 | 99.6 ( 8) | 94-100 | - | - |
| Lamium spp | 0.8 ( 2) | 0-7 | 100 ( 3) | 100 | 100 ( 3) | 100 | - | - |
| Aphanes arvensis | 0 ( 1) | 0 | 90.2 ( 2) | 80-97 | 87.1 ( 3) | 50-98 | - | - |
| Myosotis arvensis | 8.8 ( 4) | 0-87 | 70.5 ( 5) | 0-100 | 95.1 ( 5) | 64-100 | 50.0 (2) | 0-100 |
| Spergula arvensis | 100 ( 3) | 100 | 100 ( 3) | 100 | 100 ( 3) | 100 | 100 (2) | 100 |
| Viola spp | 49.5 ( 2) | 49-50 | 35.0 ( 2) | 0-91 | 85.3 ( 2) | 80-90 | - | - |
| Senecio vulgaris | 0 ( 1) | 0 | - | - | 100 ( 1) | 100 | - | - |
| Papaver spp | 68.0 ( 1) | 68 | 70.0 ( 1) | 70 | 92.0 ( 1) | 92 | - | - |
| Fumaria officinalis | 100 ( 2) | 100 | 100 ( 2) | 100 | 100 ( 2) | 100 | - | - |

Figures for weed control were obtained from transformed (angular transformation) percentages and then de-transformed to obtain the mean values indicated in the table.

TABLE 4 - YIELDS OF CLEANED SEED AS PERCENTAGE OF CARBETAMIDE CONTROL - USER TRIALS - 1975/76
(Highest yield at each site underlined)

| Location | Variety | HERBICIDE DOSE kg a.i./ha Propyzamide 0.7 | Carbetamide + Dimefuron 1.5 + 0.75 (2:1 ratio) | Carbetamide + Dimefuron 2.25 + 0.75 (3:1 ratio) | Carbetamide 2.1 (Yield tonnes/ha) = 100 | Major Weeds Nos./m² pre-spraying |
|---|---|---|---|---|---|---|
| Earls Barton Northants (A) | Rapora | 64.1 | 142.2 | 132.8 | 1.41 | V.Barley (53), Poa spp (48), Stellaria media (55), Tripleurospermum maritimum (40) |
| Earls Barton Northants (b) | Rapora | 111.6 | 261.3 | 343.6 | 0.41 | V.Barley (59), Poa spp (51), S.media (66), T.maritimum (68) |
| Turvey Beds | Rapora | - | 110.1 | 112.2 | 2.83 | S.media (87) |
| Preston Deanery Northants | Rapora | 63.9 | 97.1 | 102.0 | 2.11 | V.Barley (44), Alopecurus myosuroides (565) |
| Sutton Cheyney Leics. | Rapora | - | 93.6 | 98.3 | 2.85 | V.Barley (25), Matricaria recutita (ca 3000) |
| Fairford Glos. | Rapora | - | 123.8 | 116.9 | 1.37 | Avena sp (14), S.media (23) |
| Inkpen Berks | (Lear) | - | 106.4 | 80.7 | 1.56 | V.Wheat (20), Avena sp (10), Myosotis arvensis (27) |
| Kelso Roxburgh (A) | (Lear) | 90.2 | 125.5 | 125.5 | 1.70 | Fumaria officinalis (14), S.media (122) Spergula arvensis (18) |
| Kelso Roxburgh (B) | (Lear) | 106.5 | 74.8 | 96.6 | 1.88 | S.media (70) |
| Ormiston E.Lothian | (Lear) | - | 117.9 | 122.0 | 0.89 | Poa spp (444), S.media (300), M.arvensis (60) |
| Sedlescombe Sussex | Rapora | - | 529.0 | 700.6 | 0.19 | V.Wheat (49), T.maritimum (46) |
| Fyfield Essex | Lesira | - | 122.6 | 122.9 | 0.85 | S.media (54), Veronica spp (37), Poa annua (29) |

TABLE 4 (continued)

| Location | Variety | Propyzamide 0.7 | Carbetamide + Dimefuron 1.5 + 0.75 (2:1 ratio) | Carbetamide + Dimefuron 2.25 + 0.75 (3:1 ratio) | Carbetamide 2.1 (Yield tonnes/ha) = 100 | Major weeds Nos./m$^2$ pre-spraying |
|---|---|---|---|---|---|---|
| | | HERBICIDE DOSE kg a.i./ha | | | | |
| Alresford Essex | Rapora | - | 116.6 | 154.9 | 0.75 | V.Barley (20), Avena spp (26), Poa spp (40), S.media (17), Veronica persica (49), T.maritimum (149). |
| Rochford Essex | Lesira | - | - | 118.8 | 1.1 | V.Wheat (186), A.myosuroides (128), M.recutita (60) |
| Tonbridge Kent | Primor | - | 174.4 | 171.1 | 1.8 | Avena sp. (22), S.media (167), T.maritimum (430) |
| | Mean yield (tonnes/ha) of 5 propyzamide sites | 1.25 | 1.70 | 1.87 | 1.50 | |
| | S.E. | 0.264 | 0.220 | 0.135 | 0.296 | |
| | Mean yield (tonnes/ha) of all sites (14) except Rochford | - | 1.78 | 1.85 | 1.47 | |
| | S.E. | - | 0.208 | 0.272 | 0.216 | |

## DISCUSSION

Although due to the almost continuous wet weather, spraying of the replicated sites in 1974/75 was carried out very much later than optimum, the results obtained clearly endorse the potential benefit of adding dimefuron to carbetamide.

The level of grass weed control (particularly of Alopecurus myosuroides, and Poa spp.) obtained with the 2:1 mixture in these earlier tests invariably compared unfavourably with that obtained with the higher, commercially recommended rate of carbetamide alone, or propyzamide (see range of % control - table 1). Although not necessarily reducing ultimate yield, the overall grass weed control of plots treated with the 2:1 mixture appeared unsatisfactory for commercial practice. However, the effect on the commoner broad-leaved weeds encountered (notably Stellaria media, Tripleurospermum maritimum spp. inodorum and Veronica spp.) was often dramatic as both levels of control and yield responses indicate (see tables 1 and 2).

Under the lower rainfall conditions encountered in the user trial programme of 1975/76, the 2:1 mixture proved more reliable on grass weeds than in the previous year. It still, however, appeared somewhat inadequate under conditions of heavy grass infestation, though again, not necessarily incurring any yield penalty as a result. The percentage weed control and yield responses obtained with the 3:1 mixture more than justified its inclusion as an additional test treatment - the extra carbetamide providing the reliability required on the whole range of common annual grass weeds likely to be encountered in winter rape crops in the U.K. (volunteer cereals, A. myosuroides, Avena spp. and Poa spp. - see table 3 for details). The results suggest that this higher ratio mixture should prove extremely reliable as a post-emergence, broad-spectrum herbicide in commercial practice enabling users to control Lamium spp., mayweeds, and Veronica spp. relatively common weeds outside the scope of existing commercial standards. Although the extremely dry conditions have probably done much to blunt the competitive edge of surviving weed spp. in the 1975/76 programme, the yield responses obtained at Earls Barton, Sedlescombe and Tonbridge suggest that under conditions in that season, T. maritimum spp. inodorum was more competitive than other broad-leaved weeds.

Bioassay of soils taken from 13 sites showed that, at all but one with a very low pH, residues of carbetamide/dimefuron lost 80% of their biological activity by rape harvest. Herbicide residues, therefore, offered no hazard to the subsequent cereal crop even under the dry conditions encountered.

Although commercial availability of the 3:1 mixture will considerably expand the spectrum of broad-leaved weeds that may be controlled in winter rape, it shares what is, perhaps, the major disadvantage of all currently available post-emergence herbicides for use in this crop, namely slowness of action on annual grass weeds. It is considered that our present inability to deal speedily with heavy infestations of volunteer cereals (arising from combine straw trials) or A. myosuroides remains one of the major obstacles in the successful establishment of winter rape on many farms. Preliminary work using post-sowing, pre-emergence applications of 4:1 ratio mixtures of carbetamide/dimefuron (up to 2.0 + 0.5 kg a.i./ha respectively) has suggested a possible way of overcoming this problem.

## CONCLUSIONS

In practice the reliable ratio for the post-emergence control of overwintering weeds of oil seed rape in the U.K. with carbetamide/dimefuron mixtures is 3:1. At 0.75 kg a.i./ha dimefuron appears capable of giving reliable control of most of the commoner broad-leaved weeds normally associated with this crop.

## Acknowledgements

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# TERBACIL AS A RESIDUAL HERBICIDE FOR MENTHA SPICATA

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Summary Between 1968 and 1971 experiments were conducted on commercial spearmint beds with terbacil at different rates and in combination with other herbicides. 1.25 kg/ha may be applied to the dormant bed in mid-winter; after summer cuts of mint the rate should be restricted to 0.5 kg/ha, or lenacil may replace it @ 1.25 kg/ha. Paraquat, @ 0.5 kg/ha, may also be used in combination with terbacil.

Résumé Entre 1968 et 1971, on a fait des expériments sur des planches de menthe crépue de commerce, avec du terbacil à raisons variés et en combinaison avec des autres herbicides. 1.25 kg/ha peut être appliqué à la planche dormante au milieu de l'hiver; aprés qu'on a coupé la menthe en l'été on doit limiter la raison à 0.5 kg/ha, où on peut le remplacer avec du lenacil à 1.25 kg/ha. On peut aussi utiliser du paraquat à 0.5 kg/ha en combinaison avec du terbacil.

## INTRODUCTION

Mentha spicata (var. Brundall) is grown to provide green leaf for mint sauce production, and as such the crop has to be completely free of weeds; residual herbicides provide a useful supplement to handweeding (Daniel 1964) and with the introduction of terbacil it has been possible particularly to eliminate grasses from mint beds, and thus considerably extend the production life of mint.

Experiments with terbacil covered the period from 1968 to 1971, and were conducted at a number of sites in commercial crops in Norfolk.

## METHODS & MATERIALS

For testing application rates of terbacil (1968 only) 0.001 ha (5m x 2m) plots were used, replicated four times at each of four sites. Herbicide was applied in 1 l of water from a Dorman 'Osprey' handlance pressurized by propane. Combinations of treatments (1969 - 71) were tested on a larger scale, with main-plot dimensions 20m x 2m, and treatments applied from a 100 l sprayer fitted to a Mayfield tractor. Sub-plot treatments were applied with the Dorman 'Osprey' sprayer.

1968 Terbacil was tested at four sites, at three rates, 1.75, 1.25 and 0.50 kg/ha, applied once or three times during the season. Results are shown in Table I.

1969 At three sites:

| I | II |
|---|---|
| Terbacil @ 1.25 kg/ha in January | No winter herbicide |
| March application, for first period of growth | Combinations of treatments for three summer growth periods, applied March, June, August: |
| A Lenacil @ 1.25 kg/ha | AAA |
| B Terbacil @ 0.5 " | ABB |
| C " @ 1.0 " | BBB |
| D " @ 1.5 " | DBB |
| E Nil | EEE |

Results are shown in Table 2.

1970 Observation study at one site of interaction of terbacil and lenacil.

S Terbacil @ 1.5 kg/ha
O No terbacil

M Lenacil @ 1.5 kg/ha in March
J " " " June

Results are shown in Table 3.

1971 A single trial was designed to study the interaction of terbacil and paraquat. The crop was sprayed with paraquat @ 0.5 kg/ha and terbacil @ 1.25 kg/ha in January.

Summer treatments were:

Terbacil @ 0.5 kg/ha after 1st cut (June) in split plots with

G0 No paraquat during summer
G1 Paraquat @ 0.5 kg/ha after 1st cut
G2 " " " " 2nd cut

Results are shown in Table 4.

## DISCUSSION

The results in 1968 (Table 1) showed that three seasonal applications of terbacil @ 0.5 kg/ha caused minimal loss of crop yield, with good weed control and no adverse effect on the density of the mint stand. However, considerable weed growth can develop during mild weather in January and February, and in 1969 terbacil was applied as a midwinter treatment, at the higher rate of 1.25 kg/ha to ensure adequate persistency; this was followed in March with lenacil, or terbacil at different rates, and this combination was tested against repeated doses of lenacil/terbacil in the absence of the midwinter treatment (Table 2). While the single midwinter treatment resulted in the highest yield of green mint, the crop had become very weedy by the end of the season, and obviously some application of residuals during summer was desirable; ABB and BBB combinations (Table 2) gave reasonable yields with a very good reduction of weeds. However, the work in 1970 (Table 3) showed that a winter application of terbacil is advisable as it helps to control an early build up of weeds such as groundsel and seedling docks.

Paraquat is useful for eliminating young weeds immediately after cutting mint. Table 4 summarises the final experiment of the series; although the slight setback in killing all mint leaf remaining after a cut reduced the annual yield slightly, the use of paraquat strongly reinforced the residual action of terbacil and kept the crop largely free of weeds for the remainder of the season.


## Acknowledgements

These experiments were conducted on commercial mint beds, and the author acknowledges with thanks the co-operation of growers and the help and advice of the manufacturers of the chemicals used.


## Reference


DANIEL G.H. (1964) Control of annual weeds in spearmint (*Mentha spicata*) *7th Brit. Wd. Control Conf.* Vol. 2. 760-6

Table 1

Effect of different rates of terbacil (1968: four sites)

| Treatments | Green yield t/ha | % mint at end of season | % weeds at end of season |
|---|---|---|---|
| No herbicide | 47.7 | 74 | 26.3 |
| Terbacil (kg/ha) | | | |
| 1.75 in March | 38.4 | 69 | 5.0 |
| " + 2 @ 0.5 | 35.1 | 50 | 0 |
| 1.25 in March | 43.1 | 69 | 3.8 |
| " + 2 @ 0.5 | 31.1 | 54 | 5.0 |
| 0.5 in March | 53.5 | 89 | 7.5 |
| " + 2 @ 0.5 | 43.2 | 70 | 2.0 |
| SE | ± 5.1 | ± 8.7 | ± 5.5 |

Weeds not fully controlled: Senecio vulgaris, Convolvulus arvensis, Ranunculus spp.

Weeds eliminated: Poa spp, Agrostis spp, Agropyron repens, Chenopodium album Urtica urens, Laminum purpureum, Veronica spp.

Table 2

Effect of combinations of terbacil & lenacil (1969 : three sites)

| Treatments | Green yield t/ha | 12 month change in mint stand | % weeds at end of season |
|---|---|---|---|
| I. Terbacil @ 1.25 kg/ha in January | | | |
| March applications: | | | |
| A. Lenacil @ 1.25 kg/ha | 39.8 | -10 | 3.7 |
| B. Terbacil @ 0.5 kg/ha | 43.6 | 0 | 5.0 |
| C. " @ 1.0 " | 39.7 | -20 | 2.7 |
| D. " @ 1.5 " | 39.5 | +3 | 2.7 |
| E. Nil | 48.6 | -2 | 11.7 |
| II. No winter herbicide | | | |
| March/June/August applications: | | | |
| AAA | 37.4 | -2 | 1.0 |
| ABB | 46.4 | -5 | 0.3 |
| BBB | 42.9 | +25 | 2.7 |
| DBB | 41.4 | -2 | 1.7 |
| EEE | 42.8 | +20 (72%) | 8.7 |
| SE | ± 3.5 | - | ± 3.7 |

Weeds surviving ABB: Convolvulus arvensis, Ranunculus repens, Senecio vulgaris.

Weeds eliminated in ABB: Chenopodium album, Poa spp, Agrostis spp. Agropyron repens, Polygonium aviculare, Anthemis cotula, Veronica spp.

Table 3

Effect of combination of terbacil & lenacil (1970 : one site)

| | Terbacil @ 1.25 kg/ha February (S) | | No terbacil (O) | |
|---|---|---|---|---|
| | Lenacil @ 1.25 kg/ha | | | |
| | In March (M) | In June (J) | In March | In June |
| Green yield (t/ha) | 67.0 | 67.4 | 53.7 | 51.9 |
| Mint stand: | | | | |
| % in October | 84 | 84 | 79 | 74 |
| % improvement since May | 21 | 17 | 13 | 21 |

| | Weed species present in October | | | | % weeds in no treatment area |
|---|---|---|---|---|---|
| | SM | SJ | OM | OJ | |
| Ranunculus repens | 0.3 | 0.9 | 0.5 | 0.5 | 8.0 |
| Rumex spp. | 0 | 0.1 | 1.4 | 2.4 | 3.0 |
| Urtica dioecia | 0.3 | 0.4 | 0.9 | 2.8 | 2.0 |
| " urens | 1.8 | 1.5 | 1.7 | 1.7 | 5.0 |
| Senecio vulgaris | 1.7 | 1.6 | 3.5 | 2.3 | 5.0 |
| Stellaria media | 0.1 | 0.1 | 0.1 | 0.5 | 5.0 |
| Veronica spp. | 0 | 0 | 0 | 0 | 1.0 |
| Chenopodium album | 0 | 0 | 0.1 | 0 | 3.0 |
| Grasses: | | | | | |
| Poa spp. | 0 | 0 | 0.6 | 1.0 | 7.0 |
| Agrostis spp. | 0 | 0 | 1.3 | 1.8 | 5.0 |
| Total % weed | 4.2 | 4.6 | 10.1 | 13.0 | 44.0 |

Table 4

Effect of terbacil & paraquat applied after cutting

| | 0.5 kg/ha terbacil overall after 1st cut (May) | | |
|---|---|---|---|
| | No paraquat | Paraquat @ 0.5 kg/ha after 1st cut | after 2nd cut |
| Green yield (t/ha) | 32.7 | 27.3 | 28.6 |
| % mint stand (Oct) | 77 | 72 | 65 |
| % improvement since May | 34 | 25 | 18 |
| Weeds persisting: | | | |
| Senecio vulgaris | 4.0 | 4.3 | 2.0 |
| Potentilla anserina | 3.2 | 0.3 | 0 |
| Stellaria media | 1.0 | 2.0 | 0 |
| Grasses (Annual) | 0 | 1.3 | 0 |
| " (Perennial) | 0 | 0 | 0 |
| Veronica spp. | 0 | 0 | 0 |
| Vicia spp. | 0.2 | 0 | 0.2 |
| Others | 3.3 | 0.3 | 0.2 |
| Total weeds (Oct) | 11.7 | 8.2 | 2.4 |
| % change since May | + 3.3 | - | - 9.3 |

# HERBICIDE TOLERANCE IN LUPINS

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Summary Alternate rows of *Lupinus albus* (cv Kiev mutant) and *Lupinus angustifolius* (cv Unicrop) were established on a light sandy loam and then sprayed overall with a range of twenty nine herbicides and mixtures, largely in the absence of weeds, to assess crop tolerance. In general cv Unicrop was less tolerant than cv Kiev mutant to many herbicides.

The extremely dry spring and summer soil conditions of 1976 may have reduced the activity of the fifteen pre-emergence soil acting herbicides but even so isoproturon, metobromuron, chlorbromuron and atrazine appear to have been very active on both species down to one quarter of the starting dose (ie just below normal dose rate).

Of the post-emergence herbicides the crop appeared to tolerate only metamitron, dinoseb, amine, barban, benzoylprop ethyl and difenzoquat at half the starting rate and below (less than 1.8 times the normal dose rate).

## INTRODUCTION

Interest in the development of the protein and oil potential of the lupin crop for temperate conditions has created a demand for adequate weed control techniques, firstly to allow the crop development to proceed experimentally and secondly for the commercial development of the crop. Little information is available on the tolerance of lupins to the range of herbicides currently available. This pilot investigation was initiated to screen these herbicides for crop tolerance.

