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EVALUATION OF HERBICIDES FOR POST-EMERGENCE APPLICATION IN CARROTS

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Summary Results of trials conducted on fen peat from 1970-72 show that chlorbromuron, methoxuron, linuron and prometryne can be safely applied to carrots in the late cotyledon stage. Chlorbromuron gave better control of broadleaved weeds than linuron and methoxuron. Prometryne gave poor weed control. The use of TVO as a carrier reduced the selectivity of prometryne but increased the herbicidal properties of all the materials except linuron. This was most pronounced with chlorbromuron which gave very good control of young and advanced plants of *Senecio vulgaris* a problem weed in carrots.

INTRODUCTION

The practice of applying pre-and post-emergence sprays to carrots on peat (Allott & Uprichard 1966, MacNaeidhe 1970) is more costly and less effective than on mineral soil because heavier doses of herbicides are required and these are rapidly adsorbed allowing weeds to emerge shortly after application. The effectiveness of herbicides applied to carrots on peat soil depends on contact action and spraying should be delayed until as many weeds as possible have emerged, but before they are too advanced. This usually occurs when the crop is in the late cotyledon stage. Preliminary investigations conducted in 1970 showed that carrots at this stage of development were tolerant to chlorbromuron. The results of this trial and other trials carried out in 1971 and 1972 are reported in this paper.

MATERIALS AND METHODS

All trials were sited on soils derived from cutover peat. A randomised block design was used with three to four replicates. Plot size was 5 yd x 2 yd. Herbicides were applied using a pressure retaining sprayer. A volume of 40 gal water/ac or 8 - 20 gal TVO/ac was used in 1970-71 and 50 gal water/ac and 30 gal TVO/ac was used in 1972. All doses are given in lb/ac a.i. Visual assessments of crop and weed growth were carried out regularly during the season. The standard 1 - 10 rating scale was used in 1970-71. The European Weed Research Council (EWRC) rating scale was used in 1972. Weed density was recorded either by counts from whole plots or from 6 x 1 ft^2 random quadrats per plot. Crop density was recorded from counts within four x 1 ft sections in each of the two centre crop rows in each plot. In 1970 trials cv. Red Winter, a late cultivar suitable for overwintering in the peat was sown in early July. In 1971 and 1972 the cv. Regulus was sown in May.

RESULTS

1970 trial

In the experiment carried out in 1970 all treatments showed high crop selectivity. No weeds had emerged when pre-emergence sprays were applied and crop emergence coincided with weed emergence in control plots. Senecio vulgaris and Poa annua had formed two true leaves when the crop was in the cotyledon stage but Rumex acetosella emerged much later in the season and although the density of this weed was high it remained small and uncompetitive except in control plots. Chlorbromuron at 1.5 lb applied pre-emergence + chlorbromuron at 1.5 lb applied at the late cotyledon stage gave excellent control of P. annua and S. vulgaris for five weeks but further seedlings had emerged when weed density was being recorded two weeks later. Linuron 1.0 lb applied pre-emergence + linuron 1.0 lb applied at the two true leaf stage of the crop and chlorbromuron 1.5 lb applied pre-emergence + chlorbromuron 1.5 lb applied at the two true leaf stage of the crop gave good control of S. vulgaris but poor control of P. annua. (Table 1). Weeds were in the 6 - 8 true leaf stage when chlorbromuron .1.5 lb was applied at the two true leaf stage of the crop. This treatment gave good control of S. vulgaris but poor control of P. annua.

Table 1

Effect of stage of application of herbicides on crop and weeds - 1970

Treatment	Dose lb/ac	Stage of application*	Plant stand % of control	Yield ton/ac	Assessments[1] Crop	Assessments[1] Weeds
Chlorbromuron +	1.5	1	100	15.4	8.6	6.8
"	1.5	3				
Linuron +	1.0	1	100	16.8	8.8	7.8
"	1.0	3				
Chlorbromuron +	1.5	1	100	12.6	8.4	8.0
"	1.5	2				
Chlorbromuron	1.5	3	88	13.7	8.8	6.8
Control			100	11.9	9.0	4.2
S.E. of treatment mean (df = 21)			6.25	1.64		

* Pre-emergence

[2] Application at late cotryledon stage of the crop

[3] Application at the two true leaf stage of the crop

Rating scale:- Crop 0 (complete kill) - 10 (no damage)
Weeds 0 (dense cover of weeds) - 10 (no weeds)

1971 trials

In the main trial, four herbicides were applied at different doses using water at 40 gal/ac and in some cases TVO at 8 gal/ac as a carrier. In a further trial chlorbromuron was applied in water at 40 gal/ac and in TVO at 20 gal/ac in an advanced crop of carrots. The main purpose of these trials was to examine the selectivity of herbicides in carrots at different stages of growth and to control large weeds in the crop.

Table 2

Effect of treatment at the cotryledon stage on crop and weeds - 1971

Treatment	Dose lb/ac	Carrier	Plant stand % of control	Yield ton/ac	Assessments Crop	Weeds	S.v.	C.a.
Chlorbromuron	1.0	Water 40 gal	109	33	9.8	9.6	49	67
"	2.0	"	97	35	10.0	10.0	69	99
"	0.5	TVO 8 gal	92	31	9.2	10.0	52	95
"	1.0	"	88	33	8.8	10.0	69	90
Methuxuron	2.0	Water 40 gal	103	33	10.0	7.6	0	98
"	4.0	"	108	28	10.0	9.8	50	100
Linuron	1.0	"	99	28	10.0	9.8	68	97
"	2.0	"	99	32	9.6	10.0	80	100
"	0.5	TVO 8 gal	76	35	9.2	10.0	50	73
Prometryne	1.0	Water 40 gal	101	26	9.6	8.6	31	97
"	2.0	"	100	37	8.8	9.2	56	85
Control			100	33	9.6	5.4	0	0
No. of weeds/ft^2 in control plots							5	5
S.E. of treatment mean (df = 78)			8.82	2.56				

Rating scale :- as in Table 1

S.v. = Senecio vulgaris C.a. = Cerastium arvensis

In the first trial (Table 2) the crop was sprayed when the cotyledons were fully developed. Chlorbromuron at 1.0 lb in TVO caused a slight reduction in crop stand and vigour. Linuron at 0.5 lb in TVO caused approximately a 25 per cent reduction in crop stand but although vigour was reduced the crop recovered rapidly. Prometryne at 2.0 lb in water caused slight crop damage. Of the treatments applied in water chlorbromuron at 1.0 lb and 2.0 lb, methoxuron at 2.0 lb and 4.0 lb, linuron at 1.0 lb and 2.0 lb and prometryne at 1.0 lb caused no crop damage. Chlorbromuron at 0.5 lb in TVO also showed good crop selectivity. None of the treatments applied caused a reduction in crop yield.

S. vulgaris and Cerastium arvensis were in the cotyledon -two true leaf stage at the time of herbicide application. Seedlings of S. vulgaris emerged again throughout the entire trial area three weeks after herbicide application but further emergence of C. arvensis did not take place. Chlorbromuron at 2.0 lb, methuxuron at 4.0 lb and linuron at 1.0 lb and 2.0 lb in water and chlorbromuron 1.0 lb in TVO gave excellent control of S. vulgaris and C. arvensis. Excellent control of C. arvensis was given by methuxuron at 2.0 lb, prometryne at 1.0 and 2.0 lb in water and chlorbromuron 0.5 lb in TVO. Although less effective, chlorbromuron 1.0 in water and linuron 0.5 lb in TVO gave satisfactory control of both weed species.

The second and third trials were conducted in an early carrot crop with a high density of S. vulgaris. Due to the low temperatures in April and May the emergence of S. vulgaris did not occur until a few weeks after the final application of the routine pre- and post-emergence treatment with linuron. In the second trial the treatments were applied when carrot roots were ¼ - ½ in. diameter and the foliage was 6 - 9 in. high. S. vulgaris was 2 - 15 in. high. Chlorbromuron was applied at 1.0 lb in TVO 40 gal and at 1.0 lb, 2.0 lb and 4.0 lb in TVO 20 gal. All treatments caused slight temporary foliar chlorosis, but the crop recovered rapidly on plots treated with chlorbromuron at 1.0 lb and 2.0 lb in the lower volume of TVO. Chlorbromuron at 1.0 lb in TVO 40 gal was slightly less selective and chlorbromuron at 4.0 lb in TVO at 20 gal caused a slight scorch on the leaf tips but the crop had fully recovered after three weeks. All treatments at first gave control of weeds less than 3 in. high only, but two weeks after application the larger weeds were also killed. None of the treatments containing TVO caused crop taint.

In the third trial treatments were applied when the carrot roots were ½ - 1 in. diameter. The crop was completely covered by S. vulgaris which was 18 - 24 in. high and was flowering. Chlorbromuron was applied in TVO 20 gals and in water 40 gal at doses of 2.0 lb and 4.0 lb. None of the treatments applied caused crop injury. The activity of chlorbromuron was again not evident for approximately 12 days but weed kill was more rapid using TVO instead of water as a carrier. Excellent weed control was obtained with the 4.0 lb dose applied in either water or TVO. Satisfactory control was also given by the 2.0 lb dose particularly where TVO was used as a carrier. No crop taint was found in roots from plots treated with TVO.

1972 trials

Four trials were conducted in carrots in 1972. In the first trial the effect of different doses of the four herbicides applied the previous year were compared using water at 50 gal/ac and TVO at 30 gal/ac as carriers.

Table 3

Effect of treatment at the cotyledon stage on crops and weeds - 1972

Treatment	Dose lb/ac	Carrier	Plant stand % of control	Assessments Crop	Assessments Weeds	% weed kill P.a.	% weed kill S.v.	% weed kill S.m.
Chlorbromuron	1.5	Water 50 gal	92	2	5	0	82	56
"	3.0	"	100	3	5	0	82	96
"	1.0	TVO 30 gal	75	4	3	67	85	89
Linuron	1.0	Water 50 gal	100	1	4	39	85	59
"	0.5	TVO 30 gal	92	3	5	50	71	59
Methuxuron	4.0	Water 50 gal	100	2	5	3	72	63
"	1.0	TVO 30 gal	83	3	5	24	68	71
Prometryne	1.5	Water 50 gal	92	2	8	3	54	63
"	1.5	TVO 30 gal	25	9	3	71	87	71
Prometryne + Linuron	0.5 0.5	Water 50 gal	83	5	5	26	82	63
Control			100	3	8	0	0	0
Weeds no/ft^2 in control plots						21	12	7
S. E. of treatment mean (df = 54)			6.34					

Table 3 continued

[1]Rating scale : Crop 1 (no damage) - 9 (complate kill)
Weeds 1(no weeds) - 9 (dense cover of weeds)

P.a. = Poa annua. S.v. = Senecio vulgaris. S.m. = Stellaria media

Treatments were applied when the crop was in the cotyleydon stage. Prometryne at .1.5 lb in TVO caused severe crop damage reducing plant stand by approximately 75 per cent. A severe crop check caused by chlorbromuron at 1.0 lb,inlinuron at 0.5 lb and methuxuron at 1.0 lb in TVO and prometryne at 0.75 lb + linuron at 0.5 lb in water was still evident seven weeks after application. A slight reduction in crop stand was caused by methoxuron at 1.0 lb in TVO and prometryne at 0.75 lb + linuron at 0.5 lb in water. Chlorbromuron at 1.5 lb and 3.0 lb, linuron at 1.0 lb, methoxuron at 4.0 lb and prometryne at 1.5 lb showed good crop selectivity. Of the three main weed species S. vulgaris, S. media and P. annua were in the cotyledon - two true leaf stage. Although S. vulgaris was less numerous than P. annua it was the main competitor in the trial at all stages and control of this species was more critical than that of P. annua or S. media. S. media was severely damaged by all treatments and was never a serious competitor except in control plots. Chlorbromuron at 1.0 lb and prometryne at 1.5 lb in TVO gave good control of all weed species. None of the other treatments controlled P. annua, but the use of TVO as a carrier tended to increase the toxic effect of herbicides on this weed. S. vulgaris was well controlled by chlorbromuron at 1.5 lb and 3.0 lb, and prometryne at 0.75 lb + linuron at 0.5 lb in water. Methoxuron at 4.0 lb in water and linuron at 0.5 lb and methoxuron at 1.0 lb in TVO gave moderate to good weed control. Prometryne at 1.5 lb applied in water 50 gal/ac failed to control P. annua and S. vulgaris effectively. Results are given in Table 3.

On peat potato seedlings become a weed problem in areas where flower heads of late harvested potatoes are allowed to form seeds. In a trial designed to control potato seedlings in carrots the crop was in the 1 - 2 true leaf stage and the seedlings were in the four true leaf stage. Chlorbromuron at 2.0 lb applied in TVO caused slight foliar scorch but the crop was fully recovered within two weeks. Methoxuron at 2.0 lb and chlorbromuron at 2.0 lb applied in water completely controlled the potato seedlings (Table 4).

Table 4

Effect of post-emergence application of herbicides on crop and weeds - 1972

Treatment	Dose lb/ac	Carrier	*Stage of crop	Assessments Crop	Assessments Weeds	% weed kill S.v.	% weed kill P.a.	% weed kill Potato seedlings
Methoxuron	2.0	50 gal water	1	1	4	NP	NP	100
"	2.0	30 gal TVO	1	2	1	NP	NP	100
Chlorbromuron	2.0	50 gal water	1	1	3	NP	NP	100
"	2.0	30 gal TVO	1	5	1	NP	NP	0
Control				1	9	NP	NP	0
Methoxuron	2.0	30 gal TVO	2	2	5	59	41	NP
"	4.0	20 gal TVO	2	1	4	93	41	NP
"	4.0	50 gal water	2	1	6	53	34	NP

Table 4 continued

Treatment	Dose lb/ac	Carrier	* Stage of crop	Assessments Crop	Assessments Weeds	% weed kill S.v.	% weed kill P.a.	% weed kill Potato seedlings
Control			2	2	9	0	0	
Chlorbromuron	4.0	30 gal TVO	2	3	3	82	NP	NP
"	4.0	50 gal water	2	4	3	79	NP	NP
Control			2	1	9	0	NP	NP
No. of weeds/ft^2 in control plots						3	10	44

Rating scale as in Table 3

* 1 = 1 - 2 true leaf stage of the crop

2 = crop 2 - 3 in. high.

Np = not present

Two trials were conducted in 1972 to control large weeds in a carrot crop 2 - 3 in. high. In the first trial using methoxuron P. annua was in the 8 - 10 true leaf stage and S. vulgaris was in the 6 true leaf stage. All the treatments caused a slight chlorosis and a slight reduction in crop vigour for two weeks. S. vulgaris and P. annua were inadequately controlled by methoxuron at 2.0 lb in TVO. Methoxuron at 4.0 lb in water gave poor control of S. vulgaris but caused a severe check to P. annua which was still very chlorotic and stunted 6 weeks later. Similar but more rapid effects occurred on this weed with methoxuron at 4.0 lb in TVO and excellent control of S. vulgaris was obtained.

In the second trial chlorbromuron was used. The only weed occurring, S. vulgaris, was in the 6 true leaf stage. Both treatments (Table 4) caused a reduction in crop vigour which persisted for seven weeks after application. Chlorbromuron at 4.0 lb in TVO and chlorbromuron at 4.0 lb in water gave good weed control but seedlings of S. vulgaris began to emerge again after seven weeks. Although both treatments were eventually equally effective the TVO treatment gave more rapid activity at first.

DISCUSSION

Results show that from the point of view of selectivity there was little to choose between application pre-emergence or at the late cotyledon stage. The 1970 trial also suggests that application at the latter stage was equal in effectiveness to a combined pre- and post-emergence application at the 2 true leaf stage. Chlorbromuron, linuron and methoxuron showed the most promise for application at the cotyledon stage. Chlorbromuron had a definite advantage over linuron in better control of broad leaved weeds and more effective contact action on larger weeds but linuron provided better control of P. annua. Although methoxuron gave good weed control it was not as effective as linuron or chlorbromuron.

The use of TVO as a carrier was a definite help towards better weed control. Although doses up to 40 gal/ac did not cause taint in well developed roots, the 20 - 30 gal dose was only marginally selective at the cotyledon stage and the use of lower doses might provide a greater safety margin. However, serious crop damage occurred only where prometryne and TVO were used in combination. With the exception of linuron the activity of all the herbicides applied in TVO was more rapid and more lethal than in water. All herbicides applied in TVO at the cotyledon stage gave better control of *P. annua* and the effect of methoxuron 4.0 lb applied in TVO 30 gal/ac on *Poa* in the 8 - 10 true leaf stage was more rapid and more damaging than a similar dose applied in water. Similarly the control of weeds with chlorbromuron applied in TVO was approximately twice as effective.

S. vulgaris can be a most difficult weed to control in carrots on peat with the standard herbicides - linuron and prometryne. Chlorbromuron at 2.0 to 4.0 lb in volumes of TVO varying from 20 - 30 gal gave excellent control of this weed at all stages of growth without significantly affecting crop vigour or yield.

Acknowledgements

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STUDIES ON THE ACTION AND EFFICIENCY OF CHLORFENPROP-METHYL AGAINST AVENA FATUA L (SPRING WILD OATS)

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Summary Work is described which shows that chlorfenprop-methyl, which causes cell autolysis, must reach the meristematic tissue of *A. fatua* plants for optimum effectiveness. *A. fatua* is most sensitive between the 2 and 3 leaf stage although a good effect is obtained from the 1 to 4 leaf stage. Older, tillering *A. fatua*, become progressively more difficult to kill, however, a vigorously growing crop will assist the chemical. Careful spray application is necessary, and good results seem best achieved using 4.25 lb a.i./ac in 25 gal/ac, with fan nozzles working at approximately 40 lb/in^2.

INTRODUCTION

Avena fatua (the spring wild oat) is becoming an increasing problem in cereals, even though selective chemical control has been a possibility for a number of years using barban and triallate in Britain. Another selective chemical, chlorfenprop-methyl, discovered by Bayer AG. Leverkusen, West Germany, has been widely tested in Europe for the control of *A. fatua* in cereals (Eue, 1968; Gummesson, 1970; Erskine, 1968; Holroyd and Bailey, 1970; and Kampe, 1969).

Chlorfenprop-methyl (Bayer 70533) is the common name for methyl 2 - chloro - 3 - (4 - chlorophenyl) propionate, a compound of relatively low mammalian toxicity (Anon, 1971). The herbicidal properties are described by Eue (1968) and the method for determining residues in plant material by Jarczyk (1968).

The biochemical nature of the herbicide's action is reported by Fedtke (1972) who, working with cucumber hypocotyls, mitochondria from bean epicotyls, isolated chloroplasts, and *A. fatua* plants was able to show that the basic metabolic pathways of protein synthesis, RNA synthesis, respiration and photosynthesis were not inhibited by herbicidal rates of chlorfenprop-methyl. The action of the herbicide on *A. fatua* results in a large increase in γ - amino - butyric acid (GABA). This indicates the increase in the treated plant of enzymes with pH optima in the 4 - 6 range. It would seem that these "acid enzymes" e.g. ribonuclease, protease and amylase, cause autolysis through their combined activity; probably as a result of the rupture of intracellular compartments including the vacuolar membrane.

Kampe (1969) has also shown with tests carried out on seeds surviving treatment with chlorfenprop-methyl (ca 4 lb a.i./ac), that germination was significantly reduced by 50% and coleoptiles were shortened in length by 20%.

Development work by Bayer Agrochem Ltd in the United Kingdom began in 1967 with an emulsifiable concentrate formulation, coded 5710, containing 53% w/v chlorfenprop methyl. In 1971 field work was continued with an 80% w/v formulation, coded 6370, the majority of field trials results with this latter formulation being reported by Forrest et al (1972) at this conference. This report describes studies designed to elucidate some of the more fundamental aspects of the herbicide's action. These experiments include studies of the morphological site of maximum effectiveness by administering chlorfenprop-methyl to different parts of A. fatua plants (Experiment I). Growth stage susceptibility was determined by application to plants growing in pots (Experiment II), and by marking plants in field trials (Experiment III). Fluorescent tracers were used to study spray distribution on the plant with different application methods (Experiment IV) and replicated small plot trials to determine the optimum rate and timing under field conditions using logarithmic dilution (Experiment V) and finite rates (Experiment VI), were also carried out.

METHODS AND MATERIALS

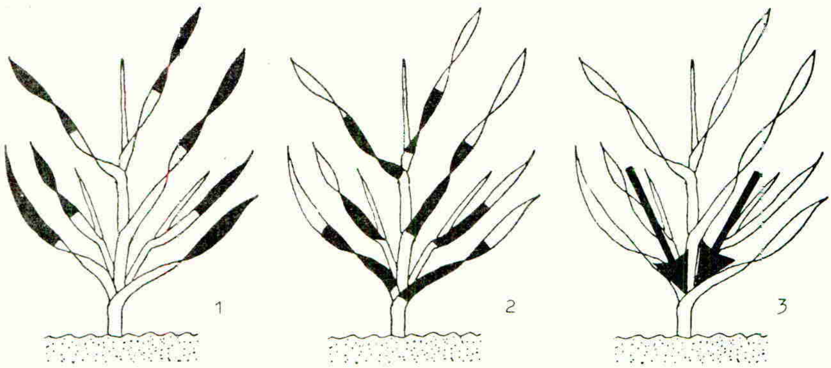
Chlorfenprop-methyl as the 53% w/v formulation, 5710, was used in Experiments I to V inclusive and as the 80% w/v formulation, 6370, in Experiment VI. All rates of use in the following report are expressed as active ingredient.

Morphological site of maximum effectiveness
Experiment I - Rowhill, Kent, 1968

A concentration of 1.6% chlorfenprop-methyl was applied to different parts of A. fatua plants grown in pots. The treated areas are illustrated in Figure 1, the emulsion being applied by means of a paint brush. In the case of treatments 1 and 2 the treated area was evenly painted without run-off occurring, whilst in treatment 3 the paint brush was used to apply one drop of emulsion to each plant.

Figure 1

Treatments in leaf painting experiment, Rowhill, Kent, 1968



1 Distal half of each leaf treated
2 Proximal half of each leaf treated
3 Drop of emulsion (ca 0.05 ml) at the base of the tillers

Continuous observations and records of chemically induced symptoms were made, as well as measurements of size reduction 7 and 14 days after application, together with mortality of treated plants.

Growth stage susceptibility
Experiment II - Pot tests - Rowhill, Kent, 1968

Seeds of A. fatua were sown at intervals in 6 in. pots to obtain a range of growth stages. Chlorfenprop-methyl at 3.98 lb/ac was applied by means of a knapsack sprayer to simulate a normal crop sprayer application. The percentage of the leaf area showing scorch symptoms was recorded 12 days after spraying. The total length of foliage on 3 plants per plot was also measured and the percentage reduction compared with the untreated was calculated.

Experiment III - Plant marking - Field trials, 1968

A range of growth stages of A. fatua plants were marked at application using coloured wire rings in 4 field trials, one on winter wheat and 3 on spring barley. Treatments were applied with knapsack or Land Rover mounted sprayer, and with cone and fan nozzles. The marked A. fatua plants were observed at intervals throughout the season and finally just prior to harvest records of mortality were made.

Spray distribution on the plant
Experiment IV - Frittenden, Kent, 1968

Work was carried out in 1968, using saturn yellow fluorescent tracer, to test the efficiency of two different nozzles at the volume and pressure combinations shown in Table 4. Applications were made by tractorised equipment, following which 24 plants per treatment were examined under ultra violet light to estimate the percentage spray cover on different parts of the plant.

Optimum rate and timing
Experiment V - Logarithmic dilution trial - Bradfield St Clare, Suffolk, 1970

A duplicated trial was carried out on a crop of spring wheat, in which chlorfenprop-methyl was diluted logarithmically from approximately 8.0 lb/ac to 0.8 lb/ac. The comparison material, barban, was logarithmically diluted from approximately 10 oz to 1.0 oz/ac. Both materials were used at two timings: the first spray being applied when the A. fatua plants had a mean of 1.8 leaves and the second when they had a mean of 2.6 leaves.

The number of A. fatua plants in 0.5 yd^2 fixed quadrats, placed at 1/10 intervals along the length of the plot, was recorded at the time of treatment. Shortly before harvest the number of A. fatua plants remaining and the number of panicles were also counted.

Experiment VI - Replicated timing trials - 1971

Two replicated small plot trials were carried out on spring barley cv. Sultan using 4.3 lb/ac chlorfenprop-methyl applied at 3 timings with intervals of approximately 5 days between sprays. Barban at 0.3 lb/ac was applied at each time of application as a comparison.

The numbers of A. fatua plants in 4 x 0.5 yd^2 fixed quadrats per plot were recorded at application. Shortly prior to harvest the numbers of panicles were counted in each quadrat and these were graded into three categories: 0 - 10 spikelets, 11 - 30 spikelets and $>$30 spikelets. Thus the estimated number of spikelets per quadrat could be calculated. Crop yields were measured by cutting strips from each plot at harvest with a Hege (4 ft. cut) mini combine and weighing the grain. The weight of A. fatua seeds in grain samples from each plot was recorded and the yield from each plot was corrected accordingly.

RESULTS

Morphological site of maximum effectiveness
Experiment I

The results are presented in a condensed form for the sake of clarity (Table I)

Table 1

Leaf painting experiment, Rowhill, Kent, 1968

Treatment	Size reduction % 7 days	Size reduction % 14 days	Plant death %	Observations
1 Distal area of leaf	20	40	0	Treated areas became a duller green, then bleached and necrotic. Proximal half of leaves remained green. Some delayed stunting occurred. 0.8 panicles per plant produced.
2 Proximal area of leaf	75	95	40	Plants initially stunted, with brown-green colouration. Leaves collapsed and plants appeared dead after 14 days. Weak tiller re-growth occurred. No panicles produced.
3 Base of tillers	80	100	100	The basal leaf sheaths became quickly brown and then bleached. After 14 days all the plants were dead.

The most effective single site of application was to the base of the tillers. Application to the distal areas of the plant, although temporarily causing a reduction in vigour, was virtually ineffective, the majority of plants eventually being able to produce panicles. Treatment of the proximal half of each leaf was very nearly as effective as applying the chemical to the base of the tillers. Another treatment, where a drop of emulsion was placed into the youngest rolled leaf of each tiller produced similar effects to treatment 3, eventually all plants dying.

Growth stage susceptibility
Experiment II

Scorch symptoms (light brown and white marks) were apparent on the foliage within 2 days after spraying. A damage index was calculated to illustrate the loss of effective leaf area to the plant by combining the reduction in leaf length with the leaf area scorched. A damage index of 1 is equivalent to total loss of the effective leaf area.

Regeneration by tillering occurred on even severely affected plants, probably due to the excellent growing conditions and mutual shading in the pots, which may have hindered spray cover.

The results show that the 2, 3 and older leaf stages were more sensitive to treatment than the $\frac{1}{2}$ or 1 leaf stage, whilst the 2 leaf stage seemed the most sensitive. The 5 - 7 leaf stage suffered considerable damage but had a higher regenerative capacity.

Table 2

Leaf stage pot experiment with chlorfenprop-methyl at 3.98 lb/ac.

Rowhill, 1968

A. fatua leaf stage	% leaf area scorched	% reduction in leaf length	Damage* Index
½	2.0	0	0
1	2.0	21.1	0.23
1½	2.0	22.0	0.24
2	50.0	70.3	0.85
3	18.3	42.7	0.53
5 - 7	50.0	46.2	0.73

$$* \text{ Damage Index} = \frac{\text{length of leaf on untreated} - \left\{\text{length of leaf on treated} \times \frac{(100 - \%\text{ leaf area scorched})}{}\right\}}{\text{length of leaf on untreated}}$$

Experiment III

It was noted that there tended to be a natural mortality of, particularly, the youngest plants on the untreated areas. In most cases these were the later emerging *A. fatua* seedlings. This natural mortality was taken into account when calculating the percentage control of plants by the treatment.

Table 3

Levels of control of marked plants in field trials, 1968, with chlorfenprop-methyl at 3.98 lb/ac.

