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THE CONTROL OF PERENNIAL AND ANNUAL WEEDS IN STRAWBERRIES WITH N-(1,1-DIMETHYLPROPYNYL)-3,5-DICHLOROBENZAMIDE (RH 315)

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Summary Pronamide (RH 315) is a promising new herbicides for the control of perennial grasses in established strawberries. Experiments using doses of 1 to 2 lb a.i./ac have shown that when applied in the autumn it gave good control of Agropyron repens, annual grasses and some annual broad leaved weeds. Control persisted until after harvest. At high doses pronamide was phytotoxic to established strawberries but maiden plants were susceptible to all doses.

INTRODUCTION

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

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

METHOD AND MATERIALS

Pronamide was applied in all cases as a 75% wettable powder in 35 gal/ac without incorporation. The trials were carried out on established strawberries except on Site 5 when the runners had been planted out on September 2nd. There were three replicated small plot trials and two more replicated field strips. All treatments were applied in autumn or winter using a knapsack, or standard tractor mounted sprayer. The mounted sprayer was used at 35 p.s.i.

The following methods of assessment were used:-

Crop vigour - on a 1 - 10 grading where 10 = untreated.
Yield (% control) - obtained by weighing crop from two non-adjacent rows in each plot.
Weed results - as % untreated.

Table 1

Crop variety, application and site details

Site	Variety	Plot size	No. of reps.	Date of Application	Date of Assessment	Soil type
1	Favourite	50 yd^2	2	21.12.68	30.6.69	Sand loam
2	Favourite	5 yd x 40 yd	1	27.10.69	6.6.70	Clay loam
3	Favourite	50 yd^2	3	21. 2.69	23.6.70	Clay loam
4	Royal Sovereign	50 yd^2	3	20.10.69	11.6.70	Loamy fine sand
5	Favourite	5 yd x 40 yd	1	27.10.69	6.6.70	Clay loam

RESULTS

Table 2

The effect of pronamide on strawberries and weeds

Site	Treatment in lb a.i./ac	Crop vigour	Crop yield	Weed Control of % Untreated		
				Agropyron repens	Annual grasses	Broad leaved weeds
1	Pronamide 1.0	10	221	84	100	71
	1.5	10	270	90	100	82
	Simazine 1.0	9.5	170	5	59	93
	Control	8.0	100	-	-	-
2	Pronamide 1.5	10	170	81	100	65
	2.0	7.5	96	95	100	76
	Control	8.0	100	-	-	-
3	Pronamide 1.0	10	-	48	100	48
	2.0	8.5	-	64	100	68
	Simazine 1.0	10	-	11	88	76
	Control	8.0	-	-	-	-
4	Pronamide 1.0	10	-	74	90	60
	1.5	10	-	88	94	78
	2.0	9.0	-	96	94	64
	Simazine 1.0	10	-	14	78	72
	Control	8.0	-	-	-	-
5	Pronamide 1.0	9.0	96	-	97	69
	1.5	7.5	68	-	100	80

DISCUSSION

All the strawberries, apart from those at Site 5, were in their 3rd or 4th year. Control of *Agropyron repens* following autumn applications of pronamide was good and the yields obtained were greatly increased where *Agropyron repens* was satisfactorily controlled. Treatments were applied in the autumn except at Site 3 where it was delayed until February. The weed control at this site was not satisfactory. In established strawberries, crop vigour and, in one trial, yield was reduced at doses above 1.5 lb a.i./ac but at these higher doses the plots were ultimately superior to the controls due to the effect of removing severe weed infestations. In maiden strawberries at Site 5, crop vigour and yield were reduced at both doses. Broad leaved weed control was reasonable, the resistant weeds present being *Senecio vulgaris*, *Matricaria* spp, *Cirsium* spp. and some clover. The herbicide continued to give efficient weed control until after harvest. A mixture of pronamide and another herbicide may be of advantage in extending the broad leaved weed spectrum.

From initial observations, pronamide may also be of use in other soft fruit such as raspberries and blackcurrants. In one unreplicated experiment with raspberries, variety Norfolk Grant, a dose of 1.5 lb a.i./ac gave good *Agropyron repens* control with no apparent injury to the canes. Other promising horticultural uses at present under investigation are in top fruit and ornamentals.

Acknowledgments

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THE PERSISTENCE OF SIMAZINE IN A RANGE OF SOILS IN SELECTED AREAS OF THE UNITED KINGDOM

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Summary The persistence of simazine was tested in a series of twenty experiments on a range of soil types in six regions of England. Bare soil plots were treated with simazine at 2 lb/ac a.i. in spring 1968 and the simazine residue measured in soil samples taken from the treated plots in autumn 1968. Two similar trials were conducted in N. Ireland and two in Scotland.

In all but three of the experiments the residue recovered in autumn was 10% of the applied dose or less. The largest residue (5 oz/ac) was found at Terrington on a silt loam soil in a dry area of England. The results presented confirm that residues from single applications of simazine are unlikely to be a hazard to subsequent crops.

The effect of soil organic matter content on bioassay E.D. 50 values and also the relevance of these E.D. 50 values in assessing the potential hazard from particular levels of simazine remaining in the soils are discussed.

INTRODUCTION

Simazine is used at doses of up to 2 lb/ac for the control of annual weeds in significant proportions of the acreage of fruit, hops and roses, in forest tree and woody ornamental nurseries and plantings. It is also widely used at rather lower doses in the field bean crop. Because of its persistence in the soil the possibility of crop injury from residues of the herbicide has always been apparent. Where the possibility of residual toxicity in the soil is suspected damage has been avoided by restricting its use in perennial crops prior to grubbing and by avoiding growing sensitive crops immediately after a crop in which the herbicide has been used.