## METHODS AND MATERIALS

The crop was sown 25 March 1976 with a precision drill ("Monosem") in 50 cm rows, with seeds 6.5 cm apart in the row. Two species were used in each plot; *L albus* (cv Kiev mutant) and *L. angustifolius* (cv Unicrop) each giving a final plant density of 30 plants/$m^2$.

The starting rates for each herbicide were set at 3 to 4 times the normally recommended levels, with the exception of trifluralin and triallate emulsion, which started at 6 times the recommended level.

Treatments were applied with a modified van de Weij sprayer using Allman '0' jets, spraying 450 l/ha at 2.21 bar.

Trifluralin and triallate emulsion were incorporated pre-sowing.

Visual assessment scores were recorded on each plot, comparing it with an adjacent unsprayed control strip. Assessments were made in three sections, start to ½ dose, ½ dose to ¼ dose and ¼ dose to ⅛ dose.

Rainfall over the period of experiment was, April 21 mm, May 17 mm and June 6.5 mm, less than one third the long term average.

TREATMENTS AND RESULTS

Table 1

Crop Development

| | cv Kiev | cv Unicrop |
|---|---|---|
| First emergence | 6.4.76 | 9.4.76 |
| 50% emergence | 11.4.76 | 18.4.76 |
| Full Flower | 13.6.76 | 15.6.76 |

Table 2

| Treatment | Starting rate a.i. kg/ha | Stage of Crop | Date applied |
|---|---|---|---|
| Trifluralin | 6.72 | Pre Sowing | 24.3.76 |
| Triallate emulsion | 10.4 | " " | " |
| Carbetamide | 3.6 | Pre emergence | 1.4.76 |
| Propyzamide | 1.5 | " " | " |
| Terbutryne + Terbuthyalazine | 3.5 + 1.5 | " " | " |
| Terbutryne | 7.5 | " " | " |
| Prometryne | 5.0 | " " | " |
| Methabenzthiazuron | 9.1 | " " | " |
| Dimefuron | 1.5 | " " | " |
| Linuron | 3.2 | " " | " |
| Simazine | 2.0 | " " | " |
| Isoproturon | 9.5 | " " | " |
| Metobromuron | 6.0 | " " | " |
| Chlorbromuron | 6.0 | " " | " |
| Atrazine | 3.0 | " " | " |
| Metamitron | 14.7 | Post emergence | 17.5.76 |
| Metribuzin | 2.1 | " " | " |
| Asulam | 11.2 | " " | " |
| Dinoseb amine | 2.8 | " " | " |
| Bentazone | 4.8 | " " | " |
| MCPB | 3.2 | " " | " |
| Barban | 1.0 | " " | " |
| Benzoylpropethyl | 3.2 | " " | " |
| Difenzoquat | 3.1 | " " | " |
| Chlorfenpropmethyl + additive | 7.8 + additive | " " | " |
| Bromofenoxin + terbuthyalazine | 0.92 + 0.58 | " " | " |
| HOE 23408 | 3.6 | " " | " |
| Ethofumesate | 4.0 | " " | " |
| Nitrofen | 5.0 | " " | " |

## Table 3

### Crop tolerance to herbicides (Assessed end of June)

| Treatments | *L. albus* cv Kiev mutant | | | *L. angustifolius* cv Unicrop | | |
|---|---|---|---|---|---|---|
| | Start to ½ dose | ½ dose to ¼ dose | ¼ dose to ⅛ dose | Start to ½ dose | ½ to ¼ dose | ¼ to ⅛ dose |
| Trifluralin | 4 | 8 | 9 | 4 | 8 | 9 |
| Triallate Emulsion | 7 | 9 | 9 | 7 | 9 | 9 |
| Carbetamide | 7 | 9 | 9 | 6 | 9 | 9 |
| Propyzamide | 7 | 9 | 9 | 6 | 9 | 9 |
| Terbutryne + Terbuthyalazine | 7 | 9 | 9 | 7 | 8 | 9 |
| Terbutryne | 6 | 8 | 9 | 6 | 8 | 9 |
| Prometryne | 6 | 9 | 9 | 6 | 8 | 9 |
| Methabenzthiazuron | 7 | 8 | 9 | 6 | 8 | 9 |
| Dimefuron | 5 | 8 | 9 | 4 | 7 | 9 |
| Linuron | 7 | 8 | 9 | 6 | 7 | 9 |
| Simazine | 6 | 8 | 9 | 5 | 7 | 9 |
| Isoproturon | 4 | 7 | 9 | 4 | 7 | 9 |
| Metobromuron | 4 | 7 | 9 | 4 | 6 | 8 |
| Chlorbromuron | 5 | 7 | 9 | 4 | 6 | 8 |
| Atrazine | 5 | 7 | 9 | 3 | 5 | 7 |
| Metamitron | 4 | 6 | 8 | 4 | 6 | 8 |
| Metribuzin | 3 | 4 | 5 | 1 | 1 | 2 |
| Asulam | 2 | 3 | 4 | 1 | 2 | 4 |
| Dinozeb Amine | 6 | 7 | 8 | 6 | 7 | 8 |
| Bentazone | 0 | 0 | 1 | 0 | 0 | 1 |
| MCPB | 0 | 2 | 4 | 0 | 2 | 3 |
| Barban | 7 | 8 | 9 | 7 | 8 | 9 |
| Benzoylprop Ethyl | 8 | 8 | 9 | 8 | 8 | 9 |
| Difenzoquat | 6 | 8 | 9 | 4 | 6 | 8 |
| Chlorfenprop Methyl + additive | 3 | 4 | 6 | 2 | 4 | 5 |
| Bromofenoxin + Terbuthyalazine | 3 | 5 | 7 | 0 | 0 | 6 |
| HOE 23408 | 5 | 7 | 9 | 4 | 5 | 8 |
| Ethofumesate | 3 | 4 | 7 | 2 | 3 | 6 |
| Nitrofen | 2 | 4 | 6 | 1 | 3 | 5 |

Scores 0 = total kill 9 = no visual effect on crop


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# HERBAGE YIELD AND WEED INGRESS OF SOWN PERENNIAL RYEGRASS SWARDS

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Summary An experiment is described in which comparisons were made of the herbage yields and botanical compositions of sown swards of perennial ryegrass (Lolium perenne L. cv. S24) of various ages. Four management treatments were applied: cutting 4 times/yr with fertilizer nitrogen applied at 188, 376 or 752 kg/ha/yr, or rotational grazing with sheep at the intermediate level of N fertilizer.

There was only a small decline in herbage DM yield as swards became older, those in their 7th year producing over 90% of the quantity from 2nd yr swards. All grazed swards had a high content of perennial ryegrass, but half of the land surface in the older cut swards was occupied by unsown grasses, the most abundant being Agrostis tenuis at the lowest N level, and Agropyron repens at the higher N levels. These findings are discussed in relation to the concept of deterioration of a crop and the desirability of taking weed control measures.

Résumé Une expérience est décrite dans laquelle des comparaisons sont faites entre les rendements et les compositions botaniques de parcelles de ray-grass (Lolium perenne L. variété S24) de différents âges. Les traîtements étaient au nombre de quatre: parcelles fauchées 4 fois par an et recevant des doses d'azote de 188, 376 ou 752 kg/ha/an et parcelles pâturées par moutons avec un apport d'azote de 376 kg/ha/an.

On note une diminution insignificante du rendement en matière sèche avec l'âge des parcelles, celles étant dans leur 7eme année produisant plus de 90% de la quantité de celles étant dans leur 2eme année. Le peuplement de ray-grass des prairies pâturées est resté constant, alors que la moitié de le surface des parcelles les plus vieilles était envahie par des espèces spontanées, les plus abondantes étant Agrostis tenuis au plus faible niveau azote et Agropyron repens aux plus forts apports d'azote.

Ces résultats sont discutés en relation avec le concept de dégradation des prairies et la nécessité de contrôler les 'mauvaises herbes'.

## INTRODUCTION

The most widely used crop grass sown in Britain, perennial ryegrass, usually produces its greatest yield of herbage when harvested by infrequent defoliation close to the ground surface. This can be achieved by cutting at a height of about 5cm at intervals of about 6 weeks, timing the first cut at ear emergence such that there are usually 4 or 5 cuts per annum. While this management involves defoliation at less frequent intervals than in most grazing systems, it is directly relevant to the production of herbage for conservation. Information on whether there are long-term limitations to this method of herbage production is required.

An experiment was carried out in which swards were established by sowing perennial ryegrass, and as these became older their performance was assessed against that of young swards. Three treatments involved harvesting by machine four times per year, and for comparison, one further treatment involving rotational grazing by sheep was incorporated.

The purpose of the present paper is to give an initial description of the contrasting populations of indigenous grasses which had become established in the swards by the seventh year, under various managements. Being unsown, these other grass species may be regarded as being 'weeds' of the perennial ryegrass 'crop'. This concept of sward deterioration, and the desirability of taking weed-control action is discussed in relation to total sward productivity, which did not decline markedly.

MATERIALS AND METHODS

A field of size 6.7 ha, central altitude 41 m O.D., consisting of loam with flints above chalk was divided into 72 plots each 15.2 x 21.3 m with intervening paths 3 m or 9 m wide. Twenty four plots were sown to perennial ryegrass (cv. S24) in 1968, 24 sown in 1969 and the remainder sown in 1970.

Of the plots sown in each year, half were designated 'short-term' and were ploughed and resown every 3 years, while half were 'long-term' and did not have any further reseeding. Each plot received one of four management treatments: cut 4 times/yr (mid-May, early July, late August, late October) with fertilizer nitrogen applied at 188 kg/ha/yr (Treatment N1), 376 kg/ha (N2) or 752 kg/ha (N3); or grazed rotationally ca. 5 times/yr by sheep at the intermediate level of N (Treatment N2G).

The experiment was a criss-cross design with 3 replicates, management treatments running across the field from N to S, and treatments producing different ages of sward (i.e. 'long-term' versus 'short-term') running from E to W. All swards were occasionally irrigated, i.e. at least during the major periods of drought, and received 98 kg/ha of fertilizer K and 39 kg/ha of P per annum from 1973 onwards; half of those amounts were applied in earlier years.

Herbage yields of cut plots were measured using a forage harvester modified for experimental use, and on grazed plots by assessing the quantity of herbage removed by the sheep at each grazing, using an electronic pasture yield estimator. Changes in the botanical compositions of the various swards were obvious, and were quantified by making detailed maps of the vegetation types present in plots of contrasting ages. The area mapped was 24 $m^2$ within each cut plot and 36 $m^2$ within each grazed plot. Calculations were made from the maps to derive the proportion of land surface occupied by each angiosperm species present.

The use of herbicidal sprays was avoided as far as possible in order to avoid any influence on the diverse populations of grass species which developed. However, the minimum of spraying against Rumex obtusifolius and R. crispus was thought desirable, and was restricted to: an application of a mixture of dicamba, benazolin and MCPA, at 1.4 kg a.i./ha (1969); and two applications of mecoprop at 2.7 kg a.i./ha (1970 and 1973).

A more thorough account of theoretical considerations in designing this experiment has been published previously (Smith, 1969).

## RESULTS

The pattern of sowing (or re-sowing) plots in various years resulted in young short-term swards (of ages 1, 2 and 3 years) being available each year for comparison with the long-term swards. The latter differed in age by 1 year such that in the most recent year quoted in this paper their ages were 5, 6 and 7 yr. Because the short-term swards were resown during their third year, results on total annual herbage yield were obtained for only two complete calender years, i.e. year 1 and year 2, counting the year of sowing as year 0.

Yields of herbage DM are summarised in Table 1. Since there was year to year variation due to climatic differences, the yield of each sward in any one year was expressed as a percentage of that for the year 2 sward, and mean values for the years of observation are quoted in the table.

Table 1

Yield of herbage (kg DM/ha) as a percentage of that in the second year, of swards in various years after sowing perennial ryegrass, at three levels of fertilizer N under cutting, and one level of N under grazing.

| Sward age (yr) | Years of observation | YIELD Percentage relative to that of second year swards | | | | |
|---|---|---|---|---|---|---|
| | | cut N1 | cut N2 | cut N3 | grazed N2G | SE ± |
| 1 | 5 (1971-5) | 99 | 101 | 105 | 103 | 2.6 |
| 2 | 5 (1971-5) | =100 | =100 | =100 | =100 | |
| 3 | 3 (1971-3) | 92 | 95 | 89 | 97 | 2.5 |
| 4 | 3 (1972-4) | 96 | 96 | 97 | 102 | 3.3 |
| 5 | 3 (1973-5) | 97 | 95 | 95 | 103 | 4.3 |
| 6 | 2 (1974-5) | 101 | 93 | 93 | 102 | 6.5 |
| 7 | 1 (1975) | 98 | 96 | 91 | 95 | 6.0 |

The 100% figures relate to an absolute production of 12.3, 14.2, 14.4 and 13.3 t/ha for N1, N2, N3 and N2G respectively. The yields did not alter greatly with age.

There have, however, been conspicuous changes in the botanical composition of the older swards. Table 2 summarises the vegetation types present in swards of contrasting ages. The records were made when a dense cover of vegetation was present, in April and July for grazed and cut swards respectively. It was clear that the grazed swards were relatively stable with a high percentage of perennial ryegrass, and *Poa annua* and *Agropyron repens* were the only unsown grasses present in measurable amounts. Some increase in *Agropyron* relative to *P. annua* was noted later during the year.

The cut plots had developed mosaics of vegetation types, most of which were simple pair 'mixtures' with perennial ryegrass. There were also areas dominated by (or exclusively occupied by) a single species, these being designated as 'pure' species. It was observed that the 'mixtures' of 2 spp tended to approach 50:50, such that it was possible to calculate approximately the overall proportion of each species present (Table 3).

The young cut swards had a high proportion of perennial ryegrass and *Agrostis gigantea* was the most conspicuous unsown grass in them. For brevity, values quoted for this species include records for a small proportion of *A. stolonifera* and forms which were intermediate morphologically between the two species. The most common indigenous grass of the older cut swards was *A. tenuis* at N1 and *Agropyron* at N3. *Poa trivialis* was also recorded at N1. The N2 swards were intermediate between those at N1 and N3 except for their low contents of *A. tenuis*. In interpreting Tables 2 and 3 it should be noted that the values quoted for other species include data for *Dactylis glomerata*, *Poa pratensis*, and broad-leaved angiosperms.

## DISCUSSION

Factors that may have contributed to the relatively high content of perennial ryegrass in the grazed swards include nutrient returns via excreta, and differences in frequency and defoliation pattern between the grazing and cutting regimes.

The results for cutting by machine have shown that after 7 years only about half of the land surface was occupied by perennial ryegrass, the sown species, and the other half had become dominated by unsown indigenous grasses.

It would seem that some species, particularly *Agrostis tenuis* at the lowest rate of N, and *Agropyron repens* at the highest N rate, had a competitive advantage under this system of defoliation. Their success was probably influenced also by edaphic factors where one nutrient, nitrogen, had been made non-limiting to growth and there were corresponding limitations arising from shortage of, for example, potassium and soil moisture. A further reduction in perennial ryegrass could thus be expected in future years.

Although yields were below the theoretical maxima, the data form a useful basis for a consideration of crop protection as applied to the grass crop, in view of the finding that total sward DM yield had not declined markedly. An appraisal of this situation from the point of view of weed control would depend upon the relative usefulness of the sown and unsown species. Clearly, nutritive value and seasonal yield patterns are important in addition to total sward DM yield. Data on these factors are in the process of being obtained for this experiment. If the unsown grasses had an acceptable yield and quality under the system of cutting which also allowed sown species to do well (i.e. 'well' in terms of yield, but not necessarily in persistance) it would not be a disadvantage to allow swards to change towards a quasi-permanent pasture, with control of only major defects in the plant population if they arose, by, for instance, occasionally reseeding without ploughing. If, on the other hand, major deficiencies in the nutritive value of the indigenous species are identified, then the case for the control of these grasses with existing or new herbicides will be a strong one.

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SMITH, A. (1969) Longevity of herbage crops. A long-term experiment. *Annual Report, Grassland Research Institute, Hurley*, 1968, 135-42.

Table 2

Proportion of ground area occupied (%) by perennial ryegrass in various years after sowing, and the proportion of unsown grasses present alone or in mixtures, in cut or grazed swards at various levels of fertilizer nitrogen.

| | CUT SWARDS | | | | | | GRAZED SWARDS | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2 yr old | | | 7 yr old | | | 2 yr old | 5 yr old | 7 yr old |
| | N1 | N2 | N3 | N1 | N2 | N3 | N2 | N2 | N2 |
| PURE SPECIES | | | | | | | | | |
| Perennial ryegrass | 58 | 64 | 60 | 34 | 45 | 24 | 81 | 80 | 79 |
| *Agrostis tenuis* | 4 | - | - | 19 | 3 | 2 | - | - | - |
| *Agrostis gigantea* | 4 | 8 | 12 | 1 | 5 | 2 | - | - | - |
| *Poa trivialis* | - | - | - | 1 | - | - | - | - | - |
| *Poa annua* | - | - | - | - | - | - | 3 | 6 | 4 |
| *Agropyron repens* | - | - | 2 | - | 6 | 26 | - | - | - |
| MIXTURES WITH PERENNIAL RYEGRASS | | | | | | | | | |
| Prg + *A. tenuis* | 5 | 5 | - | 15 | - | - | - | - | - |
| Prg + *A. gigantea* | 16 | 11 | 10 | 3 | 4 | - | - | - | - |
| Prg + *P. trivialis* | - | - | - | 15 | - | - | - | - | - |
| Prg + *P. annua* | 1 | 2 | 2 | - | - | - | 8 | 7 | 4 |
| Prg + *A. repens* | 2 | 1 | 9 | 2 | 24 | 37 | 1 | 2 | 4 |
| Prg + two of above grasses | - | - | - | 3 | 5 | 3 | - | 1 | 3 |
| BARE GROUND | 2 | 2 | 5 | - | 1 | 1 | 4 | 2 | 1 |
| OTHER SPP, COMPLEX MIXTURES etc. | 8 | 7 | - | 7 | 7 | 5 | 3 | 2 | 5 |
| TOTAL | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Table 3

Ground area occupied (%) by perennial ryegrass and unsown grasses, as a total for each species of the amount 'pure' or in mixtures, from Table 2.

| | CUT SWARDS | | | | | | GRAZED SWARDS | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2 yr old | | | 7 yr old | | | 2 yr old | 5 yr old | 7 yr old |
| | N1 | N2 | N3 | N1 | N2 | N3 | N2 | N2 | N2 |
| Perennial ryegrass | 73 | 75 | 71 | 54 | 62 | 44 | 87 | 86 | 85 |
| *Agrostis tenuis* | 8 | 3 | - | 27 | 3 | 3 | - | - | - |
| *A. gigantea* | 13 | 14 | 16 | 3 | 7 | 3 | - | - | - |
| *Poa trivialis* | - | - | - | 10 | 4 | - | - | - | - |
| *P. annua* | - | - | - | - | - | 2 | 7 | 10 | 7 |
| *Agropyron repens* | 2 | 1 | 6 | 2 | 21 | 47 | 1 | 1 | 4 |
| Bare ground | 2 | 2 | 5 | - | 1 | 1 | 4 | 2 | 1 |
| Other species etc. | 2 | 5 | 2 | 4 | 2 | - | 1 | 1 | 3 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

# THE EMERGENCE, GROWTH, FLOWERING AND SEED PRODUCTION OF HOLCUS LANATUS L. SOWN MONTHLY IN THE FIELD

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Summary. This report describes a growth study of spaced plants of Holcus lanatus, arising from seed sown monthly in bare soil in 1975. No artificial watering was used and seedling emergence was low during the hot, dry summer. At other times of the year seedling emergence was usually very rapid. There was a large difference between the growth of plants from seed sown in June and those sown in July. The June sown plants produced more than five times as many tillers per plant, 200 days after sowing, and more than twice as many seeds per plant, as the July sown plants. But, the July sown plants produced more seeds per panicle than the June sown plants.