% Control *A. fatua* plants

A. fatua leaf stages	Walsham Suffolk	Babraham Cambs.	Stanwick Northants	Stanningfield Suffolk	Median
½ - 1	51.4	52.6	0		51.4
1 - 2	73.1	81.4	26.8	83.3	77.3
2 - 3	48.4	100	84.1	75.0	79.6
3 - 4	12.5	100	66.2	60.0	63.1
4 + tillers			58.3	45.0	51.7

The results show that chlorfenprop-methyl has a good effect on *A. fatua* between the 1 and 4 leaf stages. Control at the ½ to 1 leaf stage generally seemed poorer, and also tended to decrease at the 4 leaf stage and when the *A. fatua* plants were tillering. Panicle counts showed that plants treated at these later stages tended to produce more panicles than those treated at an earlier growth stage. This experiment demonstrated that *A. fatua* plants in the 2 - 3 leaf stage were the most sensitive to the herbicide.

Spray distribution on the plant
Experiment IV

The results, in Table 4, indicate that the important areas of the culm and, particularly, the proximal parts of the foliage, were better sprayed by means of fan nozzles working at 40 lb/in^2. It was also concluded that 25 gal/ac was an optimum water rate, higher rates causing run-off from the plant and a decrease in spray cover.

Table 4

Per cent spray cover of A. fatua plants

Gal/ac	Hollow Cone nozzle ($10 lb/in^2$)		Fan nozzle ($40 lb/in^2$)	
	Proximal foliage	Culm	Proximal foliage	Culm
15	8.9	3.0	7.2	3.3
20	9.6	7.3	20.0	7.8
25	13.7	7.5	27.7	7.8
30	9.2	7.5	24.4	9.0

Optimum rate and timing
Experiment V

The results are presented graphically in Figure 2, the figures for the control of panicles being calculated from panicle indices where:

$$\text{Panicle Index} = \frac{\text{Number of panicles at harvest}}{\text{Number of plants at application}}$$

A high level of wild oat control was obtained when chlorfenprop-methyl was applied at rates above 3.3 lb/ac at both treatment times and when barban was applied at rates above 3 oz/ac at the 1.8 leaf stage timing. The results obtained with barban agree with those reported by Pfeiffer et al (1960).

Experiment VI

The results are shown in Table 5. Per cent control of A. fatua being based on the panicle index, described under Experiment V, and the spikelet index.

$$\text{Spikelet Index} = \frac{\text{Number of spikelets at harvest}}{\text{Number of plants at treatment}}$$

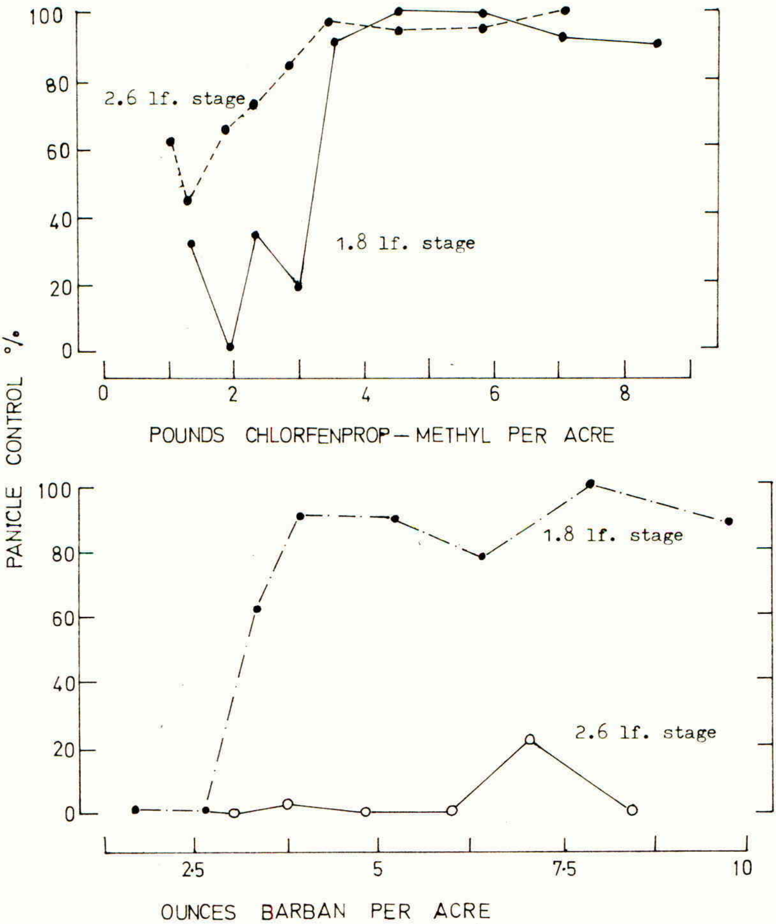
Good results were obtained with chlorfenprop-methyl at both sites up to a mean A. fatua leaf stage of approximately 2.50. At the Ainderby site good results were obtained even up to a mean A. fatua leaf stage of 3.72 but this can probably be explained by two factors; a lower population of A. fatua at the Ainderby site (28.6 compared with 60.4 per yd^2 at spraying) and greater crop competition at Ainderby, where the barley was more vigorous throughout the season as is shown in the resultant yields. Considerable yield increases were obtained at the Tewkesbury site with chlorfenprop-methyl, which demonstrates the benefits of controlling a high population of A. fatua in a rather weak crop. Barban gave quite good control at Ainderby when applied early, but at Tewkesbury, even the earliest application, was past the recommended timing for barban.

DISCUSSION

It can be concluded from Experiment I that chlorfenprop-methyl must reach the base of the plant and hence the meristematic tissue either by the direct route of spray run-down or indirectly by diffusion from the proximal parts of the foliage. This is substantiated by work carried out by Hack (1973). According to Fedtke (1972) the mode of action is to induce cell autolysis. Experiments II and III demonstrate that although the chemical has a good effect against A. fatua from the 1 leaf stage until tillering, the A. fatua plants are most sensitive when they have between 2 and 3 leaves. This is also reflected by the results from the field trials, Experiments

Figure 2

Chlorfenprop-methyl and barban, effect of rate and spray timing, Bradfield St Clare, Suffolk, 1970



V and VI, best control being obtained when the majority of plants were in these growth stages. There is reasonably close agreement with independant experiments since Holroyd (1968) found that the maximum effect was on plants having 1.5 - 2.5 leaves. Older *A. fatua* plants become progressively more difficult to kill due to the presence of tillers or tiller buds giving the plant a greater regenerative capacity. In the field, the control of these older *A. fatua* plants may, therefore, be influenced by other factors such as crop vigour and possibly weather conditions (Experiment VI). Obtaining adequate spray cover of the vital parts of the *A. fatua* plant can be difficult and careful application is, therefore, essential. Experiment IV indicates that this is best achieved by the use of fan nozzles as opposed to hollow cones, and a combination of approximately 25 gal/ac and 40 lb/in^2. Other factors may have an important bearing on the efficiency of spray penetration, for

Table 5

Two replicated timing trials, 1971

Timing	Tewkesbury, Gloucestershire: Application date	Mean *A. fatua* leaf stage	Crop growth stage (Feekes-Large scale)	Ainderby, N. Yorkshire: Application date	Mean *A. fatua* leaf stage	Crop growth stage (Feekes-Large scale)
Early	13 May	2.10	1 - 2	1 May	1.74	1
Mid	17 May	2.67	2 - 3	8 May	2.50	2
Late	21 May	3.21	3 - 4	14 May	3.72	4

Treatment lb/ac	Timing	Tewkesbury: % Control panicles	% Control spikelets	% Yield	% reduct. *A. fatua* seeds in grain	Ainderby: % Control panicles	% Control spikelets	% Yield	% reduct. *A. fatua* seeds in grain
Chlorfenprop-methyl 4.3	Early	89.3**	93.0**	140.9	94.4*	85.7*	92.3**	100.9	96.5
	Mid	70.9**	82.7**	129.7	84.4	96.9**	99.4**	96.6	87.4
	Late	35.9	57.0*	104.2	69.6*	81.4**	93.9**	115.1	92.5
Barban 0.3	Early	39.3	38.2	109.9	45.5	72.3*	75.9	97.3	76.8
	Mid	24.2	36.2*	102.1	21.7	38.2	73.3	95.7	0.0
	Late	40.7*	50.5*	112.1	39.5*	0.0	4.7	101.9	35.0
		Number/yd^2		Cwt/acre		Number/yd^2		Cwt/acre	
Untreated (approximate figures)		70	1200	13.7		50	1100	32.1	

* significantly different from untreated at p = 0.05

** significantly different from untreated and barban at p = 0.05

example, very dense A. fatua populations might create mutual "shading" conditions as might vigorous well tillered crops. The shape of the A. fatua plant when in the 2 to 3 leaf stage probably allows better penetration of the spray to the vital areas. The logarithmic dilutions trial (Experiment V) indicated that good control may be obtained with a dose of as little as 3 lb/ac provided spray timing is optimal. However, performance fell off rapidly with decreasing dose rate and for consistency under variable conditions a rate of greater than 4 lb/ac seems necessary. This allows a greater latitude in timing compared to barban as is evident from Experiment VI. The rate used in field trials and now recommended to farmers is 4.25 lb/ac. Optimum timing is when the mean A. fatua leaf stage is approximately 2.5, which is generally when the oldest A. fatua plants in a population have just reached the 4 leaf stage.

Acknowledgments

We would like to thank all of our colleagues who have contributed to the development programme with chlorfenprop-methyl.

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GERMINATION PERIODICITY, PLANT SURVIVAL AND SEED PRODUCTION IN POPULATIONS OF AVENA FATUA L. GROWING IN SPRING BARLEY

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Summary Natural stands of *Avena fatua* growing in twelve fields of spring barley were studied. Germination was found to be spread over several weeks and appeared to be initiated by a rise in soil temperature to 6-7°C. In general, the earliest germinating plants at each site had a greater chance of survival, tended to have more tillers and produced a greater number of seeds per panicle than later ones. However, as there were relatively few seedlings in the earliest flush of germination, the greatest proportion of seed produced usually came from plants that emerged just before, at or up to 3 weeks after the emergence of the crop.

INTRODUCTION

Seeds of *A. fatua* can remain dormant in the soil for several years. They germinate both in spring and in autumn, the main flush occurring in the spring irrespective of age of seed or cultivations of the soil (Thurston 1951 and 1961). The relative times of emergence of *A. fatua* and spring cereals is an important factor in their competitive interaction. Pfeiffer *et al.* (1960) report that about 75% of *A. fatua* seedlings emerge during a fairly short period after drilling the crop and that 95% of the seed shed was formed by the first flush of *A. fatua* plants. Otherwise little is known of the factors that affect the timing of this flush, or of the mortality, tillering, seed production etc. of plants emerging at different times.

The purpose of the present study was to investigate the patterns of germination of *A. fatua* with regard to date of drilling and emergence of the crop, and to follow the individual plants through to seed production. Several sites were investigated in order to see the effects of various environmental factors.

METHODS AND MATERIALS

In 1971 twelve experiments on germination periodicity, plant development and seed production of *A. fatua* were laid down at different sites within 60 miles of Oxford. All the fields were under normal farm management. The wild oat populations were all naturally occurring and ranged in density from 16 to 700/m^2. The crop in all the fields was spring barley, of various cultivars, and plant densities (Table 1).

At each site 3 plots of 1 or 0.25 m^2, were laid down 6 metres apart, as far as possible over the same crop rows in a selected drill width. In each plot the *A. fatua* seedlings were counted frequently, in some instances at weekly intervals. At each assessment all newly-emerged seedlings were ringed with plastic coated wire using a different colour at each assessment. To ensure that the same area was assessed at each visit a metal quadrat was positioned around the plot by 4 pegs.

The date of crop emergence was noted and when this was complete the number of crop plants was counted. Every effort was made to avoid interference of any kind with the growth of crop or weed on the plots.

Each plot was finally assessed just before harvest. All the A. fatua plants were hand-pulled, counted, the number of stems recorded and each plant sorted according to the colour of its ring. The number of seeds produced per plant in a particular group was obtained by counting all the panicles in that group, and then obtaining a mean value and multiplying by the mean stems per plant.

RESULTS

The germination data for each site is presented separately in the graphs (Fig.1) as the percentage of the total germination given cumulatively at each date of assessment (hollow circles). The line below this (solid circles) gives the number of plants that survived to maturity from each germination batch as a percentage of total survivors in the plots. The third line (hollow squares) is of the mean number of stems per plant (right-hand scale). The graphs are given in sequence according to the date of drilling of the crop (March 11-April 29). The date of drilling is given as a short vertical line on each graph.

The seed production by the groups of plants germinating between various dates at each site are given in Table 2 as the mean number of seeds produced per plant and the mean number of seeds produced by each group per square metre.

DISCUSSION

The germination pattern at the first ten sites in Figure 1 is essentially the same, in that the wild oats at all of them reach 50% emergence between April 14th and April 26th (a period of 12 days) although the dates of drilling ranged from March 11th to April 7th (a period of 27 days). From this it is evident that the earlier the sites were drilled the longer the time to 50% emergence of the wild oats. The two last sites to be drilled, on April 16th and 29th, reached 50% emergence much later of course.

The mean weekly soil temperature covering the period from drilling to complete emergence (February to June inclusive) is shown in Figure 2. During the period from March 11th (the first drilling date) to April 14th (the first site reaching 50% emergence) the mean soil temperature rose steadily from 4°C to 7°C. As the earliest germinating wild oats were few in number it would appear that a mean temperature of 6–7°C is the lowest at which rapid seedling growth occurred. The soil temperature data is from Stratford-upon-Avon, which was the nearest source of meteorological data to a majority of the sites, a number of which were quite close. A depth of 10 cm was selected as representative of the depth from which the majority of A. fatua plants emerged, although the temperature in shallower layers (5 cm) or in deeper ones (18 cm) does not vary greatly from the 10 cm depth. Fluctuations in shallower layers are more pronounced than in deeper ones.

Kühnel (1965) in Germany found that A. fatua germinated in the spring mainly between 0 and 6 cm depth approximately 10–14 days after the soil temperature in these layers first exceeded 5°C. From Figure 2, 10–14 days after the first time the temperature exceeded 5°C is March 25th-29th, which is at the very start of emergence of some of the earliest drilled sites, indicating perhaps that in Britain the weed requires a slightly higher temperature for germination. On the other hand, Koch (1968) showed under laboratory conditions that germination at 2°C was 10% of the possible maximum and with increasing temperature up to 15°C the germination increased more or less linearly up to the maximum at 15° and thereafter declined again up to a maximum temperature of 35°C. Zverev (1966) reported that the main germination period

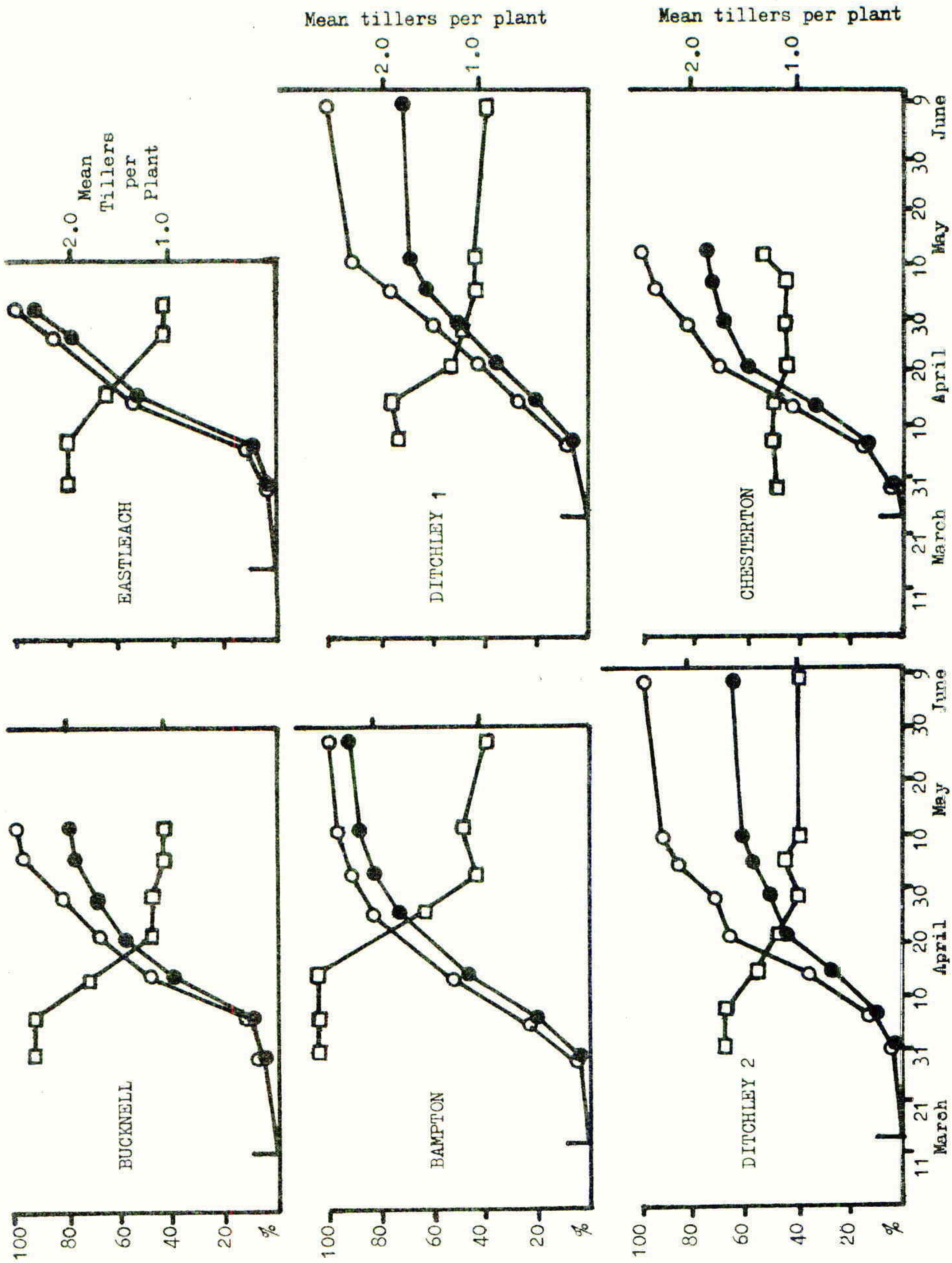

Fig. 1. The percentage germination and percentage survival of wild oats and the mean tillers per plant for plants emerging at different dates in spring barley at 12 sites in 1971. (O, percentage germination - cumulative; ●, percentage of plants surviving until harvest; ◘, mean tillers per plant)

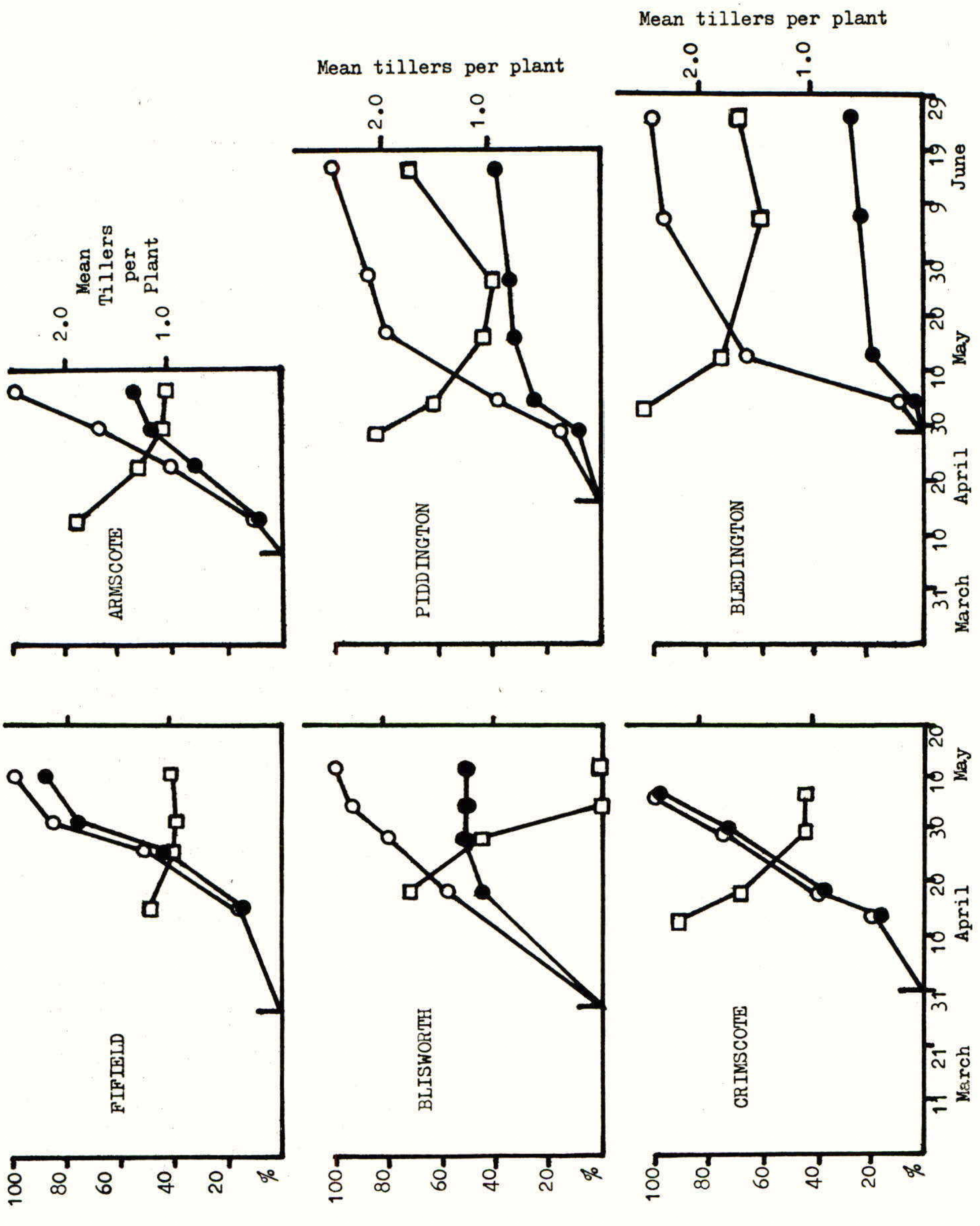

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Table 1

Details of the experimental sites

Site	Soil type	Barley Cultivar	Row width (cm)	Crop drilling date	Crop emergence date	Mean crop plants/m^2	Mean wild oat plants/m^2 in spring
Bucknell	Silty loam	Sultan	18	11 Mar	30 Mar	305	101
Bampton	Silty loam	Proctor	18	13 Mar	3 Apr	283	53
Ditchley 2	Silty clay loam	Zephyr	18	14 Mar	4 Apr	261	178
Eastleach	Silty loam	Julia	18	14 Mar	6 Apr	169	54
Ditchley 1	Clay loam	Julia	18	24 Mar	15 Apr	189	175
Chesterton	Loam	Proctor	18	24 Mar	10 Apr	328	528
Fifield	Silty clay loam	Sultan	18	28 Mar	19 Apr	424	700
Blisworth	Loam	Vada	12	29 Mar	15 Apr	216	612
Crimscote	Clay loam	Zephyr	18	31 Mar	16 Apr	224	16
Armscote	Clay	Vada	18	7 Apr	23 Apr	188	692
Piddington	Clay loam	Sultan	18	16 Apr	28 Apr	201	150
Bledington	Clay	Julia	18	29 Apr	8 May	84	444

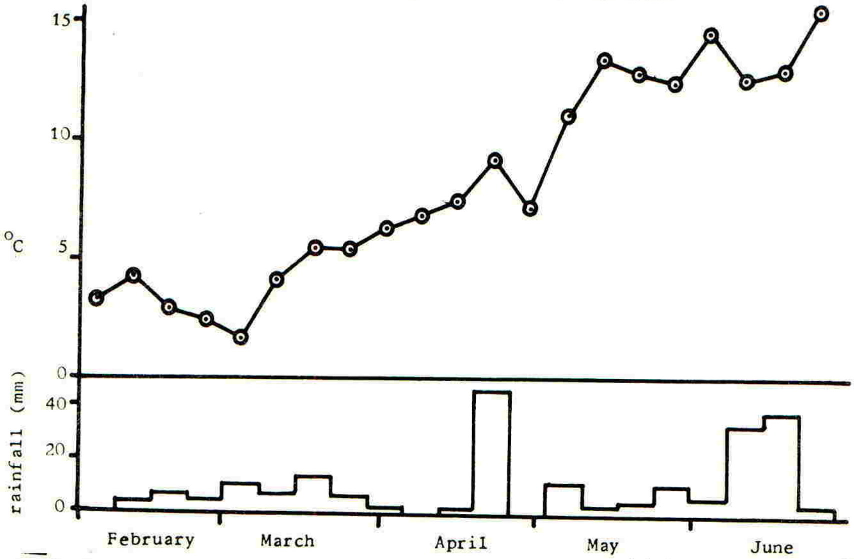
in Russia occurred when the soil temperature reached 10–13°C (May 1st–10th in Fig.2). Similarly, Friesen and Shebeski (1961) in Canada found that germination was very slow at 10°C (May 1st in Fig. 2), but quick at 15°C (June 2nd or later in Fig.2). From Figure 1 it can be seen that by 10°C (May 1st) the majority of wild oats had emerged at all sites except the two last, showing either that in Britain intermediate temperatures between the German and the Russian and Canadian ones are required for rapid seedling growth or that other factors are influencing the rate of emergence of seedlings.

All the germination graphs are plotted as percentages of the total number of plants recorded, but there is the possibility that a few seedlings emerged after the last assessments. However, negligible numbers of plants were found without rings at harvest, indicating that very few were either overlooked in the period of the assessments or germinated subsequently.

The mortality of A. fatua plants ranged from 4-75%. The main cause of mortality was thought previously to be plant density (including the crop), but when overall plant density was plotted against percentage mortality in a scatter graph (not presented), no obvious relationship was apparent. Date of drilling also appeared to be of some importance because the last two sites to be drilled had the highest mortalities (Piddington 63% and Bledington 75%) though whether this was a direct or indirect consequence is not known, for both these sites had a moderate infestation of mildew which may have been a contributory factor. At the earlier drilled sites there was a wide range of mortality, which did not bear a direct relationship with time of drilling.

The graphs of the mean number of stems per plant (Fig.1) show in general that the number of stems per plant was highest in the earliest germinating A. fatua and declined with time, reaching a minimum in the last ones to germinate. This is to be expected, for when crop competition is least and the wild oat population smallest then tillering is most likely to occur, but with time, intra- and inter-specific competition presumably increases to such an extent that little or no tillering is possible and most wild oat plants have but one stem. At the Fifield and Chesterton sites there was little tillering even by the earliest germinators, which was

Fig. 2. The mean weekly soil temperature at 10 cm depth under bare soil and the weekly rainfall at Stratford-upon-Avon in spring 1971.



probably due to the high density of their weed populations (616 and 388 plants/m² respectively). They were the highest and the third highest of the sites in this respect. On the other hand, at one or two sites, especially at Piddington, there was an increase in the mean number of stems per plant with time. This was mainly due to the small sample available for counting at the last assessments and there is the possibility too that one or two earlier germinators, that had been overlooked, were counted then for the first time, when identification was easiest.

The number of seeds produced per plant was invariably greatest in the earliest germinators, i.e. those germinating up to a maximum of 3 weeks after drilling (Table 2). However, despite their large seed production, they were not necessarily the group producing the greatest number of seeds per square metre. This was especially so in the earlier drilled crops, where they often only formed a small percentage of the total wild oat population. These results are very similar to those reported by Pfeiffer et al. (1960), despite the fact that 1960 was very dry during the germination period. In later drilled crops the earliest group of germinators did occasionally produce the most seed per unit area, possibly because germination and growth was more rapid at that time and the germination period shorter. The bulk of the seed of these twelve wild oat populations was produced by plants that emerged either before, at or up to 3 weeks after the emergence of the crop. Later ones contributed little seed. Fewer observations were carried out on the later drilled sites, because of the rapid growth of crop and weed and the relatively shorter period of wild oat germination at that time.

Individual crop cultivars do not appear from the data to have differed perceptibly in their influence upon wild oat behaviour. This agrees with a previous finding (Chancellor & Peters, 1970). Likewise particular soil types are not associated with any particular attribute of the wild oat populations although this might not follow under different conditions. However, as might be expected, there was a tendency for the heavier soils to be drilled later than the lighter ones and this of itself might be said to have caused indirectly some effects such as shortened germination period, etc.