Little information on the actual quantity of simazine remaining in soil following its use in Britain has been published. In experiments on uncropped soil at three sites over a three year period Holly and Roberts (1963) found with simazine applied at 1 or 2 lb/ac, the time taken for 80% of the herbicide to disappear varied from 6 to 27 weeks. The time for the disappearance of detectable residues ranged from 12 to 53 weeks. Differences in the period of persistence were far less between the soils used than between different years on the same soil. The longer periods of persistence were recorded in a dry year. On an uncropped sandy loam soil Clay and McKone (1968) reported residues of 2 oz/ac remaining after 8 months from a dose of 2 lb/ac applied in spring which had fallen to 1 oz/ac after 12 months.

Some measurements have been made of residue levels in soil under crops receiving annual applications of simazine over a period of years. In a raspberry soil management experiment where simazine had been applied at 2 lb/ac each spring for 4 years, Clay and Ivens (1966) found only small residues of simazine (2.5 oz/ac) in unmulched soil and even less (1.6 oz/ac) in soil under a straw mulch.

Allott (1969) in experiments in N. Ireland found residues of 4.8 oz/ac in soil under gooseberries 12 months after the last of seven annual applications of simazine at 2 lb/ac. In comparable plots that had received annual dressings of farmyard manure residues were of the order of 1.6 oz/ac. In all the work on end of season simazine residues the simazine was confined to the top 4 in. and was mainly in the 0-2 in. layer.

While available evidence appeared to indicate only a small carry over of simazine from normal commercial doses this was only from a limited number of soil types and geographical areas. To provide confirmation that this degree of breakdown of the chemical could be expected generally it was decided to carry out a series of simple trials on a range of soils in each of eight different regions of the United Kingdom to test the residues remaining on uncropped plots from applications of simazine at 2 lb/ac.

METHOD AND MATERIALS

Selection of sites

Sites were obtained in spring 1968, in six areas (Somerset, Herefordshire, Yorkshire, E. Anglia, Surrey and Kent - see Table 1). Within each area the aim was to find sites on light, medium and heavy land and one distinctive soil type, but it was not always possible to obtain this variety. Because of difficulty in obtaining sites, they were widely separated in some areas leading to some climatic differences. There were two similar experiments in N. Ireland (by D.J. Allott) and two in Scotland (by H.M. Lawson).

The sites were intended to be uniform over the area, free of perennial weeds, away from the influence of hedges and trees and with little or no slope. The land generally was taken over following ploughing and rough cultivation.

Layout and treatments

There were three treatments in each experiment; simazine applied in spring, simazine applied in autumn, both at 2 lb/ac a.i. and a control treatment. Plots sprayed in spring 1968 were retreated in spring 1969 after sampling; only the results of the first treatment are included in this paper.

The experiments were laid out on a randomised block design with four replicates. Plot size was 4 or 5 yd by 1 yd with 1 yd alleys between plots. The number of control plots, used to provide untreated soil for the residue analysis, was reduced to two in some cases where space was restricted.

Plots treated in spring 1968 were worked down to a moderately fine seed bed prior to spraying; the plots treated in autumn 1968 were worked down during the course of the summer. Simazine (50% w.p. formulation) was applied using an Oxford Precision Sprayer at a volume rate of 100 gal/ac. The first site was treated on 26.3.68 and the last on 11.4.68.

Maintenance

The sites were visited at one to two monthly intervals during the growing season, when weed growth on treated and control plots was assessed. Weeds on untreated plots were controlled by spraying with a paraquat and diquat mixture or by cultivation. Any weeds that developed on simazine treated plots were removed by careful handweeding if infrequent or by overall treatment with paraquat and diquat. Perennial weeds were treated with a mixture of 2,4-D and aminotriazole at normal commercial rates once or twice during the growing season as necessary. An experiment at Begbroke Hill indicated that applications of this mixture to plots treated with simazine did not affect the rate of breakdown of simazine.

Soil sampling and processing

Soil samples were taken for simazine determination between 18.10.68 and 11.11.68. The sampling system was the same at each site.

Samples were taken from ten positions selected at random along two lines 9 in. from each long edge of the plot. The points were at least 1 ft 6 in. from each end of the plot and 6 in. apart along the lines. The positions of the sampled points were fixed by means of tagged wires; the same positions were used on each sampled plot at each site.

Samples were taken from the 0-4 in. layer with a 2 1/4 in. diameter modified bulb planter and from 4-6 in. with a 1 in. diameter sampling tube. In some very light soils samples were also taken from the 6-8 in. depth. Control soil was taken in the same way but with two or three cores at each position to give an adequate quantity of soil for the simazine analysis. Holes on all plots were filled in with untreated soil. Samples from each plot were bulked and placed in polythene bags for transport. When received at WRO the samples were laid out to dry as soon as possible, sieved through 1/4 in. mesh during the drying period, mixed thoroughly and then stored air dry in polythene bags at room temperature to await analysis.

Determination of simazine residues

The amount of simazine in the samples was determined using a bioassay method based on that described by Holly and Roberts (1963) but using turnip (cv. Green Globe) as the test plant. Using this method an E.D. 50 value (dose of simazine causing 50% growth reduction) was determined for each soil at the time of the assay which was used to calculate the quantity of simazine present in the samples.