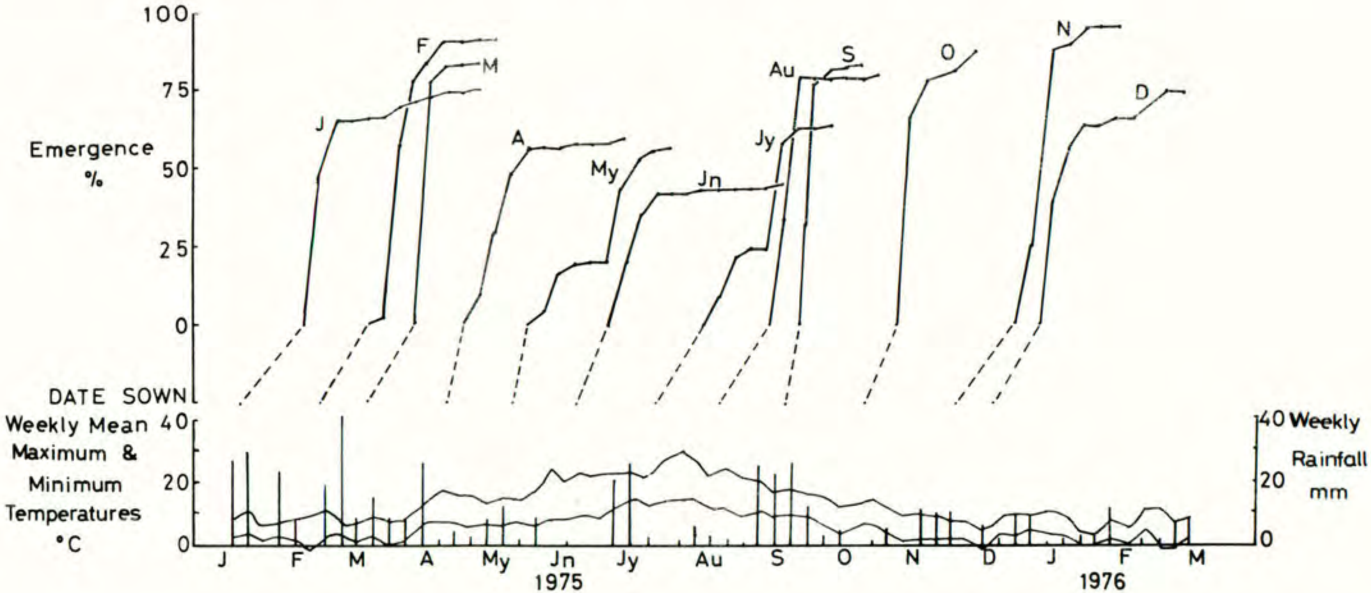
Résumé. Ce travail présente un compte-rendu d'une étude de la croissance de plantes espacées de Holcus lanatus provenant de semis en sol nu à intervalles d'un mois en 1975. Aucun arrosage artificiel ne fut apporté, et la levée des plantules fut irrégulière pendant cet été chaud et sec. A d'autres époques de l'an la levée des plantules se trouvait généralement bien rapide. It y eut de grandes différences de croissance entre les plantes provenant du semis de juin et celles du semis de juillet. Deux cent jours après le semis, les plantes semées en juin produisaient cinq fois plus de talles/plante que celles semées en juillet - et plus du double de semences. Mais le rendement de semences/panicule était supérieur chez le semis de juillet.

## INTRODUCTION

Little is known about how environmental factors affect the emergence, growth, flowering and seed production of Holcus lanatus (Yorkshire Fog) sown at various times of the year in the field. The laboratory test recommended by the Association of Official Seed Analysts (1970) is that seed should be germinated under alternating conditions of 16 hr dark at 20°C and 8 hr light at 30°C, in moist conditions. McNeill (1973) at Ascot, Berkshire, found H.lanatus flowering from late May onwards. And, Mortimer (1974), working at Bangor, Gwynedd, found H.lanatus shed seed from June to September with a peak during the first two weeks of July. He sowed seed which was 64.8% viable on the soil surface in October 1970. Only 24% of the total seed sown germinated and the maximum number of seedlings occurred in November. By the following May only 11% of the seed sown had given rise to established plants. Böcher and Larsen (1958) found that H.lanatus plants grown from northern European seed needed to be vernalised before they would flower.

This report presents the results of an experiment designed to study the emergence, number of tillers, dry weight of shoot growth, time and duration of flowering and the seed production of H.lanatus sown monthly in 1975 in the field.

Figure 1. Emergence (% of viable seed sown) of *H. lanatus* sown each month during 1975 and also weekly rainfall (mm) and weekly maximum and minimum air temperatures (°C).



## METHOD AND MATERIALS

The site (6m x 1.2m) was on a sandy loam soil at the Weed Research Organization, Oxford. The top 75 mm of soil was removed and placed in a 'Camplex' electrical soil sterilizer. It was heated to 77°C and then left until the soil temperature stopped rising, before it was returned to the site. This technique is recommended by the manufacturers and it killed any seed present in the soil.

Holcus lanatus seeds, collected the previous summer at WRO were sown monthly during 1975. The seeds were stored at room temperature before sowing. Each plot measured 1m x 0.3m and 100 seeds per plot were sown, 2mm deep at 30mm spacing in 4 rows each 50mm apart. The same number of seeds was sown every month into a freshly prepared seed bed with a fine tilth. Laboratory tests showed that the unsown seeds remained about 60% viable throughout the year. The experiment was of an unrestricted random design with two replicate plots for each monthly sowing.

After sowing, each plot was protected from birds by plastic netting. Every week, the number of seedlings which had emerged on each plot was recorded. As each month's seedlings grew, they were thinned at intervals, to prevent intra-specific competition. At each thinning the tiller numbers and shoot dry weights of the harvested plants were noted. One plant was selected at random and left to grow on in each plot; the number of panicles was recorded each week. The time at which anthesis occurred was recorded by scoring the plants each week for the proportion of flowers which had produced anthers.

The maximum height of the plants above the ground was measured on 15 June after which the plants were cut down to ground level on 29 June and their fresh and dry weights were recorded. Twenty panicles (which appeared to have shed little, if any, seed) were selected from each plant at random at the time of harvest. Their fresh weight was recorded and they were kept in linen bags at ambient temperature for 16 days. Then the seed was removed from the rachis and weighed. Two sub-samples, each of 100 seeds were taken from each sample and weighed. The mean number of seeds produced on each plant could then be estimated.

The term 'seed' refers to the caryopsis surrounded by the lemma and palea. Groups of plants are referred to by the months in which they were sown. Weekly rainfall and weekly mean maximum and minimum air temperatures were recorded at a nearby meteorological site and are shown in Figure 1. Monthly mean rainfall figures for 1975 are presented in Table 2. No artificial watering was used.

## RESULTS

### Germination and emergence

Under favourable conditions, the seeds germinated rapidly and started to emerge between one and two weeks after sowing (September). But when it was dry and/or cold, emergence was delayed (July) (Table 1). In Figure 1, weekly maximum and minimum air temperatures and weekly mean rainfall are plotted to help explain these differences. Once emergence had begun it continued rapidly for all sowing dates, although April, May, June and July sowings emerged more slowly than those of other months. The May and July sowings emerged in two batches. Most months' sowings produced between 75% and 95% emergence of viable seeds, but, far fewer seedlings emerged from April to July sowings.

### Plant growth

The tiller numbers of plants of the 12 sowing dates at various times after 50% emergence of their seedlings are shown in Figure 2. The January to June sown plants all increased rapidly in tiller numbers between 100 and 200 days after the date of 50% seedling emergence. The plants from the July sowing onwards tillered to a much lesser extent. The maximum height of the plants above the ground was measured on 15 June 1976. All the plants were more than 500 mm tall, with the exception of those

Table 1

Emergence of Holcus lanatus seed

| Month of sowing | Maximum % emergence of viable seeds | Number of days to maximum emergence | Number of days to 50% emergence |
|---|---|---|---|
| Jan | 75.0 | 105 | 35 |
| Feb | 91.7 | 77 | 35 |
| Mar | 84.2 | 49 | 24 |
| Apr | 59.2 | 77 | 21 |
| May | 56.6 | 70 | 45 |
| Jun | 44.2 | 98 | 22 |
| Jul | 63.3 | 77 | 52 |
| Aug | 79.2 | 70 | 31 |
| Sept | 81.6 | 28 | 10 |
| Oct | 88.3 | 56 | 17 |
| Nov | 95.8 | 56 | 31 |
| Dec | 75.8 | 70 | 31 |
| L.S.D. (p=0.05) | 25.3 | 16.9 | 16.3 |

Table 2

Monthly rainfall mm

| Month | 1975 | Mean 1965-1974 | 1975 versus 10 year mean |
|---|---|---|---|
| Jan | 64.9 | 53.8 | + 11.1 |
| Feb | 34.4 | 43.2 | - 8.8 |
| Mar | 85.1 | 31.7 | + 53.4 |
| Apr | 45.6 | 43.6 | + 2.0 |
| May | 39.7 | 55.5 | - 15.8 |
| Jun | 9.5 | 63.2 | - 53.7 |
| Jul | 48.0 | 53.6 | - 5.6 |
| Aug | 18.4 | 59.3 | - 40.9 |
| Sep | 85.9 | 51.9 | + 34.0 |
| Oct | 16.8 | 51.1 | - 34.3 |
| Nov | 34.0 | 58.8 | - 24.8 |
| Dec | 18.8 | 46.4 | - 27.6 |

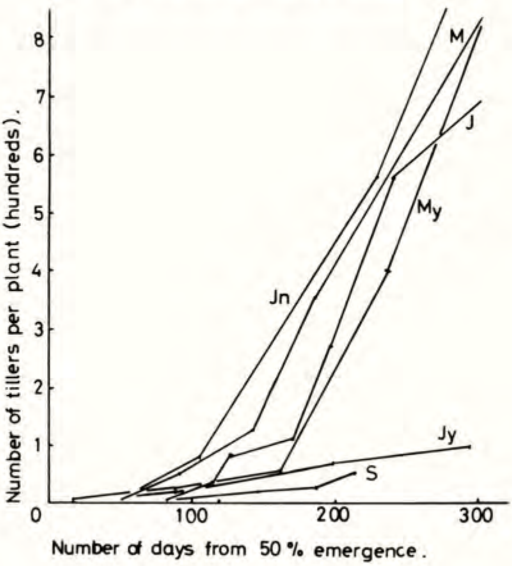
from the last three sowing dates, October, November and December 1975 which were 435, 240 and 130 mm tall respectively. The plants were harvested to ground level on 29 June 1976 and the shoot dry weights are recorded in Table 3. The January to June plants all weighed more than 300 g, whereas plants from July sowings onwards all weighed less than 150 g.

Table 3

Shoot dry weight, number of panicles and number of seeds per plant and per panicle for each sowing date

| Month of sowing in 1975 | Number of days from 50% emergence to harvest | Dry wt.g on 29 June 1976 | Mean total number of panicles per plant | Estimated mean seed numbers per plant | Mean seed numbers per panicle |
|---|---|---|---|---|---|
| Jan | 487 | 339.3 | 403.5 | 128,130 | 307.1 |
| Feb | 452 | 349.4 | 495.5 | 138,983 | 265.8 |
| Mar | 441 | 627.5 | 754.5 | 242,665 | 321.6 |
| Apr | 410 | 437.7 | 535.0 | 171,697 | 316.2 |
| May | 357 | 331.9 | 500.0 | 146,811 | 293.6 |
| Jun | 352 | 457.0 | 759.5 | 236,078 | 310.8 |
| Jul | 288 | 134.7 | 184.5 | 89,148 | 483.2 |
| Aug | 281 | 108.7 | 133.5 | 83,680 | 677.6 |
| Sep | 271 | 77.0 | 119.0 | 75,837 | 469.9 |
| Oct | 232 | 7.2 | 17.5 | 3,639 | 207.9 |
| Nov | 179 | 12.9 | 5.0 | 2,222 | 444.4 |
| Dec | 163 | 2.1 | 0 | 0 | 0 |
| L.S.D. (p = 0.05) | 6.1 | 339.9 | 281.1 | 87,748 | 274.5 |

Figure 2. Tiller numbers present after 50 % emergence of H.lanatus seed sown on a selection of the sowing dates.



Panicle Production

A large number of panicles was produced by all the early sown plants, (Table 3). There was a sharp drop in the number of panicles from 759 per plant for the June sowing to 184 per plant for the July sowing. This decline continued throughout the later sowings with the October plants producing very few panicles. Only one of the November plants produced any flowers and the December plants did not flower at all. The mean time at which 50% of the panicles had emerged was during the first week in June for all plants with the exception of October and November sowings in which it did not occur until 13 and 15 June respectively. Likewise, the estimated mean time at which 50% anthesis occurred was between 10 and 14 June for all plants except the October and November ones. In these it did not occur until 23 and 29 June respectively.

Number of seeds per plant

In general, the plants produced a very large number of seeds with a maximum of 240,000 seeds per plant from the March sowing. Large numbers of seeds were produced by the January to June sown plants but the numbers declined from the July sowing onwards. However, the July, August and September sowings all had a larger number of seeds per panicle than the earlier sowings. Even the relatively very small plants from the October and November sowings produced more than 2000 seeds per plant.

## DISCUSSION

The very hot and dry summer of 1975 and the very mild winter of 1975/76 must be taken into account when considering these results. May and June were unusually dry (Table 2). The number of seedlings which emerged from sowings during these months was low. Air temperatures were high in June, July and August and what little rain there was evaporated quickly and plants wilted. Many April seedlings died when they had only just emerged or had only one or two leaves. Both the May and June sowings emerged in two batches, the second batch in each case co-inciding with rainfall after a dry period. The relatively mild weather in January 1976 allowed the November and December sowings to emerge rapidly. A low total number of seedlings emerged from the April to June sowings. As the viability of the seeds was approximately the same for all sowings, it seems likely that many seedlings died between germination and emergence. With the exception of these summer months during which seedling emergence was slow, H.lanatus seedlings emerged rapidly. This is consistent with the seed being non-dormant. Mortimer (1974) found a peak in seedling numbers in early September from H.lanatus seed sown at the natural time in summer. This experiment however, shows a peak in seedling numbers in late September - early October for summer sowings. The exact time of the peak may depend on the amount and timing of autumn rain.

There is a great difference in the number of tillers produced by plants from June and July sowings at any given time after 50% seedling emergence (Figure 2). In order to begin tillering a grass must have reached a certain stage of growth. After that, the degree to which it tillers depends to a large extent on environmental conditions. The June sowing reached 50% seedling emergence on 10 July whereas the July sowing did not reach this level until 14 September. At the thinning on September 11, the July sown plants which had emerged were only just beginning to tiller whereas the June sown plants already had 11 tillers. This difference in plant growth stage in early autumn was probably very important in determining the absolute increase in tiller numbers in both groups of plants over the winter. By February 20, 1976, the June plants had 500 tillers compared to the July plants 60 tillers. This large difference between the June and July sowings was also reflected in both plant dry weight on 29 June 1976 and in panicle numbers. The larger number of tillers formed during the autumn and winter by the June plants compared with the July plants meant that a much larger number of tillers on the June plants were formed in time to be vernalised in the winter and were therefore able to flower in the following summer. Mortimer (1974) found that H.lanatus shed seed from June to September with a peak during the first two weeks of July. In a summer like 1975, the seed shed before mid-June would have been at a great advantage, in terms of subsequent plant growth, over the later shed seed.

The fact that neither of the two December plants and only one of the November plants flowered confirms the statement of Evans (1964) that H.lanatus plants need to undergo a period of vernalisation as vegetative plants before they can flower. There is no record of any effect of day length on the flowering of H.lanatus. Böcher and Larsen (1958) collected H.lanatus seed from all over Europe and sowed it indoors in spring, transplanting the seedlings outside in June. They found that plants from southern Europe flowered in the first year without 'reinforcement' (a long vegetative period before wintering) and before wintering. Plants from northern Europe only flowered in the second year and required 'reinforcement' and overwintering.

Plants from the July, August and September sowings in this experiment produced a larger number of seeds per panicle than plants from the earlier sowings. This indicates that the vernalised tillers on these plants grew well in 1976 and were able to compensate, to some extent, for their low numbers by producing more seeds per panicle. Thus, the direct effect of sowing at different times was on total tiller numbers and numbers of vernalised tillers rather than on seed numbers per plant. The November and December plants were very small and produced little or no seed. But, if they were kept free from competition they would probably produce a large amount of seed in summer 1977. The times of 50% panicle emergence and anthesis were approximately the same for all the plants which flowered except the October and November sowings in which they were delayed by about a week. Thus, there is a gradient in the plants from the various sowing dates from those which flowered at the normal time, through those which flowered late to those which did not flower at all.

The number of seeds produced by plants from the late summer - early autumn sowings is still very large. If there was one H.lanatus plant per square metre in a sward and each plant produced about 100,000 seeds a year, of which 60% were viable, 600 million viable seeds would be shed over a hectare in one year. These figures are based on spaced plants however and would be lower for plants in the competitive situation of a sward. Milton (1948) found 173,000 H.lanatus seedlings per ha. germinated from soil cores taken to a depth of 180 mm on a mainly Agrostis-Festuca sward. This is a large number of seedlings but it represents only 0.02% of the potential annual seed production of H.lanatus plants at a density of one per square metre in a sward. These estimates point to the high mortality of H.lanatus seed in grassland. Mortimer (1974) has worked out a relevant seed population flux diagram. He has shown that the seeds are very vulnerable both when they are on the soil surface and when they become part of the buried seed bank.

Although these results show that H.lanatus seeds have little dormancy, the potential number of seeds which a plant can produce is so large that even a 1% level of innate or enforced dormancy would result in a large amount of buried vaible seed. Dormant H.lanatus seeds may be brought to near the soil surface by moles and worms so that, potentially, they may germinate at any time of year. This has been shown by Jalloq (1975) who found a few H.lanatus seedlings germinating from seeds brought up in mole hill soil whereas Mc Rill (1974) found a mean number of 158.2 seedlings germinated per 100 g of worm cast soil, removed from a permanent sward in February and kept moist for one year.

## Acknowledgements

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# THE BARLEY GRASS PROBLEM IN NEW ZEALAND

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Summary Barley grass (*Hordeum* spp.) has become a serious pasture weed problem in New Zealand. It is found throughout most of the country though more frequently in summer dry areas. The weed is a problem because of seed damage to sheep and sheep products and the consequent economic losses. Paddock scale herbicide trials have shown that a number of herbicides may give a measure of control of barley grass in pasture but all those currently available have some adverse effect on pasture composition and dry matter production. In those trials total yearly stock productivity was reduced in the first year after the use of herbicides but lamb growth rates on treated pasture, in summer, were increased, following reduced seed damage. The possibility of reducing the incidence of barley grass by stock manipulation is discussed.