Table 2

The mean number of seeds produced per wild oat plant and the seed production/m² for the groups of wild oat plants germinating between a given day and the previous assessment at 12 sites

Site	Time and type of Assessment								
Bucknell	Days after drilling	19	26	34	42	49	56	62	
	Mean seeds/plant	108	108	61	24	12	2	1	
	Seeds/m^2	541	649	1833	432	121	167	1	
Bampton	Days after drilling	18	24	32	44	51	59	76	
	Mean seeds/plant	117	117	117	37	6	4	7	
	Seeds/m^2	117	1287	1638	552	32	8	14	
Ditchley 2	Days after drilling	18	25	32	39	46	52	58	85
	Mean seeds/plant	54	51	28	13	8	6	5	11
	Seeds/m^2	109	979	911	374	93	55	29	54
Eastleach	Days after drilling	17	24	33	44	50			
	Mean seeds/plant	116	118	58	23	9			
	Seeds/m^2	116	580	1356	347	65			
Ditchley 1	Days after drilling	15	22	29	36	42	48	75	
	Mean seeds/plant	103	83	46	25	11	6	3	
	Seeds/m^2	1027	2755	1098	559	233	64	11	
Chesterton	Days after drilling	6	14	21	28	36	43	49	
	Mean seeds/plant	120	12	6	9	5	5	2	
	Seeds/m^2	480	720	1536	1124	240	132	16	
Fifield	Days after drilling	19	30	35	44				
	Mean seeds/plant	50	19	9	3				
	Seeds/m^2	5404	4180	1860	276				
Blisworth	Days after drilling	21	31	37	44				
	Mean seeds/plant	102	32	0	0				
	Seeds/m^2	27360	1152	0	0				
Crimscote	Days after drilling	13	19	30	37				
	Mean seeds/plant	200	56	50	10				
	Seeds/m^2	399	225	350	30				
Armscote	Days after drilling	6	16	23	30				
	Mean seeds/plant	142	59	19	14				
	Seeds/m^2	6792	10436	2100	884				
Piddington	Days after drilling	13	19	31	42	61			
	Mean seeds/plant	59	38	9	1	16			
	Seeds/m^2	592	761	110	1	94			
Bledington	Days after drilling	5	14	39	57				
	Mean seeds/plant	143	59	75	39				
	Seeds/m^2	1716	4312	1200	312				

These results indicate that it is essential, to use control measures which kill or substantially reduce the earlier germinating A. fatua in spring, for, because of their size, they are the most competitive with the crop and produce the bulk of the seeds returned to the soil. Later germinating A. fatua can generally be ignored, for, in general, a large proportion of them die before harvest and those that do survive produce little seed.

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A STUDY ON THE SURVIVAL OF WILD OATS (AVENA FATUA) SEEDS BURIED IN FARM YARD MANURE AND FED TO BULLOCKS

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Summary The possible role of stock and of farm yard manure as agents in Wild Oat dispersal was investigated in three experiments. It was found that up to 12% of *Avena fatua* (Wild Oat) seeds fed to bullocks were excreted in a viable condition and that a proportion of seeds remained viable after 12 - 13 weeks burial in manure stored out of doors in a heap or after 4 weeks indoors in an occupied bullock pen.

INTRODUCTION

The practical difficulties and high costs of controlling existing infestations of *Avena fatua* (Wild Oat) underline the importance of preventing its spread to clean land. The possible role of farm animals and farm yard manure as agents for *A. fatua* seed dispersal is a subject which requires further attention. The experiments described below are the preliminary results of an attempt to remedy this situation.

It has long been known (Dorph-Petersen 1899-1900, 1903-4) that seeds of certain plant species when eaten by cattle can pass through the digestive tract and emerge with the faeces having retained their ability to germinate and grow. Information on this subject is of particular interest for *A. fatua* as its seeds have been found in silage and frequently form a substantial contaminant of imported feeding barley. Thurston (1963) reported that 10 *A. ludoviciana* (Winter Wild Oat) seedlings emerged from the faeces of a calf which had been fed 2,000 intact seeds in bran mash. Atkeson *et al* (1934) who fed *A. fatua* seeds (viability 74%) to cattle found that of those recovered from the faeces only 10% were viable after 47 hours digestion and none after digestion followed by 3 months storage in manure.

As a result of handling damage *A. fatua* seeds in animal feeds are not always intact so it was decided to study the behaviour of scarified and dehusked seeds in addition to normal intact seeds. Seeds of all three types were therefore fed to cattle in an experiment (Experiment 1) designed to assess their chances of survival.

Avena spp. seeds spilled from contaminated feeding stuffs, from the digestive tracts of cattle and from contaminated straw (Wilson 1970) could readily be incorporated in animal bedding. An experiment was carried out at the Agricultural Research Institute, Hillsborough, Co. Down, to determine the survival of *A. fatua* seeds in bedding in a pen in which bullocks were being fattened under practical farming conditions. (Experiment 2).

Contaminated faeces, contamined straw and contamined feeding stuffs could all be expected in certain circumstances to contribute Wild Oat seeds to farm yard manure. Further, contaminated sweepings from combine harvesters and floors where contaminated grain, straw or hay have been stored could also be carelessly put onto manure heaps. In early Danish experiments Dorph-Petersen and Holmgaard (1928) showed mainly for weed species that seeds are killed by a period of burial in farm yard manure. The length of time required to kill the majority of the seeds was found to depend on (i) the species involved (ii) the depth of burial and (iii) the maximum temperature attained in the manure, seeds on the surface surviving very much longer than buried ones. On the basis of evidence from both natural heaps and containers full of manure they concluded "If one refrains from putting seeds on the surface of heaps, one can reckon in practice that only a very small part of the weed seeds which are brought to the heap will retain their germ power".

To investigate the fate of A. fatua seeds buried in a manure heap under the relatively mild conditions of a Northern Ireland winter an experiment (Experiment 3) was set up at the Plant Testing Station, Crossnacreevy, Co. Down. Seeds of the cultivated oat (A. sativa) cv Sceptre from 1971 harvest were also included to examine the extent of any variation in response between the wild and cultivated species.

METHOD AND MATERIALS

Experiment 1

The feeding trials were carried out in April/May 1972 at the Agricultural Research Institute, Hillsborough, Co. Down, using 6 - 8 cwt. bullocks kept in stalls and fed on a normal daily ration of 3 kg meal nuts and 3 kg chopped hay. For each trial each best was fed 2,000 seeds in $\frac{1}{2}$ kg ground meal and when this was consumed the balance of the daily ration was given (the hay in two parts, early and late). Faeces were collected on polythene sheets and removed at intervals of 24 hours from the time the seeds were fed. In a trial run one bullock was fed 2,000 intact seeds and the faeces were collected over a period of 10 days. In the main part of the trial this period was reduced to 8 days. Seeds were recovered from the faeces by washing with water in a seive basket 48cm x 48cm (1·6mm Mesh) and hand sorting of the fibrous residue. A 'treatment' consisted of feeding each of three bullocks (pre-conditioned for 5 days to experimental diet) 2,000 A. fatua seeds, in the form intact, scarified or dehusked (see below), the trial being carried out three times so that each bullock was given all three seed types in a different order. This achieved replication where both facilities and beasts for experiments were in limited supply. In each case the recovered seeds were counted and all set up for germination test to determine the number of surviving viable seeds.

Intact and dehusked A. fatua seeds for all experiments were from English barley cleanings of the 1971 harvest. Scarified A. fatua seeds were extracted from contaminated Canadian feeding barley. To determine viability A. fatua seeds were dehusked (lemma and palea removed) and cut with a scalpel on the dorsal surface behind the embryo. Seeds were set to germinate in 88 mm diameter glass Petri dishes on two circles of Whatman's No. 3 filter paper wetted with 6 mls tap water. Lots of not more than 50 seeds per dish were kept moist at $20 \pm 1^{\circ}$C in a cooled incubator. At intervals of about 2 days the seeds were examined and those with at least 2 mm white radicle were counted as 'viable' and removed. After 10 days seeds that were obviously dead were discarded and the remainder transferred to other dishes containing filter paper wetted with a solution of 100 ppm Gibberellic acid. Seeds failing to germinate after this treatment were counted as dead. It was not possible to grow on A. fatua to check seedling growth.

Experiment 2

An area of about 4·5 m^2 was marked out on one week's accumulated bedding, dung and urine in an enclosed pen containing three bullocks, 10,000 A. fatua seeds were scattered over this area and the animals left to trample, dung and urinate on it.

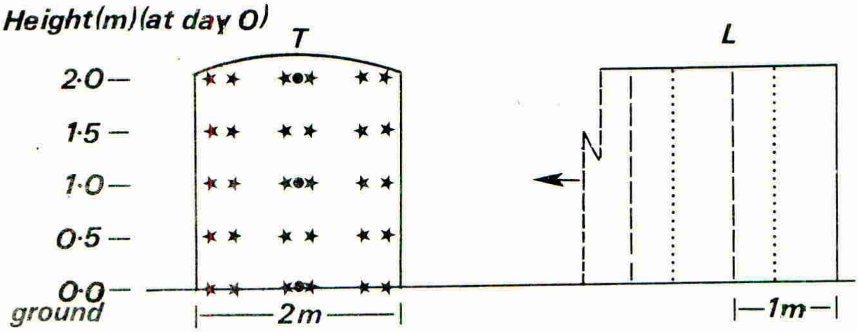
As was the commercial practice in other similar fattening pens small quantities of straw bedding were added at intervals thereafter. At 4 weeks and 13 weeks pairs of 15cm square vertical cores were removed from the bedding for washing and seed extraction. Seeds were counted and tested for germination as in Experiment 1.

Experiment 3

Fresh bullock manure composed of straw bedding 4 - 6 weeks old obtained from Greenmount Agricultural College, Co. Antrim, was built up a layer at a time into a 13 metre long heap just over 2 metres high by 2 metres wide on a concrete apron. During construction in January 1972, Terylene net bags containing seed samples were incorporated in pairs at selected sample positions throughout the heap. In each one-metre long section of the heap there were 15 possible sample positions (see fig. 1) in one central and two outer columns (25 cms from face) at 5 levels above the ground.

Figure 1

Transverse (T) and Longitudinal (L) sections of manure heap showing seed (★), probe (•) and sample plane (····) positions



Temperature sensitive thermistor probes were also incorporated at several sample positions in different sections of the heap. Wires leading from these probes enabled temperature readings to be taken from outside the heap. Each seed sample comprised 300 seeds. Temperature readings inside and outside the heap were taken at frequent intervals during heap construction and afterwards daily at noon for about 100 days. After 1 week, 2 weeks, 3 weeks, 6 weeks, 12 weeks and 21 weeks sections of the heap were removed (as bread from a loaf) from alternate ends of the heap. The contained seed samples were washed in cold water and tested for viability. The germination of A. fatua seeds was determined as in Experiment 1. A. sativa seeds were tested according to the International Rules for Seed Testing (1966) being pre-chilled at 5°C for 5 days before being set to germinate at 15°C in lots of 100 in a substrate of sand. Viable seeds in this case were counted as those which germinated and produced 'normal' seedlings.

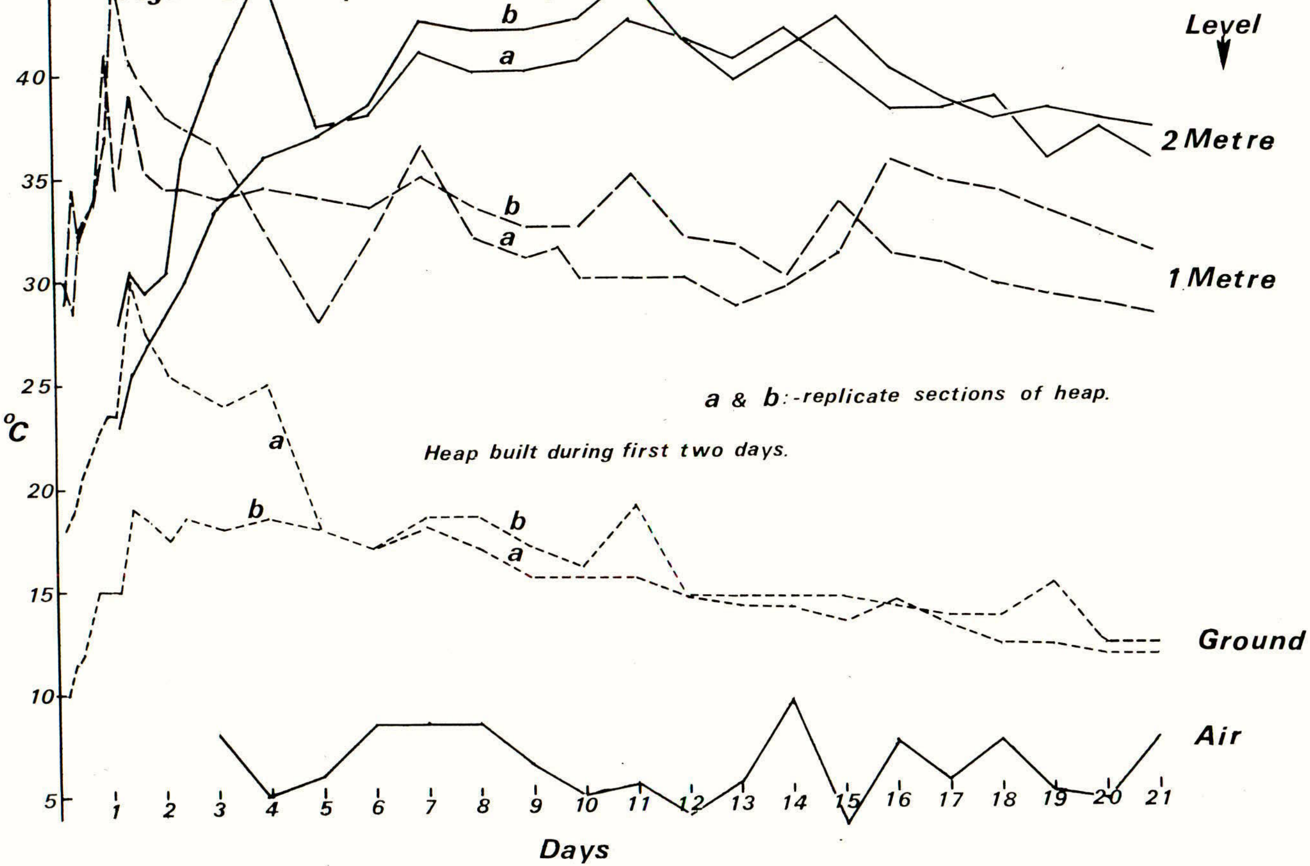


Figure 2 **Temperature changes within farmyard manure heap :– central zone.**

RESULTS

Experiment 1

Table 1

Avena fatua seed numbers and viability in dung collected at daily intervals
Means from 3 bullocks each fed 2,000 seeds

Days from ingestion		1	2	3	4	5	6	7	8	Total No	%
Type of seed											
Intact	Rec.	1·3	25·3	31·2	8·0	1·7	0	0	0	67·5	3·4
	Viab.	1·0	11·3	2·3	0	0	0	0	0	14·6	0·7
Control	Viab.										95·0
Scarified	Rec.	3·0	148·0	134·7	25·3	2·7	0·3	0	0	314·0	15·7
	Viab.	1·7	62·0	5·7	0	0	0	0	0	69·4	3·5
Control	Viab.										94·0
Dehusked	Rec.	14·7	345·0	144·0	23·7	2·7	0·3	0	0	530·4	26·5
	Viab.	4·7	110·3	34·7	0	0	0	0	0	149·7	7·5
Control	Viab.										95·0

Rec. - Total number of identifiable seeds recovered   S.E. of means
Viab. - The number of the seeds which were capable of germination (Rec.) = 54·9
(Viab.)= 18·2

Table 1 shows the number of seeds recovered from the faeces and their viability for each of the 8 days of collection, together with the mean totals for recovery and viability over the full 8-day period. The majority of seeds were excreted by the third day. No seeds retained in the digestive tract subsequent to the third day were found to be capable of germination. The maximum number of viable seeds recovered in any one trial was 238 dehusked (12% of those fed). Overall some 15% of seeds fed were recovered and on average approximately one-quarter of these (Intact 22%, Scarified 22% and Dehusked 28%) were viable. Analysis of variance of the 8-day totals for each beast with each seed form revealed no significant differences between beasts (blocks) for either recovery or viability (data transformed to arcsin of the percentage). In terms of numbers of seeds recovered in the faeces the ranking with regard to seed form was always the same, with a significant ($p = 0{\cdot}05$) difference in recovery between the seed forms.

i.e. recovery of Dehusked > Scarified > Intact

Experiment 2

The viability of A. fatua seeds before scattering was 95%. At 4 weeks the mean viability of seed recovered was 27% and this was reduced to zero by the 13-week sampling date.

Experiment 3

Some of the temperature changes which occurred inside and outside the heap for 21 days following initiation of heap construction and subsequent burial of the seed samples are shown in Fig. 2. Temperatures attained at ground level are clearly considerably lower than those in the upper parts of the heap. These temperature differences were maintained for more than 40 days after the heap was built.

Temperatures in the outer zone (not illustrated) of the heap were lower than those in the central zone at the same level.

Table 2 shows the changes occurring in % viability of successive samples of seed of the two oat species buried for various periods at different positions (see Fig. 1.) in the manure heap. Seeds of both species survived longest at ground level. Seeds in the central zone of the heap were killed more rapidly than those nearer the side faces. Seeds of cultivated oat were virtually all dead at 6 weeks while some A. fatua seeds still survived after 12 weeks. At 21 weeks no viable seeds of either species remained.

Table 2

The % Viability of A. Fatua and A. sativa seed recovered from different positions within a manure heap

Period of Burial (Weeks)		1		2		3		6		12		21	
Transverse Position		O	C	O	C	O	C	O	C	O	C	O	C
Height (M)													
2	A. fatua	0	0	29	0	34	0	0	0	+	0	0	0
	A. sativa	0	0	5	0	0	4	0	0	+	0	-	0
1·5	A. fatua	61	9	15	0	24	0	0	0	0	0	0	0
	A. sativa	15	0	9	0	9	0	0	0	0	0	-	0
1·0	A. fatua	42	0	7	0	2	0	2	0	0	0	0	0
	A. sativa	11	0	0	0	0	0	0	0	0	0	-	0
0·5	A. fatua	77	36	27	1	23	0	0	0	2	0	0	0
	A. sativa	19	0	2	0	8	0	0	0	0	0	-	0
Ground	A. fatua	83	74	78	73	84	73	23	4	18	5	0	0
	A. sativa	62	38	19	0	57	19	1	0	0	0	-	0

Initial viability A. fatua = 95% A. sativa = 91% + = lost samples
Outer (O) zone figures are mean of 4 replicate samples - = none buried
Central (C) zone figures are mean of 2 replicate samples

DISCUSSION

The results of Experiment 1 confirm earlier observations that intact Avena spp. seeds can pass through the digestive tract of adult cattle without being killed though the majority (99·3%) do suffer that fate. Whilst in this experiment a significantly greater number of scarified and dehusked seeds were recovered the difference in their viability from intact seeds was not statistically significant. It is evident that the form of the seed has an effect on its chance of safe passage. The greater retention and destruction of intact seeds may result from some mechanical effect of size and/or presence of hairs and awns which scarified and dehusked seeds do not have. Remaining differences in recovery of dehusked and scarified seeds may result from a size difference. The small proportion of viable seeds among those recovered is evidence of the effects of toxic digestive chemicals and/or high temperatures within the alimentary canal.

The importance of temperature to the survival of seeds buried in manure has previously been documented by Dorph-Petersen who found in Denmark that maximum temperatures attained in natural manure heaps were 46°C in summer-made heaps and 14°C in winter-made heaps. In summer heaps, seeds buried at 40 cm depth were practically all killed after 72 days in contrast to those in winter-made heaps where viability retention was up to 33% of control. It has now been demonstrated (Experiment 3) that (good) long survival of A. fatua seeds in the lower and outer regions of a manure heap relative to that in the upper and central is paralleled by respectively low and high manure temperatures. The eventual death of the seeds in the cooler lower parts of the heap was not, however, unexpected. Kiewnick (1964) found evidence of A. fatua seed mortality associated with storage in a high moisture environment at relatively low temperatures. Thus seeds stored at 20 - 22°C at 100% r.h. in the presence of soil microflora had their % viability reduced by 23% after 3 months and by 36% after 6 months compared with controls stored at 60 - 80% r.h. in open dishes. In soil he found that where soil water exceeded 50% capacity, secondary dormancy was induced in buried A. fatua seeds thereby increasing their susceptibility to attack by soil microflora. Such high moisture conditions over a period led to autolysis of the seed.

It is probable that death of moist A. fatua seeds buried in manure results from the action of one or more factors at least two of which are temperature dependent. The first of these is a high temperature physical process involving denaturing of vital proteins within the embryo or endosperm. The second factor - that of microbial action - operates over a wider range of temperatures becoming increasingly important as moisture and temperature levels rise. Experiments on the effects of high temperatures on moist A. fatua seeds in the absence of manure are now being carried out in the laboratory. The temperature changes occurring in bullock bedding "in situ" were not monitored. It might be expected, however, that chemical toxicity, high moisture and trampling injury would be at least as important lethal factors as high temperatures in this situation. That chemical factors may also be important is suggested by Reider (1966) who soaked a number of weed seeds for periods of up to 40 days in liquid manure. Of the weed seeds so exposed, A. fatua was among the most resistant to a toxic factor which he concluded was NH_3. After 3 - 4 months samples of liquid manure showed minimal numbers of viable seed.

Metz (1970) in East Germany has reported on the survival of caryopses (i.e. dehusked seeds) of A. fatua. These were killed after storage in farmyard manure for 7 weeks, liquid manure for 3 weeks or when ensiled for 2 weeks.

Whatever the factors operating in a manure heap which lead to loss of viability of buried seeds it is clear that they do not operate equally throughout the heap. It is therefore possible for A. fatua seeds coming to a manure heap to survive for at least 3 months. Seeds on the surface of the heap might be expected to survive even longer.

Parallel experiments run on a smaller scale in the same heap revealed broadly similar responses to burial by A. strigosa (Bristle-pointed oat) and Rumex obtusifolius (Broad-leaved dock), the only differences being in the rate at which viability was lost. A. strigosa seeds were all dead at 6 weeks while some Rumex seeds were still germinating at 21 weeks.

These experiments have proved that a proportion of A. fatua seeds eaten by cattle whether intact, scarified or dehusked can pass through the animal and retain viability: that intact seeds which whether by way of contaminated faeces, straw or spilled feed are incorporated in bedding during the housing of animals can be capable of germination for at least 4 weeks and that seeds from the same sources put in manure heaped outside can still be alive after 12 weeks.

Although the proportions of seeds remaining alive after these treatments is small, it need not be restated here that only one plant is required to create the nucleus of an infestation in clean land. The possibility of causing infestation of

A. fatua by spreading contaminated manure on the land must therefore be considered a real one.

Just as farmers were made aware of the dangers of the A. fatua seed contamination of straw bales it is now necessary to publicise the possible dangers of spread which could be caused by animals and their waste products.

Acknowledgements

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Proc. 11th Br. Weed Control Conf. (1972)

THE EFFECT OF AUTUMN CULTIVATIONS ON THE EMERGENCE OF AVENA FATUA SEEDLINGS

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Summary In six experiments, carried out over two years, cereal stubbles containing seeds of A. fatua were cultivated at various times after harvest. Rotary cultivation in the early autumn resulted in a two to threefold increase in A. fatua seedlings emerging in the following spring, compared with leaving the stubbles undisturbed until late autumn. In two experiments seeds were recovered from the soil after assessments of seedling emergence. In both cases early cultivation resulted in a greater survival of viable seeds in the soil, than late cultivation. When early cultivation was followed by ploughing, fewer seedlings emerged but more seeds persisted in the soil in the following year.

INTRODUCTION

Wild oats are an increasing menace in cereal crops in this country, although herbicides for their control have been available for many years. In addition to the use of herbicides, other cultural aspects of husbandry whereby infestations may be limited are of considerable importance.

Cultivations of the seedbed in the spring, associated with delayed drilling of the crop, have been shown to be effective in reducing infestations of wild oats (Whybrew 1964). However, the effect of autumn cultivations before cropping appears to be less well known. Although stubble cultivations will stimulate a small proportion of the seed on the surface to germinate, most of the seed is dormant during the autumn after shedding. Autumn cultivation has been reported to result in an increase in wild oats emerging in the following spring. Leggett, H. W. (1957) reported that in Canadian field experiments, when autumn tillage was practised, wild oats germinated earlier and in greater numbers the following spring. Whybrew (1964) reported a more rapid build up of wild oats associated with rotary cultivation of the stubble on Boxworth Experimental Husbandry Farm, and birds were suggested as a likely cause for losses of seed from undisturbed stubble.

The need to control perennial grass weeds and to reduce carry over of diseases on straw and volunteer cereals has lead to an increase in early cultivated stubbles during recent years. This early cultivation is not always followed by autumn mouldboard ploughing. Experiments are described in this report in which the influence of autumn cultivations upon the subsequent emergence and fate of wild oats has been investigated.

METHOD AND MATERIALS

1969/70 Experiments

Three experiments were set up in early September 1969 on barley stubbles where the crop had been heavily infested with A. fatua, with the result that large quantities of seed were present on the stubbles. The soil types encountered were: Yarnton - sandy loam, Tackley - loam and Spelsbury - clay loam.

Identical experiments were set up at each site. Each was of split plot randomised block design, replicated three times. Main plots of 27 ft x 6 ft each contained three sub-plots of 9 ft x 6 ft. The main plots either remained uncultivated or the stubble was rotary cultivated to 3-4 in. in early September or in early October. Some sub-plots were not dug, and some were dug to depths of 4 in. or 8 in. in late October. The soil on the dug plots was inverted as far as possible to simulate ploughing.

In mid October, A. fatua seedlings which emerged on plots cultivated in September were counted, and similar counts were taken on plots which had remained uncultivated.

No further cultivation was carried out in the spring, and no crop was sown. A. fatua seedlings which emerged were counted on the centre yd^2 of each sub-plot. Counts of seedlings were made at approximately weekly intervals from mid April until the end of May. Newly emerged seedlings were identified at each count by ringing them with coloured wires, the colour being related to the date of emergence.

At the beginning (mid April) and again towards the end (mid May) of the main flush of emergence, wild oat seedlings were assessed for the depth from which they emerged. On each sub-plot, six recently emerged seedlings, selected at random, were dug, and the depth from which they emerged was recorded.

1970/71 Experiments

Three experiments were set up on barley stubbles in early September 1970, all situated on sandy loam soils. One experiment at Yarnton was sited on stubble containing seed of A. fatua on the surface which had shed from a heavy infestation in the previous crop. Two experiments at Begbroke were sited on stubbles free from naturally shed seed; here, recently collected seed was broadcast by hand on to small plots in the stubble at a density of 1000 seeds/yd^2.

Yarnton

This was of randomised block design with four replicates, and plots 30 ft x 8 ft. Plots either remained uncultivated or were rotary cultivated to 3-4 in. in early September, early November or early February 1971. There was no further cultivation and no cropping. Seedlings emerging in the autumn on the early cultivated plots were counted. Seedlings emerging in the spring were counted at intervals between mid March and mid May in fixed quadrats, colour coding the newly emerged seedlings with wire.

Begbroke 1

This was of randomised block design with four replicates and plots 30 ft x 8 ft. Within each plot, two areas of stubble each 5 ft x 5 ft were seeded with A. fatua, and the centre yd^2 of each subsequently assessed. One of these seeded areas was covered with nylon net and the other remained uncovered. Cultivation treatments identical to those at Yarnton were carried out at the same dates.

Seedlings emerging in the autumn on the early cultivated plots were counted. Seedlings emerging in the spring were counted at intervals between mid March and mid May, colour coding the newly emerged seedlings with wire.

In June, when seedling emergence was complete, plots were assessed for the seed remaining in the soil. Each yd^2 assessment area was dug to the cultivated depth, and the seed extracted from the soil by wet sieving over $\frac{1}{4}$ in. and 1/20 in. mesh sieves. The material from the fine sieve, containing wild oat seeds, was dried, and the seeds separated by winnowing and hand sorting. The numbers of full seeds containing normal caryopses were recorded.