Soil analysis

Soil from each site was analysed by the National Agricultural Advisory Service Soil Science Laboratory at Cambridge; pH, organic matter content, density and moisture retention were measured and the soils classified texturally. The organic matter determination was by a wet oxidation method.

RESULTS

The results of the bioassay determinations and the soil analytical date for each site are presented in Table 1. Samples from each replicate plot were analysed separately but the mean of the four replicates is given in the table. Generally variations between replicates were only small.

The E.D. 50 values show considerable differences from soil to soil, the variations being generally closely related to the differences in organic matter content. The residue data from this first sampling date indicates the breakdown of most of the simazine in the seven months following spring treatment. The maximum residue recorded (at Terrington) was 16% of the applied dose and only at two others (Worplesdon and Glastonbury) was over 10% recovered. Only at two sites (Kings Lynn and Merrist Wood) where the soil was very sandy were residues detected below 4 in. depth. Where a non-detectable residue is recorded in the table any residue present would be less than the E.D. 50 value for that soil.

Table 1

Soil characteristics and simazine residues recovered (oz/ac) in the autumn 1968 sampling, 7 months after spraying

Location: Area	Location: Site	Soil characteristics: pH	Organic matter (%)	Textural class	ED 50 value (oz/ac)	Residue (oz/ac)
E.Anglia	Terrington	7.5	2.5	ZL	1.0	5.1
	Kings Lynn	7.6	1.3	CS	0.5	1.0x
	Kirton (Lincs)	7.7	2.7	VFSL	1.1	3.0
Yorks	Cottingham	7.2	7.5	SL	2.9	TR+
	Cawood	5.4	1.9	LCS	1.1	1.0
	Shepley	6.5	5.6	ZyL	2.1	ND
Surrey	Woking	5.8	2.4	Org. Sand	6.0*	ND
	Worplesdon	6.9	3.6	LFS	1.1	3.2
	Merrist Wood	7.5	1.9	LS (gritty)	0.8	2.4x
	Effingham	7.7	4.9	Calc L	1.0	0.8
Kent	Wye	7.2	6.1	Calc FSL	2.6	ND
	Faversham	7.4	3.3	VFSL	0.8	1.9
	Hadlow	7.0	2.6	VFSL	1.1	ND
Hereford	Tillington	6.2	2.7	VFSL	1.0	ND
	Kings Acre	7.5	2.7	FSL (gritty)	1.0	1.6
	Much Birch	6.3	2.0	FSL	1.0	ND
Somerset	Cheddar	5.8	6.4	ZL	1.9	ND
	Glastonbury	7.6	7.0	ZyCL	2.1	3.5
	South Petherton	6.0	2.5	LVFS	0.6	ND
	Bishops Lydeard	7.5	2.2	LFS	1.1	1.1
N.Ireland	Loughgall	7.1	3.5	FSL	1.3	1.9
	Crossnacreeve	5.8	7.5	VFSL	3.0*	ND
Scotland	Ayr	-	-	-	1.9	ND
	Dundee	6.9	4.7	FSL	2.2	ND

Key to soil textural classes

S - Sand
Z - Silt
Zy - Silty
CS - Coarse sand
C - Clay
L - Loam
F - Fine
VF - Very fine
Calc- Calcareous
Org.- Organic

ND No detectable residue
* Value estimated from subsequent assays.
\+ Trace residue present.
x Trace residue present in 4-6 in. layer.

DISCUSSION

The result of the residue determinations presented in Table 1 confirm that the amount of simazine persisting in autumn following spring treatment is low, being generally less than 10% of the applied dose. This held true for a range of light and medium soils over the whole of the country. There were clear differences between sites but any attempt to establish firm correlations between persistence and soil and climatic factors must await the results from the later sampling dates and the analysis of the meteorogical data. A distinctly greater residue (5 oz/ac) than anywhere else was recorded at Terrington in a low rainfall area and on a relatively heavy soil.

The result from Cottingham and a number of the soils with a high orgainc matter content illustrates the reduced sensitivity of the bioassay method in such soils. The actual residues in these soils may well have been measurable if samples had been taken from the 0–2 in. layer only, where the major part of the simazine persists.

The variation in E.D. 50 values for the various soils indicates that the possibility of crop injury from a particular level of simazine residue has to be interpreted in relation to soil organic matter content.

In view of this, assessment of residual toxicity by means of planting over the plots test crops of varying sensitivity to simazine (e.g. Hauser and Switzer, 1960) might appear to be a more useful method. This would, however, have been difficult to effect on a large scale and the results from such tests are affected by weather conditions in the early growing period of the test crop (Buchholtz, 1965).

The preliminary results from these experiments are reassuring in that, in all but one, only small residues of simazine were found and it would not be expected that such residues would cause any injury to subsequent crops following normal cultivations.

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THE EFFECT OF BARLEY POPULATION AND ROW WIDTH ON THE GROWTH OF AVENA FATUA, WILD OAT

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Summary In an experiment to ascertain the reaction of A. fatua to competition from spring barley, 30 seeds/yd^2 of A. fatua were pre-germinated and sown either within or between rows of spring barley planted 4 and 8 in. apart, and at seed rates of 84 and 168 lb/ac. From a series of assessments made during the growth of crop and weed, it was found that the effects of the weed on the crop were minor compared with those of the crop on the weed.