Résumé En Nouvelle-Zélande, l'herbe d'orge (*Hordeum* spp.) est devenue un très grave problème comme mauvaise herbe de pâture. Elle se trouve presque partout dans le pays bien que plus fréquemment dans les régions de sécheresse estivale. Cette herbe représente un problème car sa graine porte atteinte aux produits de mouton, et de graves pertes économiques s'ensuivent. Des expériences herbicides au niveau de l'enclos nous montrent que plusieurs herbicides peuvent donner un certain contrôle de l'herbe d'orge dans les pâturages mais tous ceux dont on dispose actuellement portent atteinte en quelque sorte à la composition des pâturages et à la production de matière sèche. Au cours de ces expériences, la productivité annuaire des bêtes fut rêduite un an après l'introduction des herbicides; de l'autre côté, la croissance moyenne des agneaux s'augmenta en été suivant une réduction dans les mauvais effets de la graine. On discute aussi de la possibilité de réduive la portée de l'herbe d'orge au moyen de manipuler les bêtes.

## INTRODUCTION

Barley grass (*Hordeum* spp.) known in New Zealand for over 100 years, has become a considerable weed problem in the last 30 years. During the 19th Century, the natural cover of bush and forest was hand-cleared and pasture dominated by brown top (*Agrostis tenuis*) and danthonia (*Notodanthonia* spp.), was established. Since 1950 aerial topdressing with phosphate fertilisers and oversowing has increased the legume component of the sward. The resulting higher soil fertility, along with increased stocking rates, has led to the partial replacement of the mat-forming grasses by more productive but summer drought-sensitive perennial ryegrass (*Lolium perenne*). Associated with this development there has been an upsurge in barley grass invasion of the more open higher fertility swards.

Much of New Zealand is too steep for wheeled vehicles and the pastoral economy is based on year round grazing with a minimum of supplementary feeding. The dependence on year round grazing works to the advantage of barley grass. During the spring, in spite of the presence of lambs, feed exceeds demand, while during dry spells in summer demand often exceeds feed supply. Pasture is therefore, under grazed in spring and barley grass, being relatively unpalatable when approaching flowering, is avoided by stock and allowed to flower freely. During summer, pastures may be over grazed which is harmful to the perennial grasses but does not affect barley grass since it "over-summers" as a seed.

Barley grass invasion generally commences in areas of excessive stock congregation, "stock camps", and may spread from these to the surrounding pasture. Stock, particularly sheep, like to "camp" on dry ground, the tops of hills and ridges and under the shelter of trees. Congregation of stock results in excessive trampling and the transfer of nutrients, in dung and urine, from the surrounding pasture in the stock camps. The increase in soil nutrients, in areas chosen because they are dry, accentuates the summer drought effects by adding a physiological drought component due to increased soil salinity.

From the stock camps barley grass tends to spread to the surrounding pasture. In areas with rainfall adequate to maintain summer pasture growth the spread of barley grass is limited but where summer drought and heavy grazing result in pasture damage barley grass may become a major component of the sward.

## OCCURRENCE

Barley grass occurs throughout most of New Zealand but is more prevalent on the drier eastern sides of both islands and central South Island, in the rain shadow of the main mountains. The incidence of barley grass increases further south with the exception of Southland (Atkinson and Hartley, 1976) where cooler conditions and adequate rainfall maintain summer pasture growth. There are seven species of *Hordeum* present in New Zealand. The two common tetraploid species *H. murinum* and *H. leporinum* are widespread and plants with intermediate characteristics suggest possible interbreeding (Allen, 1973). The two maritime species, *H. geniculatum* (= *H. hystrix*) and *H. marinum* are restricted to saline soils of East Coasts and Central Otago; *H. glaucum* is found only in central South Island while the two perennial species, *H. jubatum* and *H. secalinum*, are of very limited distribution and minor importance.

## THE WEED

Barley grass germinates in autumn (March-April) and seeds the following summer (December-February). The "seed" consists of a fertile central floret and two sterile lateral florets, each with two awned glumes and an awned lemma. The three florets remain attached to each other and separate from the plant by fracture of the rachis.

The seeds of the common species show some innate dormancy, especially at higher temperatures but this is short term and is lost by autumn (Popay, 1975). Moderate rainfall (> 15 mm) is required to initiate germination (Rumball, pers. comm.) which is then rapid (3 days). The structure of the seed, apart from assisting in animal dispersal, helps to hold the seed in litter or in cracks in the ground while the radicle penetrates the soil. Barley grass seedlings cannot compete with established pasture but their rapid initial growth rate enables them to establish quickly where conditions are suitable. These conditions occur where the vegetation cover has been reduced, either in stock camps or in pasture that has been over grazed during drought stress. Because of their rapid germination and initial growth rate barley grass seedlings compete successfully with ryegrass seedlings and drought affected perennial species. Though initial growth is rapid the total yearly production is less than that of ryegrass and total sward production may be reduced where initial barley grass growth suppresses other species (Popay, unpublished).

## THE PROBLEM

Barley grass has become a serious problem through seed damage to stock. The fractured rachis of the triad "seed" is sharply pointed and, driven by the unidirectional barbs on the awns, can penetrate into the skin and flesh of animals. Lambs are particularly severely affected though older sheep and cattle also suffer. Sheep dogs, an essential part of New Zealand stock farming, suffer from barley grass seed penetrating between the toes and working up the muscles of the legs.

Trials conducted to measure the effect of seed damage to lambs have indicated a growth depression of 6-8 kg per affected lamb during the three summer months, December to February, as a consequence of seed irritation particularly to the eyes, nose, mouth and body (Hartley and Atkinson, 1972; Hartley and Bimler, 1975).

Seed in the eyes has a sudden severe effect on lambs. Weight losses of as much as 2.5 kg per lamb in three weeks were recorded in a flock due to seed damage (Hartley and Bimler, 1975). In another trial weight losses of 1.0 to 2.4 kg per lamb in two weeks were recorded (Hartley and Atkinson, 1972). The incidence of seed in the eyes can be high, one lamb flock, grazing in a bad barley grass area, averaged nearly three seeds per eye during January (Hartley and Bimler, 1975). Unless the seeds are removed at frequent intervals considerable stock losses may occur. The incidence of seed in the eyes varies between breeds and ages of sheep. In comparative trials, three times more seed damage was recorded among Southdown/Romney cross lambs, with woolly faces, then Border Leicester/Romney cross lambs, with clean faces. A comparison between ewes and lambs, of the same breed, showed a 7-9 times greater seed problem with lambs than with ewes (Hartley and Bimler, 1975).

The seed of *H. geniculatum* will also penetrate the gums and nostrils of sheep but few data are available on the effects of such seed irritation. The effect on lambs of seed irritation to the body is difficult to measure because of the difficulty of obtaining unaffected control stock grazing in conditions identical except for the barley grass. However data indicate a possible growth depression of about 2 kg per 100 seed punctures, as measured by holes in the processed pelt (Hartley and Atkinson, 1973a). Here again the breed of sheep has a marked effect on the severity of the problem because of the different wool types. Of those breeds examined, least pelt damage was recorded for Border Leicesters with their coarse lustrous wool and most among Merinos and Southdowns which have highly crimped dense fleeces. Romneys were intermediate (Hartley and Atkinson, 1973a). In two flocks grazing among moderate and severe barley grass infestations the mean numbers of holes/pelt for Southdown type lambs were 150 and 500.

## EFFECT ON NATIONAL ECONOMY

Devaluation of lamb pelts, due to seed induced scars, has been estimated to cost New Zealand $500,000/annum (Rumball, 1970; Shugg and Vivian, 1973). The devaluation of slipe wool (wool pulled from processed skins) has been put at $280,000/annum (Shugg and Vivian, 1973) and slipe wool accounts for only 12% of New Zealand's wool production. Greater losses may occur through the effect on animal health. It is estimated that up to 10% (4 million) of New Zealand's lambs may be affected by barley grass (Shugg and Vivian, 1973). At current prices, every 1 kg live-weight loss, on this number of lambs, costs the farmers $1 million and the country rather more. With weight depression up to 8 kg recorded in trials a mean weight loss of 1 kg may well be an underestimate.

## CONTROL

Barley grass occurs in two fundamentally different situations, stock camps and open pasture each requiring different control measures involving both herbicides and stock manipulation.

### Stock Camps

On stock camps and other non-productive areas non-selective herbicides can be used. Paraquat is the most widely-used herbicide but, because it is non-selective, it removes not only barley grass but most other plant species also. The bare ground makes an ideal seed-bed for any remaining or subsequently introduced seed. This problem can be overcome to some extent by the addition of a residual material such as simazine. However, there must always be a stage when herbicide activity falls below a critical level and the open ground is exposed to invasion by many weeds.

For this reason better control should result from the use of selective herbicides and the establishment of desirable species. Here ethofumesate has the advantage of good barley grass control with little effect on ryegrass which is a good competetive species to establish on stock camps.

The prime cause of barley grass invasion of stock camps is the bare ground created by stock. Control has been achieved by fencing sheep off stock camps and allowing a vegetation cover to establish (Taylor, 1971). Rotational grazing also reduces the formation of stock camps.

### Pasture

In pasture the problem is one of removing one grass from among others. Much trial work has been done to find herbicides that can do this satisfactorily. As yet no herbicide is truly selective for barley grass and they all affect either the grass or clover component of the sward and reduce productivity for a period. However, because of the nature of the barley grass problem, some loss of productivity may be acceptable if barley grass can be controlled and damage reduced.

A number of paddock scale herbicide trials have been conducted over the last few years where results have been measured not only in terms of barley grass control and pasture production but also in terms of stock performance. The details of these trials are published elsewhere (Hartley and Atkinson, 1972, 1973b; Hartley *et al*, 1974) but a summary of the results will show the degree of barley grass control that can be achieved with herbicides on pasture and the associated effects.

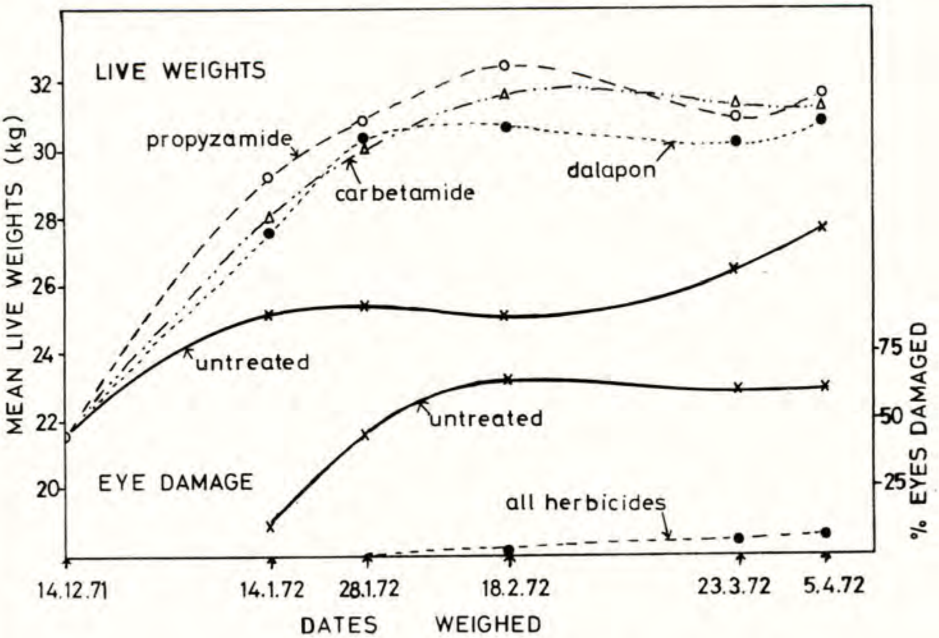
The herbicides tested included propyzamide, carbetamide, dalapon, TCA/dalapon and ethofumesate all applied to 0.2 ha paddocks in replicated trials. Barley grass control generally ranged from 80 to 99+% control but where application and weather conditions were satisfactory over 95% control was regularly attained and this continued with over 80% control into the second year after treatment. Retreatment during the second year increased the level of control in all trials and in two trials gave an apparent 100% control which was still over 99% the following year.

Pasture dry matter production was reduced by all treatments over the first six months after treatment. Reductions ranged from 9-36%, the high reduction being recorded where barley grass, at the time of treatment, made up one third of the sward. During the following 12 months pasture dry matter production was unaffected by the treatments being within ± 10% of that from untreated pasture. A second application of propyzamide or TCA/dalapon had negligible effects on pasture production but a repeat application of ethofumesate was very depressive (20-60% reduction); the other herbicides were not reapplied. Production in the third year after initial treatment was as good or better than that of untreated pasture, from both single and double applications, except following double application of ethofumesate.

The effect of treatment on stock growth rates depended on the density of the barley grass infestation and the age of sheep. Stock production generally followed pasture production except where lambs were grazed over the "barley grass season", December-February. Fig. 1 shows the growth rates of lambs on treated and untreated pasture during the summer. The sudden check in growth rates of lambs on untreated pasture coincided with the start of seed fall and the increase in eye damage (and probably body irritation), due to seed. A similar growth pattern was observed at a second stocking rate on the same trial (Hartley and Atkinson, 1972) and in another trial measuring effect of seed damage (Hartley, 1975).

Fig. 1

Mean live weight gains of lambs on four pasture treatments from December to April. Stocking rate - 35 lambs/ha (21 lambs in mean, 3 replicates)




The barley grass density on the trial illustrated in Fig. 1 was 95 seed heads/$m^2$ on the untreated pasture and 1-3/$m^2$ in the treated pastures. Lambs showed measurable effects of seed damage when the density of seed heads was about 10/$m^2$. Older sheep could tolerate 20-30/$m^2$ without measurable effect but high densities, up to 300/$m^2$ on one trial, affected all sheep.

Grazing management offers a possible alternative to herbicides for barley grass control in pasture. The success of barley grass is helped by the natural grazing pattern of a year round grazing system. Trials, recently commenced, are measuring the effects of increased spring grazing pressure and reduced summer grazing.

The spring grazing trials have shown that heavy set stocking can reduce barley grass seed head production by more than 50% while rotational grazing gave reductions between 30% and 60% according to intensity and frequency of grazing. Meanwhile a small plot trial where summer grazing pressure was lessened reduced barley grass seed heads the following year by 50-80% according to amount of summer pasture growth left uneaten (unpublished data).

## DISCUSSION

Barley grass is of concern to New Zealand because of the damage it does to stock. It has become well established because the climate suits it and the pastoral farming system, dictated by the terrain and the need for low cost production, works to its advantage. The development of 'improved' ryegrass/white clover (*Trifolium repens*) pastures, capable of carrying more stock, which in turn like to 'camp', has led to an increase in the distribution and density of barley grass.

The climate and terrain cannot be altered but to a limited extent the farming system could. The development of more drought-tolerant strains of ryegrass may increase the perenniality of the pasture and stock manipulation, on problem areas, could assist in the reduction of barley grass. The national seasonal imbalance of pasture production cannot be effectively buffered where the ground is too steep for cultivation or conservation of feed. However barley grass is only present on about 5% of the farmed land (Atkinson and Hartley, 1976) so there should be scope for stock manipulation on the worst barley grass areas at the possible expense of low risk pasture.

The use of herbicides is effective for the temporary control of barley grass but their use is not without undesirable side effects. With all currently available herbicides, other than ethofumesate, the margin between barley grass susceptability and ryegrass tolerance is fairly small. Slight variations in timing, environmental conditions or soil type can result in either poor barley grass control or excessive depression of pasture growth. Any 'opening up' of the sward by herbicides may lead to invasion by other weeds, and more barley grass if initial control is not good. This problem does not occur after the use of ethofumesate because of the phenomenal tolerance of ryegrass to this herbicide. However, in a pastoral agriculture dependant on clover for nitrogen, the clover depression caused by ethofumesate is a serious drawback to its widespread use. The herbicide has great potential, however, for eradication of small areas of initial infestation. The combination of TCA and dalapon has a non-spectacular but long term beneficial effect. Initial barley grass control may be only moderate but the herbicides leave a good balanced sward which appears more resistant to re-invasion. In field trials this was the only treatment to give relatively better control of barley grass during the second year after application than in the first year.

The main adverse effects of barley grass (seed damage to lambs) can be reduced by the use of herbicides, stock manipulation and breed selection. However, it will remain a serious problem as long as barley grass persists in quantity.

Herbicides can greatly reduce seed damage to stock which is reflected in better growth rates of lambs. Heavy grazing in spring reduced and delays seeding. A reduction in seeding has obvious advantages in terms of lambs' health but delay would also be beneficial. This is because a substantial number of lambs reach killing condition about the time barley grass seeds. If seeding could be delayed it would allow extra time to get the lambs off the farms before their condition is reduced by seed irritation. The adverse effect of seed could also be reduced by the choice of sheep breeds less susceptible to damage namely those without wool on the face and an open fleece.

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# MIXTURES OF ASULAM/PHENOXYALKANOIC HERBICIDES FOR GENERAL WEED CONTROL IN PERMANENT PASTURE

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Summary This paper reports the results of trials carried out with tank-mixes and formulations of asulam with phenoxyalkanoic acid herbicides over the seasons 1969/70 and 1973-1976.

In user trials tank-mixes of asulam with MCPA or MCPA/MCPB gave good control of Cirsium arvense, Ranunculus repens, and Rumex spp. Asulam controlled only Rumex. Mixes of asulam with mecoprop gave good control of Stellaria media growing in association with Rumex, and proved more reliable on the latter than mecoprop alone.

A formulation of MCPB/asulam/MCPA was safe to clover but did not control as wide a range of pasture weeds as mecoprop/asulam/MCPA, which in practice is giving satisfactory control of Cirsium arvense, Rumex spp, Stellaria media, Urtica dioica and Senecio jacobaea. Pasture reacted to treatment under dry conditions, as it did to the other mixtures tested, but under good growing conditions no reaction has been reported. Effects were observed on pastures with a high content of the asulam-susceptible grasses Bromus mollis and B. erectus.

Resumé Les resultats des essais effectués avec des mélanges extemporanés et des formulations d'asulame et d'acides phenoxyalkanoiques, au cours des campagnes 1969/70 et 1973-76, sont rapportes.

Dans les essais á grande échelle, les mélanges extemporanés d'asulame et de MCPA ou de MCPA/MCPB ont permis de maitriser Cirsium arvense, Ranunculus repens et Rumex spp. L'asulame seul a maitrisé le Rumex. Des mélanges d'asulame et de MCPA ont maitrisé Stellaria media, lorsque cette espece poussait en association avec le Rumex, et ils sont révelés plus fiable sur cette derniére espéce que le mécoprop utilisé soul.

Une formulation de MCPB/asulam/MCPA était inoffensive pour le tréfle mois n'a pas permis maitriser un certain nombre de mauvaises herbes des prairies que le mélange mecoprop/asulam/MCPA, qui a fait preuve d'une efficacité satisfaisante sur Cirsium arvense, Rumex spp. Stellaria media, Urtica dioica et Senecio jacobaea. Les prairies ont réagi au traitement en conditions séches comme tous les autres mélanges essayés, mais, dans les bons conditions climatiques aucure réactions n'a été observie. Un certain effet a été noté sur les prairies ayant un fort pourcentage de graminées sensibles á l'asulame, comme Bromus mollis et B. erectus.