Begbroke 2

This experiment was set up in September 1970 and continued until June 1972. A Latin square design was used with four replicates and plots of 30 ft x 7 ft. Within each plot, three areas of stubble each 6 ft x 6 ft were seeded with A. fatua, and the centre yd^2 of each subsequently assessed. These three yd^2 assessment areas were dug for seed extraction either in June 1971, November 1971 or June 1972. Seedlings of A. fatua were counted on the areas not dug in the autumn of 1970, spring and autumn 1971 and in the spring of 1972. Seed shedding was reduced as far as possible during the summer of 1971 by hand roguing.

Cultivation treatments in this experiment were extended to include ploughing. Plots were either rotary cultivated to 3-4 in. in September (as in Begbroke 1), rotary cultivated in September followed by ploughing to 10 in. in November, the undisturbed stubble ploughed to 10 in. in November, or the stubble remained uncultivated.

All plots were planted to barley in the spring. A triple disc drill was used, designed to ensure uniform penetration on plots at different degrees of compaction.

RESULTS

1969/70 Experiments

Relatively few wild oats emerged in the autumn. Cultivation of the stubble in September resulted in 1, 5 and 5 seedlings/yd^2 at Yarnton, Spelsbury and Tackley respectively. This was more than on the uncultivated plots, but very few in comparison with those which subsequently emerged on the same plots in the following spring (Table 1).

Table 1

A. fatua seedlings/yd^2: Spring 1970

Time of Rot. cult:		YARNTON Sept.	Oct.	Nil	SPELSBURY Sept.	Oct.	Nil	TACKLEY Sept.	Oct.	Nil
Digging (soil inversion)	Nil	124	74	40	379	259	42	122	63	31
	4 in.	181	81	14	346	197	185	54	107	74
	8 in.	142	109	24	246	307	112	99	81	62
	Mean	149	85	26	324	254	113	92	84	56

At each site, errors were large, due mainly to the variable distribution of wild oats within the experimental areas. However, cultivation in early autumn appears to have been associated with increased numbers of wild oats at each site. There was a tendency for fewer wild oats to emerge after cultivation in October than after cultivation in September, and for fewer to emerge after digging the uncultivated stubble rather than digging stubble which had previously been cultivated.

Table 2

Relative emergence of A. fatua seedlings
Seedlings at two dates expressed as % of total emergence until 27th May

	YARNTON		SPELSBURY		TACKLEY		Mean of 3 sites	
	24 Apr	1 May	24 Apr	1 May	24 Apr	1 May	24 Apr	1 May
No cultivation	53	74	35	62	39	47	42	61
R. cult. Sept.	39	84	58	82	55	74	51	80
R. cult. Oct. (no digging)	33	81	51	81	58	74	47	79
Digging 4 in.	38	68	52	75	54	66	48	70
Digging 8 in. (no R. cult.)	47	66	49	73	61	75	52	71

The effect of cultivations on the pattern of emergence is shown in Table 2. With the exception of the first date at Yarnton, wild oats emerged more slowly on plots which remained undisturbed than on cultivated plots. There was a tendency for a higher proportion to have emerged on 1st May following rotary cultivation than after digging.

There was considerable variation in the depth from which wild oats emerged on any one plot at each assessment. The mean values shown in Table 3 indicate that the late emerging seedlings tended to come from a greater depth than those emerging early. There was little difference in the depth of emergence between the different cultivations, but on plots which remained uncultivated wild oats arose from nearer the soil surface than on cultivated plots.

Table 3

A. fatua seedlings - depth of emergence in.; means of 3 sites

	Mid April			Mid May		
R. cult.	Sept.	Oct.	Nil	Sept.	Oct.	Nil
Digging						
None	1.8	1.8	0.7	2.5	2.4	1.4
4 in.	2.0	1.9	1.9	2.2	2.2	2.9
8 in.	2.0	2.2	1.5	2.3	2.5	2.7

1970/71 Experiments

Relatively few wild oat seedlings emerged in the autumn after setting up the experiments. On the plots cultivated in September, 17, 2 and 7 seedlings/yd^2 were recorded at Yarnton, Begbroke 1 and Begbroke 2 respectively.

Table 4

Spring emergence of A. fatua; recorded until 14th May 1971

	YARNTON			BEGBROKE 1		
	Total /yd^2	% of total emergence 16 April	30 April	Total / yd^2	% of total emergence 16 April	30 April
R. cult. Sept.	918	68	86	154	49	81
R. cult. Nov.	539	62	82	78	58	80
R. cult. Feb.	335	70	88	34	66	80
No cult.	203	41	61	9	30	61
SE	±58			±8.5		

In the two experiments with similar cultivation treatments (Table 4), significantly more wild oats emerged in the spring following rotary cultivation in September than where the stubble remained undisturbed until November. Fewer emerged following February cultivation, and the lowest numbers arose from the untouched stubble. The pattern of emergence was similar for the cultivation treatments, but with no cultivation, wild oats were slower in emerging.

At Begbroke 1, the numbers of seeds recovered from the soil showed a similar trend to that of seedling emergence (Table 5). Most seeds were recovered from the early cultivated plots, significantly more than from plots not cultivated until November. Both the numbers of seedlings emerging and the seeds recovered were higher from the caged plots than from plots left uncovered for the September and November cultivation treatments.

Table 5

Seedling emergence and seed recovery from caged and uncaged plots

BEGBROKE 1	Seedlings emerged/yd^2 Caged	Uncaged	MEAN	S E MEAN	Seeds recovered/yd^2 Caged	Uncaged	MEAN	S E MEAN
R. cult. Sept.	165	144	154	9.8	137	87	112	16.4
R. cult. Nov.	90	68	79	8.0	87	50	68	7.3
R. cult. Feb.	33	34	34	4.2	6	8	7	1.6
No cult.	11	8	9	1.3	9	10	10	0.7

Table 6

Seedling emergence and seed recovery from Begbroke 2

	Seedlings Autumn 1970 + spring 1971	Seeds in soil June	Nov 1971	Seedlings Autumn 1971 + spring 1972	Seeds in soil June 1972
R. cult. Sept.	158	87	168	161	8
R. cult. Sept. + plough Nov.	54	131	206	124	14
Plough Nov.	14	33	45	32	4
No cult.	27	6	29	10	1
S E	±5.6	±14.0	±21.4	±9.9	±2.0

Table 6 follows the fate of seed on Begbroke 2 for two years after 1000 seeds/yd^2 were originally sown in September 1970. Rotary cultivation in September resulted in 158 seedlings/yd^2 emerging during the following autumn and spring, a similar number to those emerging from this treatment on Begbroke 1. The effect of following this rotary cultivation with ploughing in November was to reduce seedling emergence to 54/yd^2, but to increase the numbers of seeds recovered from 87 to 131/yd^2. Ploughing the undisturbed stubble in November resulted in far fewer seedlings emerging and fewer seeds remaining in the soil. Small numbers of viable seeds were recovered from the soil during the summer of 1972. The apparent increase in seed reserves between June and November 1971 must be, in part, due to random error and, in part, to some seeds being shed despite hand roguing of the plots on three occasions in the summer of 1971.

DISCUSSION

The most significant result arising from these experiments is that consistently more wild oats emerged where the stubble was cultivated soon after harvest than where cultivation was delayed. This effect was common to all six experiments carried out over two years on varying soil types. Numbers of wild oats emerging were more than doubled by early cultivation.

In considering the effects of the autumn cultivation on wild oat seeds, it is necessary to consider the two main sources of seed reserves separately. Seeds may either have been recently shed to the soil surface or have been buried from a previous year's infestation. Any increase in germination of the old buried seeds must reduce the carry over of reserves of those seeds. Current work is investigating the ratio of old to new seed in some natural infestations and studying the fate of seeds over a long period.

Some of the experiments reported here were concerned only with new seeds artificially broadcast on to the soil surface. In these experiments, treatments which increased seedling emergence have increased the seed reserves contrary to what has been suggested for old seed. Early cultivation, which resulted in more wild oat seedlings was also associated with higher numbers of seeds being recovered from the soil. Other experiments (Wilson 1972) have shown considerable deterioration and loss of viable seeds from the surface of undisturbed stubble during the autumn months. Losses of seeds from undisturbed stubble have been shown to take place more rapidly during the autumn than losses of seeds incorporated into the soil by cultivation. The seedlings emerging and the seed reserves appear to have been linked more closely to the viable seeds cultivated into the soil, than to the numbers of seeds originally present on the surface. This suggests that the larger the interval between shedding and cultivation, the greater will be the losses of seeds from the stubble surface, with a consequent reduction in the subsequent infestation.

In one experiment, the type of cultivation affected the subsequent infestation. Ploughing a cultivated stubble reduced the numbers of seedlings emerging but allowed more seeds to persist in the soil, than where the cultivated stubble was not ploughed. All the seeds were originally on the stubble surface and presumably the result of ploughing was to bury a higher proportion of these at a depth too great for germination. Indications of induced dormancy with deeply buried seeds were also reported from Rothamsted (Thurston 1961). Viable A. fatua seeds survived longer after being placed 15 cm deep and ploughed to this depth than when harrowed into the top 5 cm of soil.

In some treatments the soil was left uncultivated throughout, either uncropped or spring barley was established by means of a special drill. In these situations relatively few seedlings emerged and those tended to emerge later (Tables 2 and 4) and from nearer the soil surface (Table 3). It is likely that with a compacted stubble more of the deeper seeds remained dormant.

It is difficult to interpret the increased numbers of seedlings and seeds found under the cages on Begbroke 1. Birds may well have taken some seeds from the plots left uncaged during the autumn months; however more seedlings and seeds were found on the caged plots where the seeds were cultivated in, out of reach of the birds, immediately after sowing. There was more growth of vegetation under the cages; this could have modified the micro climate at ground level which may in turn have slightly reduced the loss of seed in the soil during the autumn.

Similar results have been obtained in these experiments from both natural and artificial infestations. There are, however, a number of factors which could influence the response of wild oats to autumn cultivation. Soils which crack deeply or have a lot of surface stone may provide greater opportunity for seeds to escape from the surface by means of their hygroscopic awns. The burning of straw at harvest may result in death or breaking of dormancy of some seeds, so that fewer dormant viable seeds are cultivated into the soil.

It does not seem likely that delayed autumn cultivation will serve as a control measure; the timing and type of cultivation are likely to only affect the rate of population increase. It would however seem that farmers have an opportunity to encourage the maximum loss of wild oat seeds from cereal stubbles by delaying initial cultivation. If early stubble cultivation is necessary or desirable for other husbandry reasons, more consideration should be given to the possible need for spraying against wild oats in the following crop. Systems involving early cultivation without the mouldboard plough seem especially likely to result in serious build up of wild oats.

Acknowledgements

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STUDIES OF THE FATE OF AVENA FATUA SEEDS ON CEREAL STUBBLE, AS INFLUENCED BY AUTUMN TREATMENT

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Summary Seeds of Avena fatua on cereal stubbles declined considerably in viability as the autumn progressed. The rates of decline were similar where the stubble was caged against birds, and where seeds were placed either on a natural stubble surface, or on a cultivated surface or on a sterilised stubble surface. Seeds which were cultivated into the soil in the early autumn retained their viability during the autumn. Reasons for the differences between surface and buried seeds are discussed.

INTRODUCTION

The success of A. fatua as a weed is due largely to the fact that the large numbers of seeds produced are shed to the ground, and once mixed into the soil can remain dormant for a considerable time. After an infested crop is harvested, the density of seeds in the stubble can often amount to several thousands/yd^2 (Wilson, 1970). Although the majority of these seeds are initially viable, only a small percentage will eventually give rise to seedlings (Thurston 1961). Experiments described elsewhere (Wilson and Cussans 1972) have shown large differences in seedling emergence of wild oats in the spring as the result of different autumn cultivation treatments. It was suggested that the differences in seedling emergence and seed reserves were, in part, a reflection of the loss of viable seeds in the autumn.

The fate of seeds on stubbles during the autumn after harvest is considered in this report. The decline of viable seeds was followed in a naturally infested stubble, and again when seeds were broadcast into a stubble and subjected to various treatments.

METHODS AND MATERIALS

Charlton Experiment

This was carried out on a loam soil overlying limestone. An area of barley of 0.25 ac. with a fairly uniform infestation of A. fatua, was selected on 14th July when most of the panicles were showing. On 26th July the infestation was assessed by a) counting all panicles in three representative areas of 12 yd^2 each and b) counting seeds on selected panicles. Four groups, each of 10 panicles were selected at random. Each panicle was labelled and the seeds thereon counted. The seeds on each labelled panicle were again counted on 4th, 11th and 16th August during which time some shedding had occurred. The crop was harvested on 16th August, and the numbers of seeds shed to the ground at harvest were calculated.

On 24th August the swathes of straw were removed by hand, and yd^2 plots for recovering seeds from the stubble were marked out. These plots were placed either where the straw had laid or midway between the swathe positions. Half the plots were caged with wire netting of 0.5 in. mesh. Sufficient plots were laid down to allow for four assessment dates, fully randomised within each replicate. Four replicates were set up.

Seeds were recovered on 3rd September, 1st and 29th October and 29th November. At each date, cages were removed where appropriate, and the stubble on the plots cut to ground level. The loose material was swept up, the soil surface then lightly raked and swept again to recover any seeds which may have become embedded in the surface soil. Seeds were separated from the other material by sieving and hand sorting, and then counted.

Seeds which were recovered from the uncaged plots between the straw swathe positions, were subjected to a qualitative test. 100 seeds from each plot were taken at random, dehusked, and classified into full seeds containing normal white caryopses, shrivelled seeds where the caryopses were discoloured and shrunken, empty husks, and seeds which had pre-germinated. The full seeds were tested for viability.

Begbroke Experiment

Barley stubble on a sandy loam soil where wild oats had not been recorded previously was selected for this experiment. Four main plots each 9ft x 28ft and replicated three times were marked out on 10th September. Within each main plot four small areas of the stubble were seeded with A. fatua. Seeds which had been collected during the previous July were used at a seeding rate of 2000 full seeds/yd^2. These seeded plots allowed for four recovery dates. The seeded areas were 3ft x 3ft on the main plots where seeds were applied to the surface and 4ft x 4ft where seeds were cultivated in.

On one main plot the stubble was treated with formeldehyde before seeding took place. Areas 4ft x 4ft were treated before seeding 3ft x 3ft. Commercial formalin was applied at a rate of 1 gallon in 9 gallons water per 10yd^2 of stubble. Seeds which had been immersed in calcium hypochlorite solution for 30 minutes, rinsed in distilled water and allowed to dry, were broadcast on to these plots.

With the remaining three treatments, seeds were either broadcast on to the surface of the stubble, or on to the cultivated surface following rotary cultivation, or broadcast on to the surface and incorporated by rotary cultivation to 3 in.

Plots were dug for seed extraction on 5th October, 8th November, 16th December or 25th February 1972. On each occasion an area 2ft x 2ft was dug out within the area originally seeded. Cultivated plots were dug to 6 in. and uncultivated plots to 3 in. The seeds were extracted by wet sieving over $\frac{1}{4}$ in. and 1/20 in. mesh sieves. The material from the fine sieve containing the wild oat seeds was dried, and the seeds separated by winnowing and hand sorting. The seeds were counted, weighed and subjected to a qualitative test as described for the Charlton experiment.

RESULTS

Charlton Experiment

Table 1

Seed shedding of A. fatua

	26 July	4 Aug.	11 Aug.	CROP HARVEST 16 Aug.
Average seeds/panicle	89	72	57	46
Average panicles/yd^2	19.3			
Seeds on panicles/yd^2	1718	1390	1100	888
Seeds on ground/yd^2	0	328	618	830

The initial count of panicles showed a moderate infestation of 19.3 panicles/yd^2. Table 1 shows that an average of 89 seeds/panicle was reduced by shedding to 46 seeds/panicle at harvest, when it was calculated that 830 seeds/yd^2 had shed to the ground. An average of 888 seeds/yd^2 still present on the panicles were harvested with the crop on 16 August.

Seeds recovered from the stubble between the original straw swathes would have originated almost entirely from seeds shed naturally before harvest. Additional seeds from where the straw swathes had laid would have reached the ground via the combine. Table 2 shows that the effect of the combine was to approximately treble the density of seeds on the ground where the straw had laid.

Table 2

Total seeds recovered/yd^2 stubble

	3 Sept.	1 Oct.	29 Oct.	29 Nov.	Mean (±104)
Between straw - caged	774	594	410	185	492
uncaged	682	759	446	349	559
Beneath straw - caged	2059	1440	1818	869	1547
uncaged	1748	1643	1447	673	1327
Mean (±202)	1317	1109	1005	494	

S.E. body of table ± 271

Table 3

Qualitative Analysis of seeds recovered (between straw uncaged plots only)

%	3 Sept.	1 Oct.	29 Oct.	29 Nov.
* Full seeds	55	54	48	16
Shrivelled seeds	19	34	9	38
Empty seeds	25	11	42	45
Pre-germinated seeds	1	1	1	1

* Full seeds averaged 94% viability

Table 4

Viable seeds/yd^2 recovered from stubble (between straw uncaged plots only)

3 Sept.	1 Oct.	29 Oct.	29 Nov.
352	385	201	53

There was no consistent difference in the numbers of seeds recovered between the caged and uncaged plots throughout the autumn (Table 2).

The numbers of seeds recovered declined as the autumn progressed (Table 2). The quality of this seed deteriorated as shown in Table 3, when the percentage of full seeds fell sharply from October onwards; there was a corresponding increase in the proportion of empty husks as the autumn progressed. Tests for viability showed that an average of 94% of the full seeds germinated; the shrivelled seeds were not viable.

Begbroke Experiment

Table 5 shows that similar numbers of seeds were recovered at the three autumn assessments, but slightly fewer seeds were recovered from the surface treatments on 25th February.

Table 5

Total seeds recovered/4ft^2

	5 Oct.	8 Nov.	16 Dec.	25 Feb.	Mean
					(±58.6)
Seeds on stubble surface	928	903	856	738	856
Seeds on sterilised surface	830	894	916	723	841
Seeds on cultivated surface	989	929	854	555	832
Seeds cultivated in	914	745	934	970	891
Mean (± 36.6)	915	868	890	746	

S.E. body of table ±86.4

Table 6

Average dry wt.(mg)/seed recovered

	5 Oct.	8 Nov.	16 Dec.	25 Feb.	Mean
					(±0.22)
Seeds on stubble surface	15.3	14.1	9.1	7.2	11.4
Seeds on sterilised surface	17.1	14.3	7.6	6.4	11.4
Seeds on cultivated surface	15.8	14.0	8.8	7.2	11.5
Seeds cultivated in	14.8	13.5	13.7	11.3	13.3
Mean (± 0.21)	15.8	14.0	9.8	8.1	

S.E. body of table ± 0.42

The quality of seeds deteriorated more rapidly on the surface than when cultivated in. Table 6 shows that with the three treatments in which seeds remained on the surface, there was a sharp decline in the mean seed weight, from the 8th November onwards. Seed weight declined at a lower rate where seeds had been cultivated in. The seed weights are a reflection of the proportion of full seeds which declined to a much greater extent where seeds remained on the surface. Table 7 shows the numbers of full seeds recovered.

Table 7

Numbers of full seeds recovered (On average 89% were viable)

	5 Oct.	8 Nov.	16 Dec.	25 Feb.
Seeds on stubble surface	687	605	171	74
Seeds on sterilised surface	639	572	92	29
Seeds on cultivated surface	682	641	214	89
Seeds cultivated in	667	544	588	689

DISCUSSION

In both experiments there was a considerable deterioration in the quality of the seeds recovered from the soil surface as the autumn progressed. The proportion of full viable seeds fell most rapidly during November in both experiments. By December the viable seeds at Charlton had declined by 85% compared with those originally recovered, and the viable seeds originally broadcast on the three surface treatments at Begbroke had declined by an average of 76%. The poor quality of the seeds initially recovered at Charlton was attributed to a previous attack by Frit fly.

The seeds which were cultivated into the soil at Begbroke were largely preserved. This substantiates previous work (Wilson and Cussans 1972) where more seedlings emerged and more seeds were recovered from plots cultivated early in the autumn than where the stubble was left undisturbed until late autumn.

In addition to the deterioration in quality, the total recovery of seeds also declined. This loss could be attributed to the carrying off of seeds by mice and birds, but the washing and sieving techniques did lead to some fragmentation of empty husks, so that not all of these were recovered. A pilot study of the recovery technique had indicated over 95% recovery of full new seeds introduced into the soil.

Whybrew (1964) attributed a high proportion of seed loss from the stubble to predation by birds. Mice and small rodents are also capable of removing wild oat seeds, but it seems unlikely that these animals played a significant part in these experiments. At Charlton there was no consistent difference between caged and uncaged plots on a site chosen so that a large area of untouched stubble surrounded the experiment. There was thus no likelihood of a concentration of birds on to the experimental area.

Some seeds which were recovered from these experiments were obviously decaying, but the possibility of large scale deterioration of seeds due to primary attack by micro organisms seems to have been refuted by the experiment at Begbroke. Seeds in a sterile situation deteriorated at a similar rate to untreated seeds in a normal stubble. It is likely that sterile conditions were not maintained through the whole autumn, but if micro organisms were the prime cause of decay, then some response to this treatment would have been expected, particularly as the straw stubble was visibly preserved from decay. The straw treated with formalin retained its original colour for 6 to 8 weeks after treatment, while straw surrounding the plots became progressively darker. Furthermore, seeds placed on a cultivated surface where the microbial population would have been considerably modified, declined in quality at a similar rate to seeds placed on an untouched stubble.

The main difference in these experiments has been between seeds which have been buried, and seeds which have remained on the surface, regardless of other treatments. Buried seeds are protected from light and buffered from variations in temperature and moisture that occur on the surface diurnally and from day to day. It is possible that this could be an important contributory factor, and that the self burial mechanism of the wild oat seed assists survival by protecting the seed from these environmental extremes.

These experiments do not explain the way in which exposure to the surface environment could be damaging to the wild oat seed. Viability or dormancy could be affected and work in Canada carried out by Bibbey (1948) demonstrated that the after ripening of A. fatua seeds occurred more rapidly during the autumn with seeds on the ground surface than with seeds buried in the top 3 in. of soil. By November 1st, 70-80% of seeds on the ground surface had lost dormancy, compared with less than 10% of the seeds which remained buried.

The percentage of visible germination during the autumn was very low in these experiments. It is possible that some seeds reached an imbibed and partially germinated state and then died, giving rise to the shrivelled seed category which was such a feature in these experiments.

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FIELD EXTENSION TRIALS AND A FARMER USAGE SURVEY WITH CHLORFENPROP-METHYL FOR THE CONTROL OF AVENA FATUA L IN SPRING BARLEY CROPS IN THE UNITED KINGDOM

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Summary Chlorfenprop-methyl was found in two years of field usage to give effective control of *Avena fatua* providing that treatment occurred before the weed had tillered, i.e. when in the 1 - 4 leaf stage and the material was applied in 25 gal/ac of water at 45 lb/in^2. Effective control was also obtained in some instances with application after tillering had commenced but spraying criteria are then much more critical.

INTRODUCTION

Chlorfenprop-methyl was discovered by Bayer Leverkusen and was shown to be specific for the control of *Avena fatua* and introduced commercially on the Continent in 1968. The chemical and herbicidal properties of chlorfenprop-methyl have already been described by Eue (1968) and Martin (1972), its mode of action by Fedtke (1972) and performance in the U.K. by amongst others Holroyd (1968), Holroyd & Bailey (1970) and Erskine (1968). Trials began in the U.K. in 1967 with a formulation coded 5710 containing 53% w/v chlorfenprop-methyl. An improved formulation coded 6370 containing 80% w/v chlorfenprop-methyl was produced in 1970. Further trials were continued to investigate the biological efficiency, crop tolerance and application criteria. From all of this work (over 120 replicated and grower trials) it was possible to formulate a suitable recommendation for the use of chlorfenprop-methyl for the control of *A. fatua* in spring barley and spring wheat. This report describes field extension trials carried out on spring barley in 1971 and a farmer usage survey in 1972 to assess performance in the first commercial year.

METHOD AND MATERIALS

1. Field extension trials 1971. These were unreplicated trials designed to assess the field performance of chlorfenprop-methyl in formulation 6370 (80% w/v) under varying field conditions throughout the U.K. and carried out under the supervision of Bayer Agrochem regional technical staff. Co-operating growers were supplied with chlorfenprop-methyl sufficient to treat one acre and asked to apply it at the following recommendation:-

Rate of Use: (4.3 lb/ac) "Apply as an overall spray in either approximately 25 gal/ac at 45 lb/in^2 or 45 gal/ac at 90 lb/in^2 when the majority *A. fatua* are between the 1 and 4 leaf growth stage."

It was suggested that all varieties of spring barley could be treated. Co-operators were requested to leave an untreated control and where possible to compare with a standard material.

Assessments were as follows:-

1.1. *A. fatua* leaf stage - at application random 'hand-grab' samples were taken from the field for laboratory inspection.

1.2. Post-application inspection

Trials were visited within one month after application to examine the effect on wild oats and crop tolerance.

1.3. *A. fatua* control

At least 5 x 1 m^2 quadrats were assessed per plot at random. The number of panicles per m^2 were counted to ascertain the percentage control and graded according to size as follows: small = $<$10 spikelets per panicle, medium = 11 - 20 spikelets per panicle, large = $>$21 spikelets per panicle.

To estimate the percentage spikelet control the following mean number of spikelets per panicle within each grading was used, 4.5, 14.5 and 25.

1.4. Yield

Trials were either harvested with the farmers' combines or with a Hege 125 mini-combine. In the majority of trials grain samples were analysed to determine the percentage by weight of *A. fatua* seed, chaff and straw. In some trials the proportion of large grain was determined by using a 2.5 mm sieve.

2. Farmer Usage Survey 1972

Following successful fundamental and field extension trials a limited marketing of chlorfenprop-methyl was planned for 1972. ACAS approval was obtained for a rate of 4.25 lb/ac chlorfenprop-methyl on spring barley. As trials work had shown that stage of growth of *A. fatua*, timing and application criteria were all important, the farmer application was monitored by Bayer Agrochem staff. To appraise results, a survey form was produced to document each application covering variety, stage of *A. fatua* at application, density of *A. fatua* and crop, date of application, sprayer volume and pressure and degree of control.

Assessment details were as follows:-

2.1. *A. fatua* leaf stage at application

The range of leaf stages were noted and the mean stage assessed. In the majority of cases the mean leaf stage was judged in situ but in a few instances plants were removed and examined.

2.2. *A. fatua* density at application

The *A. fatua* density was assessed as follows: low = 1 - 10 seedlings/yd^2; medium = 11 - 100 seedlings/yd^2 and high = $>$101 seedlings/yd^2.

2.3. Post application

Inspections were made soon after application and again just prior to harvest when a visual score of *A. fatua* control was carried out with the gradings: 1 = 100%, 2 = 90-99%, 3 = 80-89%, 4 = 70-79%, 5 = 60-69%, 6 = 50-59%, 7 = 40-49%, 8 = 1-39% and 9 = no control.

RESULTS

The results are reported below in two sections, 1 - Field extension trials 1971 and 2 - Farmer usage survey 1972.

1. Field Extension Trials - 1971

1.1. Distribution of sites

24 trials were located throughout the U.K. in the following regions: Eastern 8, Southern 4, Western 2, Midland 3, Northern 6, Scotland 4.

1.2. *A. fatua* stage at application - Details are summarised in Table 1.

Table 1

A. fatua leaf stage at application - 1971

Mean leaf stage	2	2½	3	3½	4	% of trials where tillering had commenced
% of trials	16.7	29.2	37.5	8.3	8.3	37.5

A. fatua stages at application varied from a mean of 1.8 leaves per plant up to 42% of wild oats having tillered. In most cases the standard comparison, barban 12.5% formulation, was applied beyond the manufacturer's recommended timing.

1.3. *A. fatua* control

Table 2 summarises all trials where there was an untreated control. 66.6% of the trials gave over 80% control.