A. fatua plants within the rows did not grow so well as those planted between the rows: this difference was intensified by the use of 8 in. rows. The cumulative result of the competitive effects was a threefold difference in the average number of seeds formed on each Avena plant. There were 35 seeds/plant with 168 lb/ac seed and a row width of 8 in. (A fatua within rows) as against 108 seeds/plant at 84 lb/ac seed and a row width of 8 in. (A. fatua between rows).

INTRODUCTION

Avena fatua, the spring germinating wild oat appears to be increasingly abundant in the cereal fields of Britain and there is concern at the spread of the weed. A great deal of research is in progress at the Weed Research Organization (WRO) and elsewhere to develop improved methods of control. The experiment that is reported is part of a complementary programme of biological, herbicidal and agronomic research in progress at WRO with this object in view.

However well a weed may appear to survive and flourish in a crop, it is often the case that the crop has a marked influence on its growth. Small and inexpensive changes in the way a crop is grown may beneficially reduce the weed's performance. Selective herbicides, and particularly the herbicide barban rely on crop competition to continue their suppressive effect. For these reasons a knowledge of a weed's reaction to the crop is important to an achievement of improved control, particularly is this so in respect of A. fatua growing in cereals.

* The experiment was carried out when attached to the Weed Research Organization.

METHOD AND MATERIALS

The experiment was carried out at Begbroke Hill during the period March - July 1969 on a deep sandy loam soil. Spring barley (cv. Zephyr) was sown by a conventional farm drill in different ways (as indicated below) into a seedbed that had previosuly received 3½ cwt/ac of a complete fertiliser (N 20%, P_2O_5 10% and K_2O 10%). The barley was sown on 20th March.

Before sowing, the seeds of A. fatua were pricked, soaked and repricked to break dormancy. They were then placed on wet paper at 20°C to germinate. As soon as germination was evident the seeds were transferred to an aqueous gel made from sodium alginate and were sown. The plot-size for A. fatua was 1 yd^2 into which were planted 30 seeds equi-distant apart, the central 12 plants being used for assessment. Each block was randomised and there were 4 replicates.

Details of treatments

Treatment no.	Barley seed rate lb/ac	Row width	Wild oat position relative to barley rows
1	84 (L)	4 (4)	between (B)
2	84	4	within (W)
3	84	8 (8)	between
4	84	8	within
5	168 (H)	4	between
6	168	4	within
7	168	8	between
8	168	8	within

The whole area was sprayed with a selective herbicide containing ioxynil and mecoprop for broad-leaved weed control at a time appropriate to the growth state of the barley.

Assessments

From emergence to the maturity of the crop and weed, assessments were made of the growth of each at frequent intervals. Each assessment included aspects of growth relevant to the particular time; the first being of tiller and leaf numbers and of plant height, while the final assessment was on plant height, numbers of panicles/plant and seeds/panicle, and dry weight of stem and panicle.

The dates of assessment were:

1. 14th - 21st May
2. 28th May - 2nd June
3. 30th June - 9th July
4. 14th - 18th July (final)

Much more data was obtained than can be included in this report. The figures that are included have been selected to show the trend of events.

RESULTS

The growth of the barley

The two seed rates of 84 and 168 lb/ac resulted in the emergence of mean populations of 209 and 390 plants/yd^2 respectively. The addition of 30 plants/yd^2 of

A. fatua did not, therefore, alter substantially the total number of mono-cotyledonous plants present on the plots.

An indication of the tiller and stem production of the barley can be obtained from the counts made at the time of the first and third assessments which occurred in May and early July (table 1). In the same table are the mean weights of barley stem and head per plant and per yd^2 at the final assessment on about 17th July.

Table 1 Spring barley

Means for each treatment

Treatment	Live stems/plant at assessment: 1 (May)	3 (June/July)	Total weight of stem and head in gm at final assessment (July) Per plant	per yd^2*
1. L.4.B.	2.8	2.9	3.56	469
2. L.4.W.	3.1	3.0	3.79	454
3. L.8.B.	2.9	3.2	3.73	480
4. L.8.W.	2.8	2.4	3.59	490
5. H.4.B.	2.6	2.6	3.00	586
6. H.4.W.	2.8	2.5	2.33	514
7. H.8.B.	2.5	2.4	2.45	505
8. H.8.W.	2.3	3.1	2.30	441
S.E. ±	0.21	0.28	0.25	

* calculated by multiplication of wt/plant by mean population.

The assessments show that the number of live stems/plant was approximately similar on all the treatments at each of the two dates. However, if allowance is made for the two different populations of barley it will be appreciated that the total stem density was much higher on the high seed rate plots. Confirmation of the greater quantity of barley on these plots is provided by the final assessment in July which indicated a greater difference in total barley plant material due to seed rate than to row width. The overall means for yield of barley dry matter were:

Low seed rate	424 gm/yd^2
High seed rate	511 "
4 in. rows	506 "
8 in. rows	480 "
Weed between rows	510 "
" within rows	475
S.E.	± 19.5

The figures indicate that of the 3 main factors in the experiment seed rate was the most important in contributing to total barley vegetation.

The growth of A. fatua

Since the number of plants of Avena was much less than that of the barley it was expected that the weed would be much affected by barley competition as varied by changes in seed rate, row width etc.