## INTRODUCTION

Although Rumex obtusifolius and R. crispus are often the only serious grassland weeds present on an intensively stocked dairy farm, it has been our experience that where utilization is rather erratic and nitrogen usage lower, they are frequently found in association with Ranunculus repens and Cirsium arvense. If Rumex spp alone are removed from such swards by asulam or other means, these other broad-leaved species tend to invade the areas vacated. Because of farmer demand for control of all weeds in one operation, user trials of tank-mixes of asulam with the phenoxyalkanoic herbicides MCPA and MCPB/MCPA were initiated in 1969.

In the following year the work was extended to include trials on the combined control of Rumex spp and Stellaria media with tank-mixes of mecoprop and asulam. This weed association is quite common on stock farms of normally high rainfall where there is a high use of nitrogen.

From 1973 onwards, two formulations of asulam with phenoxyalkanoic herbicides (MCPB/MCPA or mecoprop/MCPA) were prepared and tested in comparison with standard products on all common broad-leaved weeds of grassland. In 1976 it was decided to carry out extensive user trials with mecoprop/asulam/MCPA, since it gave equivalent weed control to a standard mecoprop/dicamba/MCPA material, albeit with the same disadvantage of causing clover damage. Asulam used alone can have a delaying effect on certain pasture grasses, and it is therefore not recommended for use prior to a hay cut. In 1975/76 herbage yield trials were carried out to see whether the same conditions of use would apply to the mecoprop/asulam/MCPA formulation with its reduced dose of asulam. The opportunity was taken to include recommended asulam/ phenoxyalkanoic tank mixes in these same tests.

## METHODS AND MATERIALS

### Sites

Sites for the 1969 asulam/MCPA and MCPB/MCPA tank-mix experiments were all located on grass/clover swards where Rumex spp were growing in association with Ranunculus repens. Cirsium arvense was also present at three sites. All trials were unreplicated and they were in the South-West of England.

The 1970 asulam/mecoprop tank mix trials were carried out on sites where Rumex spp were growing in association with Stellaria media, in Lancashire and South Westmorland. These sites were also unreplicated.

The 1973 and 1974 small plot experiments with asulam and phenoxyalkanoic mixtures were carried out on pasture containing Rumex spp in association with a range of broad-leaved weeds, in East Anglia and Dorset. These trials were replicated twice.

The 1975 and 1976 pasture yield experiments with the same materials were situated in pasture free from broad-leaved weeds, half on high-nitrogen pasture and the remainder on low nitrogen regimes. These sites were also replicated twice.

The 1976 user trials with the mecoprop/asulam/MCPA formulation were selected for their weed content and sited mainly in Scotland and the West of England.

### Spraying

Small plot efficacy and yield sites were sprayed with single-wheeled small plot machines and the unreplicated experiments with farm sprayers. All spraying was at approximately 225 l/ha.

Plot size

The unreplicated user trials were conducted on 0.2 ha strips in 1969/70 and on 3 ha areas in 1976. Replicated plots were 25m x 2.5m.

Assessments

In the unreplicated experiments Rumex spp and Cirsium arvense were counted on a $83.6m^2$ ($100m^2$ in later experiments) transect, other weeds were visually assessed on percentage ground cover.

Small plot efficacy experiments were assessed by EWRC scores (for crop and weed) 1-2 months post-spray; the yield trials were cut with an Allen scythe as for a hay crop and calculated as dry matter yields, 4 to 6 weeks after spraying.

Formulations

Aqueous solutions of alkali salts of the following were used:-

Asulam, 40% w/v
Mecoprop, 30% and 60% w/v
MCPA, 25% w/v
MCPB, 40% w/v
MCPB/MCPA, 30% w/v
MCPB/asulam/MCPA, 62.5% w/v
mecoprop/asulam/MCPA, 37% w/v
and mecoprop/dicamba/MCPA, proprietary formulation

RESULTS

Table 1

after treatment in April/May 1969 (unreplicated)

(a) Rumex spp (10 sites)

| Site | Asulam 1.12 kg/ha | | Asulam 1.12 kg/ha + MCPA 1.75 kg/ha | | Asulam 1.12 kg/ha + MCPB/MCPA 2.1 kg/ha | |
|---|---|---|---|---|---|---|
| | Pre-spray Nos/$m^2$ | % Control | Pre-spray Nos/$m^2$ | % Control | Pre-spray Nos/$m^2$ | % Control |
| E. Harptree | 23.7 | 93 | 22.1 | 91 | 24.9 | 95 |
| Woodbury | 15.5 | 88 | 12.2 | 92 | 25.8 | 92 |
| Totnes | 13.5 | 84 | 11.8 | 80 | 11.1 | 85 |
| Ashprington | 10.5 | 98 | 8.0 | 98 | 6.5 | 98 |
| Lydeard St. Lawrence | 7.6 | 82 | 8.2 | 79 | 6.8 | 94 |
| Withleigh | 5.0 | 96 | 4.9 | 97 | 2.0 | 95 |
| Hartpury | 4.6 | 78 | 2.8 | 88 | 0.8 | 50 |
| Tiverton | 2.6 | 54 | 1.2 | 72 | 2.4 | 86 |
| Tetbury | 1.8 | 76 | 2.1 | 59 | 1.4 | 77 |
| Dunsford | 1.6 | 36 | 3.1 | 69 | 2.3 | 81 |
| Mean | | 78.5 | | 82.5 | | 85.3 |
| (b) Cirsium arvense (3 sites) | | | | | | |
| Dunsford | 1.7 | 0 | 22.7 | 93 | 11.9 | 88 |
| Woodbury | 0.4 | 0 | 0.2 | 80 | 0.1 | 75 |
| Tiverton | 0.3 | 0 | 0.5 | 9* | 0.2 | 100 |
| Mean | | 0 | | 61 | | 88 |

* Thistle shoots emerged late (post-spray) on this plot

## Table 2

### Control of Ranunculus repens five months after treatment in April/May 1969 (unreplicated)

Ranunculus repens (10 sites as for Rumex spp)

| Treatment | Infestation Category pre-spray | No of sites given: No Control | Useful reduction (EWRC 3-5) | Excellent control (EWRC 1-2) |
|---|---|---|---|---|
| Asulam | moderate | 5 | 0 | 0 |
| | low | 5 | 0 | 0 |
| Both asulam/ phenoxyalkanoic mixtures | moderate | 0 | 4 | 1 |
| | low | 1 | 0 | 4 |

## Table 3

### Control of Rumex spp 5-7 months post-spray - treatments applied May 1970 (unreplicated)

Rumex spp (5 sites)

| Site | Asulam 1.12 kg/ha + mecoprop 1.7 kg/ha | | Asulam 0.85 kg/ha + mecoprop 1.26 kg/ha | | Mecoprop 2.5 kg/ha | |
|---|---|---|---|---|---|---|
| | Pre-spray Nos/$m^2$ | % Control | Pre-spray Nos/$m^2$ | % Control | Pre-spray Nos/$m^2$ | % Control |
| Holme | 6.0 | 92 | 5.7 | 93 | 5.8 | 77 |
| Old Hutton (1) | 4.4 | 69 | 3.5 | 73 | 3.2 | 30 |
| Bayhorse | 4.3 | 68 | 1.8 | 69 | 3.4 | 75 |
| Hornby | 3.7 | 55 | 3.6 | 52 | 3.7 | 51 |
| Old Hutton (2) | 2.6 | 82 | 3.4 | 93 | 2.0 | 84 |
| Mean | | 73.2 | | 76.0 | | 63.4 |

## Table 4

### Control of Stellaria media 5-7 months post-spray - treatments applied May 1970 (unreplicated)

| Site | Pre-spray % cover | % cover in Autumn: All above treatments (in Table 3) | Unsprayed Control |
|---|---|---|---|
| Kendal | 5-10 | 0 | 20-30 |
| Old Hutton (2) | 5-10 | 10-20 | 20-30 |
| Old Hutton (3) | 5-10 | 0 | 20-30 |
| Old Hutton (1) | 10-20 | 5-10 | 20-30 |
| Bayhorse | 10-20 | 5-10 | 20-30 |
| Hornby | 10-20 | 10-20 | 20-30 |
| Holme | 20-30 | 5-10 | 40-80 |
| Mean | 13 | 7.5 | 30 |

Table 5

Mean EWRC scores for weed control and pasture tolerance
1-2 months post-spray (2 replicates/site)

| Treatment kg a.i./ha | Cirsium arvense | Rumex spp | Urtica dioica | Ranunculus repens | Grass | White clover |
|---|---|---|---|---|---|---|
| Asulam + MCPA/MCPB<br>1.15 1.94 | 5.7 | 4.2 | 4.8 | 6.3 | 2.6 | 1.6 |
| Asulam + MCPA/Mecoprop<br>0.85 2.28 | 4.6 | 3.3 | 2.5 | 6.5 | 2.5 | 3.8 |
| Asulam<br>1.12 | 7.9 | 4.5 | 5.8 | 8.8 | 3.3 | 1.5 |
| MCPA/MCPB<br>2.10 | 5.4 | 5.7 | 5.8 | 7.5 | 1.5 | 1.6 |
| Dicamba/MCPA/Mecoprop | 4.5 | 3.0 | 2.5 | 5.5 | 2.3 | 4.2 |
| No. of sites | 5 | 4 | 1 | 1 | 8 | 4 |

EWRC Scores

Weed Control
2-3 = good control
4-5 = satisfactory control
5+ = unsatisfactory control

Pasture Tolerance
2 = slight effect
3 = discoloured & retarded
4 = scorch

## Table 6

### Effect on hay yields of herbicide mixtures compared to unsprayed control

Mean yield* and index 4-6 weeks after given spray dates

| Treatment | kg a.i./ha | St. Albans<br>27.7.76 | Hertford<br>2.7.76 | Shalford<br>21.5.76 | Collingbourne (1)<br>13.8.76 | Ducis (2) | Mean |
|---|---|---|---|---|---|---|---|
| Asulam | 1.12 | 64 | 67 | 68 | 87 | 83 | 73.8 |
| Asulam/MCPA/mecoprop | 3.13 | 68 | 66 | 78 | 97 | 87 | 79.2 |
| Asulam/MCPA/mecoprop | 6.26 | 64 | 48 | 58 | 93 | 63 | 65.2 |
| Asulam + mecoprop | 1.12 + 1.68 | 87 | 46 | 80 | 95 | 85 | 78.6 |
| Asulam + MCPB | 1.12 + 2.8 | 64 | 52 | 65 | - | 54 | 58.8 |
| Asulam + MCPA | 1.12 + 2.8 | 99 | 54 | 71 | - | 74 | 74.5 |
| Mecoprop/MCPA/dicamba | | 68 | 60 | 89 | 94 | 79 | 78.0 |
| Unsprayed t/ha (= 100) | - | 2.1 | 1.8 | 5.6 | 3.2 | 3.6 | 3.24 |
| | | *Lolium perenne* 100 | *L. perenne* 85<br>*Trifolium repens* 15 | *L. Multiflorum* 80<br>*Bromus mollis* 20 | *L. perenne* 50<br>*H. lanatus* 30<br>*Phleum pratense* 10 | *D. glomerata* 30<br>*B. erectus* 30<br>*L. perenne* 10<br>*P. pratense* 10<br>*Alopecurus pratensis* 10<br>*Poa* spp 10 | |

* corrected to 85% dry matter

## Table 7

### Effect of mecoprop/asulam/MCPA formulations on broad-leaved weeds - user trials 1976

| Site Location | % ryegrass in sward | Sward tolerance (EWRC score) | % weed control<br>*Rumex* spp | *Cirsium arvense* | *Urtica dioica* | *Stellaria media* | *Ranunculus repens* | *Senecio jacobaea* |
|---|---|---|---|---|---|---|---|---|
| Bridge of Weir | 100 | 2 | - | 98 | - | - | - | - |
| Bridge of Weir | 100 | 1 | 98 | - | - | 100 | - | - |
| Langbank | 99 | 1 | 90 | - | 90 | 90 | - | - |
| Lochwinnoch | 50 | 1 | 90 | 90 | - | - | 60 | 90 |
| Lochwinnoch | 60 | 1 | 90 | - | - | - | - | - |
| Lochwinnoch | 50 | 1 | 80 | - | - | - | 60 | - |
| Lockerbie | 90 | 1 | 90 | - | - | 90 | 60 | - |
| Shalford | 80 | 4 | 90 | 90 | - | - | - | - |
| Population range pre-spray (no./$m^2$) | | | 1-10 | 1-3 | 1-3 | 3-6 | 6-40 | 10 |

## DISCUSSION

In the early tank-mix trials (Table 1) it was shown that the addition of MCPA or MCPA/MCPB to asulam did not reduce its effectiveness on *Rumex* spp and possibly enhanced it. Both additions gave good control of *Cirsium arvense* and reduction of *Ranunculus repens*, but asulam alone had no effect. The mixtures did not have any long-term effect on white clover which recovered to its spring level by the autumn.

In the 1970 user trials mecoprop alone was less reliable on *Rumex* spp (Table 3) than the mixtures with asulam, which gave about the same standard of *Rumex* control (75%) as straight asulam the previous year (Table 1). All treatments reduced *Stellaria media* or prevented it from building-up in the autumn. The usage of mecoprop was acceptable to the farmers, since the high nitrogen regimes had reduced any clover to negligible proportions prior to treatment.

In 1973/74 replicated trials (Table 5), although the MCPB/asulam/MCPA formulation had the advantage of clover safety (verifying the 1969 tank-mix experience), it was inferior to mecoprop/asulam/MCPA in the control of *Cirsium arvense*, *Rumex* spp, and in particular, *Urtica dioica*. Its effect on these weeds was equivalent to the dicamba/mecoprop/MCPA formulation. At 4-8 weeks after spraying, both mecoprop-based formulations were showing a better immediate effect on *Rumex* spp than asulam alone, a psychological advantage. The weedkillers used were all least effective on *Ranunculus repens*. Any grass damage was extremely slight, though as expected MCPA/MCPB was safer than all three-component formulations which were safer than asulam alone.

All treatments in the yield experiments gave a herbage loss compared to the unsprayed control. Asulam, used in the spring, prior to taking a hay cut (this is not recommended), gave a one-third loss; the mean yields from mecoprop/asulam/MCPA (giving a reduced dose of asulam) and mecoprop/dicamba/MCPA were equivalent but an improvement over asulam. Most asulam-based mixtures gave poor yields at Shalford and Collingbourne Ducis (2) due to their effect on *Bromus* spp, otherwise, the overriding factor was not pasture composition, but the drought. In the user trials with the mecoprop/asulam/MCPA spray, damage to grass was not sustained in the wet areas (Table 7). It is extremely encouraging that in large-scale evaluation this material is giving good control of *Cirsium arvense*, *Rumex* spp, *Urtica dioica*, and *Stellaria media*, with a moderate effect on *Ranunculus repens*. Control of *Senecio jacobaea* is also being achieved.


## Acknowledgement

The help of Mr. David Marland, who conducted the 1969/70 user trials, is gratefully acknowledged.


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# THE USE OF BAND APPLICATIONS OF THREE HERBICIDES IN THE ESTABLISHMENT OF DIRECT DRILLED GRASSES AND LEGUMES BY THE WRO ONE-PASS SOWING TECHNIQUE

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Summary Results are presented from a spring and an autumn experiment where paraquat, glyphosate and dalapon were evaluated for bandspray use in conjunction with the WRO one-pass sowing technique for the direct drilling of ryegrass and clover. All three herbicides greatly improved the establishment of ryegrass and clover at both sowings. Glyphosate was most effective at improving establishment, paraquat intermediate and dalapon was least effective. Full sward destruction rates of herbicide did not improve establishment above that obtained with 2/3 rate. It is suggested that glyphosate at 1 kg a.i./ha should be used for this bandspraying technique on this sward type.

Résumé Une technique d'amélioration d'un gazon a ete élaboré à WRO utilisant un seul passage d'une machine munie d'une buse suivie d'un coutre à disque et d'un semoir. Dans deux essais, un de printemps et l'autre d'automne, le paraquat, le glyphosate et le dalapon on été évalué pour la destruction du gazon associée à l'implantation du ray-grass et du trèfle. Aux deux époques de semis tous les trois herbicides ont provoqué une amélioration sensible dans l'établissement des espèces fourragères, le glyphosate étant le plus et le dalapon le moins efficace. La dose préconisée pour une destruction totale du gazon ne s'est pas montrée plus efficace que les $\frac{2}{3}$ de cette dose pour ce qui est de l'établissement de ces espèces. On suggère alors une dose de 1 kg/ha de glyphosate pour cette technique d'amélioration dans des gazons composés de ces deux espèces.

## INTRODUCTION

The WRO one-pass sowing technique has been devised for the introduction of desirable species of grasses and clovers into undisturbed swards with minimum interruption to pasture utilization (WRO Technical Leaflet No 2). Band spraying on the shoulders of the sowing slot is an essential part of the technique preventing the competition of the old sward to the new seedlings.

The work reported here was carried out to evaluate three sward-killing herbicides for this purpose and to see if introduced species differ in their requirement for bandspraying.

METHOD AND MATERIALS

Experiment 1. Comparison of 3 herbicides in autumn on the establishment of Italian ryegrass and white clover.

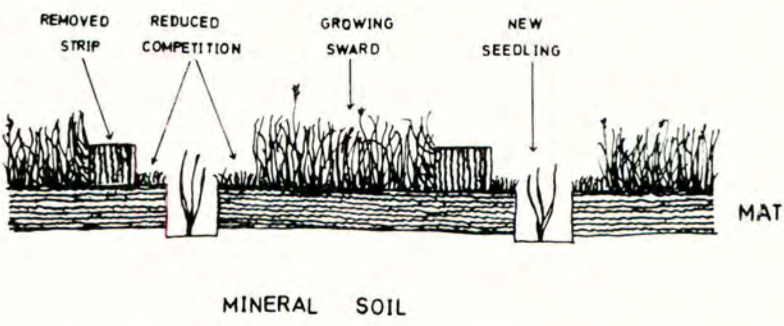
The experiment was carried out at Begbroke Hill on a permanent pasture consisting mainly of Agrostis spp, Festuca rubra and Holcus lanatus. The field is on an alluvial sandy loam soil overlying gravel but subject to a high water table. Formerly the field was lightly grazed and received little fertilizer but since 1966 it has been divided into paddocks grazed rotationally by beef cattle and has received about 175 kg/ha of nitrogen annually.

The following herbicide treatments, replicated three times in a randomised block design, were applied on 19 September 1975 immediately after the sward had been grazed:

| | | | |
|---|---|---|---|
| Paraquat | 0.3 kg a.i./ha | Glyphosate | 0.5 kg a.i./ha |
| | 0.6 " | | 1.0 " |
| | 0.9 " | | 1.5 " |
| Dalapon | 3.0 kg a.e./ha | Control, no herbicidal bandspray | |
| | 6.0 " | | |
| | 9.0 " | | |

Each plot comprised one 10 m run of the WRO one-pass drill sowing four rows at 30 cm centres. A 7.5 cm bandspray of herbicide was applied over the line of each row and the centre 2.5 cm of this was removed by the action of the drill in cutting the sowing slot thus leaving a 2.5 cm band of treated sward on the shoulders of each sowing slot (Fig. 1).

Fig. 1 Cross-section of slots cut by WRO one-pass seeder




Each bandspray was applied by a single nozzle containing a Spraying Systems 730039 Brass Teejet tip operating at 2.1 bar giving a volume rate of 310 litres/ha over the sprayed area. Fertilizer was applied to the slots during sowing at the rate of 41 kg/ha of N and 115 kg/ha of $P_2O_5$ and $K_2O$ (i.e. an equivalent overall rate of 3.4 kg/ha of N and 9.6 kg/ha of $P_2O_5$ and $K_2O$) and slug pellets at the rate of 5 kg/ha were also applied.