Table 2

% frequency of panicle control in 24 trials - 1971

% panicle control	chlorfenprop-methyl
>95	20.8
90 - 95	25.0
85 - 90	12.5
80 - 85	8.3
75 - 80	4.2
70 - 75	0
< 70	29.2

Median % control 87.5

Range of control 17.4% - 99.5%

Out of 16 trials where spikelet assessments were made 12 (75%) gave over 85% control. There were 13 trials where barban was used as a comparison and a summary of results is given in Table 3. These results indicate the good control achieved by chlorfenprop-methyl in terms of both panicle and spikelet control.

Table 3

% frequency of panicle and spikelet control in 13 trials - 1971

	Panicle		Spikelet	
% control	chlorfenprop-methyl	barban	chlorfenprop-methyl	barban
>95	15.4	0	30.8	0
90 - 95	23.1	0	30.8	7.7
85 - 90	15.4	7.7	15.4	7.7
80 - 85	7.7	0	0	15.4
75 - 80	7.7	0	0	7.7
70 - 75	0	7.7	23.1	23.1
<70	30.8	84.6	0	38.5
Median % control	86.9	50.9	91.8	71.6
Range of control.	17.4% - 99.5%	0.0% - 89.9%	77.4% - 99.8%	0.0% - 94.8%

1.4. Yield

Yields were taken from 9 trials where there were comparative data and results are summarised in Table 4.

Table 4

Mean yield data from 9 trials - 1971

	cwt/ac	cwt increase/ac	% increase
chlorfenprop-methyl	29.88	2.97	11.0
barban	28.86	1.95	7.2
control	26.91		

In these trials *A. fatua* density was high and the results show that apart from good control of *A. fatua* useful increases in yield were achieved.

Table 5 shows the distribution of yield increases between chlorfenprop-methyl and barban.

Table 5

% frequency of yield from 9 trials - 1971

% increase or decrease	chlorfenprop-methyl	barban
>+20	33.3	0
+19 to +10	11.1	44.4
+ 9 to 0	33.3	33.3
- 1 to -10	22.2	22.2

An analysis of grain samples from East Anglian trials showed that treatments had reduced the amount of wild oat seed as a contaminant in the harvested grain (Table 6) This was reflected in higher net increases in barley yield where cleaned and uncleaned grain were compared. In one trial chlorfenprop-methyl reduced the *A. fatua* contaminants by the equivalent of 2.5 cwt/ac. By controlling *A. fatua* the proportion of larger sized grain was increased.

Table 6

A. fatua control and grain analysis results from trials in 1971

	6 trials	3 trials	
	chlorfenprop-methyl	chlorfenprop-methyl	barban
Median % panicle control.	87	88	51
Median % spikelet control.	90	91	56
% wt. decrease of *A. fatua* seed, chaff and straw.	-4.2	-5.6	-3.7
% reduction *A. fatua* seed, chaff and straw.	59	88	43
Uncleaned grain - increase in cwt/ac.	2.3	1.6	0.1
Cleaned grain - increase in cwt/ac.	3.1	2.8	0.9
Uncleaned grain - % increase.	8.5	4.4	0.3
Cleaned grain - % increase.	13.7	14.8	4.6
Barley grain size > 2.5 mm increase in cwt/ac.	2.64	0.94	0.76

1.5. Crop tolerance

Some bleaching of the crop occurred immediately after application, particularly in tractor wheelings or where overlapping occurred. This was transient and had no apparent detrimental effect on the crop.

1.6. Nitrogen determinations

Kjeldahl nitrogen content analyses were carried out on the grain and there were no differences between treated and untreated, indicating that malting quality was not affected.

1.7. Application

Some application problems did occur in the field. There was the common "striping" effect due to either blocked nozzles or bad matching up of boom widths. In some trials where spraying had been carried out at over 3 m.p.h. results were impaired due to boom bounce or "whip", this was more pronounced on uneven ground. High pressures and volumes were necessary to obtain good spray penetration and cover. This was important for the most effective results with chlorfenprop-methyl and the application information was incorporated into the final field recommendation.

1.8. Field recommendation - 1972

As a result of this work chlorfenprop-methyl was recommended for commercial usage in 1972 to be applied in not less than 25 gal/ac of water using a pressure of at least 45 lb/in^2 when the oldest *A. fatua* have just reached the 4 leaf stage or before they start to tiller. This is usually when the majority have between 2½ and 3 leaves. If more than 10% of the *A. fatua* have tillered or there is a further germination after application less satisfactory results would occur. To obtain optimum cover a tractor speed of 3 m.p.h. or less was recommended.

2. Farmer Usage Survey - 1972

241 fully completed survey sheets were received for fields treated with chlorfenprop-methyl. It is not possible to include all the reported data in this report but a summary of some of the major points is given below under the relevant headings:-

2.1. Distribution of sites

From Table 7 it can be seen that usage covered the U.K. with the main proportion concentrated on the eastern side of the country where the wild oat problem is most serious.

2.2. A. fatua density pre-treatment

The highest proportion is in the medium and high density categories (Table 7).

Table 7

A. fatua densities - 1972

Region	No. of fields	Percentage fields of A. fatua densities: High >101/sq yd	Medium 11-100/sq yd	Low 1-10/sq yd
Eastern	70	41.4	51.4	7.1
Midland	48	31.3	50.0	18.8
Northern	58	13.8	77.6	8.6
Scotland	31	33.3	58.1	9.7
Southern	20	0.0	65.0	35.0
Western	14	28.6	64.3	7.1
TOTAL	241	27.4	60.2	12.4

2.3. A. fatua stage at application

It was planned that Bayer Agrochem personnel would assess the stage of A. fatua as close to application as possible. However, because of inclement spraying conditions application was in many cases delayed more than 7 days after assessment which meant that tillering of A. fatua had commenced when the chlorfenprop-methyl was applied. Of the fields assessed in 55.6% of cases some tillering of A. fatua had taken place (Table 8).

Table 8

A. fatua leaf stages at application - 1972

Region	No. of fields	Percentage fields at each mean A. fatua leaf stage: 1	1½	2	2½	3	3½	4	4½	% fields where tillering commenced
Eastern	70	-	1.4	-	5.7	22.9	21.4	32.9	15.7	68.5
Midland	48	-	-	2.1	16.7	14.6	58.3	6.3	2.1	64.6
Northern	58	-	1.7	5.1	29.3	41.4	17.2	1.7	3.4	48.3
Scotland	31	3.2	-	19.4	25.8	25.8	12.8	9.7	3.2	22.6
Southern	20	-	-	5.0	5.0	20.0	50.0	5.0	15.0	65.0
Western	14	-	-	-	14.3	28.6	21.4	35.7	-	50.0
TOTAL	241	0.4	0.8	4.6	16.6	26.1	29.0	14.6	7.5	55.6

2.4. A. fatua control

A visual score was taken just before harvest. In some fields there was no untreated area left but fortunately "striping" was present which showed the effectiveness of control. These results are given in Table 9.

Table 9

A. fatua control - 1972

Region	No. of fields	Percentage fields at each A. fatua score								
		1	2	3	4	5	6	7	8	9
Eastern	70	1.4	31.4	27.1	12.9	12.9	7.1	2.9	2.9	1.4
Midland	48	-	25.1	29.2	22.9	6.3	8.3	-	6.3	2.1
Northern	58	-	24.1	24.1	19.0	6.9	8.6	12.1	5.2	1.7
Scotland	31	38.9	32.3	6.5	9.7	3.1	-	-	3.2	6.5
Southern	20	5.0	20.0	15.0	20.0	25.0	15.0	-	-	-
Western	14	-	-	42.9	28.6	7.1	14.5	7.1	-	-
TOTAL	241	5.8	29.9	24.1	17.4	9.5	7.9	4.1	3.7	2.1

Judged on the number of panicles only at least 77.2% of fields recorded showed control of over 70% (Table 9). In some cases common oat (A. sativa) was mistaken for A. fatua. It is known that chlorfenprop-methyl may affect some varieties of A. sativa but not Astor, Luxor or Condor (Van Dort 1969).

2.5. Varieties treated

The following varieties were treated in the survey: Berac, Clermont, Deba Abed, Gerkra, Golden Promise, Imber, Julia, Lofa Abed, Midas, Nackta, Proctor, Sultan, Tern, Vada, Ymer and Zephyr. Of these, the most frequently occurring were, Proctor, 30.6%; Julia, 29.4%, Golden Promise, 10.1%; Vada, 6.6% and Zephyr, 6.6%. The frequency of the varieties may reflect to some degree their popularity but it must be remembered that Proctor should not be treated with barban so obviously growers with that particular variety were interested in a new post-emergence material for A. fatua control.

2.6. Application

As shown by Martin et al (1972), application criteria are important for successful results. In many cases spraying was not carried out in accordance with the specifications set out in the recommendation. Either water volumes or pressures, or both, were incorrect and forward speed was often more than 3 m.p.h. Some spray equipment was not always up to the standard required. For example, in one case '00' and No. 1 fan nozzles were found on the same boom and these were chipped!

DISCUSSION

The results of field extension trials in 1971 described in this report showed that chlorfenprop-methyl gave effective control of A. fatua under field conditions providing that application took place at the correct growth stage of A. fatua, namely 1 - 4 leaf stages but before tillering commenced. Some satisfactory results were also obtained beyond this stage (up to 42% tillered) but application criteria such as water volume, pressure and forward tractor speed then became even more critical. In most cases the comparison material barban was applied beyond the manufacturer's recommended timing which emphasises the problem a farmer may have in timing post-emergent herbicides for A. fatua control because of weather conditions and other management factors. The results may be judged in this light.

Chlorfenprop-methyl was found to cause a decrease in size of surviving panicles, i.e. spikelet control (a measure of seeds produced per acre) was greater than panicle control. It is considered that the high degree of spikelet control obtained with chlorfenprop-methyl is important in terms of the amount of seed returned to the soil and the long term control of A. fatua.

Furthermore, germination of seed from survivers may be impaired (Kampe 1969). Substantial yield increases were obtained where A. fatua was controlled with chlorfenprop-methyl. Analysis of grain samples indicated a high A. fatua seed content in the untreated and chlorfenprop-methyl reduced this considerably. It is, therefore, important to remove A. fatua seed from samples to obtain correct yield data. The reduction of A. fatua seed may assist in producing cleaner grain for seed. A. fatua control by chlorfenprop-methyl improved grain quality and nitrogen determinations indicated that malting quality was not affected.

In the farmer usage survey in 1972 similar results to the 1971 work were obtained on a wide range of barley varieties including Proctor. 87.6% of fields treated had A. fatua populations of more than 11 per square yard. In these situations with over 80% control high numbers of A. fatua per acre can remain. This would suggest that even effective chemical control of A. fatua should be supplemented by cultural and hygiene measures particularly in areas of high density.

A high proportion of the fields were treated at a timing later than recommended i.e. in 56% of cases tillering of A. fatua had commenced at application, this was due in the main to weather conditions delaying spraying. Results showed that 45% of fields gave below 80% control. However, in Scotland, particularly in the East Lothians, where weather conditions were more conducive to recommended timing where 77% of fields were treated before A. fatua tillering had commenced over 80% control was achieved in 78% of fields in the survey.

Where timings of chlorfenprop-methyl were late some growers commented that after application A. fatua were scorched and looked dead. It can only be assumed that tiller buds were already initiated and these developed further. It is essential for most effective results with chlorfenprop-methyl that applications are carried out according to the recommended timing and application criteria.

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THE USE OF A MIXTURE CONTAINING METOXURON AND SIMAZINE FOR THE POST-EMERGENCE CONTROL OF ALOPECURUS MYOSUROIDES IN WINTER CEREALS

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Summary Post-emergence applications of a mixture containing 3.0 lb/ac metoxuron and 3.0 oz/ac simazine have given good, selective control of blackgrass (*A. myosuroides*) in winter cereals in two seasons' research. Early spring applications on young blackgrass plants proved more effective than later spring applications. Later research demonstrated the value of early post-emergence applications of the metoxuron/simazine mixture in autumn and winter. Improved control of larger blackgrass plants in late spring was obtained by slightly increasing the dose of the mixture. A large programme of farmer trials was also carried out and proved successful.

INTRODUCTION

The value of metoxuron for the post-emergence control of *A. myosuroides* in winter cereals was reported four years ago (Glenister and Griffiths, 1968).

This report describes work on a mixture of metoxuron with simazine in which a lower rate of metoxuron than is normally recommended is combined with 3.0 oz/ac simazine to give a herbicide mixture similar in effect to the full rate of metoxuron alone.

Results are presented from replicated, small plot experiments, reliability/timing trials, and a programme of farmer trials in the seasons 1969/70 and 1970/71, prior to commercial introduction in the 1971/72 season.

METHOD AND MATERIALS

1969/70

The following treatments were included in twelve experiments for the post-emergence control in the spring of *A. myosuroides* in winter wheat.

Metoxuron 3.0 lb/ac + simazine 3.0 oz/ac

Metoxuron (a) Early application 3.6 lb/ac (recommended rate)
(b) Late application 4.0 lb/ac (recommended rate)

Methoprotryne 1.0 lb/ac + simazine 3.0 oz/ac (recommended rate)

Within each experiment two separate applications of the treatments were made - one mid/late March when the *A. myosuroides* generally had less than three leaves on the main stem, the other mid/late April by which time the A. myosuroides had reached the 4-5 leaf stage and had begun tillering.

The experiments were sprayed at 20 gal/ac using a knapsack sprayer. Application pressure was approximately 25 lb/in^2, and size 00 Allman nozzles were used. Plot size was 10 yards x 2 yards. Visual assessments were carried out in both March and June.

Eleven experiments were harvested.

1970/71

(a) Replicated, small-plot experiments

Treatments:	Metoxuron	3.0 lb/ac + simazine 3.0 oz/ac
	Metoxuron	3.4 lb/ac + simazine 3.4 oz/ac
	Metoxuron	3.6 lb/ac
	Methoprotryne	1.0 lb/ac + simazine 3.0 oz/ac

The above treatments were applied once in the spring (late February/early March) to three winter wheat experiments. Each experiment was divided into three areas each containing winter wheat drilled at intervals during the autumn, giving in consequence three infestations of A. myosuroides each at a different stage of growth within each experiment.

(b) Reliability/timing trials

The following treatments were applied post-emergence at four separate times to thirteen winter wheat experiments:

Metoxuron	3.0 lb/ac + simazine 3.0 oz/ac
Metoxuron	3.4 lb/ac + simazine 3.4 oz/ac
Metoxuron	3.6 lb/ac

Timing of applications was as follows:

1. Autumn (Nov/Dec)	(Crop 1½-2 leaves (A. myosuroides 1 leaf
2. Winter (Jan)	(Crop 2½-3 leaves (A. myosuroides 2 leaves
3. Early spring (Feb)	(Crop 3-5 leaves + 1-2 tillers (A. myosuroides 3 leaves + 1 tiller
4. Late spring (April)	(Crop 6 leaves + 1-3 tillers (A. myosuroides 5-6 leaves + 1-3 tillers

Yields were taken at three of the experiments.

(c) Farmer trials

The metoxuron/simazine mixture was applied by growers using ground spraying machines to 160 winter wheat field trials varying in size from 2 - 6 acres each.

The standard rate (metoxuron 3.0 lb/ac + simazine 3.0 oz/ac) was used in the majority of trials where the A. myosuroides had less than five leaves on the main stem at spraying, but an increased rate (metoxuron 3.4 lb/ac + simazine 3.4 oz/ac) was used for larger plants in late spring. The volume of application was 20 gal/ac.

RESULTS

1969/70

A. myosuroides germinated relatively late in the autumn 1969, and its growth was further retarded by the cold conditions of early winter with the result that the plants were at a smaller growth stage than normal in March/April when the herbicide applications were made.

Table 1*

Comparison of metoxuron/simazine, metoxuron and methoprotryne/simazine for the post-emergence control of A. myosuroides in twelve winter wheat experiments 1969/70

	Time of Application	Metoxuron + simazine 3.0 lb + 3.0 oz/ac	Metoxuron 3.6/4.0 lb/ac	Methoprotryne + simazine 1.0 lb + 3.0 oz/ac
Control of A. myosuroides (12 expts)	Early spring	97	98	85
	Late spring	84	87	64
Relative yields of winter wheat at 85% D.M. (11 expts)	Early spring	105.0	108.4	103.6
	Late spring	103.7	107.6	100.5

No crop damage was recorded with any of the treatments in these experiments.

In general the metoxuron/simazine mixture gave similar control of A. myosuroides to the recommended rates of metoxuron alone. As expected, control of A. myosuroides with all treatments was better at the early spring application than at the later application when the A. myosuroides was more advanced. The methoprotryne/simazine mixture gave generally poor results - particularly at the later application.

At harvest only small increases in winter wheat yields were obtained with all treatments in most of the experiments, due mainly to the lack of competition provided by even heavy weed infestations in untreated areas under the very dry conditions during the season. In consequence, differences in yield between individual treatments were also generally small.

1970/71

(a) Replicated, small plot experiments

High levels of weed control were obtained with all treatments at seven of the nine experiments. Poorer results at the remaining two experiments were attributable to the stage of growth of the A. myosuroides at spraying - well beyond that recommended for commercial application. On average the standard rate of the metoxuron/simazine mixture gave similar results to metoxuron alone, and much better results than the methoprotryne/simazine mixture.

Table 2*

Control of A. myosuroides and yields of winter wheat from post-emergence applications of metoxuron/simazine, metoxuron and methoprotryne/simazine in the spring 1971

	Metoxuron + simazine 3.0 lb + 3.0 oz/ac	Metoxuron + simazine 3.4 lb + 3.4 oz/ac	Metoxuron 3.6 lb/ac	Methoprotryne + simazine 1.0 lb + 3.0 oz/ac
% control of A. myosuroides (9 expts)	83	85	79	52
Relative yields of winter wheat at 85% D.M. (3 expts)	121.0	128.8	114.2	100.7

A relationship between the degree of control of A. myosuroides and the yield obtained is indicated in the results presented (Table 2).

Tolerance of winter wheat varieties to the metoxuron/simazine mixture (greenhouse studies)

(i) The following degrees of tolerance to metoxuron/simazine were found in thirteen winter wheat varieties under test:

Tolerant or only slightly susceptible	Cama Cappelle Desprez Champlein Joss Cambier	Maris Ranger Maris Settler Maris Widgeon Professor Marchal
Susceptible	Maris Beacon Maris Huntsman Maris Nimrod	Maris Templar Mildress

This result is in close agreement with those reported by Griffiths and Ummel (1970). No increase in varietal susceptibility was caused by the addition of simazine.

(ii) In a second experiment, metoxuron at the recommended rate was compared with the reduced rate as used in the metoxuron/simazine mixture (i.e. at a ratio of 3.6 : 3.0 lb/ac) on eight winter wheat varieties.

Susceptible	Maris Nimrod	Maris Templar
Moderately susceptible	Champlein Maris Settler	Maris Ranger Cama
Resistant	Cappelle	Professor Marchal

At the time of application all the cereal varieties were at the two-leaf stage of growth. Three replications were sprayed.

Using the chemical at this fixed ratio, but at different levels of active ingredient per acre, a clear advantage in crop safety was shown at the most critical level with the reduced rate of metoxuron as used in the mixture over the recommended rate.

Table 3

Comparison of the % crop effects of two rates of metoxuron on eight winter wheat varieties (in greenhouse studies)

Tolerance of winter wheat varieties	Rate of metoxuron 1.5 lb/ac	1.8 lb/ac
Susceptible	47	72
Moderately susceptible	22	37
Resistant	25	23

(b) Reliability/timing trials

The early post-emergence applications in autumn and winter gave equally good control of A. myosuroides as the early spring application. As in the previous season, the later spring application gave slightly inferior results.

No crop damage was evident during the season with any application.

A relationship between degree and duration of A. myosuroides control and the yield obtained is indicated in the results presented (Table 4).

Table 4 *

Mean % control of A. myosuroides and yield results from applications of metoxuron/simazine and metoxuron made at four separate times to winter wheat 1970/71

	Time of Application	Metoxuron + simazine 3.0 lb + 3.0 oz/ac	Metoxuron + simazine 3.4 lb + 3.4 oz/ac	Metoxuron 3.6 lb/ac
% control of A. myosuroides (13 expts)	1. Nov/Dec	97	98	98
	2. Jan	96	97	96
	3. Feb	96	96	94
	4. Apl	89	91	88
Relative yields at 85% D.M. (3 expts)	1. Nov/Dec	132.4	129.9	127.8
	2. Jan	127.9	128.8	129.5
	3. Feb	123.2	121.3	121.8
	4. Apl	109.6	107.7	113.2

(c) Farmer trials

Crop safety

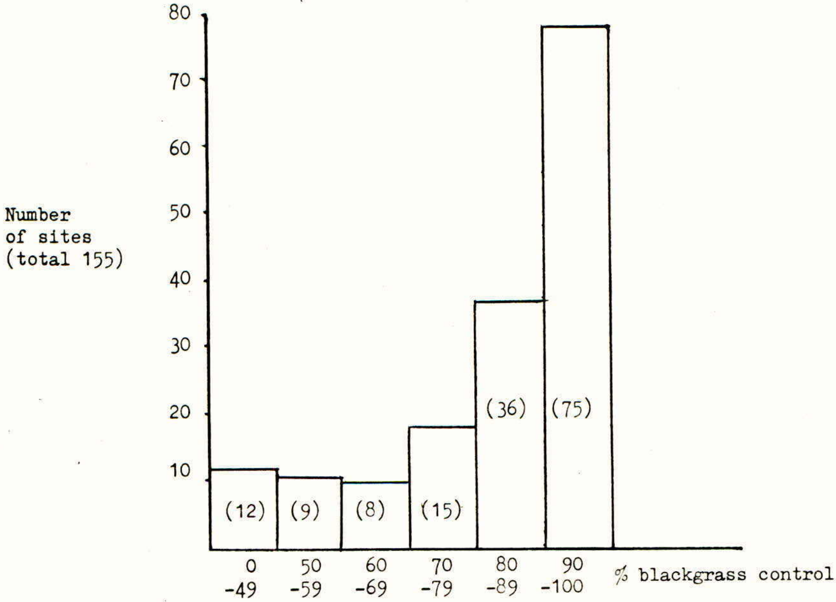
In the 161 trials, there was no crop damage recorded with the standard dosage rates of metoxuron/simazine on any of the winter wheat varieties previously listed as tolerant to the metoxuron/simazine mixture.

Weed control (June assessment)

90-100% control of A. myosuroides was achieved on half the experiments, and 70-90% on a further third. Moreover, there is clear evidence that the poorer results were due to the use of a batch of experimental material with poor physical properties.

Figure 1

Frequency distribution of % control of A. myosuroides obtained in 155 grower trials 1970/71



Generally, the best results were obtained from the earliest applications in the spring - regardless of differential dosage rates as the season progressed.

Table 5

Mean % control of A. myosuroides in relation to date of application

Date of application	Mean % control of A. myosuroides	No. of trials
15/28th Feb 1971	88	13
1/15th Mar 1971	80	64
16/31st Mar 1971	79	54
1/15th Apl 1971	73	19

Most autumn-germinating annual broad-leaved weeds including Stellaria media and Matricaria spp. (but with the exception of Galium aparine), as well as many spring germinating annual weeds, were well controlled by the metoxuron/simazine mixture.

Control of Avena fatua and A. Ludoviciana, although sometimes very good, was variable.

*
Individual tests of significance (analysis of variance) were carried out on each individual yield experiment in this research programme. For the sake of brevity, however, only mean yield results are quoted in this paper.

DISCUSSION

Results from replicated small plot experiments and farmer trials together with the experience from large-scale usage in 1971/72, have clearly shown the value of the metoxuron/simazine mixture for the post-emergence control of *A. myosuroides* in winter cereals. Although autumn and winter applications have given extremely good results in experimental work, practical experience (particularly under water-logged conditions - when winter application could be less effective) indicates that the metoxuron/simazine mixture is most successfully applied in early spring.

In general, the metoxuron/simazine mixture has given similar results to the recommended rates of metoxuron used alone. Obviously conditions will exist which slightly favour one or other of the two herbicides - as already seen in the results in this paper.

However, it is felt that the greater persistence of simazine compared with metoxuron could prolong the efficacy of the mixture compared with metoxuron alone. On the other hand, conditions may arise where the higher rate of metoxuron would produce a more pronounced immediate effect than the solely root-absorbed simazine fraction in the mixture.

On winter wheat varieties, particularly those more susceptible to metoxuron, the mixture, with a reduced rate of active metoxuron, is considered safer than the recommended rate of metoxuron - particularly since the rate of additional simazine has in previous research always been selective in winter wheat, and has never shown a tendency to differential varietal tolerance. This aspect may be of greater importance in future years than at present with the recent introduction of new wheat varieties showing intermediate degrees of tolerance to metoxuron.

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FIELD EXPERIENCE OF GRANULAR TRI-ALLATE FOR CONTROL OF AVENA SPP IN WINTER AND SPRING CEREALS

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Summary Tri-allate granules were applied to 70 sites from 1970-72 for the control of Avena spp in winter and spring cereals. Field results confirm that granules can be accurately applied with the Horstine Farmery Airflow applicators. In winter wheat 1.5 a.i./ac applied to the soil surface post drilling and pre-emergence gave better results than 2.0 lb applied post weed emergence. In spring barley 1.5 lb a.i./ac applied pre-drilling was most effective. Post emergence applications were more effective in spring barley than winter wheat. Tri-allate granules introduce greater flexibility into the programmes available for the control of Avena spp, but are best used pre-em.

INTRODUCTION

Avena spp have been successfully controlled pre-em. by di-allate and tri-allate emulsion (Hannah et al 1970, Lush and Mayes 1964). The post-em. use of tri-allate granules was first described by Holroyd (1968). A detailed programme was set up to evaluate the performance of tri-allate granules under commercial conditions. Early results were encouraging (Evans 1970) but further work had to be done to establish the best technique of use and to evaluate the granule applicator. This paper describes the work done over the past two years in winter wheat and the past three years in spring barley.

METHOD AND MATERIALS

The trials were all run in cereal crops on commercial farms. A randomised block design with 4 replications was used throughout and plot sizes varied from 1/16 to ¼ ac.

The Horstine Farmery Microband Airflow TMA 2 granule applicator was used in the main, but some TMA 4 machines were also employed.

Normal commercial 10% w/w tri-allate granules (Avadex BW Granular) and base 24/48 mesh attapulgite clay were used. In some trials normal commercial 40% w/v tri-allate emulsion was applied at 1.25 lb a.i./ac by the co-operating farmer as a standard. Calibration of the applicators was carried out by Horstine Farmery Limited. The quantities of granules delivered by 100 rev/min of the rotors in a single Microband unit were averaged from several runs to give the pulley sizes required for each rate. In field checks were also made. The pulley combinations used are shown overleaf :-

lb a.i./ac	lb granules/ac	Driving Pulley		Driven Pulley
1.25	12.5	5 in.	:	7 in.
1.5	15.0	4½ in.	:	5 in.
2.0	20.0	5 in.	:	4 in.

The spread pattern of the TMA 2 was determined by using a series of 4 in. trays placed across the width of spread of the machine. Sufficient granules for a 70 yd run were applied and the weights from each tray plotted on a graph.

Tri-allate granules were applied both pre and post weed emergence. In winter wheat pre-em. applications were made as soon as possible after drilling to simulate normal commercial conditions. In the following spring post em. applications were made as soon as the land would carry a tractor and applicator.

In spring barley tri-allate granules were applied immediately pre-drilling and post drilling. Some post drilling sites were part harrowed after application. Post-em. applications were made as soon as possible after emergence of Avena fatua. Generally from emergence to 2 leaves.

Crop assessments were made visually and some trials were taken to yield. Weed assessments were made by counting Avena spp panicles. 10 throws of a 1 yd^2 quadrat were made per plot. Yields were taken with the farm combine, 1/40 ac being cut from each plot.

RESULTS

Winter wheat. Tri-allate granules were applied pre-em. to 17 sites in 1970/71 and 1971/72 seasons (Table 1). No damage was seen in drilled crops where the granules were applied post drilling to the soil surface. In 13 of these sites over 90% control of Avena spp was obtained at 1.5 lb a.i./ac. In 1970 4 sites gave similar control at 1.25 lb a.i./ac. In 1971 2.0 lb a.i./ac did not improve control, except at Deeping in Lincolnshire on high organic soil.

Tri-allate granules were applied to emerged Avena spp at 14 sites in 1971 and 1972 (Table 2). Control varied from 55-91% at 20 lb a.i./ac.