Table 2 A. fatua

Means for each treatment

Treatment	Tillers/plant at assessment May	June	at final assessment panicles/ plant	seeds/ panicle	Seeds/yd^2**
1. L.4.B.	1.0	0.8	1.06	53.8	1706
2. L.4.W.	1.1	1.1	1.13	69.5	2483
3. L.8.B.	1.9	1.6	1.19	91.0	3342
4. L.8.W.	1.9	1.1	1.04	76.0	2488
5. H.4.B.	0.9	0.4	1.00	30.5	915
6. H.4.W	0.5	0.4	1.07	41.0	1310
7. H.8.B.	1.4	1.1	1.00	50.0	1500
8. H.8.W	0.7	0.6	1.02	34.8	1066
S.E. ±	0.17	0.16	0.06	8.4	430

** Calculated on the basis of 30 plants/yd^2 of A. fatua.

Many other detailed assessments were made of the growth of A. fatua which cannot be included due to limitations of space.

The results indicate that competition affected some attributes of growth more than others. For example, plant numbers and height were altered little; but tiller, panicle, and seed numbers were significantly altered by barley competition: these have been included in table 2.

Differences in tiller production were observed during the first assessment in mid-May and these continued until the beginning of July. At the third assessment the mean numbers of tillers per 12 wild oat plants were:

	4 in. rows	8 in.	between rows	within
Seed rate low	11.6	16.4	14.6	13.4
Seed rate high	5.0	10.3	9.5	5.8
Weed located between rows	7.8	16.4		
Weed located within rows	8.9	10.3		

S. E. ± 1.37

In general, more tillering occurred at the low seed rate than at the high: A. fatua plants between the rows tillered more than did those within the rows, but this latter result was modified by row width. A location of the weed between 8 in. rows (as compared with within the row) encouraged tillering more than placement between 4 in. rows. In June the most abundant tillering (1.6 tillers/plant) was on A. fatua plants between 8 in. rows at the low seed rate; while the least was associated with 4 in. rows at the high seed rate. Success in tillering set the pattern for the production of panicles; the contrasting treatments mentioned above represented the most and least panicles/plant (1.19 and 1.00 respectively) though these differences were very small. They also accounted for the extremes of seed numbers/panicle and therefore of seed produced/yd^2 (3342 and 915 respectively). Within these extremes panicle and seed production followed closely the competitive reaction described for tiller production. Barley seed rate was the major factor influencing differences in A. fatua seeds/yd^2 (overall means of 2505 and 1198 for low and high barley seed rates respectively) while a lesser difference resulted from row width (1603 and 2099 for 4 and 8 in. rows respectively).

DISCUSSION

The results confirm that crop competition can be an important contributor to the suppression of A. fatua and that the way the crop is grown can affect the extent of the suppression. Of the factors considered in this experiment two (seed rate and row width) can be controlled by a farmer, while the third (position of A. fatua relative to the rows) cannot in a barley crop. Since the weed's success in vegetative growth appeared to dictate the abundance of seed set and therefore shed onto the ground in a normal barley crop (Wilson, 1970), the way in which the crop is grown in one year could be expected to influence the numbers of A. fatua seedlings appearing in subsequent cereal crops.

The most abundant growth and seed set resulted from plants growing between 8 in. rows at the low seed rate. It seems reasonable to suggest that this success arose from the paucity of early competition provided by the crop. In contrast the two lowest figures for seed set were associated with the high seed rate and 4 in. rows; and this crop situation would be the one expected to provide vigorous and early canopy of barley foliage that would compete with the weed. The later growth of the barley as indicated by the weight of material harvested in July would not appear to have been sufficiently different (441 - 586 gm/yd^2) to cause the large differences in seed set.

The various assessments of A. fatua showed that the biggest difference due to treatment occurred in the number of seeds/panicle, and there were only minor differences in panicles/plant. In view of this it might be suggested that panicle/unit area may be a good indicator of the relative numbers of Avena plants present but is a poor indicator of the seed set and therefore of the seed passing into the soil to infest the next crop. Assessment of seeds/panicle coupled with panicles/unit area would be a much better indicator of the weeds performance than the latter assessment used alone.

Acknowledgments

The authors wish to acknowledge with thanks the assistance of many members of the staff of the Weed Research Organization.

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Proc. 10th Br. Weed Control Conf. 1970

STUDIES OF THE SHEDDING OF SEED OF AVENA FATUA IN VARIOUS CEREAL CROPS AND THE PRESENCE OF THIS SEED IN THE HARVESTED MATERIAL

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Summary Straw derived from wild oat infested crops was found to contain seeds of *Avena fatua* in varying quantities. All the bales examined were contaminated to some extent. The density of infestation and the shedding of *A. fatua* were examined before harvest in both winter and spring cereal crops. The degree of shedding at the time of harvest was related to the contamination of the straw. Where large numbers of seed were present on the panicles at harvest, many thousands of seed were found in each straw bale; where 99% of the seed had shed at harvest, approximately 100 seeds were recovered from each bale.

INTRODUCTION

Despite the increasing use of herbicides for the control of *Avena fatua*, this weed continues to be a major problem in cereal crops. Surveys of the incidence of *A. fatua* in England and Wales, (Thurston 1954, Pfeiffer 1968), indicate that it is spreading into areas of the country which were previously uncontaminated. The fact that new infestations are arising implies that seed of *A. fatua* is being transported from infested to clean areas. The means by which this seed is transported is of obvious importance and it is likely that the produce harvested from an infested crop will contain seeds of *A. fatua*. These seeds may give rise to new infestations if this material is transported to uncontaminated areas.

This report describes the examination of straw for the presence of *A. fatua* seed and of the factors which can affect the quantity of seed present in the straw. The level of infestation before harvest and the proportion of *A. fatua* seed which had shed at the time of harvesting were recorded.