In each plot 2 rows of RvP Italian ryegrass were sown at a rate of 10 kg/ha and 2 rows of Blanca white clover at 4 kg/ha. After sowing, the sward was grazed 28 days later, with a further grazing being taken in November. Assessments were made for the effect of the herbicide by means of scoring at intervals for bulk of green material on treated bandspray areas as compared to untreated control plots. A score of '0' represented complete kill and '9' as control. Counts were made of the numbers of plants that were established 6 weeks after sowing in six random 30 cm row lengths per crop per plot.

Experiment 2. Comparison of 3 herbicides applied in spring on the establishment of perennial ryegrass and white clover.

This experiment was carried out in the same field as experiment 1 and using the same herbicide treatments, layout and assessments. The experiment was sown on 21 May 1976 with two rows per plot of Melle perennial ryegrass at a seed rate of 16 kg/ha and two rows of Blanca white clover at 3 kg/ha. During 1976 a continuous grazing system was used in this field and grazing by beef cattle was continuous on the experimental area before and after sowing. Exceptionally dry weather occurred after sowing and the experiment was irrigated on several occasions in order to provide suitable soil conditions for germination and establishment.

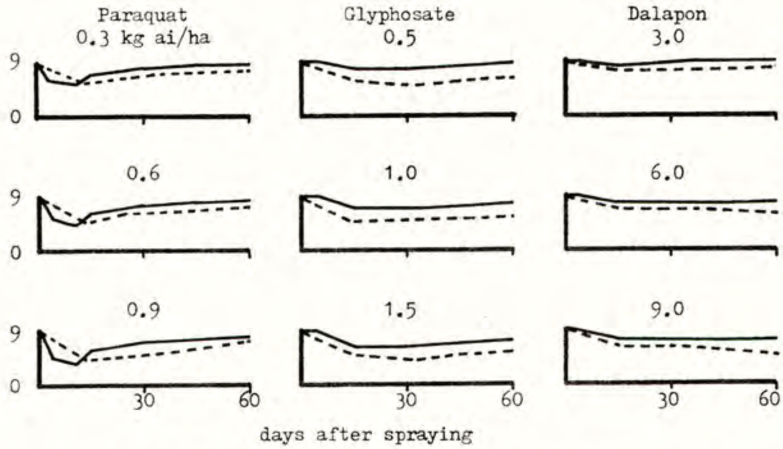
## RESULTS

Experiment 1. Autumn sowing of Italian ryegrass and white clover

Figure 2 shows the amount of green material present on the shoulders of the sowing slots after treatment. Paraquat quickly produced a suppression of the sward and this reached its maximum effect by about 15 days after spraying but recovery of the sward was rapid after this. The action of glyphosate tended to be slower with the maximum effect not being reached until about 30 days after spraying. Recovery was also slower resulting in a longer period of suppression. However at equivalent rates the degree of suppression did not differ greatly between the two herbicides. Dalapon was very slow to act and the degree of suppression was less than paraquat or glyphosate although the effect was very long lasting.

Fig. 2 The amount of green material present on bandspray treated area

(Scored 0-9 for bulk of green material)

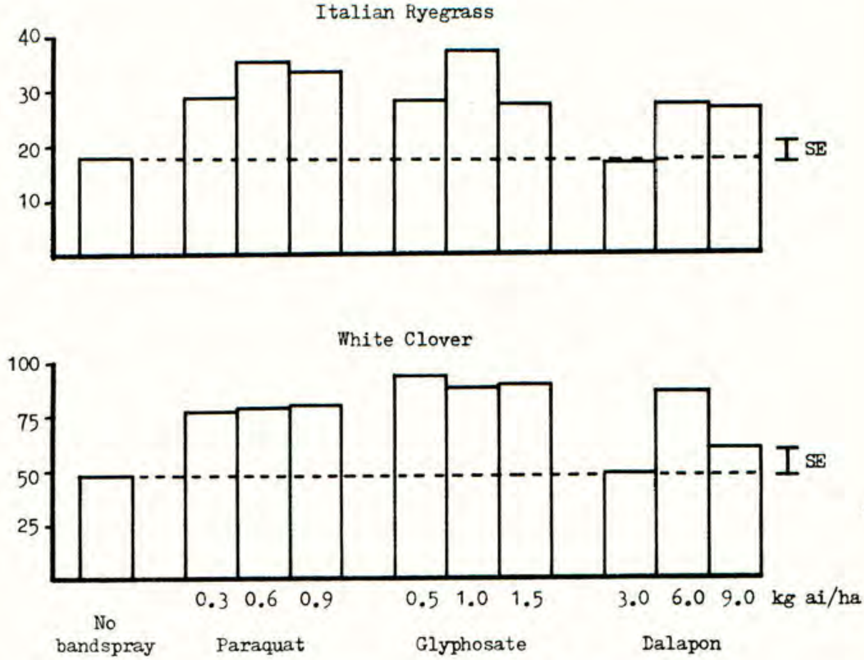



Experiment 1 sprayed on 19.9.75

Experiment 2 sprayed on 21.5.76

The numbers of ryegrass and clover plants which were established 6 weeks after sowing are shown in Figure 3. On the control plots without bandspray there were 18 ryegrass plants/m (15% establishment) and 48 clover plants/m (30% establishment). The establishment of both crops was significantly improved by the bandspray and all three herbicides allowed greater numbers of plants to establish although individual treatment differences from control did not reach significance due to very uneven distribution of plants within the row. All three rates of paraquat were equally effective at improving the establishment of ryegrass and clover. All glyphosate rates gave higher establishment of clover than paraquat but only the medium rate gave better establishment of ryegrass than paraquat. Dalapon was not as effective as the other two herbicides and compared to control the lowest rate gave no improvement in establishment of ryegrass or clover.

Fig. 3 Numbers of established plants present per metre of row 6 weeks after sowing on 19.9.75

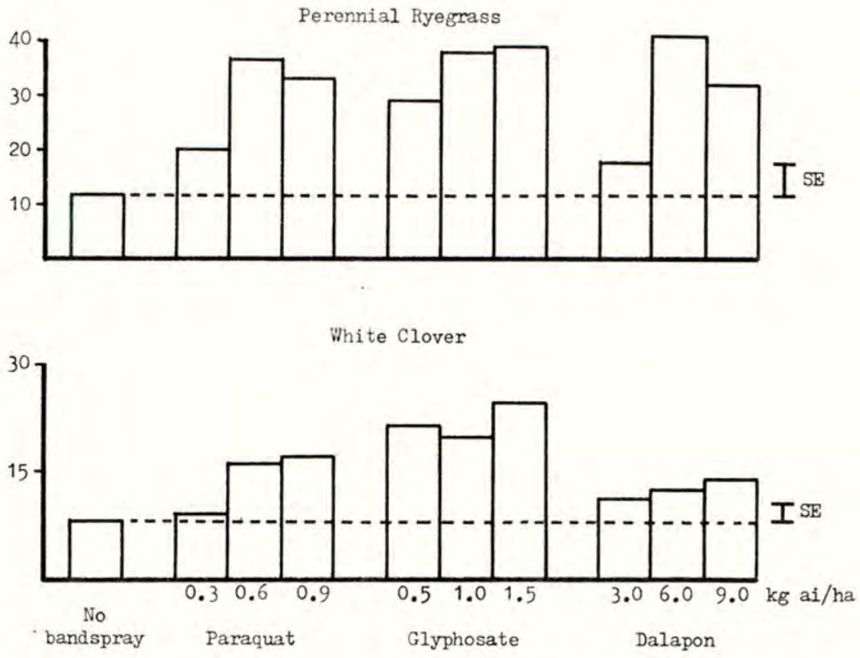



Experiment 2. Spring sowing of perennial ryegrass and white clover

The amount of green material present on the shoulders of the sowing slots after May treatment is shown in Fig. 2. The scores were generally higher than for the autumn spraying showing that the herbicides were not so effective at this spring spraying. Paraquat showed its maximum effect after about 7 days but the treated sward was almost completely recovered by 30 days. Glyphosate took about 15 days to reach its maximum effect, which was less than for paraquat, but it then remained at this level for a further 15 days before the treated sward gradually recovered. The effect of the dalapon was not as great as the other two herbicides and it took longest to appear although sward recovery time was about the same as for glyphosate.

Figure 4 shows the numbers of plants of ryegrass and clover which were established 6 weeks after sowing. Without bandspraying there were 12 ryegrass plants/m (6% establishment) and 8 clover plants/m (7% establishment). The establishment of both crops was significantly improved by bandspraying although individual treatment differences from control did not reach significance. The lowest rates of paraquat and dalapon increased the establishment of ryegrass by about 60% and all other treatments at least trebled the number of ryegrass plants, with glyphosate producing marginally the best results. The establishment of white clover was not increased by the low rate of paraquat but the higher two rates were able to double the numbers of plants established. All rates of glyphosate were able to treble the establishment of clover compared to control. However the establishment of clover was not improved greatly by dalapon.

Fig. 4 Numbers of established plants present per metre of row 6 weeks after sowing on 25.5.76




DISCUSSION

The results from these experiments demonstrate that bandspraying is an important part of the WRO one-pass sowing technique. Without bandspraying the establishment of ryegrass and clover was low but in contrast all three herbicides were able to affect an improvement in the establishment of ryegrass and clover in both spring and autumn sowings.

Glyphosate provided the best and most consistent establishment of ryegrass and clover in both spring and autumn sowings. The use of paraquat produced a lower level of establishment while dalapon produced a lower level than either glyphosate or paraquat. It seems likely that glyphosate gave the best results because its mode of action most nearly accords with the needs of the establishing seedlings; germination takes place 7-14 days after sowing and suppression is needed from this time onwards. The action of glyphosate fits this pattern well. Paraquat, however, has passed its maximum effect after approximately 2 weeks and its maximum suppression is fading while the best suppression of dalapon is not yet fully developed.

The manufacturers recommended rate for sward destruction was represented by the highest rate of each herbicide but this did not provide a complete suppression of vegetation adjacent to the slit as the narrow sprayed area was subject to reinvasion from the unsprayed sward between the rows. However for this technique the highest rates offered little or no advantage in terms of establishment over the medium rate. The lowest rate of use was however generally much less effective. From these results it seems that bandspraying with glyphosate and to a lesser extent with paraquat will give improved establishment of ryegrass and white clover sown in spring and autumn using the one-pass sowing technique. However since these results apply to one sward further experimentation is required for other sward types subject to different management regimes.


## Acknowledgements

I would like to thank M J Loach for assistance with the field work, C J Marshall for analysing the results and R J Haggar for helpful guidance and criticism.


## References


Technical Leaflet No. 2 Weed Research Organization (1976) pp 4.

# A COMPARISON OF GLYPHOSATE AND PARAQUAT FOR SWARD DESICCATION PRIOR TO DIRECT DRILLING OF FODDER CROPS

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Summary Trials at 8 sites with different rates of glyphosate and paraquat for sward desiccation prior to direct drilling with fodder brassicas have been summarised. At most sites, effective desiccation was obtained with both herbicides except at the lowest dose rates. Effectiveness of both was sometimes reduced by stage of grass growth and timing of spray. Glyphosate showed certain advantages over paraquat in sustaining the desiccation on *Lolium perenne* and other species particularly on *Phleum pratense* and *Dactylis glomerata*; it was generally more effective where *Rumex obtusifolius* and *Cirsium arvense* were present.

Brassica crops grew well after both herbicides, yield advantage on glyphosate treatments was only significant at one site.

## INTRODUCTION

Direct drilling into swards desiccated with paraquat is now a popular technique for establishing fodder brassicas. Jeater and McIlvenny (1968) showed that with open swards of *Lolium multiflorum*, sprayed after mid-June, adequate desiccation for kale drilling could be obtained with paraquat at 0.56-1.12 kg ai/ha. Older grass and leys with a high content of *Dactylis glomerata* and fields sprayed before mid-June required dose rates of 1.12-1.68 kg ai/ha. Kale usually gives fewer problems with this technique than turnips or swedes - Squires and Elliott (1972) have referred to the greater ability of the kale seedling to compete with desiccated organic matter because of its comparative aggressiveness. Success, however, depends on adequate preparation of swards for spraying as outlined by Toosey (1972) and making the necessary adjustments for each site he suggested that split applications of paraquat could be more effective than single sprayings where sward regrowth is a problem.

For various reasons, regeneration of both grasses and weeds do sometimes create problems especially with swedes, and difficulties can arise where *Agropyron repens*, *Agrostis gigantea*, *Rumex obtusifolius* or *Cirsium arvense* are present.

A series of trials by Davison (1972) showed that the new herbicide glyphosate was most effective on sward grasses and also on a wide range of broad-leaved weeds. It was decided to evaluate this herbicide for direct drilling in a number of ADAS trials on commercial farms during 1973 and 1974.

## METHODS AND MATERIALS

At 3 sites in 1973 and 5 in 1974, glyphosate and paraquat were compared at different dose rates for sward desiccation prior to drilling of kale, turnips and swedes.

## Table 1

### Site Details

| Site Ref: | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| Location | Bury Lancs | Meifod Powys | Beulah Powys | Shepton Mallet Somerset | Meifod Powys | Senny-bridge Powys | Muggin-ton Derby | Wormhill Derby |
| Sward:- Age (yr) | 3 | 3 | 7 | 3 | 6 | 7 | 6 | - |
| Pre-spray Use | Paddock Gr. | Silage | Grazed | Silage | Silage | Grazed | Grazed | Grazed |
| Soil Texture | Sandy Loam | Silty Clay Loam | Med. Loam | Fine Sandy Loam | Med. Loam | Sandy Loam | Sandy Loam | - |
| Spraying Dates | 27.7.73 | 2.7.73 | 19.6.73<br>26.6.73 | 3.7.74 | 4.6.74<br>11.6.74 | 30.5.74 | 27.6.74 | 9.5.74 |
| Vol. Rate (l/ha) | 220 | 275 | 275 | 220 | 330 | 275 | 330 | 330 |
| Direct Drill Dates | 28.7.73 | 5.7.73 | 26.6.73 | 9.7.74 | 11.7.74 | 4.6.74 | 30.6.74 | 3.6.74 |
| Crop (Cultivar) | Kale (Marrow Stem) | Turnip (Debra) | Swede (Ruta Otofte) | Swede (Bangholm Wilhelms-burger) | Swede (Bangholm Wilby) | Swede (Magni-ficent) | Kale (Canson) | Swede (Victory)<br>Kale (Maris Kestrel)<br>Rape (Lair) |
| NPK kg/ha | 137/68/68 | 125/75/75 | 92/65/65 | 40/115/90 | 115/128/103 | 100/75/75 | 238/55/55 | - |

The treated swards varied in age and composition but were all basically Lolium perenne with some L. multiflorum in the younger leys, also Phleum pratense, Dactylis glomerata, Poa annua, P. trivialis and in the older swards varying amounts of Holcus lanatus and Agrostis spp. One of the sites had an infestation of Agropyron repens, whilst the broad-leaved species Rumex obtusifolius, Cirsium arvense, Taraxacum officinale and Ranunculus repens were present on several sites.

The location of sites and other relevant details are given in Table 1.

Herbicide treatments and dose rates varied between sites; these are summarised in Table 2.

Table 2

Treatments and Dose Rates/ha

| Site | Glyphosate (kg ai) | | | | Paraquat (kg ai) | | | |
|---|---|---|---|---|---|---|---|---|
| Ref: | 0.56 | 1.12 | 1.68 | 2.24 | 0.56 | 1.12 | 1.68 | 1.12 + 0.50* |
| A | ✓ | ✓ | | ✓ | ✓ | ✓ | | |
| B | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ |
| C | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ |
| D | | ✓ | | ✓ | | ✓ | | |
| E | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ |
| F | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ |
| G | | | ✓ | ✓ | | | ✓ | |
| H | | | ✓ | ✓ | | | ✓ | |

* Split application, the 0.56 kg dose applied a few days after the 1.12 kg

Volume rate ranged from 220 to 330 l/ha of water; application was by hand sprayer at sites B, C, E, F and G and by tractor-mounted equipment at A, D and H. Pressures were all at 2.068 bar. At all sites except H, treatments were laid down in replicated randomised blocks.

## RESULTS

### Effectiveness of Sward Desiccation

Grass desiccation prior to direct drilling was reasonably satisfactory except at site H where drilling had been delayed owing to drought conditions. Additional applications of 0.56 kg/ha of each treatment had to be made on the day after drilling; following this, the desiccation was satisfactory.

The general picture was one of rapid desiccation following paraquat, taking about 3 days whilst glyphosate took 10-12 days. Grass regeneration was usually more rapid on the paraquat treatments but the glyphosate produced longer lasting effects. The extent of regeneration, however, varied between sites. At site A, on the lower rate of paraquat (0.56 kg ai) there was up to 50% recovery of Lolium perenne and L. multiflorum in the kale crop about 4 weeks after spraying. Following the 1.12 kg ai treatment the regeneration was 40% as compared with about 10% on all glyphosate treatments. At site G, although initial desiccation had been good with both herbicides, grass recovery in the kale crop was stronger following the paraquat treatment.

At site D, where swedes were drilled, ryegrass desiccation was very good with both herbicides but Phleum pratense was better controlled by glyphosate than by paraquat.

On fodder root sites in Powys there was recovery of Lolium and Agrostis spp. In the turnip crop this occurred, particularly on the paraquat treatments. Agropyron repens which was troublesome at this site was not effectively controlled by either herbicide. In the direct drilled swedes at sites C, E and F initial desiccation was on the whole effective but some recovery occurred particularly at the lower dose rates of each herbicide, i.e. glyphosate at 0.56 kg and paraquat at 1.12 kg ai. Dactylis glomerata was more evident on the latter treatments.

At several sites seedlings of Poa annua and Poa trivialis re-colonised on sprayed plots irrespective of treatment, although these had been effectively desiccated initially.

Effect on Broad-leaved Weeds

Of the broad-leaved weeds, Rumex obtusifolius was the most prevalent on all sites, it became particularly competitive to the swedes at site D on the paraquat treated plots. The suppression of this weed was better on glyphosate treatments at sites C, E, F and H but this was not the case at site B. Glyphosate also produced a better kill of Cirsium arvense than paraquat at site E.

Weeds which colonised on some of the sites during the period after desiccation were Stellaria media, Senecio vulgaris and Sonchus arvensis. At sites B and D, Taraxacum officinale was present on all treatments but at site H it was reported that glyphosate was effective against this weed.

Establishment and Development of Direct Drilled Crops

Kale establishment was retarded at site A by recovery of the grass especially at the lower rate of paraquat treatment (0.56 kg ai), the effect being reflected in lower plant population and reduced crop height. Some evidence of magnesium deficiency was observed in the crop but it was considered that the low yields on all treatments were due mainly to the late sowing and inadequate nitrogen.

At site G, kale established well on all treatments although the crop was somewhat shorter on the paraquat plots. No toxic effects to the crops were observed from either chemical at these sites. Table 3 illustrates the level of crop yields achieved at sites A and G.