Spring barley. Pre-em. applications were made both pre-drilling and post-drilling at 20 sites in 1970, 71 and 72. (Table 3). Tri-allate emulsion gave better results. Pre-drilling treatments were more effective than post drilling, particularly at Ringstead, Uffington and Pocklington. Although 1.25 a.i./ac gave satisfactory control, more reliable results were obtained at 1.5 lb a.i./ac. Post-em. applications in spring barley gave good control at 2.0 lb a.i./ac at 19 sites (Table 4). No crop damage was seen in barley either pre-em. or post-em.

Direct drilling. (11 sites) wheat and barley treated both pre-em. and post-em. at Bozeat, Northants were direct drilled. The best treatments were 1.5 lb a.i./ac pre-em in wheat and 2.0 lbs a.i./ac early post-em in barley.

Crop Yields. With heavy population of Avena spp yields are dramatically increased by application of tri-allate granules. Pre-em. applications are superior but, even in wheat with less than 90% control, higher yields were achieved (Table 6).

TABLE 6

The effect of Tri-allate Granules on crop yield in sites with 70-200 panicles of Avena spp per yd^2.

	Cwts/ac	Mean Yields
	Barley (18 Sites)	Wheat (10 Sites)
Pre-emergence at 1.5 lb a.i./ac	41.25	47.2
Post-emergence at 2.0 lb a.i./ac	35.8	39.6
No treatment	31.7	35.2

It is regretted that a statistical analysis of the data is not available at present. However, a new computer system is being set up and the results will be available in the near future.

DISCUSSION

The results show that tri-allate granules can be successfully used in commercial conditions for the control of Avena spp in cereals. A range of soil types and soil conditions were used and 1.5 lb a.i./ac pre-em. and 2.0 lb a.i./ac post-em. gave good results except on organic soils where higher rates were required.

Accurate distribution with 10% variation across the working width of the Airflow applicators is shown in Table 5 and elsewhere (Hodkinson 1972) and must contribute to the success of the field trials.

Tri-allate granules were shown by Evans 1970 to be more effective than tri-allate emulsion on winter cereals. Although tri-allate emulsion is more effective in spring cereals, easier application and less reliance on efficient incorporation give the granules greater flexibility in practical usage. Tri-allate granules may be used in those conditions which preclude the use of emulsion, e.g. cloddy soils, dry soils, stones and direct drilling. Farmers who also find it difficult to use the emulsion because of pressure of work, shortage of labour or machinery may be able to use the granules, but must expect a slight reduction in control.

In direct drilling conditions a pre-em. post drilling treatment can be applied, but winter wheat seed should be well covered with soil to avoid contact with the granules. In direct drilled spring cereals an early post crop emergence treatment of 2.0 lb a.i./ac has given good results.

In early October for winter wheat, if conditions are hot and dry, a delayed application may be made, but before weed emergence. At Little Hinton and Uffington in 1970 a delay of 2 weeks was not detrimental. Hot dry conditions at the time of drilling winter wheat may affect performance in Avena spp, but not so great as with A myosuroides (Hodkinson 1972). With both grass weeds present 1.5 lb a.i./ac must be applied immediately post drilling winter wheat and winter barley.

The poor performance at Lighthorne in 1971/72 was due to a heavy late spring flush of Avena fatua after the tri-allate had been broken down in the soil and this was also a factor at Fairford. Commercial experience confirms this observation.

The field results confirm the prediction of Holroyd and Thornton (1970) who found a pre-em., post drilling surface application of tri-allate granules to be effective in winter wheat. Incorporation of the granules for wheat was found to be phytotoxic by Evans (1970). However, no crop damage was recorded in spring barley when granules were applied pre-drilling or post drilling with incorporation by harrows. In a dry Spring, harrowing barley after application of tri-allate granules removes wheel marks and gives a slightly improved performance. Pre-drilling applications are the most effective.

Post-em. applications were very good in spring barley, but poor in winter wheat. In barley application could be made with the Avena fatua at emergence to 2½ leaves, but in winter wheat land conditions did not allow application until the Avena spp were often at the tillered stage. The winters of 1970 and 1971 were mild and large tillered Avena spp were always present in the spring following autumn and winter germination. Results were good at Pocklington due to little winter germination of Avena fatua.

Even greater flexibility has been introduced with the advent of the drill mounted applicator. Table 5 shows the distribution pattern of a Horstine Farmery TMA 2 mounted on an MF 29 drill. This system ensures application at the optimum time and improved performance of the granules. Although different nozzles must be used depending on drill width, combined application and drilling gives economies with machinery and labour.

Acknowledgements

The author is grateful to Horstine Farmery Limited for help and advice with applicators and, in particular, the late John Brown. Thanks are due also to the staff of Monsanto U.K., the distributors and farmers who provided trial sites.

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TABLE 1

WINTER WHEAT TRI-ALLATE GRANULES PRE-EMERGENCE

1970/71

Site	Application date	% Control 1.25 lb	% Control 1.5 lb
Little Hinton Wilts	6/10 (20/10)	86 (84)	89 92
Uffington (1) Berks	8/10 (20/10)	91 (88)	92 (91)
Uffington (2) Berks	(20/10)	94	96
Deeping Lincs	20/10		87
Pocklington Yorks	24/10	95	97
Pocklington Yorks	25/10		90
Bozeat (1) Northants	29/10		97
Bozeat (2) Northants	6/11		92
Tolleshunt D'Arcy Essex	6/11		99
Pocklington (3) Yorks	4/11		97

1971/72

Site	Application date	% Control 1.5 lb	% Control 2.0 lb
Lighthorne Warwicks	8/10	50	50
Bozeat Northants	10/10	94	97
Easton Hunts	15/10	94	94
Pocklington Yorks	25/10	96	98
Fairford Glos	26/10	84	93
Gt. Barford Beds	28/10	96	98
Deeping Lincs	10/11	62	83

N.B. Figures in brackets are for a later application.

TABLE 2

WINTER WHEAT TRI-ALLATE GRANULES POST EMERGENCE

1970/71

Site	% Control 1.5 lb	% Control 2.0 lb
Easton (Hunts)	75	71
Fairford (Glos)	86	91
Milverton(Soms)	20	57
Bozeat (1) Northants	87	88
Bozeat (2) Northants	76	85
Pocklington (Yorks)	79	90

1971/72

Site	% Control 1.5 lb	% Control 2.0 lb
St. Neots (Notts)	68	80
Lighthorne(Warwicks)	50	55
Bozeat (Northants)	72	75
Godmanchester (Hunts)	86	90
Easton (Hunts)	74	81
Pocklington (Yorks)	81	91
Fairford (Glos)	47	61
Great Barford (Beds)	80	86

TABLE 3

SPRING BARLEY TRI-ALLATE GRANULES - PRE-EMERGENCE

Site	Pre-drilling		Post Drilling		Tri-allate Emulsion
	1.25 lb	1.5 lb	1.25 lb	1.5 lb	1.25 lb
1970					
Pocklington, Yorks	91	92	83	84	
Bozeat, Northants	70	87	81	84	
Forston, Dorset			75	90	99
Wouldham, Kent			70	76	95
Hoo, Kent	70	80			
Ringstead, Norfolk	95	97	85	90	99
Little Hinton, Wilts	86	90	86	96	
Forston, Dorset			80	90	99
1971					
Fairford, Glos	86	93	87	84	
Uffington, Berks	93	92	76	79	98
Milverton, Soms.		97		90	
Bozeat, Northants	93	94	91	92	
Pocklington, Yorks	97	98	88	85	100
Little Hinton, Wilts		95		95	95
1972					
Milverton, Soms.	88.5	92.5	89	90	
Donnington, Salop	90.5	94	77	85	85
Bozeat, Northants	62	77	76	86	
Great Barford, Beds			92	95	
Fairford, Glos		91.5		90	90
Lighthorne, Warwicks			83	91	

TABLE 4

SPRING BARLEY TRI-ALLATE GRANULES POST EMERGENCE

Site	1.5 lb	2.0 lb
1970		
Little Raveley, Hunts	89	92
Wendover, Bucks	78	85
Patrington, Yorks	87	93
St. Neots, Hunts	70	90
1971		
Faiford, Glos	90	97
Great Barford, Beds (1)	90	95
Great Barford, Beds (2)	94	96
Lighthorne, Warwicks	91	95
Farnham, Dorset	81	94
Milverton, Somerset	90	96
Bozeat, Northants	88	93
Pocklington, Yorks	91	92
1972		
Fairford, Glos.		96
Donnington, Salop	90	93.5
Great Barford, Beds	89	95
Bozeat, Northants	80	88
Lighthorne, Warwicks	85	93
Warmwell, Dorset	85	
Milverton, Soms.	78	90.5

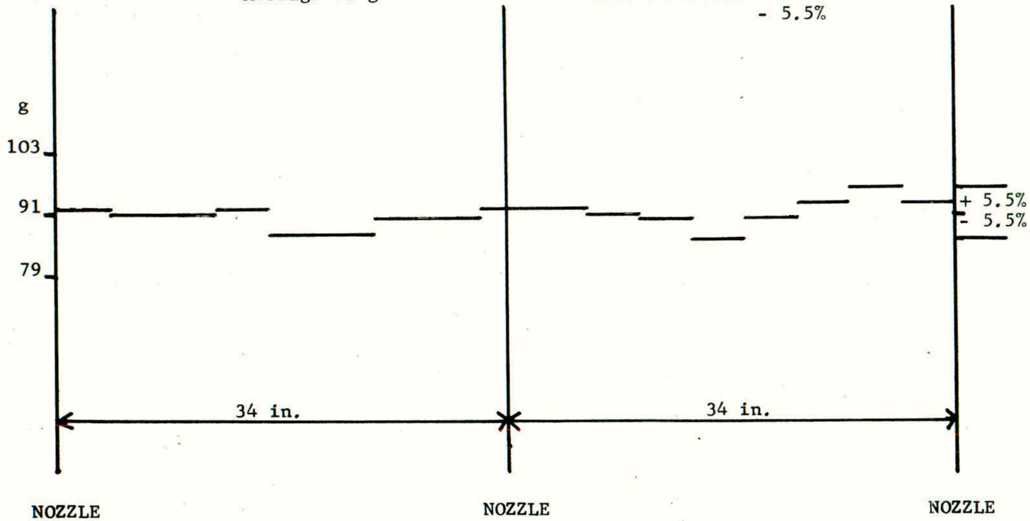
TABLE 5

DISTRIBUTION PATTERN FOR TRI-ALLATE GRANULES APPLIED BY HORSTINE FARMERY MICROBAND AIRFLOW FITTED TO M F 29 DRILL

Recorded spread 68 in. from 3 nozzles fitted with 27° impact plates and ¾ in. gap

Fan Speed 4,000 rev/min — Ground Clearance 18 in.

Average 91 g — Max. Variation + 5.5% / - 5.5%



Proc. 11th Br. Weed Control Conf. (1972)

THE CONTROL OF ALOPECURUS MYOSUROIDES BY MECHANICAL APPLICATION OF TRI-ALLATE GRANULES

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Summary Tri-allate granules were applied by a Horstine Farmery Airflow granule applicator to 13 winter wheat sites from 1969-1971 for the control of Alopecurus myosuroides. Good control was achieved from 1.5 lb a.i./ac applied after mid-October. Earlier applications in dry weather conditions can give variable results because early germinations of A myosuroides may not be killed by the drilling and harrowing operations. Thorough cultivations leading to a good Winter tilth are essential prior to drilling, or the use of a total contact herbicide and in direct drilled fields.

INTRODUCTION

After successful trials in the 1969/70 winter cereal crop (Evans 1970) tri-allate granules were introduced commercially into the United Kingdom in 1970. Tri-allate emulsion had been used for the control of A myosuroides for a number of years. The introduction of the granular form of tri-allate posed a problem to the machinery manufacturer, the farmer and contractor. The early granule applicators were designed for the application of granular insecticides. Granular herbicides called for greater precision during application, particularly even distribution. This paper describes the results on A myosuroides and the distribution pattern of the field applicator.

METHOD AND MATERIALS

All the trials were run in commercial wheat crops. Experimental design was a randomised block with four replicates of each treatment. Plot sizes varied from 1/16 to ¼ ac depending on field space available.

Normal commercial 10% w/w tri-allate granules (Avadex BW Granular) base, 24/48 mesh attapulgite clay were used throughout. Rates used were 1.25, 1.5 and 2.0 lb a.i./ac. In 1969/70 tri-allate granules were applied pre-drilling and post-drilling. In 1970/71 and 1971/72 granules were applied post seeding except at Little Hinton and Uffington where split treatments were tried.

The Horstine Farmery TMA 2 Microband Airflow granule applicator was used throughout the programme. Calibration of the applicators was done in the workshop by Horstine Farmery Limited and field checks were made also. Calibration detail is given elsewhere (Hodkinson 1972). Pulley combination and rates used were the same as in the trials on Avena spp.

Assessment of the weed control were made by counting blackgrass heads. 10 throws of a 1 ft^2 quadrat being made on each plot. Results are shown on a percentage basis and are the mean of 4 replicates.

RESULTS

Table 1 shows the type of distribution pattern of the tri-allate granules obtained from the TMA 2 Airflow applicator. It is the distribution pattern of a commercial applicator fitted with new alloy nozzles and rotor housing all properly adjusted.

The results of 13 trials in winter wheat from 1969-1972 (and using the TMA 2 applicator) are shown in Table 2. The percentage control of A myosuroides is given for each site and treatment per season.

In the 1969/70 season pre-drilling applications even at 2.0 lb a.i./ac were inferior to post drilling applications. All the applications were made in late October and early November 1969.

In 1970/71 at 2 sites in early October applications were made soon after drilling and approximately 2 weeks later. Both results were poor, but 1.5 lb a.i./ac was superior to 1.25 lb a.i./ac. Application in late October and November gave better results but 1.5 a.i./ac was required.

The 1971/72 site was chosen as an early October application and for the delay between drilling and application. Results were poor even at 2.0 lb a.i./ac.

It is regretted that a statistical analysis of the results is not available at present. However, a new computer system is being set up and the results will be available in the near future.

DISCUSSION

Although efficient granule applicators are available care must be taken in the field to ensure good results. The performance of tri-allate granules in a larger series of trials was reported by Evans (1970). The factors to ensure crop safety were discussed and generally tri-allate granules will out-perform tri-allate emulsion in winter cereals. Granules may be applied for those situations where it is not possible to use the liquid emulsion e.g. cloddy seedbeds, dry conditions and direct drilling. However, the trials have shown that other soil and climatic factors should be considered when making a recommendation.

In 1969/70 incorporation of the granules proved to be less effective and phytotoxic. Application of granules in late October and early November and post drilling to winter wheat were very effective. At Uffington the poor results were due to the delay between drilling and application allowing the germination of 40-50 plants per yd^2 of A myosuroides.

In 1970/71 delayed application of tri-allate granules gave poor results as did immediate application in early October. These applications coincided with a period of hot dry weather and no rainfall. During this period tri-allate vapour may have been lost from the granules as there was no moisture for absorption of the chemical into the soil. A myosuroides could also have germinated in the dry soil after September seedbed preparations, but prior to drilling. Germination may also take place after drilling but before adequate moisture activates the tri-allate.

Application of tri-allate granules after mid-October were very effective and 1.5 lb a.i./ac gave good results. 1.25 lb a.i./ac was not sufficient and 2.0 lb a.i./ac did not improve the poor results.

Delay between drilling and application must be avoided, as can be seen at Uffington in 1970, 1971 and 1972.

Both the Bozeat sites in 1970 were direct drilled and good results obtained in a no-cultivation system. Paraquat had been used to give an efficient kill of emerged A myosuroides prior to the application of granules.

Application of tri-allate granules after mid-October is generally most effective. However, when early drilling is practised some degree of control of A myosuroides may be lost if conditions are hot and dry. The loss may be minimised by thorough cultivation prior to drilling or by the use of paraquat to kill emerged A myosuroides especially when heavy populations are present.

A range of seedbeds were encountered in the trials from direct drilling to excessive clods. An average winter tilth is all that is required.

Acknowledgements

I am very grateful to Horstine Farmery Limited, and in particular the late John Brown for help and advice with machinery, and for the calibration and distribution data. Thanks are due also to the staff of Monsanto Chemicals Limited for help with application and assessment and to the farmers who provided the sites.

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<u>TABLE 1</u>

THE DISTRIBUTION PATTERN FOR 10% TRI-ALLATE GRANULES USING HORSTINE FARMERY TMA 2 AIRFLOW APPLICATOR OVER A 16 FT SPREAD AND USING 4 in. TRAYS

Fan Speed 4,000 rev/min — Ground Clearance 18 in.

4 Impact Nozzles each spreading 4 ft with 17° Impact Plates and $\frac{5}{8}$ in. gap

Average weight 102.583 g — Variation Maximum + 4%, Minimum - 3%

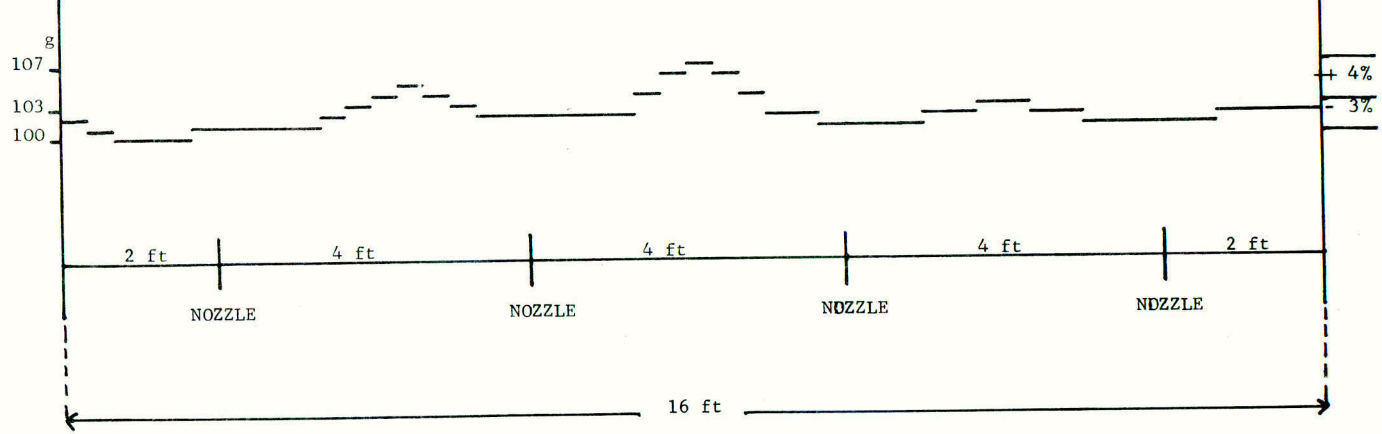

Table 2

The % Control of Alopecurus myosuroides by site and season using tri-allate granules at 1.25, 1.5 and 2.0 lb a.i./ac

Site and Year 1969/70	Pre-Drilling 1.5	Pre-Drilling 2.0	Post Drilling 1.5	Post Drilling 2.0	Drilling Date	Application Date
Keystone, Hunts	74	72			14.11.69	4.11.69
Ashill Norfolk			95	97	15.10.69.	7.11.69
Little Hinton Wilts	73	77			28.10.69	27.10.69
			97	94	28.10.69	29.10.69
Tolleshunt D'Arcy Essex			90	95	10.11.69	13.11.69
Collesden Beds			99	98	24.10.69	28.10.69
Uffington Berks			79	86	18.10.69	29.10.69
1970/71	**Early 1.25**	**Late 1.25**	**Early 1.5**	**Late 1.5**		
Little Hinton Wilts	75	71	82	77	5.10.70	Early 6.10.70 Late 20.10.70
Uffington (1) Berks	64	74	70	77	6.10.70	Early 9.10.70 Late 20.10.70
Bozeat (1)			90		22.10.70	29.10.70
Bozeat (2) Northants			94		4.11.70	6.11.70
Tolleshunt D'Arcy Essex			95		4.11.70	6.11.70
Uffington (2) Berks	86		93		20.10.70	20.10.70
1971/72			**1.5**	**2.0**		
Uffington Berks			50	67	7.10.71	12.10.71

Proc. 11th Br. Weed Control Conf. (1972)

APPLICATION OF BENZOYLPROP ETHYL* AND THE EFFECT ON YIELD OF WHEAT

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Summary This paper reviews the results from 48 replicated field trials in U.K., Europe, N. Africa and Canada and shows that the use of benzoylprop ethyl gives substantial yield increases.

(i) 32-148% under heavy infestations (160 - 600 panicles/m^2)

(ii) 14-60% under moderate infestations (115 - 150 panicles/m^2)

(iii) 5-25% under lower infestations (<100 panicles/m^2)

These yield increases were obtained with application at the relatively late stages of mid tillering to beginning of shooting in Spring sown wheat (Feekes 3 - 6) and late tillering to first/second node formation in Winter wheat (Feekes 4 - 7). Although these stages refer to crop development they ensure late germinating oats are sufficiently forward to be well controlled and these timings coincide with optimum wild oat control.

The nature of wild oat competition is discussed and suggestions put forward to explain the yield responses recorded from this late removal of wild oats.

INTRODUCTION

Benzoylprop ethyl was introduced as a post emergence herbicide for the control of wild oat in wheat in 1969 T. Chapman et al. The level of control obtained in 80 field trials during 1970 was discussed in a paper by B.A. Bowden et al (1970). While the control of wild oat was considered satisfactory, there was some doubt on the yield benefits to be gained from this rather late elimination of the wild oat, since the effects of early removal were already known ref. Holroyd (1972). The purpose of this paper is to review the yield results following the application of benzoylprop ethyl in 48 replicated field trials conducted during 1971 and 1972 in cereal growing areas of Northern and Southern Europe, North Africa and Canada.

EXPERIMENTAL METHOD

Trials were laid down in commercial crops of both Winter and Spring sown wheat. The sites considered in this report had different levels of infestation of the following species of wild oat, *Avena fatua*, *A. sterilis*, *A. sterilis* ssp *macrocarpa* and *A. ludoviciana*.

*Benzoylprop ethyl is also known under the trademark Suffix

Randomised block designs with either four or six replicates were used, the plot sizes varying from 30 to 60 sq. metres.

A 20% EC formulation was applied using precision spraying equipment at 2 dose levels 1 kg and 1.25 kg a.i./ha. The stage of the crop at application was from mid tillering to early shooting in Spring wheat, and late tillering to first/second node stage in Winter wheat. The growth stage of the *Avena* varied from the established over-wintered plant which corresponded closely to the crop growth stage, to the newly emerged seedling. This considerable variation was particularly noticeable in northern areas following the mild winters of 1970 and 1971. Depending on the location, yield data were obtained either by using a Hege mini plot harvester, a 6' Claas combine, or in a few cases by hand cutting and threshing separately.

RESULTS

Crop Yields

The Table gives a summary of the yield results from trials in N. and S. Europe, N. Africa and Canada during 1971 and 1972. They illustrate the relationship between different levels of wild oat infestation and yield gain, following the application of benzoylprop ethyl.

(i) In the absence of Wild Oat

LOCATION	NO. OF TRIALS	YIELD EXPRESSED AS % OF CONTROL +			CONTROL YIELD M.T./HA.
		NO. OF AVENA + PANICLES/M^2	BENZOYLPROP ETHYL Kg ai/ha.		
			1.0	1.25	
FRANCE : BRITTANY	2	0	99	101	3.87
U.K.* : EAST ANGLIA	2	0	103	101	5.37
SPAIN : SEVILLA	2	0	100	99	4.27
(ii) Low infestation Wild Oat					
FRANCE : BRITTANY NORTH	4	28	105	105	3.85
SOUTH EAST	3	28	106	103	3.66
GREECE : THESSALONIKA	1	80	-	119	1.54
U.K. : LINCOLN	1	90	119	-	2.55
ITALY : REA PO	1	97	125	116	3.20
(iii) Moderately heavy infestation Wild Oat					
U.K.* : EAST ANGLIA	3	115	114	116	4.17
LINCOLN	1	128	129	-	4.14
BERKS	1	115	114	-	4.05
FRANCE : BRITTANY	1	136	134	138	3.91
BENELUX	4	150	160	165	2.82
PORTUGAL	3	130	134	128	2.35

(iv) Heavy infestation Wild Oat

LOCATION	NO. OF TRIALS	YIELD EXPRESSED AS % OF CONTROL +			CONTROL YIELD M.T./HA.
		NO. OF AVENA + PANICLES/M²	BENZOYLPROP ETHYL Kg ai/ha. 1.0	BENZOYLPROP ETHYL Kg ai/ha. 1.25	
FRANCE : NORMANDY SOUTH EAST	3	167	143	135	3.90
U.K.* : WILTS	1	224	140	144	2.60
BERKS	1	500	312	-	0.72++
SPAIN : CORDOBA	1	600	175	192	1.50
BUJALANCE	1	450	172	163	1.50
OSUNA	1	165	132	121	2.4
ITALY : CERIGNOLA	2	290	140	130	2.3
S. GIULANA	1	180	142	119	3.3
MOROCCO: MEKNES	1	180	-	176	1.9
TUNIS : MATEUR	1	160	214	167	0.82
CANADA*: SELKIRK	2	450	239	248	1.15
VANSCOY	2	200	152	155	1.37
LAKE LENORE	2	200	132	146	1.45

*Rates used in U.K. and Canada were 1.0 lb and 1.25 lb/acre: METRIC EQUIVALENT 1.13 kg and 1.40 kg/ha.

+Where the results of more than one trial are quoted the figure is the mean.

++The very low yield in the control was due to lodging by the oats in all control replicates.

Statistical analysis shows that an increase of 10% in yield over control may generally be taken as being significant.

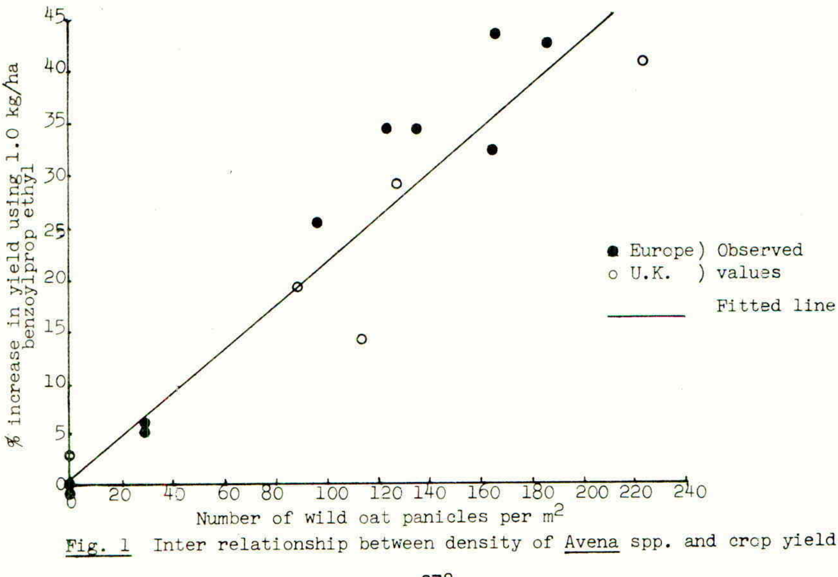

Fig. 1 Inter relationship between density of Avena spp. and crop yield.

Regression relationships for U.K. and Europe are effectively the same (i.e. statistically not significantly different) and the equation for the regression relationship is:-

$$\% \text{ yield increase} = \underset{(\pm 2.537)}{0.533} + \underset{(\pm 0.0209)}{0.2059} \text{ (Wild Oat panicles/m}^2\text{)}$$

Rate of yield increase = 0.21% per Wild Oat panicles/m^2

The data range covered by the equation does not exceed infestation levels of 225 Wild Oat panicles/m^2

The increase in yield is not significantly different from 0% at zero infestation.

Control of Wild Oat

The average reduction in wild oat panicles expressed as a percentage of the control plots in the above trials was 79% at 1.0 kg, and 84% at 1.25 kg a.i./ha.

DISCUSSION

It is accepted that the early removal of weed competition from a crop will lead to maximum yield gain, but in the case of cereals, the grain is filled at such a late stage in growth that yield responses can be achieved by the late removal of competition affecting the upper leaves. Porter, Pal and Martin (1950) working with barley emphasized the importance of these upper leaves and concluded 45% of the material which fills the ear is derived from the flag leaf after ear emergence and 30% from the ear itself. This was supported by work on all cereals by Large and Doling (1962).