METHOD AND MATERIALS

Studies were carried out during the three years 1968-70 in various cereal crops. The majority of these crops were located at Boxworth Experimental Husbandry Farm. In 1968 a study of the wild oat infestation and shedding was carried out in two crops prior to harvest; in 1969 and 1970 similar studies were followed by the examination of the straw after harvest for the presence of wild oat seed.

1968 A crop of winter wheat and one of spring barley heavily infested with *A. fatua*, were selected in July at Boxworth. Two small areas, each 2 yd x 2 yd, were selected within each crop before the *A. fatua* had commenced shedding seed. Within each area, 20 panicles were selected at random and labelled and the panicles categorised into large medium and small. The seeds present on each panicle were counted at weekly intervals from 26th July until 30th August, when both crops were harvested. The density of large, medium and small panicles was obtained by counting every panicle within an adjacent, similarly infested, area of 3 yd^2.

1969 As in the previous year a crop of winter wheat and one of spring barley were selected at Boxworth. The degree of infestation was less than in 1968. In each crop a uniformly infested strip 30 yd x 4 yd was marked out, and at each end of the strip twenty panicles were selected at random and labelled. The total number of panicles was counted in an area of 60 yd^2 within each strip. On each labelled panicle the seeds were counted on 24th July before shedding commenced, on 7th August and again on 25th August just prior to harvesting. The strip was then combine harvested and the straw baled.

The straw bales were subsequently examined for their content of *A. fatua* seed. Each bale was shaken apart and the long straw carefully removed. Short straws, awns, barley and wild oat seeds were then sieved and blown to remove most of the straws and the lighter material, leaving the seeds for final counting.

1970 Three crops infested with *A. fatua* were studied. These were a winter barley and a spring barley crop at Boxworth and a winter barley crop near Oxford. In each case small areas, approximately 0.025 ac of uniform infestation were selected before shedding had commenced. Within each area, three small groups each of ten panicles were selected at random and the panicles labelled. The seeds on each were counted, initially before shedding and finally at the time of harvest. The average density of panicles was obtained by counting all panicles in adjacent areas.

After the crops on each area were harvested, the straw was baled and the bales subsequently examined for *A. fatua* seed as in 1969. In some cases large numbers of seed were recovered; here the total seed was weighed, sub-sampled for counting, and an estimate of the total number of *A. fatua* seed obtained.

RESULTS

1968

Table 1

A.fatua-seeds/panicle

		July 26th	August 1st	9th	16th	23rd	30th
WINTER WHEAT	Large panicles	172	142	91	35	10	7
	Medium "	114	104	78	28	7	5
	Small "	42	40	31	14	6	5
SPRING BARLEY	Large panicles	207	222	224	197	148	122
	Medium "	141	151	141	139	107	81
	Small "	39	46	47	45	41	39

Table 2

A. fatua - Density of panicles and of seed

		Panicles/yd²	Seeds/yd² July 26th	Seeds/yd² August 9th	Seeds/yd² August 30th
WINTER WHEAT	Large panicles	16	2,852		112
	Medium "	23	2,622		115
	Small "	17	714		85
	Total	56	6,188		312
SPRING BARLEY	Large panicles	9		2,016	1,098
	Medium "	17		2,567	1,377
	Small "	9		423	351
	Total	35		5,006	2,826

Table 1 shows the average number of A. fatua seeds present on each panicle at different dates during the period of seed shedding before the crops were harvested. Table 2 shows the densities of panicles, from which the number of seeds per yd^2 were derived. The seed densities before shedding commenced, and at the time of harvest are also shown.

Wild oats in the winter wheat commenced shedding seed at the end of July and 95% of the seed had shed by the end of August when the crop was harvested. In the barley shedding commenced between the 9th and 16th August, and 44% of the seed had shed when the crop was harvested at the end of the month. Actual numbers of seed shed were calculated at 5,876/yd^2 in the wheat and 2,180/yd^2 in the barley at the time of harvest. The majority of the wild oat seed was shed from the large and medium size panicles and only 10% of the shed seed in the wheat and 3% in the barley came from the small panicles. The smaller panicles appeared to ripen later and probably arose from later germinating plants of A. fatua; although the small panicles had less seed initially, proportionately less was shed from them than from the larger panicles.

Table 3

1969

A. fatua seeds/panicle and density

	Panicles/yd²	July 24th	August 7th	August 25th
		Seeds/panicle		
Winter wheat		63	12	0.6
Spring barley		71	51	4
		Seeds/yd²		
Winter wheat	7.2	454	86	4
Spring barley	5.4	383	275	22

The 1969 results are shown in table 3. The intermediate count on 7th August indicated that wild oats had commenced shedding earlier in the winter wheat than in the spring barley. The final count on 25th August at the time the crops were harvested showed that the majority of seed had shed in both crops, 99% of the wild oats had shed in the wheat and 94% in the barley.

The straw from the strips yielded 2.5 bales of barley and 4 bales of wheat straw. The wild oat seeds recovered from these bales totalled 256 from the barley and 427 from the wheat bales, averaging just over 100 seeds/bale.

Table 4

A. fatua seeds/panicle and density

1970		June 30th	July 17th	July 21st	August 3rd	August 18th
			Seeds/panicle			
Oxford winter barley		185	156 - crop harvested			
Boxworth winter barley				81	19-crop harvested	
Boxworth spring barley				126	65	7-crop harvested
	Panicles/yd^2			Seeds/yd^2		
Oxford winter barley	31.4	5,804	4,894			
Boxworth winter barley	28.8			2,333	547	
Boxworth spring barley	9.2			1,159	598	64

The 1970 results are shown in table 4. The wild oats in the winter barley at Oxford contained many large panicles which ripened early and seed shedding commenced during the second week of July. The barley matured early and was harvested on 17th July when relatively few wild oats had shed and an average of 156 seeds were still present on each panicle. This was equivalent to a calculated 4,894 seeds of A. fatua being harvested with every yd^2 of crop.