Table 3

Yield of Direct Drilled Kale - tonnes/ha (Green Wt.)

| Treatments | Site<br>Date of Assessment | A<br>3/11/73 | G<br>25/10/74 |
|---|---|---|---|
| Glyphosate kg ai/ha | 0.56 | 29.8 | - |
| | 1.12 | 28.3 | - |
| | 1.68 | - | 61.8 |
| | 2.24 | 32.0 | 63.3 |
| Paraquat kg ai/ha | 0.56 | 21.2 | - |
| | 1.12 | 27.6 | 55.9 |
| | 1.68 | - | - |
| | SE | ± 0.78 | ± 12.6 |

Yields from all glyphosate treatments at site A were comparable with those obtained from the 1.12 kg ai/ha rate of paraquat and markedly superior to those at the 0.56 kg ai rate. At site G, yields were considerably higher, there was no significance in the yield differences due to herbicide treatments.

Crop establishment on the fodder root sites was generally satisfactory. Some leaf symptoms from paraquat were observed during the first weeks at site C but these cleared up later. A similar effect was experienced at sites E and F particularly with the split treatment of paraquat 1.12 kg + 0.56 kg/ha, the second application being made after the swedes had been drilled. Assessments of yields of swedes as DM/ha are given in Table 4.

Table 4

Mean DM Yields of Direct Drilled Swedes - t/ha

| Treatment | Site<br>Date of Assessment | D*<br>3.12.74 | E<br>12.11.74 | F<br>4.12.74 |
|---|---|---|---|---|
| Glyphosate kg ai/ha | 0.56 | - | 9.15 | 5.49 |
| | 1.12 | 5.92 | 8.65 | 6.39 |
| | 2.24 | 6.88 | 8.80 | 6.70 |
| Paraquat kg ai/ha | 1.12 | 3.81 | 9.00 | 6.19 |
| | 1.68 | - | 8.10 | 6.19 |
| | 1.12 + 0.56 | - | 8.65 | 6.39 |
| Ploughed Area | | 3.56 | - | - |
| SE | | ± 0.803 | ± 0.596 | ± 0.425 |
| CV | | | 8.2% | 9.4% |

* Total DM of roots and tops at this site

The mean plant population varied greatly between these sites reflecting the type of drill and the row width used. Site D with a row width of 50.8 cm had a population of 112.8 thousands per hectare whilst the figure for site E using a Bettinson drill with 30.48 cm row width was 321 thousands/ha. At site F with the same row width and using a disc rotovator and Stanhay seeder units, the mean plant population was 157.5 thousand/ha.

Differences in root numbers per treatment were not significant at these centres, but the glyphosate treatments produced significantly higher yields than paraquat at site D. Mean yield differences at the other sites were not significant except between the highest and lowest glyphosate treatment at site F.

Ploughing and "normal cultivations" were included at site D for swedes and at site H for swedes, kale and rape. Although strict comparisons were not feasible, yields obtained from herbicide treated plots were comparable with those obtained from conventional cultivations. With the root crops the direct drilled crops produced larger numbers of smaller sized roots.

## DISCUSSION

It would appear that a satisfactory degree of sward desiccation was obtained on most of these sites except at the lower rates of herbicide at site A, and the comparatively early spraying at site H. The results emphasise the importance of having adequate leaf development on both grasses and weeds at the time of spraying. The absence of sufficient sward recovery after the silage cut at sites A and B and, to a lesser extent site C, would probably explain the regeneration of grass particularly on the paraquat treatments. At site B, this would also account for the poor effect of glyphosate on Agropyron repens and Rumex obtusifolius.

On some of these situations the ability of the sown crop to complete effectively was impaired by factors not related to the herbicide treatment, e.g. late drilling of marrow stem kale at site A. Nevertheless, it was apparent that glyphosate had some advantages over paraquat in providing a more lasting suppression of the grasses which particularly benefitted the kale development at this site.

At other sites also, glyphosate treatments seemed to be more successful in delaying, or even preventing the recovery of competitive grasses and of dealing with fields which had infestations of Rumex obtusifolius and Cirsium arvense.

Generally, however, good crops of kale, swedes, turnips and rape were produced following both these herbicides. The degree of desiccation obtained from paraquat was adequate provided the competitive ability of the direct drilled crop was not impaired by any other factors. Differences in crop yields were generally small, being most evident with the swedes at site D and, to a lesser extent, the late sown kale at site A.


## Acknowledgements

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# CONTROLLING WEED GRASSES IN RYEGRASS BY ETHOFUMESATE WITH SPECIAL REFERENCE TO POA ANNUA

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Summary Ethofumesate applied pre-emergence at less than 1 kg/ha proved very effective in controlling P. annua. However, beyond the 2-3 leaf stage the herbicide became less effective and, in a field experiment, at least 3 kg/ha was required to reduce the yield of fully tillered P. annua by 80%, albeit without damage to perennial ryegrass yield. Supplementary pot experiments showed that 16 other weed grasses were also controlled by pre-emergence applications of ethofumesate. Also, that activity was reduced by organic matter and dry soil surfaces. It was concluded that the herbicide has a potential use for establishing ryegrass leys in clean seed beds free of a wide range of weed grasses.

Résumé L'ethofumesate appliqué en pré-levée à un dose inférieur à 1 kg/ha se montra très efficace dans la lutte contre le P. annua. Cependant après le stade 2-3 feuilles l'efficacité herbicide diminua, et, dans une expérience de plein champ, au moins 3 kg/ha fut nécessaire pour effectuer une baisse de 80% dans le rendement du P. annua en plein tallage; pourtant le rendement du ray-grass n'en souffrit point. Dans des expériences supplémentaires, utilisant des pots, 16 autres graminées adventices se trouvèrent détruites par des applications d'ethofumesate en pré-levée; la presence de matière humique ainsi que la sècheresse de la surface du sol réduisit l'activité du produit. On jugea que l'herbicide offre des possibilités pour l'establissements de gazons de ray-grass dans des semis propres en l'absence d'un large spectre de graminées adventices.

## INTRODUCTION

Poa annua (Annual Meadow-grass) is a major contaminant of newly sown perennial ryegrass leys (Wells, 1974) and there is good evidence that the key to establishing a productive ley is the control of weed grasses during the first few weeks after sowing (Haggar, 1976).

Work by Ball and Roberts (1974) demonstrated that ethofumesate has a potential for controlling certain grasses, including P. annua, in ryegrass crops grown for seed. The present series of experiments were carried out to investigate the activity of this herbicide on P. annua and the other grass weeds commonly found in newly sown ryegrass leys.

## METHOD AND MATERIALS

### Experiment 1. Effect of growth stage on P. annua susceptibility.

In this 15 pot experiment, ethofumesate was applied at five rates, ranging from 0 to 2.0 kg/ha, to P. annua at three stages of growth namely tillering, 2-3 leaves and pre-emergence. The growth stages were achieved by sowing seed at intervals of about two weeks starting on 21 June 1976. The seed was sown at a rate sufficient to produce approximately 80 seedlings per 16 cm diameter pot. The pots contained John Innes base soil and the seeds were covered with 3 mm of this sterilized soil.

Ethofumesate was sprayed on 23 July at 2.07 bars pressure in 300 l/ha water. After spraying, the P. annua was scored for herbicide damage at weekly intervals and a dry-matter yield was carried out on 16 August.

Experiment 2. Selectivity of 17 grasses, including P. annua

In a 102 pot experiment in the greenhouse, seed of the 17 grasses listed in Fig. 2, which were mostly collected locally, was broadcast on medium John Innes base soil, mixed with sterilized soil, contained in 13 cm diameter pots. Mean organic matter (loss on ignition on dry matter basis) was 7%. Seed rates were adjusted to produce 5 plants per pot after singling. The seed was covered with about 5 mm of sterilized soil. Dates of sowing were 29 April, 14 May and 2 June, giving three contrasting growth stages at the time of spraying. Each species and growth stage was duplicated twice.

On 10 June 1976 one duplicate was sprayed with ethofumesate at 1.9 kg/ha in 300 l/ha of water. The remaining replicate acted as the unsprayed control. Thereafter, the grasses were scored for herbicide damage at weekly intervals.

Experiment 3. Effect of soil/plant conditions on P. annua susceptibility

In a similar 20 pot experiment, the same five rates of ethofumesate as used in experiment 1 were applied to tillering P. annua plants grown under four conditions:

a) Plants defoliated to 2.5 cm immediately before spraying.
b) Plants irrigated from bottom of pot (soil surface dry).
c) Plants grown in 12% organic matter soil, compared with 7% organic matter with other treatments.
d) Plants grown normally as in experiment 1.

The plants were sprayed on 23 July 1976 when the majority had reached the tillering stage of growth. Assessments of herbicide damage and dry-matter determinations were similar to experiment 1.

Experiment 4. P. annua in newly sown ryegrass

In a field experiment on an alluvial soil overlying gravel, a seed mixture containing S.23 and S.24 perennial ryegrass was drilled at 2.5 kg/ha into a rotovated seed bed in September 1975. (The previous crop was intended to have been perennial ryegrass but this had failed to establish successfully from a previous sowing in the same year.) After spraying, and despite heavy rolling, lack of rainfall led to poor ryegrass establishment and a considerable invasion by P. annua.

Ethofumesate was applied in March 1976 by Oxford Precision Sprayer at 4 rates ranging from 0 to 3.2 kg/ha a.i. in 300 l/ha of water. Each rate was replicated 4 times in a randomised block design. Plot size was 6 m by 2 m.

On 27 May 1976 a central area measuring 4 m by 1 m was harvested on each plot with an autoscythe. After weighing and sampling for dry-matter yield, a further sample was separated into ryegrass and P. annua and their respective dry-matter yields determined.

## RESULTS

### Experiment 1. Effect of growth stage on P. annua susceptibility

Although the dry-weight response of tillering plants of P. annua to ethofumesate (Fig. 1) was similar to that of plants at the 2-3 leaf stage, it was estimated from the graph that 2.1 kg/ha of ethofumesate was required on the tillered plants to achieve a 75% reduction of the initial weight, whereas only 1.1 kg/ha was required on the younger plants. Similarly, if ethofumesate was used pre-emergence the amount required fell to 0.6 kg/ha. To obtain complete control, the rates would need to be increased to approximately 1.0, 2.1 and over 3.0 for the pre-emergence, 2-3 leaf and fully tillering stages respectively.

### Experiment 2. Selectivity of 17 grasses, including P. annua

Perennial ryegrass proved the most resistant of all the grasses at each of the three application stages (Fig. 2). Of the Poa species, only fully tillered plants of P. annua survived the 1.9 kg/ha ethofumesate application. The same applied to P. pratensis but P. trivialis was slightly more resistant.

The pre-emergence application killed all grasses except ryegrass. At the 2-3 leaf stage, more grasses survived including, in order of least damage (as indicated by the area under the respective graphs in Fig. 2), perennial ryegrass, P. trivialis, H. lanatus, B. mollis, A. tenuis and D. caespitosa.

At the tillering stage, the order of least damage was: perennial ryegrass, P. trivialis, P. pratensis, D. caespitosa, B. mollis, A. tenuis, A. sterilis, H. lanatus, A. elatius, A. odoratum, A. stolonifera, P. annua, C. cristatus, B. media, A. elatius var bulbosa, F. rubra and A. pratensis.

### Experiment 3. Effect of soil/plant condition on P. annua susceptibility

With the high organic matter treatment, ethofumesate failed to produce any marked depression in P. annua yield over the range 0.5 to 2.0 kg/ha (Table 1) and it was impossible to extrapolate how much ethofumesate was required to reduce yields down to 75% of initial values.

Table 1

Influence of various soil/plant treatments on the dry-matter response of P. annua to ethofumesate (g/pot)

| | Ethofumesate (kg/ha) 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | Mean |
|---|---|---|---|---|---|---|
| High organic matter | 8.4 | 5.7 | 6.2 | 4.7 | 4.7 | 5.9 |
| Sub-irrigation | 13.3 | 8.1 | 3.6 | 4.0 | 4.4 | 6.6 |
| Defoliation | 5.6 | 5.3 | 3.1 | 1.5 | 0.7 | 3.2 |
| Control | 6.4 | 3.7 | 3.2 | 2.2 | 1.6 | 3.4 |
| | | | | | | S.E. = 0.2 |

Subterranean watering doubled the yield of P. annua in the absence of ethofumesate. With ethofumesate the results were variable although the dry soil surface appeared to reduce herbicide activity at the high rates.

Defoliation had little effect on P. annua response; between 1.6 and 2.0 kg/ha was required to achieve a 75% reduction of both defoliated and non-defoliated plants.

Experiment 4. P. annua in young ryegrass

Harvested yield of the two species are given in Table 2.

Table 2

Dry-matter yield of ryegrass and P. annua as influenced by ethofumesate (kg/ha)

| Ethofumesate | Ryegrass | P. annua | Total |
|---|---|---|---|
| 0.0 | 2826 | 2286 | 5111 |
| 0.8 | 3473 | 1793 | 5268 |
| 1.6 | 3480 | 1394 | 4875 |
| 3.2 | 4008 | 430 | 4437 |
| S.E. | ± 580 | ± 186 | ± 467 |

In the absence of ethofumesate P. annua, which was mostly fully tillered, accounted for nearly half the total dry-matter yield. In the presence of increasing amounts of the herbicide the yield of P. annua decreased while ryegrass yields increased steadily. However, above the 0.8 kg/ha rate the increase in ryegrass did not offset the decrease in P. annua, as evidenced by the decline in total yield of dry matter. Moreover, there was still nearly 20 per cent of control of P. annua present at the 3.2 kg/ha rate.

## DISCUSSION

These experiments have demonstrated that ethofumesate is most effective when used as a pre-emergence herbicide in controlling weed grasses in perennial ryegrass. Used in this way, slightly less than 1 kg/ha is likely to be sufficient in controlling P. annua as well as other major weed grasses. However, if application is delayed beyond the 2-3 leaf stage of growth then rates need to be increased considerably. For example, fully tillered P. annua required at least 3 kg/ha to reduce yields by 80%. Even at this high level, however, perennial ryegrass appeared remarkably resistant.

Poa trivialis proved more resistant to ethofumesate than P. annua. On the other hand, F. rubra, A. elatius var bulbosa, B. media, A. pratensis and C. cristatus were all more sensitive than P. annua.

As expected, the efficiency of ethofumesate was reduced by the presence of organic matter and a dry soil surface (Whitehead, 1976). These might have been contributing factors in the need for the high rate of ethofumesate needed to control P. annua in the field experiment; the seed bed contained a considerable amount of rotovated turf and the rainfall after spraying was below average. Unfortunately, these two factors limit the use of this herbicide for the attractive purpose of preventing the ingress of weed grasses into established ryegrass swards, although poached, closely grazed swards could be considered for this purpose.

Although further confirmation of these results is required under field conditions, the findings, coupled with other published data (Blair, 1972; Ball and Roberts, 1974) suggest that the usefulness of ethofumesate in controlling grass weeds in ryegrass seed crops can be extended to the wider use of establishing ryegrass leys in clean seed beds free of a wide range of indigenous grasses.

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Fig. 1. The dry weight response of P. annua at three stages of growth to ethofumesate.

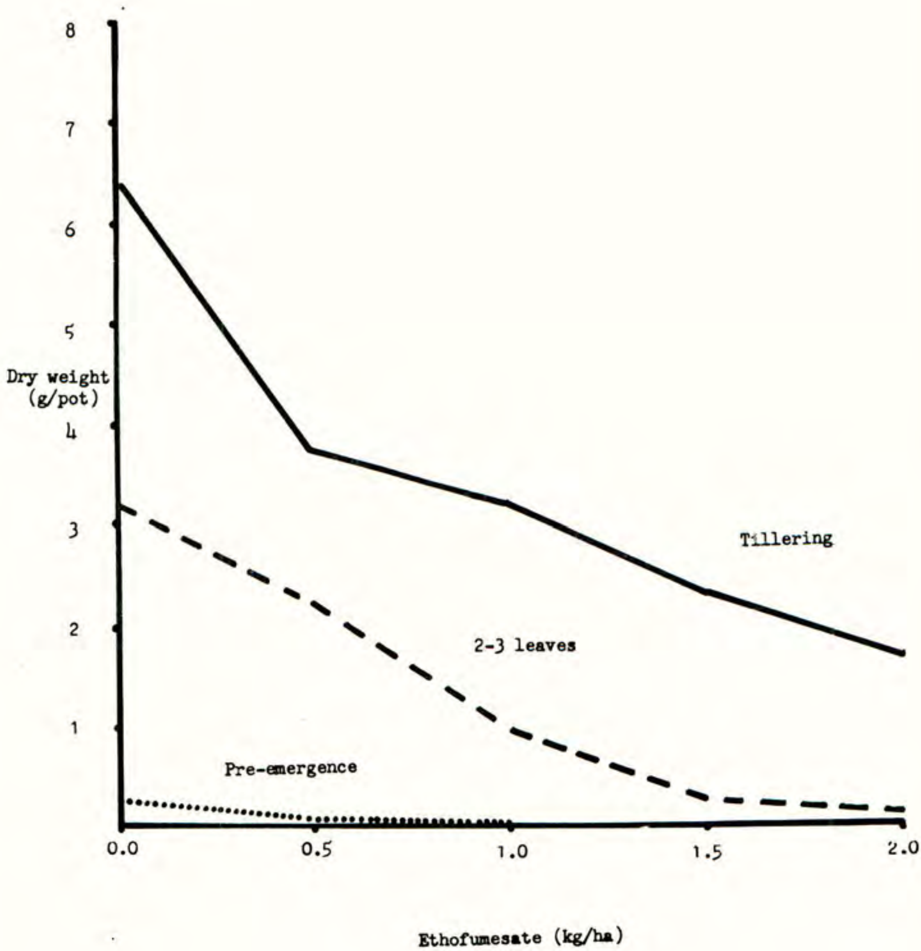
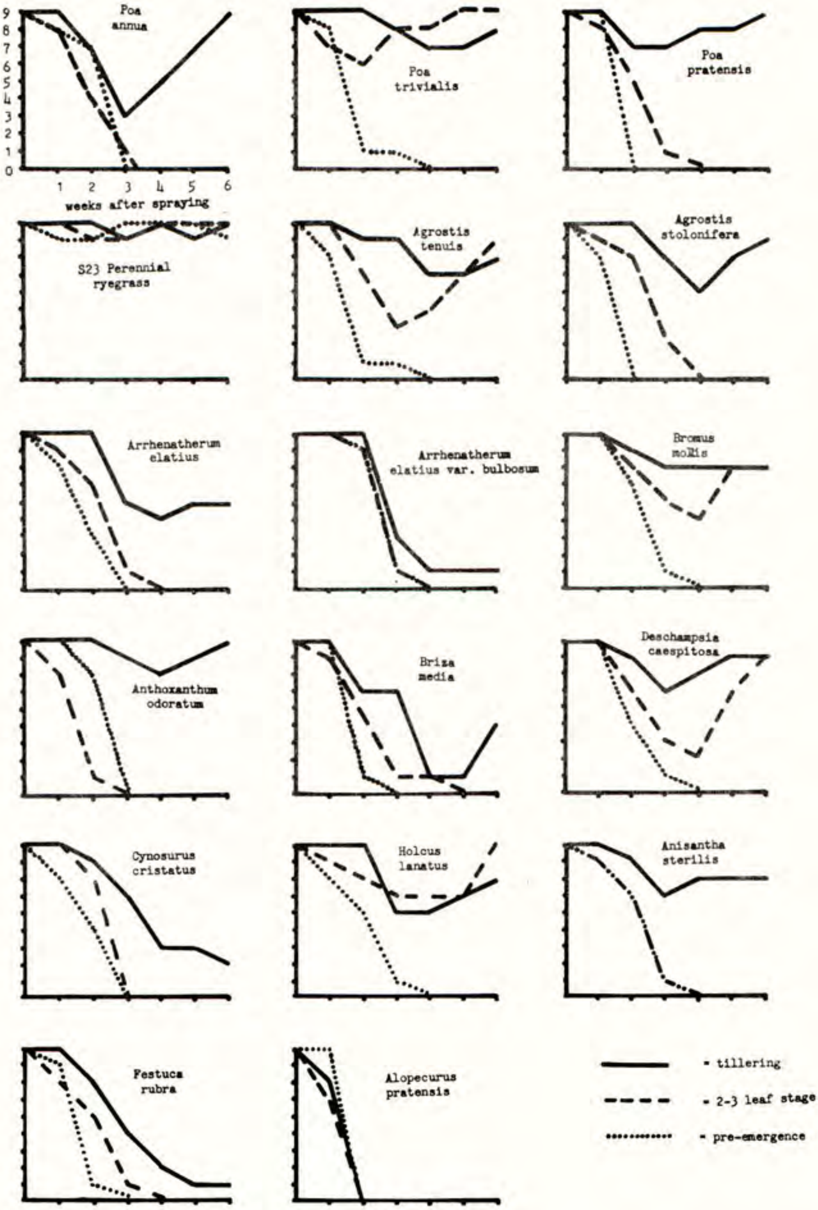


Fig. 2. Visual scores of green material on 17 grasses treated with 1.9 kg/ha ethofumesate at three stages of growth. (9 = no effect compared with untreated control, 0 = completely killed.)