Our trials show that, in spite of removing wild oat competition at a relatively advanced stage of crop development - Feekes 4 - 6, late tillering to first node stages - valuable and often very large yield increases are obtained. This shows that while early elimination of wild oat competition may be desirable it is not essential: removal of competition at or soon after tillering, affords the crop a long period of uninhibited growth and in particular gives protection against shading effects from taller wild oat plants which interfere with the essential photosynthetic processes in flagleaf and glumes. These findings have been confirmed during 1972 the first year of large scale use of benzoylprop ethyl in four countries (U.K., France, Spain and Greece).

The yield benefits obtained by removing competition are maximized with this compound, as no yield reductions have been recorded where benzoylprop ethyl has been applied in the absence of wild oat, as demonstrated in the 1971 U.K. and French trials. B.A. Bowden et al (1970) and J.P. Loubaresse et al (1971) showed no effects on yields in the absence of wild oat even at 8 kg ai/ha, illustrating the outstanding crop safety margin of this compound on wheat.

CONCLUSIONS

From the many field trials it appears that providing the shading effect of wild oat can be successfully eliminated before the ear starts to fill, its competitive effect is minimal. Experience with benzoylprop ethyl suggests that spraying should have been completed by first node stage (Feekes 7) well before the serious competitive effects of wild oat are felt. Major yield depressions are caused by the wild oat over-topping the cereal crop, thus seriously impairing the phytosynthetic functioning of flag leaf and ear (glumes) resulting in yield losses. While the early elimination of wild oat is desirable, the characteristic germination pattern of wild oat which extends into late spring demands either a persistent pre-emergence treatment or a late post emergence treatment effective over a number of growth stages: benzoylprop ethyl fully meets the requirements for the latter type of wild oat herbicide.

Acknowledgement

We wish to thank all our co-workers who have contributed their results for the production of this report. We also thank Shell Canada Ltd., for permission to publish their results.

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CHEMICAL CONTROL OF ALOPECURUS MYOSUROIDES IN WINTER WHEAT

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Summary A number of chemicals and mixtures were compared at a total of eleven centres in the years 1970/71 and 1971/72. Chlortoluron gave the highest and most consistent control of *Alopecurus myosuroides*, and pre-emergence applications were considerably more effective than post-emergence. Metoxuron gave very similar results to chlorotoluron when applied post-emergence in 1970/71 but was inferior in 1971/72. The other materials gave less satisfactory and more variable control of *A. myosuroides*, but in general an economic yield response was obtained.

INTRODUCTION

There have been a large number of herbicides introduced in recent years and the ADAS Agronomy Department at Cambridge has continued to examine them under a range of field conditions to obtain information for use in advisory work.

It was thought that the results from the 1970/71 trials, and from earlier trials reported by North and Livingston (1970) gave sufficient information about many of the herbicides for them to be omitted from the 1971/72 trial series, which concentrated mainly on materials which had given the more promising results in the past, though three more recently introduced materials were included. Results are not given for a metoxuron/simazine mixture because contamination with other chemicals occurred in the trials.

METHOD AND MATERIALS

In 1970/71 five experiments were completed, in 1971/72 there were six experiments. All the experiments were superimposed on commercial crops where naturally occurring infestation of *A. myosuroides* were expected.

Herbicides used are noted in Table 1 below, all dose rates are in terms of active ingredient per acre. Site details, treatment application dates, stage of growth of the winter wheat and *A. myosuroides* are given in Tables 2 and 3.

Plot size was 30 ft x 9 ft, all treatments were applied using a modified van der Weij sprayer with size 00 fan jets at a pressure of 32 lb/in^2. Application rate was 20 gal/ac. A randomised block design was used with treatments replicated three times.

Treatment effects were assessed by removing all the *A. myosuroides* plants in a number of quadrats from each plot in late June/early July. The total length of seed heads were then measured to give some indication of seed return. Crop yields were measured by a sample harvest technique in the remainder of the plot.

The density of the original weed population was measured by taking plant counts at various times.

RESULTS

The control of A. myosuroides is expressed in terms of length of flowering heads in metres per square metre in Tables 4 and 5 and the yields of wheat in Tables 6 and 7. Overall yields are only given when a treatment was included in all the trials that year. It would appear that only autumn applications of chlortoluron gave anything approaching complete control. Most other treatments produced a worthwhile yield increase but this was only linked to efficiency of control in very general terms.

It was again apparent that large yield increases were only obtained where the control yield was low (sites 3 and 5 in 1970/71) and that where the crop was vigorous and control yields were high (site 2 in the same year) then there was no response due to the removal of the A. myosuroides.

Table 1

Treatment 1970/71

1.	metoxuron early autumn	4.0	All doses in lb a.i./ac
2.	metoxuron late autumn	3.6	
3.	metoxuron early spring	3.6	
4.	metoxuron late spring	4.0	
5.	chlortoluron early autumn	3.2	
6.	chlortoluron late autumn	3.2	
7.	chlortoluron early spring	2.4	
8.	chlortoluron late spring	2.4	
9.	terbutryne	2.0	
10.	metabenzthiazuron	2.8	
11.	nitrofen	1.8	
12.	tri-allate (granules) autumn	1.5	
13.	tri-allate (granules) early spring	1.5	
14.	dichlobenil/flumeturon	1.5 + 0.75	
15.	metoxuron/diuron	2.8 + 0.8	
16.	cyanazine	1.5	
17.	metabenzthiazuron	2.75	
18.	metoxuron/simazine early March	3.016 + 0.19	
19.	metoxuron/simazine mid March	3.17 + 0.20	
20.	barban	0.31	
21.	barban	0.31	

Treatment 1971/72

1.	tri-allate (granules)	1.5
2.	chlortoluron autumn	3.2
3.	chlortoluron spring	2.4
4.	metoxuron	3.2 (sites 2 and 3 4.0 lb)
5.	cyanazine	1.5
6.	nitrofen/neburon	0.9 + 1.7
7.	metoxuron	4.0

Table 2

Site details

1970/71

Site	2	3	4	5	6
Soil Texture	ZL	ZL	ZL	ZyCL	ZyL
Variety	M Ranger	Joss Cambier	Joss Cambier	Cama	Joss Cambier
Date drilled	28/10	13/11	7/11	late Oct	22/10
Seedbed at first spray	Dry, cloddy	Wet	Fair tilth, moist, some clods	Moist	Moist

	Treatment	dates of application				
1.	metoxuron early autumn	4/11	17/11			
2.	metoxuron late autumn	7/12		15/12		
3.	metoxuron early spring	16/2	11/2	11/2	9/2	10/2
4.	metoxuron late spring	11/3	11/3	9/3	1/3	1/3
5.	chlortoluron early autumn	4/11	17/11			
6.	chlortoluron late autumn	7/12	11/2	15/12		
7.	chlortoluron early spring	10/2	11/2		9/2	10/2
8.	chlortoluron late spring	11/3	11/3	9/3	1/3	1/3
9.	terbutryne	4/11	17/11	15/12		
10.	metabenzthiazuron	7/12	11/2	13/12		
11.	nitrofen	4/11	17/11	15/12		
12.	tri-allate (granules) autumn	4/11	17/11			
13.	tri-allate (granules) early spring	16/2	11/2	11/2	9/2	10/2
14.	dichlobenil/flumeturon	16/2	11/2	11/2	9/2	10/2
15.	metoxuron/diuron	4/11	17/11	15/12		
16.	cyanazine	16/2	11/2	11/2	9/2	10/2
17.	metabenzthiazuron	7/12	11/2	15/12		
18.	metoxuron/simazine early March			9/3	1/3	1/3
19.	metoxuron/simazine mid March				12/3	12/3
20.	barban				9/2	10/2
21.	barban				1/3	1/3

	2	3	4	5	6
Growth stage of crop	4/11 pre-emergence 7/12 1½ leaf 16/2 tillering 11/3 tillering	17/11 pre-emergence 11/2 3 leaf 11/3 4 leaf	15/12 1-1½ 11/2 4 leaf 9/3 4-6 leaf tillering	9/2 3 leaf 1/3 tillering 12/3 tillering	10/2 tillering 1/3 tillering 12/3 tillering
Growth stage of *A. myosuroides*	4/11 - 7/12 1 leaf 16/2 2 leaf tillering 11/3 2 leaf tillering	17/11 - 11/2 2-3 leaf 11/3 3 leaf tillering	15/12 1-1½ leaf 11/2 tillering 9/3	9/2 2 leaf tillering 1/3 4-5 leaf tillering 12/3 5 leaf tillering	10/2 4-1 leaf tillering 1/3 4-5 leaf tillering 12/3 5 leaf tillering

Table 3

Site details

1971/72

Site	1	2	3	4	5	6
Soil Texture	FSCL	ZyCL	Org FSCL	FSCL	Org ZL	FSCL
Variety	Cappelle	Cappelle	Cappelle	Cappelle	Cappelle	J Cambier
Date drilled	4/11	3/11	5/11	1/10	29/10	24/10
Seedbed at first spray	Moist	Clods	Sticky large clods	Dry on surface clods	Fairly fine tilth dry on surface	Fairly fine with clods
Treatment	**Date of application**					
1. tri-allate (granules)	5/11	4/11	11/11	6/10	2/11	26/10
2. chlortoluron autumn	5/11	4/11	11/11	6/10	2/11	26/10
3. chlortoluron spring	22/3	10/3	9/3	16/11	23/3	29/2
4. metoxuron	22/3	10/3	9/3	16/11	23/3	29/2
5. cyanazine	22/3	10/3	9/3	25/2	23/3	29/2
6. nitrofen/neburon	5/11	4/11	11/11	8/10	2/11	26/10
7. metoxuron			11/4			
Growth stage of crop	5/11 pre-emergence 22/3 4½ leaf	4/11 pre-emergence 10/3 5-7 leaf	11/11 pre-emergence 9/3 early tiller 11/4 tillered	6/10 pre-emergence 8/10 pre-emergence 16/11 3 leaf 25/2 tillering	2/11 pre-emergence 23/3 4 leaf	26/10 pre-emergence 29/2 7 leaf tillering
Growth stage of *A. myosuroides*	5/11 pre-emergence 22/3 5 leaf	4/11 pre-emergence 10/3 5-6 leaf	11/11 pre-emergence 9/3 5 leaf tillering 11/4 tillering	6/10 pre-emergence 8/10 pre-emergence 16/11 1-2½ leaf 25/2 6-7 leaf tillering	2/11 pre-emergence 23/3 5-6 leaf	26/10 pre-emergence 29/2 3½-7 leaf

Table 4

1970/71 A. myosuroides control

Total length of flowering heads in m/m^2

Treatment	Site 2	3	4	5	6	Mean	% reduction
Control	16.9	60.2	12.9	51.8	77.1	43.8	0
1. metoxuron early autumn	2.4	8.0					
2. metoxuron late autumn	3.0		0.7				
3. metoxuron early spring	3.6	5.6	1.7	37.8	16.6	13.1	70.1
4. metoxuron late spring	4.9	8.0	4.8	44.4	10.7	14.6	66.7
5. chlortoluron early autumn	0.6	4.5					
6. chlortoluron late autumn	0.1	3.7	0.6				
7. chlortoluron early spring	2.5	7.1	2.7	10.5	8.8	6.3	85.6
8. chlortoluron late spring	2.5	28.1	4.4	29.1	31.5	19.1	56.4
9. terbutryne	7.6	36.4	1.9				
10. metabenzthiazuron	13.7	33.2	4.5				
11. nitrofen	6.2	49.9	2.6				
12. tri-allate (granules) autumn	6.1	36.3					
13. tri-allate (granules) early spring	12.7	35.4	5.0	13.4	29.5	19.2	56.2
14. dichlobenil/flumeturon	10.6	15.5	11.5	42.7	29.4	21.9	50.0
15. metoxuron/diuron	2.3	13.5	1.8				
16. cyanazine	16.7	48.3	12.5	24.8	44.1	29.3	33.1
17. metabenzthiazuron	16.7	12.6	4.8				
18. metoxuron/simazine early March			4.9	37.8	13.2		
19. metoxuron/simazine mid March				38.4	14.0		
20. barban				17.9	23.6		
21. barban				51.2	74.7		
s.e.	±2.73	±6.13	±2.54	±12.47	±10.56		
Number of A. myosuroides plants/m^2 in April							

Table 5

1971/72 A. myosuroides control

Total length of flowering heads in m/m^2

Treatment	Site 1	2	3	4	5	6	Mean	% reduction
Control	79.4	233.0	86.2	32.2	86.9	57.5	95.9	0
1. tri-allate (granules)	36.7	114.0	52.7	4.8	15.1	14.2	39.6	58.7
2. chlortoluron autumn	5.8	29.4	4.1	0.5	1.2	1.3	7.0	92.7
3. chlortoluron spring	28.6	25.8	34.9	1.8	1.1	2.7	15.8	83.5
4. metoxuron	28.4	68.5	90.0	3.7	1.3	7.5	33.2	65.4
5. cyanazine	27.4	109.0	70.7	19.3	21.0	15.1	43.7	54.4
6. nitrofen/neburon	62.9	181.6	60.7	6.5	50.8	29.8	65.4	31.8
7. metoxuron			63.0					
s.e.	±6.21	±11.47	±12.71	±3.90	±10.01	±6.19		
Number of A. myosuroides plants/m^2 in December	152.5	1838.0	356.0	50.5	312.0	204.0		

Table 6

Grain yield cwt/ac 85% d.m.

1970/71

Treatment	Site 2	3	4	5	6	Mean	%
Control	48.8	23.7	35.6	24.2	33.9	33.2	100
1. metoxuron early autumn	46.1	44.0					
2. metoxuron late autumn	47.7		36.8				
3. metoxuron early spring	47.8	43.0	38.8	39.5	53.0	44.4	134
4. metoxuron late spring	47.3	38.2	30.6	31.5	50.0	39.5	119
5. chlortoluron early autumn	47.1	40.0					
6. chlortoluron late autumn	47.0	43.8	36.6				
7. chlortoluron early spring	47.1	45.7	42.0	40.6	49.5	45.0	136
8. chlortoluron late spring	50.9	39.3	51.0	30.6	44.8	43.3	130
9. terbutryne	45.5	35.6	47.0				
10. metabenzthiazuron	43.9	32.2	39.4				
11. nitrofen	44.7	28.0	37.5				
12. tri-allate (granules) autumn	46.4	29.3					
13. tri-allate (granules) early spring	49.1	27.6	32.4	27.9	40.3	35.5	107
14. dichlobenil/flumeturon	46.8	34.3	36.4	24.0	44.8	37.3	112
15. metoxuron/diuron	50.1	38.0	55.7				
16. cyanazine	44.5	36.9	41.5	35.4	44.1	40.5	122
17. metabenzthiazuron	48.6	35.1	37.1				
18. metoxuron/simazine early March			32.8	33.3	49.8		
19. metoxuron/simazine mid March				26.0	50.6		
20. barban				26.6	45.1		
21. barban				30.1	35.6		
s.e.	±2.60	±2.20	±5.11	±2.73	±2.47		

Table 7

1971/72

Grain yield cwt/ac 85% d.m.

Treatment	Site 1	2	3	4	5	6	Mean	%
Control	21.4	9.1	25.6	29.7	13.9	30.4	21.7	100
1. tri-allate (granules)	34.3	23.3	32.6	46.3	19.4	36.1	32.0	148
2. chlortoluron autumn	41.1	33.6	42.1	46.7	20.0	36.8	36.9	170
3. chlortoluron spring	33.2	24.4	42.6	46.6	15.6	35.5	33.0	152
4. metoxuron	33.0	30.4	30.7	41.6	17.9	35.7	31.6	146
5. cyanazine	30.1	17.4	30.2	40.2	8.3	32.4	26.4	122
6. nitrofen/neburon	24.7	21.0	31.5	43.1	17.4	31.6	28.2	130
7. metoxuron			30.6					
s.e.	±2.63	±2.26	±3.33	±2.83	±3.65	±2.31		

DISCUSSION

These trials provide useful information on the control of *A. myosuroides* that can be expected from most available herbicides, but it is obvious that there is a great deal of variation due to site and season which cannot always be explained.

Only the most effective treatments with over 90% control, give some hope of long term eradication of *A. myosuroides*, but even the least effective herbicides generally produced an economic yield response in the crop. Other factors will influence the choice of herbicide, such as possible susceptibility of the variety, ease of application, convenience of timing, and possible control of other grass or broad leaved weeds.

The likely yield response in relation to the cost of the treatment also needs consideration, and the evidence indicates that worthwhile increases are more likely in situations where the yields of wheat are moderate to low (North and Livingston 1970, Griffiths and Ummel 1970). The removal of *A. myosuroides* by pre-emergence treatments in 1970/71 did not significantly increase yields compared with post-emergence applications, but it did appear that metoxuron or chlortoluron produced better yield responses when applied early rather than late in the spring. In 1971/72 there appeared to be a better response from pre-emergence treatments as compared with those applied post-emergence. It is possible that competition from *A. myosuroides* may not always be serious during the winter, but it is certain that large overwintered plants will begin to compete seriously and quickly with the crop when temperatures rise in the spring. (Naylor 1972).

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CHEMICAL CONTROL OF *AVENA FATUA* IN WINTER WHEAT

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Summary Thirteen replicated trials included a total of ten herbicides. Crop yields and *A. fatua* panicle weights were recorded. Best control was obtained from pre-emergence tri-allate granules and chlortoluron, and late post-emergence benzoylprop-ethyl. All treatments tended to perform less well at highest weed populations. Good yield responses were obtained. Problems of usage from the farm management angle are discussed.

INTRODUCTION

This paper reports work which continues that reported by North and Livingston (1970). A major difficulty encountered in work on *A. fatua* is the marked irregularity of its distribution within even small areas. The sites currently reported employed a special small plot method, and sampling technique designed to minimise the problem.

METHODS AND MATERIALS

Various combinations of the herbicides listed in Table 1 were compared at 6 sites in 1970/71 (Table 2) and 7 sites in 1971/72 (Table 4). A randomised block design, with an untreated control plot 3 times replicated pairing and randomised with each treatment, was used in 1970/71 (plot size 17 m^2). In 1971/72 effects of treatments on *A. fatua* were assessed on the mean of controls left on each side of treated plots (plot size 25 m^2). Herbicide sprays were applied with a modified van der Weij sprayer in 20 gal/ac with fan jets at 32 lb/in^2 (48 for chlorfenprop-methyl).

A. fatua populations were measured in all plots by taking quadrat samples from both ends of the plots just before seed shedding began. The panicles were dried and weighed. Quadrat size was varied according to weed population to give samples of adequate yet manageable size. Wheat yields were determined by hand sampling within the centre of each plot.

Table 1

Herbicidal Treatments (active ingredient per acre)

1.	Tri-allate emulsion(pre-emergence)	1.5 lb
2.	Tri-allate granules(pre-emergence)	1.5 lb
3.	Tri-allate granules(post-emergence)	1.5 lb-1970/71. 2.0 lb-1971/72
4.	Metoxuron(pre-emergence)	4.0 lb
5.	Metoxuron(post-emergence) 3.6 lb (sites 1 to 4)	4.0 lb (sites 5 & 6)-1970/71 3.2 lb-1971/72
6.	Metoxuron/diuron(pre-emergence)	2.8 lb and 0.8 lb
7.	Chlortoluron(pre-emergence)	3.2 lb
8.	Chlortoluron(post-emergence)	2.4 lb
9.	Dichlobenil and fluometuron(post-emergence)	1.5 lb and 0.75 lb
10.	Barban(post-emergence)	0.3 lb
11.	Chlorfenprop-methyl(post-emergence)	4.3 lb
12,13,14.	Benzoylprop-ethyl at crop GS3-5, 4-6 and 7-8 respectively	1.0 lb

Table 2

1970/71 Experiments, Conditions of Treatment Application

Site	1	2	3	4	5	6
Soil texture	SCL	ZyCL	ZyCL	ZL	CL	ZyCL
Variety	Cappelle	Cappelle	Cappelle	Cama	J Cambier	Cappelle
Date wheat sown	4/11	20/10	5/11	4/11	5/11	mid Nov

Dates of application 1970/71 and stages of growth of *A. fatua*
(L = number of leaves; GS = Growth Stage)

Treatments	1	2	3	4	5	6
1,2,4,6 and 7	6/11	6/11	10/11	10/11		
3,5,8 and 9	23/2	19/2	22/2	22/2	23/2	10/3
	< GS2	< 3L	1-3½L	1-3½L	< 3L	< 4L

At the time of the post-emergence spray the wheat crops were tillering.

Table 3

1971/72 Experiments, Conditions of Treatment Application

Site	1	2	3	4	5	6	7
Soil	ZyCL	CL	ZyCL	ZyL	FSL	CL	ZyCL
Variety	M Ranger	J Cambier	Cappelle	Cappelle	J Cambier	Champlein	M Ranger
Date sown	3/11	7/10	24/10	22/10	24/10	24/10	26/10

Table 4

Dates of applications 1971/72; stages of growth of wheat and (in brackets) of *A. fatua* (L = number of leaves; GS = growth stage)

Treatments/Sites	1	2	3	4	5	6	7
2 and 7	8/11	12/10	28/10	29/10	28/10	27/10	2/11
3,5,8 and 12	15/3	1/3	14/3	24/3	13/3	14/3	13/3
	GS3	GS2-3	GS3	4½-5L	GS3	GS3	GS3
	(5L)	(GS2)	(3-4L)	(4L)	(3-3½L)	(3½L)	(3L)
11	14/1	15/12	14/1	14/1	14/1	20/1	14/1
	3-4L	4-5L	3L	2½-3L	3-4L	2½-3L	2½-3L
	(1-3L)	(2½-3L)	(1-2L)	(1-2L)	(1-2½L)	(2½-3L)	(1-2½L)
13	11/4	10/4	10/4	1/5	5/4	19/4	11/4
	GS4-5	GS5	GS4-5	GS3-4	GS4	GS5	GS4-5
	(GS3)	(GS2-3)	(GS5)	(GS4)	(GS3)	(GS3)	(< GS3)
14	28/4	21/4	24/4	23/5	26/4	27/4	28/4
	(GS5)	(< GS5)	(GS6)	(GS6)	(GS4)	(GS5)	(< GS5)
15	17/5	1/5	4/5	2/6	9/5	8/5	9/5
	(GS8)	(< GS7)	(GS7)	(GS7-8)	(GS7)	(GS7)	(< GS7)

RESULTS

Effect of Treatments on Crop Population

Wheat populations were assessed on pre-emergence treatments. Effects were very small but in both seasons the population on the untreated plots was marginally superior to all treatments; in 1970/71 tri-allate granules had a more distinctly, but still only marginally, lower population than the other treatments; although worst in 1971/72, the difference was too small to be significant.

Table 5

Grain Yield cwt/acre 85% DM 1970/71

Treatment	Site 1	2	3	4	5	6	Mean Yields (sites 1-4)	(all sites)	% effect on yield (sites 1-4)	(all sites)
Control	50.6	41.0	28.0	42.8	23.5	48.6	40.6	39.1	100	100
1. Tri-allate emulsion (pre-em)	47.1	55.5	39.4	49.2			47.8		121	
2. Tri-allate granules (pre-em)	48.2	54.0	45.1	44.6			48.0		123	
3. Tri-allate granules (post-em)	50.8	51.8	35.2	45.6	35.0	51.2	45.9	44.9	115	119
4. Metoxuron (pre-em)	52.8	53.6	32.3	49.4			47.0		116	
5. Metoxuron (post-em)	48.1	54.6	32.6	48.4	39.5	57.0	45.9	46.7	114	124
6. Metoxuron/diuron (pre-em)	48.8	46.7	31.6	47.9			43.8		109	
7. Chlortoluron (pre-em)	52.6	52.4	40.2	47.2			48.1		121	
8. Chlortoluron (post-em)	47.9	52.2	35.4	49.0	31.3	54.3	46.1	45.0	116	118
9. Dichlobenil/fluometuron (post-em)	52.6	47.1	30.1	46.0	27.1	51.9	44.0	42.5	108	109
SE ± (between herbicide comparisons)	2.22	2.56	2.94	1.96	3.75	1.45	1.23			

Table 6

Grain Yield cwt/acre 85% DM 1971/72

Treatment	Site 1	2	3	4	5	6	7	Mean Yield	% effect on yield
Control	55.1	26.6	19.5	5.6	24.3	43.5	33.8	29.8	
2. Tri-allate granules (pre-em)	53.0	36.4	28.2	9.0	41.0	46.1	43.8	36.8	135
3. Tri-allate granules (post-em)	54.5	28.6	25.3	6.9	31.2	43.8	39.4	32.8	115
5. Metoxuron (post-em)	49.8	35.5	33.1	8.8	29.2	44.4	42.0	34.7	128
7. Chlortoluron (pre-em)	52.8	40.1	37.2	9.7	38.2	43.0	47.0	38.3	144
8. Chlortoluron (post-em)	51.1	30.2	25.8	9.7	27.4	46.5	40.9	33.1	122
11. Barban	57.2	40.7	27.1	3.3	39.6	45.5	40.9	36.3	120
12. Chlorfenprop-methyl (post-em)	48.3	37.2	37.7	7.3	37.3	41.7	42.0	35.9	132
13. Benzoylprop-ethyl early	51.0	32.5	36.4	14.3	38.0	43.8	42.8	37.0	149
14. Benzoylprop-ethyl mid	51.2	35.1	28.3	6.0	37.5	43.0	41.5	34.7	122
15. Benzoylprop-ethyl late	50.4	38.3	32.8	7.4	36.4	41.5	39.6	35.2	128
SE ± (between herbicide comparisons)	3.33	5.49	5.68	2.67	4.19	3.04	3.19		

Table 7

Percentage Control of **A Fatua** as Dry Weight of Panicles 1970/71

	Sites						Means	
Mean Weight panicles	1	2	3	4	5	6	(sites	(all
g/m^2 on controls	4.1	116	161	8.8	281	82.2	(1–4)	sites)
Treatments								
1. Tri-allate emulsion (pre-em)	91	95	35	94			79	
2. Tri-allate granules (pre-em)	95	96	65	85			85	
3. Tri-allate granules (post-em)	71	50	53	80	72	26	63	59
4. Metoxuron (pre-em)	54	56	44	15			42	
5. Metoxuron (post-em)	94	68	66	71	74	55	75	71
6. Metoxuron/diuron (pre-em)	72	0	25	62			40	
7. Chlortoluron (pre-em)	94	78	60	97			82	
8. Chlortoluron (post-em)	87	49	40	87	61	40	66	61
9. Dichlobenil and fluometuron (post-em)	85	32	0	90	37	36	52	47
SE ± (between herbicide comparisons)	8.23	42.8	20.3	28.4	15.7	24.0		
Amount of A. myosuroides present	*	**	*	*	**	*		

Table 8

Percentage Control of **A fatua** as Dry Weight of Panicles 1971/72

	Sites							
Mean Weight panicles	1/	2	3	4	5	6	7	
g/m^2 on controls	1.8	110	272	259	113	13.6	86.2	Mean
Treatments								
2. Tri-allate granules (pre-em)	69	89	89	41	93	98	94	82
3. Tri-allate granules (post-em)	46	41	0	45	48	74	64	45
5. Metoxuron (post-em)	66	59	49	37	31	79	66	55
7. Chlortoluron (pre-em)	99	85	93	51	81	99	94	86
8. Chlortoluron (post-em)	22	58	0	42	50	89	71	47
11. Barban	88	90	97	5	91	97	78	78
12. Chlorfenprop-m. (post-em)	91	65	92	49	84	92	72	78
13. Benzoylprop-ethyl, early	76	79	97	30	83	95	81	77
14. Benzoylprop-ethyl, mid	79	96	99	21	82	95	89	80
15. Benzoylprop-ethyl, late	83	98	99	31	93	98	91	85
SE ± (between herbicide comparisons)	26.0	17.5	31.6	13.2	13.4	4.0	9.5	
Amount of A. myosuroides present	*	**	*	*	**	*	*	

/ Panicle numbers only were recorded at this site as populations were so low that the whole plot area had to be assessed.