The winter barley at Boxworth contained wild oats with smaller panicles than those at Oxford. The crop matured later and was harvested when a higher proportion of wild oat seed had shed to the ground. It was estimated that 547 seeds were harvested with every yd^2 of crop.

The spring barley at Boxworth was harvested a fortnight later than the winter barley. There were fewer wild oats initially and 99% of the seed had shed when the crop was harvested, with an estimated 64 seeds harvested with each yd^2 of crop.

Table 5 shows the numbers of A. fatua seeds recovered from three bales at each of the three sites. Large numbers were found in the Oxford winter barley where one bale contained over 19,000 seeds. Fewer were present at Boxworth in the winter barley and least of all in the spring barley. Numbers are expressed per lb of straw because of the variation in the weight of the bales.

Table 5

A. fatua seeds recovered from the straw of 3 bales of three crops-1970

	Wt.bale lb	Seeds recovered	Seeds recovered/lb straw
Oxford winter barley	46	19,360	304
	38	8,800	
	31	6,800	
Boxworth winter barley	35	1,190	28
	34	1,250	
	31	400	
Boxworth spring barley	47	248	4
	40	156	
	12	26	

DISCUSSION

The most striking feature of these results is that wild oats were recovered from every bale of straw examined. The numbers of seed recovered were related to the numbers of seed harvested with the crop. Where large numbers of seed passed through the combine with the crop, as with the Oxford winter barley, many thousands of seed were recovered in each bale, even though it appeared at the time of harvest that the majority of seed had passed intc the grain. The straw upon first inspection in the swathe was relatively free from seed. Perhaps of more significance was the fact that with low infestations or where 99% or more of the wild oats had shed when the crops were harvested, (1969 or 1970 Boxworth spring barleys), 100 or more wild oats were still to be found in each bale. A bale of straw originates from a relatively large area of crop which, even with low infestations, is likely to contain many panicles. An average yield of barley straw of 1 ton/ac would result in approximately 70 bales/ac, so that each bale would consist of straw from about 70 yd^2 of crop. From this area, even where 99% of the seed had shed, as in the winter wheat in 1969, and there remain only 4 wild oat seeds for every yd^2 of crop, there would still be approximately 280 wild oat seeds harvested and capable of contaminating each bale of straw.

The 1968 results illustrate the large variation in the size and seed content of the wild oat panicles that can be found within a single crop. The small panicles below the level of the crop tended to shed seed later, presumably because they originated from later germinating plants.

It is interesting that the onset of shedding is earlier with the early maturing winter crops than with the later spring crops, and the ripening of the crops and weed tend to be associated. Shedding commenced about mid July with winter crops and during the last week in July or in early August with spring barley. The duration of shedding must largely depend on weather conditions and is likely to be shorter under dry conditions which advance the ripening of both the crop and the weed. In these studies the majority of the seed had shed within 3 to 4 weeks from the time that shedding commenced.

These studies illustrate the large quantities of A. fatua seed that can be returned to the soil for subsequent re-infestation. Figures of 1000-6000 seed/yd^2 are common with only moderate infestations. A large proportion of this seed can be prevented from reaching the soil if the crop ripens early and is harvested before the majority of wild oat seed have shed. This was the case with the winter barley at Oxford in 1970 where 84% of the total wild oat seed produced was harvested with the crop. Although each bale of straw was found to contain many thousands of seed, the majority of the total seed either passed into the grain or was returned to the stubble. For each pound of straw sampled an average of 304 seeds were recovered. The straw was estimated to yield 1 ton/ac, equivalent to 1 lb/2.16 yd^2, so that the straw derived from each yd^2 of crop would contain 141 seeds. Each yd^2 of crop when harvested was estimated to contain 4,894 seeds, so that 4,753 (4,894-141) either were taken off in the grain or were passed out of the combine to remain on the ground. After the straw was baled, wild oats were counted on the ground where the swathes had laid and were present at an average density of 2,250/yd^2. These consisted of wild oats shed before harvest (910/yd^2, see table 4) and wild oats harvested with the crop and passed to the ground via the combine, 1,340 (2,250-910). Thus the wild oats removed with the grain must have amounted to 3,413 (4,753-1,340)/ yd^2 of the harvested crop. These figures show that of the total A. fatua seed produced, 59% were removed with the grain, 39% reached the ground and 2% were removed with the straw. This was an unusually high proportion to be removed with the grain and was due largely to the early harvest date. More often the majority of seed is shed to the ground before harvest as was the case at the two Boxworth sites in 1970. Here, calculations as above show that with the winter barley 0.6% and with the spring barley 0.2% of the wild oat seeds originally present were recovered in the straw bales.

The wild oat seeds recovered from the bales appeared normal, and it is unlikely that their viability was affected as a result of being harvested and baled with the crops.

It seems inevitable that straw, baled from wild oat infested crops, is likely to be contaminated with wild oat seed. Even low infestations, where the majority of seed has shed before harvesting, are likely to result in straw containing wild oats capable of acting as a source of infestation if transported to a wild oat free part of the country.