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# AN EXTENDED SEASON OF HERBICIDES APPLICATION FOR THE CONTROL OF Senecio Jacobaea

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Summary. It appears likely that control of Senecio jacobaea as evidenced by the prevention of inflorescence production in the year of application may be accomplished by spraying at a range of dates between April and June. In addition there is a clear indication that an application at this time of the year could also significantly reduce the number of inflorescences produced in the year following application. Control for a longer period than this seems improbable where continued re-infestation of the sward through seedling germination and establishment is taking place.

Seedling germination appeared to occur at two periods, one in the Autumn during September-October and the second in the following Spring during the April-June period.

There was evidence from two of the three sites on which the experiments were conducted that the selective control of existing Senecio jacobaea plants, and possibly those other dicotyledonous species in the sward, was in fact encouraging a higher rate of seedling establishment compared to the unsprayed control plots.

Résumé. Il paraît probable que la lutte contre Senecio jacobaea comme manifesté par l'empêchement de production inflorescence en l'année d'application, peut exécuter au moyen de pulvérisation à une série de dates entre Avril et Juin. En plus il existe une clairè indication qu'une application à cette époque de l'année pourrait aussi réduire d'une manière significative le numéro d'inflorescences produits dans l'année suivant l'application. La lutte pour une période plus long paraît improbable où des attaques parasitaires continues de la pelaise à cause de germination et acclimation des semences ent lieu.

La germination des semences paraît avoir lieu à deux périodes - une à l'automne pendant Septembre-Octobre et la seconde le printemps prochain pendant Avril-Juin.

Il y avait des traces de deux sur trois terrains où on a effectué les expériences, que la lutte sélective de Senecio jacobaea et possiblement autre espèces dicotylédonées dans la pelouse était en effet encourageant un nombre plus haut de l'établissement de semences en comparaison des terrains remains non-pulverisé.

## INTRODUCTION

There are very real practical problems of pasture and stock management posed by the use of herbicides for ragwort control during the normally recommended May-September period. Experiments were commenced in 1973 with the primary aim of establishing whether 'out of season' spraying might provide a solution. Because in Northern Ireland there had been specific concern expressed about the hazard of Senecio jacobaea when conserved in silage, a secondary aim was to examine the possible use of herbicides to overcome infestations in fields intended for silage. Finally the experiments aimed to provide comparative data on the effectiveness of alternative herbicides to MCPA and 2,4-D. There was some evidence, from experiments carried out concurrently with the present trials in the North of Scotland (Forbes 1974) and in the Republic of Ireland (Mitchell 1974), that a more flexible programme of spray dates was possible.

Two experiments were conducted to examine the effect of:

1. a range of herbicides applied at approximately monthly intervals between May and November
2. a more limited range of herbicides applied at two sites on three occasions either in the late Autumn/Winter (Dec) period, the early Spring (April) and during the traditional early Summer (July).

## METHODS AND MATERIALS

Experiment 1. This experiment was conducted on a coastal site at Portavogie, County Down, in a two acre field subjected to continuous intensive grazing with cattle throughout the year and with a history of stock fatalities. Herbicide treatments are shown in Table 1. Dates of application in 1973 were 11 May, 12 June, 17 July, 13 August, 2 October and 1 November.

In order to allow the continued access of stock to the area the plots were arranged in 10 m strips, per date of application, in a regular progression across the field. As each set of treatments was applied the area involved was fenced off for the period, approximately a month, up to the next spray date. The 10 m strips were subdivided into four blocks within which 8 individual plots (6 herbicide treatments and two unsprayed control areas) each 2 m x 10 m were laid out. This experimental design precludes direct statistical comparison between dates of application, but was the only practical arrangement which could be agreed to obtain the use of the site. Plant counts were recorded on dates shown in Table 1 as the mean of 20, 25 x 25 cm quadrats per plot for seedlings or non-flowering plants and on a single plot (20 $m^2$) for flowering plants. The herbicides were applied with an Oxford precision sprayer with 4 '00' ceramic fan jets at 45.2 cm spacing and a pressure of 2.0 bar, giving an output of 225 ℓ/ha of water.

Experiment 2. The herbicide treatments - MCPA salt (2.24 kg ai/ha) 2,4-D ester (1.68 kg ai/ha) and Dicamba/Mecoprop/MCPA (2.56/kg/ha) - were applied in December 1974, April 1975 and July 1975 at two sites (A) Ballyesborough, Co Down and (B) Glenavy, Co Antrim. At these sites the plot size was 6 m x 25 m and application was made with a Land Rover mounted sprayer at a volume of 220 ℓ/ha. Herbicide treatments and dates of application were fully randomized within each of four blocks. The areas were assessed for Senecio jacobaea control in April, July and October 1975 and at the Ballyesborough site in July 1976. The plant population at the Glenavy site declined naturally, possibly due to changes in the grassland management. and counts in 1976 were not considered feasible.

## RESULTS

Experiment 1. Plant Population. The plant population on the control plots at Portavogie throughout 1973 and for the two dates of recording in 1974 is shown in Fig. 1. In 1973 there was a decline in total plant numbers associated with flowering

Table 1

Results - Experiment 1

% Reduction all plants (1973) - approximately 1 month post-spraying

| Date of Spray<br>Date of assessment | Conc<br>kg/ai/ha | May 11<br>June 12 | June 12<br>July 17 | July 17<br>Aug 13 | Aug 13<br>Oct 2 | Oct 2<br>Nov 1 | Nov 1<br>- |
|---|---|---|---|---|---|---|---|
| MCPA | 2.24 | 89.4 | 56.8 | 52.9 | 92.6 | 71.4 | NOT ASSESSED UNTIL APRIL 1974 |
| 2,4-D amine | 2.24 | 85.1 | -8.1 | 76.5 | 85.2 | 61.9 | |
| 2,4-D ester | 1.68 | 95.7 | -8.1 | 52.9 | 100 | 49.2 | |
| Dicamba mecoprop | 0.56 | 100 | 51.4 | 76.4 | 70.4 | 74.6 | |
| Mecoprop | 3.57 | 91.5 | 13.5 | 52.9 | 85.2 | 81.0 | |
| Dichlorprop | 2.80 | 78.7 | 29.7 | 100 | 92.6 | 11.1 | |
| Date mean | | 90.1 | 22.5 | 68.6 | 87.7 | 58.2 | |
| Control all plants Nos/$m^2$ | | (9.4) | (7.4) | (3.4) | (5.4) | (12.6) | |
| Herbicide Sig SE log (count + 1) | | NS $\pm$ 0.12 | NS $\pm$ 0.09 | NS $\pm$ 0.10 | NS $\pm$ 0.09 | * $\pm$ 0.10 | |
| Control v Rest Sig | | *** | NS | NS | *** | *** | |

## Table 2

**% Control in season following application of**

**Flowering (F) and Seedling (S) Plants Recorded July 1974 - Experiment 1**

| Date sprayed | 11.5.73 | 12.6.73 | 17.7.73 | 13.8.73 | 2.10.73 | 1.11.73 |
|---|---|---|---|---|---|---|
| Plants | F | F | F | F | F | F |
| MCPA | 90.5 | 86.7 | -71.4 | 25.0 | 92.0 | 79.6 |
| 2,4-D (amine) | 100.0 | 93.3 | 85.7 | 100.0 | 100.0 | 95.9 |
| 2,4-D (ester) | 100.0 | 100.0 | 71.4 | 87.5 | 100.0 | 95.9 |
| Dicamba/Mecoprop | 100.0 | 73.3 | 85.7 | 93.8 | 100.0 | 100.0 |
| Mecoprop | 90.5 | 100.0 | 57.1 | 93.8 | 92.0 | 95.9 |
| Dichlorprop | 90.5 | 93.3 | 100.0 | 100.0 | -12.0 | 79.6 |
| Date Mean | 95.24 | 91.11 | 54.76 | 83.33 | 78.67 | 91.16 |
| Control plant nos/$m^2$ | (2.1) | (3.0) | (1.4) | (3.2) | (2.5) | (4.9) |
| Herbicide Sig SE log (count +1) | NS ±0.14 | NS ±0.13 | NS ±0.17 | NS ±0.13 | * ±0.14 | NS ±0.08 |
| Control v Rest Sig | ** | *** | NS | *** | *** | *** |
| | S | S | S | S | S | S |
| MCPA | 10.7 | -23.6 | 43.1 | -7.5 | 18.2 | 71.2 |
| 2,4-D (amine) | -39.2 | -21.3 | -2.5 | 24.3 | 33.5 | 87.5 |
| 2,4-D (ester) | -11.1 | -63.8 | 35.1 | 15.3 | 32.5 | 62.2 |
| Dicamba/Mecoprop | -18.2 | -37.1 | -14.4 | -12.4 | 1.8 | 81.4 |
| Mecoprop | -17.1 | -27.2 | 17.0 | 41.8 | 15.6 | 70.9 |
| Dichlorprop | -24.5 | -31.2 | 10.2 | 8.4 | 6.4 | 75.7 |
| Date Mean | -30.83 | -26.92 | 14.76 | 11.47 | 18.16 | 74.83 |
| Control plant nos/$m^2$ | (104) | (61) | (68) | (62) | (39) | (63) |
| Herbicide Sig SE log (count +1) | NS ±0.05 | ** ±0.04 | * ±0.05 | NS ±0.07 | NS ±0.09 | NS ±0.13 |
| Control v Rest Sig | NS | NS | NS | NS | NS | *** |

TABLE 3

% Ragwort Control

| Spray date | December 1974 | | | April 1975 | | | July 1975 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Herbicide | MCPA | 2,4-D | DMM* | MCPA | 2,4-D | DMM* | MCPA | 2,4-D | DMM* | Control nos/$m^2$ |
| **Site A** | | | | | | | | | | |
| Flowering plants July 1975 | 97 | 59 | 97 | 96 | 100 | 100 | - | - | - | 11.50 |
| Seedlings July 1975 | 15 | 0 | 67 | 56 | 100 | 100 | - | - | - | 8.10 |
| Seedlings Oct 1975 | -62 | -62 | -130 | 76 | 37 | 51 | 42 | 51 | 51 | 6.1 |
| Flowering plants July 1976 | 30 | -5 | -12 | 41 | 83 | 63 | 78 | 84 | 92 | 8.40 |
| Seedlings July 1976 | -48 | -43 | -49 | -23 | 0 | 2 | 9 | 15 | -11 | 19.10 |
| **Site B** | | | | | | | | | | |
| Flowering plants July 1975 | 74 | 83 | 86 | 67 | 100 | 100 | - | - | - | 0.14 |
| Seedlings July 1975 | 63 | 47 | 61 | 39 | 95 | 100 | - | - | - | 0.09 |
| Seedlings Oct 1975 | 58 | 8 | 0 | 17 | 17 | 0 | 0 | 17 | 8 | 0.024 |

| | Flowering plants July 1975 | Seedlings July 1975 | Seedlings Oct 1975 | Flowering plants July 1976 | Seedlings July 1976 |
|---|---|---|---|---|---|
| **Site A** | | | | | |
| Dates (D) | *** | *** | *** | *** | *** |
| Herbicides (H) | * | NS | NS | NS | NS |
| D x H | ** | NS | NS | NS | NS |
| Control v rest | *** | *** | NS | ** | NS |
| **Site B** | | | | | |
| Dates (D) | ** | *** | NS | | |
| Herbicides (H) | * | ** | NS | | |
| D x H | NS | * | * | | |
| Control v rest | ** | *** | *** | | |

STATISTICAL SIGNIFICANCES DERIVED FROM $LOG_{10}$ (COUNT + 1) TRANSFORMED DATA

* DMM = Dicamba/mecoprop/MCPA

Fig 1 Ragwort population changes May 73-July 74 Experiment 1

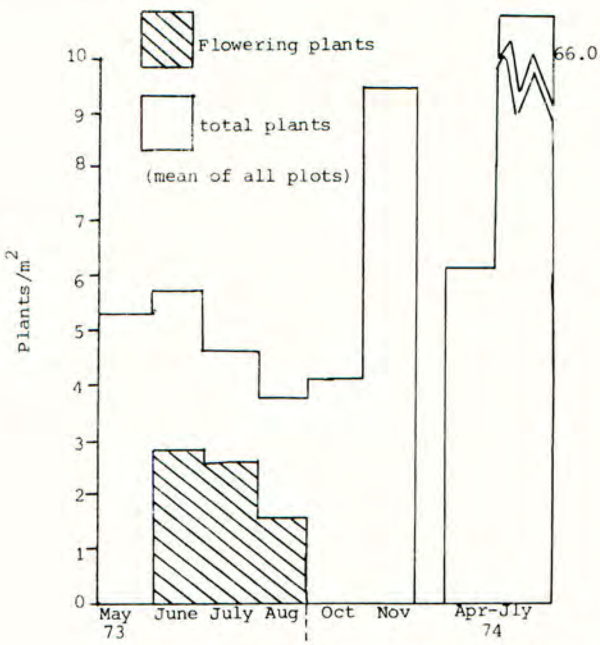
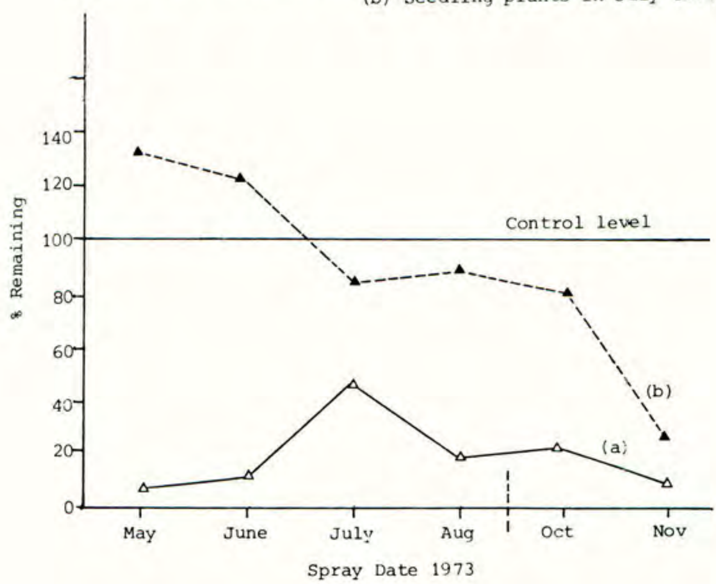



Fig 2 Mean % Remaining of (a) Flowering plants in July 1974
(b) Seedling plants in July 1974



some 43% of the July population producing inflorescences. Seedling numbers commencing at $1.1/m^2$ showed some increase in June and again to a much greater degree between October and November reaching $6.4/m^2$. Subsequently, in 1974, there was an enormous increase in the population, between the April and July dates of recording, there being 66 plants/$m^2$ present in July.

Herbicide control. The percentage reduction in plant numbers in the year of application (1973) one month after spraying (Table 1) shows that the June application gave the poorest short term control. However both the May and June spray dates had given good control of flowering plants when recorded in the following year (Table 2), showing 95% and 91% control of inflorescence production respectively.

Having otherwise recorded good control of flowering plants in the year of application the main interest lay in the level of control in the following year. This was assessed in July 1974 and is shown in Fig 2. The Date Means indicate that, for each date with the exception of the July application, as evidenced by percentage reduction in flowering, an acceptable level of control was obtained in the succeeding season. In relation to seedling control two conclusions may be drawn.

(1) there was a major flush of germination during the October period (Fig 1)

(2) the November application, which was subsequent to this flush of emergence, gave improved control of seedlings through to July 1974.

Another point of interest is the apparent increase in seedling numbers relative to the control, found in the plots sprayed in May and June 1973. The explanation for this data which will be discussed in more detail later must be that removal of existing Senecio jacobaea plants had in fact encouraged either a greater seedling germination or assisted in their establishment.

Experiment 2. The percentage reduction in plant numbers relative to the control area is given in Table 3. The December application gave good control of flowering plants at both sites as recorded in July 75, the poorest control being 59% with 2,4-D ester at Site A. April applications gave virtually 100% control of flowering plants, with the exception of MCPA at site B (67%) and more satisfactory seedling control, recorded in July 75, than the December spray date.

One year later (July 1976) site A was assessed again for the level of persistent control. By that time the Decmeber 1974 application showed only very limited control of flowering plants and in fact the use of herbicides in particular at the December date of application had apparently encouraged seedling emergence, some 50% above that on the control plots being recorded. A similar effect but at a lower level from the April application was evident particularly with respect to the MCPA treatment. Spraying in July 1974 controlled flowering plants (78-94%) but failed to limit seedling numbers one year later.

## DISCUSSION

The results from these three sites are in agreement with those published by Forbes (1974) for the North of Scotland and Mitchell (1974) for the Republic of Ireland. The results go somewhat further in indicating the significance of periods of seedling emergence, reported by Fryer and Chancellor (1956) as occurring, one in Autumn and another in Spring, in determining herbicide effectiveness. In general it appears that Senecio jacobaea plants in a sward may be selectively removed by the applications of herbicides at a range of dates both within and outside the normally recommended time of May/September. Where autumn seedling establishment occurs as in the first experiment delayed application (ie November) gave effective weed control. This may be preferable for those situations where an early silage cut is to be taken and where existing plants are seen as a hazard. The second series of experiments shows that at site A following the December application there was an increase in subsequent germination and emergence of seedlings compared to the April application. Also the April application gave a somewhat superior control of flowering plants in the first and again in the second year after application. In most circumstances therefore a Spring application would appear to be preferable.

A very interesting aspect emerging from these trials was the increased germination and/or establishment of Senecio jacobaea seedlings on the sprayed plots. This response appears akin to that demonstrated by Sagar and Harper (1961) when he observed a much higher establishment of Plantago seed where the existing sward had been artificially damaged - in that case by the application of dalapon. It may be that the removal of existing plants provided 'safe' sites (Sagar 1970) and greater opportunity for establishment. There is clearly therefore a good deal of further information required on the germination and establishment pattern of Senecio jacobaea in an existing sward and the extent to which establishment can be minimised according to date of spray application and allied management practices including defoliation intensity and nitrogen application, treatments which might be used to improve the vigour of a sward and discourage a successful establishment of ragwort seedlings, as demonstrated by Cameron (1935).

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