A myosuroides. ** indicates that it was present in sufficient numbers for it to be possible that yield could have been affected; * indicates presence in negligible quantities. It was not possible to make weight assessments.

DISCUSSION

Broad-leaved weed control is reported by Proctor and Clarke (1972).

In considering the effects of herbicides on yield it must be borne in mind that, in addition to competition from A. fatua, herbicides vary greatly in their degree of selectivity and that there was some competition from Alopecurus myosuroides at a proportion of the sites. Competition from broad-leaved weed may reasonably be discounted in view of the low populations recorded and the fact that sites received overall herbicide spray where farmers considered this desirable.

There is still inadequate comparative data on tri-allate emulsion and granules but the latter as a pre-emergence treatment performed very well in these trials. Chlortoluron pre-emergence gave comparable results. Post-emergence applications of chlortoluron were unsatisfactory in the second year. The results from barban, chlorfenprop-methyl and benzoylprop-ethyl (included in the 1971/72 trials only) were also good. The control from benzoylprop-ethyl improved with delay in application, that made at Growth Stage 7-8 being comparable with pre-emergence tri-allate granules and chlortoluron; delay in application resulted in slightly lower yields probably because of the longer period of weed competition.

It is of interest (Baldwin and Livingston, 1972) that pre-emergence applications of chlortoluron have also given notably good control of A. myosuroides compared with the other materials having activity against this weed.

There is some tendency for the degree of control from all treatments to be lower at the sites with the highest A.fatua populations though - in view of this seeming to apply to all herbicides - it is difficult to formulate an explanation.

It is not always easy to fully appreciate the husbandry implications of any application limitations which may be essential for the effective use of a material. All applications involve some manpower useage and too often will conflict with other urgent farm operations (unless contractors are employed). A material which requires to be incorporated into the soil may seriously retard drilling progress leading to overall lower farm yields; soil conditions for its use may be limited and of itself it may reduce the quality of the tilth. For much of the winter, soil conditions make land spraying impossible, while aerial spraying involves a risk of too uneven application; spring spraying is frequently curtailed by inclement weather. The appearance of two new materials having different application requirements is therefore a major step forward in increasing the opportunities of treating against A. fatua. Tri-allate granules, if applied by drill attached distributor have the advantage of requiring practically no extra man hours in their use, while benzoylprop-ethyl requires to be applied at the time of year when there is perhaps the best chance of good spraying weather occurring.

In choosing a herbicide, its ability to give some control of A. myosuroides and annual broad-leaved weeds is a major asset and the two annual grass species in question frequently occur together. How far it is an advantage to spray when the weed is emerged and the need for it to be controlled is evident, has to be balanced sometimes against the likelihood with some materials, for pre emergence applications to give better control and greater crop yield response. There is also the risk that bad weather may prevent a planned post-emergence application.

The application of barban was made, in error, at a lower pressure than advised by the manufacturer (32 instead of 40 lb/in). It is, however, likely to be difficult to achieve this pressure with many farm sprayers.

Acknowledgements

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CHEMICAL ROGUING OF AVENA SPP.

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Summary Localised application of a 10% w/v a.e. solution of glyphosate to inflorescences of *Avena fatua* at the 'soft and hard cheese' stages of development prevented the formation of any seed capable of producing healthy plants. 10% and 15% w/v a.e. dalapon and 5% w/v a.e. sodium cacodylate applied at the 'milk stage' prevented the formation of viable seed except by secondary untreated inflorescences. Applications made at the 'soft cheese' stage were only slightly less effective. Rain at the time of treatment had a relatively minor effect on the activity of dalapon but a greater effect on sodium cacodylate. Restriction of the application to the upper portion of the inflorescence reduced the effectiveness of dalapon more than that of sodium cacodylate.

INTRODUCTION

Many fields that have low populations of *Avena* spp. are 'rogued' by hand. A roguable population is in the region of 500 plants per acre and generally occurs at the early stages of an infestation or after a herbicide for the control of *Avena* spp. has been used. If seed shedding is to be prevented hand roguing requires the complete *Avena* plant to be pulled up, carried off the field and destroyed, preferably by burning. As labour and time are expensive roguing a field is not worthwhile if it takes more than one man hour per acre (Holroyd, 1972a). In 1968 the Weed Research Organization initiated the development of a chemical roguing glove as a quicker alternative to conventional hand roguing. The procedure involves direct application of a chemical to the individual *Avena* panicles shortly before harvest, thereby rendering the seed non-viable. Chemical roguing is generally twice as fast as normal hand roguing because it does not involve removing the plant from the field. The glove is constructed with a foam pad in the palm which is fed with liquid herbicide from a reservoir carried by the operator. The inflorescences are gripped by the gloved hand and the herbicide wiped over them (Holroyd, 1972b).

In the three years 1968 to 1970 over thirty potential chemicals were tested for possible use with the glove but relatively few gave worthwhile results. Paraquat and aminotriazole were effective but were ruled out on the grounds of possible toxicological risks to the operator making clearance by regulatory authorities doubtful. However two safer chemicals, dalapon and sodium cacodylate, also performed well, giving greater than 99% reduction in the number of viable seeds produced by treated inflorescences. Three of the four experiments in this paper report more detailed work with dalapon and sodium cacodylate and the fourth the initial testing of a new herbicide, glyphosate.

METHOD AND MATERIALS

All four experiments were situated within 20 km of the Weed Research Organization, and were on *Avena fatua* in individual crops of barley, field beans and a mixture of swedes and kale. Experiment A, in 1970, examined the rainfastness, and Experiment B in the same year, the effect of partial application of dalapon and sodium cacodylate. Experiments C and D in 1971 looked at the influence of stage of development of the inflorescences at application, on the effectiveness of the herbicidal treatments. Sodium cacodylate and dalapon were applied in Experiment C and glyphosate in Experiment D. General details of the experiments are given in Table 1.

Table 1

Crops and dates of application, harvest and germination tests

Experiment	Crop	Date of application	Stage of development of inflorescences at treatment	Date of harvest	Date of germination tests
A	Spring barley cv. Julia	24-7-70	Soft cheese	20- 8-70	4-11-71
		29-7-70	Medium hard cheese	"	"
B	Field beans cv. Minor Tic	22-7-70	Soft cheese	17- 8-70	4-12-70
C	Swedes and kale	18-8-71	Milk	7- 9-71	21- 7-72
		27-8-71	Soft cheese	to 5-11-71	"
D	Swedes and kale	3-9-71	Soft cheese	7- 9-71	3- 2-72
		7-9-71	Hard cheese	to 5-11-71	"

A roguing glove, because of difficulties in cleaning, is not ideal for the application of experimental treatments. Instead, a foam pad was soaked in the herbicidal solution and held in a gloved hand. To avoid contamination separate foam pads were used for each treatment. To mark treated inflorescences (as in normal chemical roguing) solutions were applied containing a red dye (R.N.S. Monolite Fast Scarlet manufacturered by Imperial Chemical Industries). 1.5% v/v dye solutions were used in 1970 and 3.0% v/v in 1971. 0.5% v/v Agral '90' was added to improve the wetting properties of the solutions. Control inflorescences were left completely untreated.

Each treatment was replicated on ten panicles in Experiments A, B and D but on twenty panicles in Experiment C. Before seed shed began the inflorescences were covered with 250 mm x 375 mm perforated polythene bags to prevent seed loss.

For germination, samples of ten randomly selected seeds (twenty in the case of Experiment B) were taken from each bag and dehusked, surface sterilised, sown into 90 mm petri dishes containing two filter papers and 5 ml of distilled water, pricked and then incubated at a constant temperature of 23°C. Surface sterilisation was by soaking in 1% silver nitrate solution for one minute followed by a further minute in 1% sodium chloride solution and finally washing in distilled water.

On germination the dehusked seeds or caryopses were sown into 50 mm pots containing a mixture of peat and soil and grown on in a glasshouse. Finally the number of caryopses that germinated, shoots which failed to emerge from the soil, shoots that emerged but subsequently died, and shoots which grew to healthy plants were recorded. All plants which had reached at least the three-leaf stage of growth and were normal in appearance were regarded as healthy. Plants showing any deformity were allowed to grow on until their potential viability could be accurately forecast.

The treatments in Experiment A were dalapon (sodium salt, 74% a.e. water soluble powder) at 5% and 10% w/v a.e. and sodium cacodylate (62.56% a.e. water soluble powder) at 1% and 5% w/v a.e. The first treatment was applied on 24-7-70 during rain (6.8 mm on 24-7-70 and 13.3 mm during the following four days) and the second on 29-7-70, the next dry day. In Experiment B the same chemicals and concentrations were applied to either the whole or only the top half of the inflorescence. The two 1971 experiments, C and D, were in a fodder crop of swedes and kale where each A. fatua plant had a number of secondary tillers from which the inflorescences could reach maturity before harvest. This is not always possible in a normal cereal crop. The treatments in C were dalapon solutions of 10% and 15% w/v a.e. and a sodium cacodylate solution of 5% w/v a.e. In Experiment D glyphosate (MON 0468 formulation, 60% w/v a.e.) solutions of 1%,5% and 10% w/v a.e. were used. In C treatments were applied at the 'milk' and 'soft cheese' stages of development whilst in D they were applied at the 'soft' and 'hard cheese' stages. These stages of development were determined by the seeds in the top spikelets of the inflorescence as these are always the most advanced. All visible inflorescences were treated but untreated inflorescences appearing later were also bagged and the viability of their seed determined. The stage of development of the main inflorescence was used as an indicator for the date of application.

RESULTS

The results of the germination tests on A. fatua seeds from Experiment A are given in full in Table 2. Tables 3, 4 and 5 which relate to Experiments B, C and D respectively, give only the numbers of seeds which germinated and of those which produced healthy plants, expressed as a percentage of the seeds in the original sample. Some of the seeds from untreated inflorescences failed to produce healthy plants either because they contained no caryopsis or because they failed to germinate. The numbers were generally a reflection of the maturity of the inflorescence at harvest.

Table 2

Experiment A: comparison of application during rain with later application when dry

Treatment			Total number of seeds	Seeds with no caryopses	Seeds germinating	Seeds germinating but failing to emerge from soil	Seeds germinating but dying after emergence	Seeds germinating and growing into healthy plants
				All as % of total seed number				
Dalapon	5% w/v	wet	120	57	32	26	3	3
		dry	100	69	2	1	1	0
	10% w/v	wet	130	68	16	9	7	0
		dry	120	82	4	4	0	0
Sodium cacodylate	1% w/v	wet	100	68	4	1	2	1
		dry	100	57	1	0	0	1
	5% w/v	wet	120	62	12	1	2	9
		dry	110	84	0	0	0	0
Control		wet	100	32	50	1	2	47
		dry	100	46	45	1	0	44

Because of the large number of zeros in the results standard errors are not very meaningful and so have not been included in the Tables.

Table 3

Experiment B: comparison of partial and complete treatment of panicles

Treatment		Total number of seeds	Seeds germinating	Seeds germinating and growing into healthy plants
			All as % of total seed number	
Dalapon	5% w/v to half panicle	200	47	17
	to whole panicle	200	46	1
	10% w/v to half panicle	200	63	17
	to whole panicle	200	20	0
Sodium cacodylate	1% w/v to half panicle	200	8	6
	to whole panicle	193	3	0
	5% w/v to half panicle	200	0	0
	to whole panicle	200	0	0
Control		200	89	89

All the herbicidal treatments reduced the numbers of viable seeds which were produced. In general the dalapon treatments allowed the development of a considerable number of seeds which germinated but then died after little further growth. In contrast the sodium cacodylate treatments resulted in the production of a greater proportion of seed which failed to germinate. The few seeds which did germinate however were much more likely to grow into healthy plants.

A typical effect of dalapon was the production of a coleoptile, which emerged from the soil surface, but failed to develop further because either the first leaf was absent or it was unable to break out from the coleoptile. In other instances the first or second leaves were trapped at the leaf bases but ultimately a healthy plant was produced and regarded as such.

The glyphosate treated inflorescences produced relatively few seed which germinated but of these some only developed coleoptiles, and others formed plants which subsequently became chlorotic and ultimately died. The respective types of effects induced by the three herbicides in the different experiments were similar and are therefore only given in full for Experiment A (Table 2). In this experiment, treatments were applied at the 'soft cheese' stage, and the effect of dalapon was reduced somewhat less by rain than that of sodium cacodylate.

In Experiment B (Table 3) the inflorescences were also treated at the 'soft cheese' stage but for maximum effectiveness the dalapon even at 10% concentration had to be applied to the whole inflorescence. In contrast the 5% sodium cacodylate was completely effective when only the upper portion of the inflorescence was treated.

The slightly disappointing results with 10% dalapon in this experiment in 1970 prompted the inclusion of a 15% solution of dalapon in Experiment C in 1971 (Table 4). On this occasion all the treatments (10% and 15% dalapon and 5% sodium cacodylate) at the 'milk' stage of the inflorescences prevented the formation of viable seeds. At the 'soft cheese' stage treatments were only slightly less effective.

Table 4

Experiment C: effect of stage of development and tiller formation

Treatment	Total number of seeds	Seeds germinating	Seeds germinating and growing into healthy plants
		All as % of total seed number	
Dalapon 10% w/v - 'milk' stage			
57 treated panicles	330	2	0
7 untreated panicles	60	63	20
Dalapon 10% w/v - 'soft cheese' stage			
51 treated panicles	380	21	1
5 untreated panicles	25	0	0
Dalapon 15% w/v - 'milk' stage			
47 treated panicles	300	3	0
11 untreated panicles	100	47	32
Dalapon 15% w/v - 'soft cheese' stage			
46 treated panicles	380	14	0.5
3 untreated panicles	27	30	22
Sodium cacodylate 5% w/v - 'milk' stage			
41 treated panicles	310	0.3	0
21 untreated panicles	130	11	9
Sodium cacodylate 5% w/v - 'soft cheese' stage			
61 treated panicles	400	1	0.5
2 untreated panicles	20	10	10
Control - 'milk' stage			
60 'treated' panicles	370	65	65
16 'untreated' panicles	140	58	56
Control - 'soft cheese'stage			
62 'treated' panicles	410	59	57
1 'untreated' panicle	4	0	0

Dalapon treatments applied to the main inflorescences on a plant did not consistently reduce the viability of the seeds produced by untreated later-developing inflorescences on the same plant although symptoms of dalapon toxicity were sometimes seen in the seedlings produced. The 5% sodium cacodylate treatment however appeared to have somewhat more effect on the seed produced by the untreated inflorescences as only 9% and 10% was viable.

Glyphosate in Experiment D was very effective at concentrations of 5% and 10% and even at the 'hard cheese' stage only 1% of the seeds treated with the 5% solution were viable and none survived treatment with the 10% solution. Treatments with the 1% solution indicated that inflorescences at the 'soft cheese' stage were affected more than those at the 'hard cheese' stage.

Table 5

Experiment D: effect of glyphosate in relation to stage of development and tiller formation

Treatment		Number of seeds taken	Seeds germinating	Seeds germinating and growing into healthy plants
			All as % of total seed number	
Glyphosate	1% w/v - 'soft cheese' stage			
	19 treated panicles	150	17	6
	1% w/v - 'hard cheese' stage			
	17 treated panicles	150	25	15
"	5% w/v - 'soft cheese' stage			
	19 treated panicles	160	12	0
	2 untreated panicles	10	0	0
	5% w/v - 'hard cheese' stage			
	19 treated panicles	170	26	1
"	10% w/v - 'soft cheese' stage			
	18 treated panicles	160	7	0
	1 untreated panicle	10	0	0
	10% w/v - 'hard cheese' stage			
	20 treated panicles	150	15	0
Control	- 'soft cheese' stage			
"	20 'treated' panicles	140	49	47
	- 'hard cheese' stage			
	15 'treated' panicles	140	54	51

DISCUSSION

The germination tests were designed to give the seeds the maximum chance of survival. Seeds which failed to germinate and grow into healthy plants in these tests are very unlikely to have done so in the field. An increase in viability under field conditions due to leaching out or breakdown of the herbicide in the seed coat also seems unlikely as the process of dehusking and sterilisation prior to germination in the experiments in all probability removed most of the readily removable herbicide. In addition surface sterilisation of the seed reduced the risks of attack by fun i and bacteria.

Why, in Experiment A, the 1% concentration of sodium cacodylate applied in the rain was more effective than the 5% is inexplicable. The relatively low viability of the seeds from the 'control' inflorescences was probably because early harvest of the cereal crop necessitated the removal of the experimental plants before they were fully mature.

The 10% and 15% solutions of dalapon and the 5% solution of sodium cacodylate, applied at the 'milk' stage in Experiment C prevented the formation of any viable seed by the treated inflorescences but, particularly on the dalapon treated plants, a considerable amount of viable seed was formed by untreated inflorescences which developed on secondary tillers. This was also a problem when the plants were treated at the 'soft cheese' stage. Admittedly a normal cereal crop would be much more competitive than the rather open crop of swedes and kale in which this experiment was situated, and in addition would be harvested considerably earlier, but viable seed from smaller secondary inflorescences must be a risk with these treatments. Glyphosate could not unfortunately be applied to inflorescences at the 'milk' stage as it was not available in time but the 5% and 10% solutions were very effective at the 'soft' and 'hard cheese' stages and no viable seed was set on any secondary untreated tillers though these were few in number. Glyphosate is known to move relatively freely in most plants (Baird et al., 1971) and therefore it seems likely that treatments applied at earlier stages of development will be equally effective. Preliminary results from experiments in 1972 indicate that tiller production is prevented by the earlier treatments. It seems likely therefore that although solutions of both dalapon and sodium cacodylate can very effectively reduce the amount of viable seed produced by *Avena* inflorescences, glyphosate solutions may be even more effective.

One disadvantage of roguing chemically with dalapon or sodium cacodylate is that the treated seed, although non-viable, may appear in the harvested grain. In crops grown for seed this will probably be unacceptable to the seed merchant who expects a sample free of *Avena* seed. The problem does not arise when the panicles are removed physically by conventional roguing. However by using glyphosate prior to the 'milk' stage it may be possible to prevent the development of any caryopses within the seeds, thus making their removal by cleaning relatively easy. This aspect is under investigation in current experiments.

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SELECTIVITY OF NC 8438 BETWEEN RYEGRASS AND WEED GRASS SPECIES

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Summary Four field experiments are described, two of which show that in the autumn doses between 1.1-2.2 kg a.i./ha NC 8438 (2 ethoxy-2,3-dihydro-3,3-dimethyl-5-benzofuranylmethanesulphonate) applied pre-emergence have more effect on Festuca rubra, Poa trivialis and Holcus lanatus than on S23 perennial ryegrass: doses above 2.2 kg a.i./ha damaged ryegrass severely. In the spring NC 8438 at 1-2 kg a.i./ha applied pre-emergence also gave good control of F. rubra in S23 perennial ryegrass in one experiment; in another experiment, also in the spring, 2 kg a.i./ha NC 8438 gave comparable control of Poa trivialis to that given by 0.75-1.5 kg a.i./ha methabenzthiazuron.

INTRODUCTION

Little is known about the rate of Festuca rubra invasion of newly sown pasture but Baker (1962) estimated that about 500,000 acres of lowland pasture was dominated by F. rubra or Festuca ovina. Elliott (1962) stated that there was a need for herbicides with selective toxicity to Festuca species which appeared to have resistance to dalapon and paraquat. This same need was again mentioned by Allen (1968); he stated that red fescue when present in more than trace amounts had increased after spraying dalapon and he implied that until herbicides are available to select against it, sites with this species should be avoided for using this technique of pasture improvement. More recently Morrison and Idle (1972) in their Pilot Survey of grassland state that F. rubra and F. ovina were uncommon in young swards and were characteristic of swards over 9 years old. In the herbicide screening trials at WRO we have been looking for herbicides capable of preventing ingress of such undesirable grasses. Pfeiffer (1969) listed F. rubra at germination as highly susceptible to NC 8438 (2-ethoxy-2,3-dihydro-3,3-dimethyl-5-benzofuranylmethanesulphonate): preliminary greenhouse experiments at WRO confirmed this. The present paper discusses results from several field experiments using this herbicide during seedling establishment.

METHOD AND MATERIALS

All experiments were carried out at Begbroke Hill on a sandy loam over Oxford clay. Normal seed beds were prepared in all cases. In experiment A, 315 kg/ha 13.13.20 compound fertiliser was applied to the seed bed. The area was sown on 22.9.69 with 2 m wide strips of each individual species which were broadcast independently and then harrowed and rolled. Herbicide treatments were applied 1 day after drilling using an Oxford Precision Sprayer fitted with 8002 'Teejets' applying 250 l/ha at 210 kN/m^2. Treatments were applied as a 2 m swath across 4 swards. Each treatment was replicated twice.

Experiment B was carried out as above but sown and sprayed 1 year later on 23.9.70; 380 kg/ha 13.13.20 compound fertiliser was used.

Experiments C and D, on mixed swards sown with two species, were both drilled on 29.4.71 when 380 kg/ha 15.15.21 compound fertiliser was applied to the seedbed. Each grass species was distributed independently over the whole area and then harrowed and rolled. Each plot was 8 x 2 m in a randomised block design with three replicates. Herbicides were applied immediately after drilling using an Oxford Precision Sprayer as for experiments A and B.

All experimental areas were cutover as required to maintain the sward at about 100-150 mm in height. Experiments A and B were assessed by scoring at intervals for bulk of green material on treated as compared to untreated control plots: a score of '0' represented complete kill, '9' as control. Experiments C and D were assessed by random sampling of ten cores of 108 mm diameter from a 2 m^2 area of each plot. The cores were then broken down and individual tillers of the two species counted.

Table 1

Tiller counts of perennial ryegrass and *F. rubra* 10 and 31 weeks after treatment on 29.4.71 (Expt. C)

(each figure is mean of 3 replicates i.e. 30 cores)

	dose kg a.i./ha	assessment: 7.7.71			assessment: 29.11.71		
		Lp.	Fr.	log(x+1)	Lp.	Fr.	log(x+1)
NC 8438	0.5	140	1	0.600	248	24	2.890
NC 8438	1.0	134	2	0.830	264	9	1.100
NC 8438	2.0	124	2	0.900	223	3	0.770
Untreated control		187	97	4.550	174	94	4.540
SE treatment means comparison ±		40.6		0.800	40.6		0.800

Lp = S23 perennial ryegrass
Fr = *Festuca rubra*

RESULTS

The results of experiments A and B are presented in graph form in Figures 1 and 2; these show development of and recovered from NC 8438 effects on four grass species. *H. lanatus* is included in these two preliminary screening experiments and is more susceptible to NC 8438 at 1.12 and 2.24 kg/ha than perennial ryegrass.

Results for experiments C and D are presented in Tables 1 and 2.

DISCUSSION

Figure 1 shows clearly that doses of NC 8438 greater than 2.24 kg/ha had a marked effect on all the species in this experiment. *L. perenne* was however more resistant than the other species. Hence in the following autumn doses below 2.24 kg/ha were examined. In this experiment (Fig. 2) *L. perenne* showed good resistance even at 2.24 kg/ha, the other species being markedly reduced. *F. rubra* was considerably affected by 1.12 kg/ha NC 8438.

In the following spring 0.5 kg/ha NC 8438 gave good initial suppression of *F. rubra* when assessed in July but recovery was apparent by November (Table 1).

Fig. 1

The effect of NC 8438 applied pre-emergence to various grasses on 23.9.69 (Experiment A)

(scored 0-9 for bulk of green material)

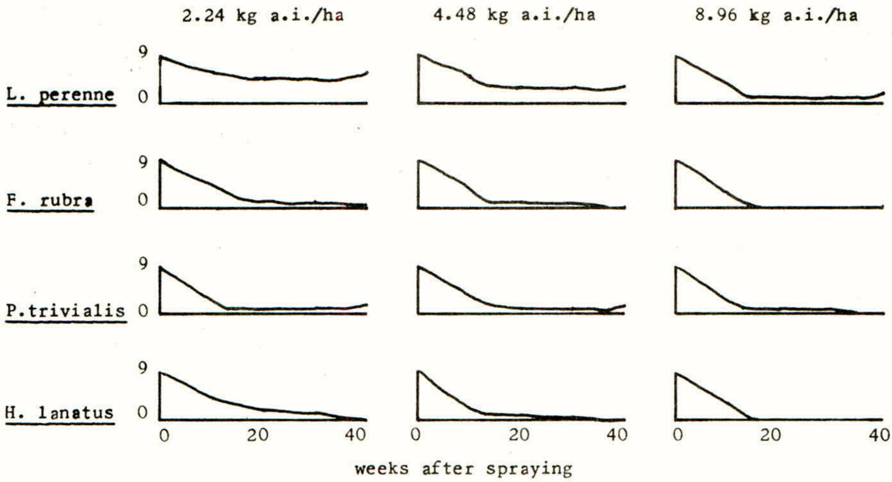

Fig. 2

The effect of NC 8438 applied pre-emergence to various grasses on 23.9.70 (Experiment B)

(scored 0-9 for bulk of green material)

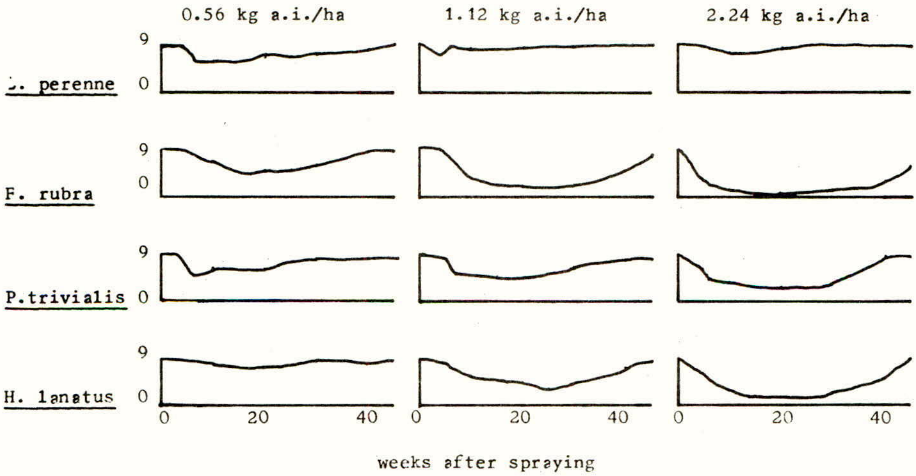

Table 2

Tiller counts of perennial ryegrass and P. trivialis 11 and 32 weeks after treatment on 29.4.71 (Expt. D)

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

	dose kg a.i./ha	assessment: 13.7.71 Lp.	Pt.	log(x+1)	assessment: 2.12.71 Lp.	Pt.	log(x+1)
NC 8438	0.5	297	71	4.273	244	48	3.821
NC 8438	1.0	307	87	4.462	208	67	4.187
NC 8438	2.0	190	8	1.679	179	11	2.434
Methabenzthiazuron	0.75	260	7	2.045	188	15	2.788
Methabenzthiazuron	1.5	215	3	1.155	146	10	2.415
Methabenzthiazuron	3.0	172	0	0.000	140	1	0.366
Untreated control		256	157	5.009	178	72	4.251
SE treatment means comparison ±		44.7		0.430	44.7		0.430
SE control treatment comparison ±		38.7		0.372	38.7		0.372

Lp = S23 perennial ryegrass
Pt = Poa trivialis

1.0 kg/ha gave better lasting control but there were signs of some recovery in November. 2.0 kg/ha gave good lasting control. There were measurable ryegrass reductions in July but by November all treated plots contained more perennial ryegrass than untreated plots. P. trivialis was not quite so well controlled by NC 8438: even at 2 kg/ha there were indications of recovery by December (Table 2). Methabenzthiazuron which was included as a standard gave good control of P. trivialis. The maximum effect caused by 2.24 kg/ha NC 8438 was similar in 1969 and 1970 although there was greater recovery from the 1970 application. Rainfall in both years was well below average.

NC 8438 persists for several months under both greenhouse and field conditions (Pfeiffer 1969, Richardson 1970). This could be advantageous in preventing seedling establishment over a period of time in the grassland context, but more needs to be known about the ingress of F. rubra into perennial ryegrass pasture before this herbicide can be used as a management 'tool' to maintain the sown species. It also has little effect on broad leaved weeds. A possible use might be to prevent seedling ingress of less desirable grasses after dalapon treatment has opened up the sward. More work on these and other aspects is required.

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