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THE TOLERANCE OF TRI-ALLATE BY WINTER WHEAT

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Summary Grain yields of winter wheat (Cappelle Desprez) were not significantly affected by 5% or 10% w/w tri-allate on 24/48 mesh attapulgite granules at doses of 2 or 4 lb a.i./ac, applied to the soil surface either (i) immediately after drilling, (ii) when the crop had 4-5 leaves or (iii) when the crop had 6-7 leaves. 2 lb a.i./ac of 5% or 10% tri-allate granules mixed with the soil to a depth of 2 in. immediately before drilling winter wheat (Cappelle Desprez) reduced the plant density by 50% but had no significant effect on the ultimate grain yield. 4 lb a.i./ac of 10% tri-allate granules applied to the soil surface either immediately after drilling or when the crops had 6-7 leaves did not significantly reduce the grain yield of the cultivars Cappelle Desprez, Maris Ranger, Champlein or Joss Cambier. It is suggested that tri-allate granules should not be mixed with the soil just prior to drilling if crop damage is to be avoided under all conditions.

INTRODUCTION

Experiments to investigate factors influencing the toxicity of granular formulations of tri-allate to *Avena fatua* and *A. ludoviciana* in wheat and barley crops were begun in 1968 and a report on this work was given to the last conference (Holroyd, 1968).

In the autumn of 1968 experiments were also begun to investigate some of the factors influencing the toxicity of tri-allate granules to winter wheat. Relatively clean crops, with no *Avena* spp., were used so that results would not be confused by weed competition. Knowledge of the factors under which tri-allate is most likely to cause crop damage should enable its selective toxicity to *Avena* spp. to be fully exploited.

The following, were the main factors investigated in the three experiments described in this paper:

Experiment A: dose of herbicide, concentration of herbicide in the granule, and stage of growth of the crop at the time of treatment;

Experiment B: susceptibility of four cultivars of winter wheat to a relatively high dose of tri-allate granules applied either pre-emergence or relatively late post-emergence;

Experiment C: concentration of herbicide in the granule and the position of the granule in relation to the crop seed.

METHOD AND MATERIALS

All three experiments were at the ARC Weed Research Organization on a sandy loam soil in which most soil acting herbicides are relatively active. Normal cultivations were used to prepare the land before drilling except that special care was taken to ensure that the final seedbed was level and even. For the final cultivations a Rau-Kombi Crumbler mounted on a tractor fitted with cage wheels was used. A standard rate of 1.5 cwt/ac of 9.25.25 fertilizer was applied before drilling and the crops were top-dressed with 2 cwt/ac of nitrogenous fertilizer (52 units of N) in the spring. The granular tri-allate, formulated on 24/48 mesh attapulgite, was applied by a Horstine Farmery tractor-mounted Airflow Distributor (model TMA-4) in a 16 ft swathe. Control plots were also wheelmarked at the time of applying the various treatments.

Details of the winter wheat cultivar, date and type of tri-allate treatment, stage of growth of the crop and soil conditions are given in Table 1.

In experiment C only the pre-drilling treatments were mixed with the soil. A Rau-Kombi Crumbler working to a depth of 2 in. was used to do this. In experiments A and C plot size was 16 x 90 ft and in experiment B 12 x 90 ft. Observations were made at intervals throughout the experiments. In experiment B samples of plants were excavated during March to determine the depth of drilling in these areas, and in experiment C plant density was assessed by counting the number of plants in 20 x 1 ft lengths of row on each plot on 21/3/69.

Table 1

Expt.	Crop cultivar and date of drilling	Treatment Type	Treatment Date	Stage of growth	Soil surface conditions
A	Cappelle Desprez 11/11/68	5 & 10% granules surface	13/11/68	pre-emergence	moist
		"	1/ 4/69	4-5 leaves	dry
		"	30/ 4/69	6-7 leaves	dry
B	Cappelle Desprez Maris Ranger Champlein Joss Cambier 11/11/68	10% granules surface	13/11/68	pre-emergence	moist
			30/ 4/69	5-6 leaves	dry
C	Cappelle Desprez 18/11/68	5 & 10% granules & emulsion surface + mixed in	18/11/68	pre-drilling	moist
			19/11/68	post drilling	moist

RESULTS

Tables 2 and 3 give the yields of grain in cwt/ac corrected to 85% dry matter from experiments A and B and Table 4 gives the plant density counts and yields of grain from experiment C.

The analysis of variance of the grain yields from Experiment A showed that there was a significant difference between the block yields due to an outbreak of Eyespot (<u>Cercosporella herpotrichoides</u>) which was localised in one of the blocks, but no other differences were statistically significant. The only other factor which approached significance at the 5% level was the date of treatment which also showed in the control yields and was presumably due to wheelmarking at a late date.

Table 2

Experiment A The influence of dose of tri-allate, granular concentration and time of treatment

Grain yields in cwt/ac corrected to 85% dry matter

Treatment	dose lb a.i./ac	Time of treatment and stage of growth: Pre-emergence 13/11/68	4 - 5 main stem leaves 1/4/69	6 - 7 main stem leaves 30/4/69	Mean
Control	0	38.8	38.1	36.6	37.8
tri-allate 5% w/w gran	2	39.7	37.7	37.0	38.1
	4	37.7	38.2	35.7	37.2
			S.E.± 1.74		S.E.± 1.01
Mean		38.7	37.9	36.3	37.6
			S.E.± 1.24		
tri-allate 10% w/w gran	2	38.9	38.2	35.8	37.6
	4	38.7	37.9	37.5	38.0
			S.E.± 1.74		S.E.± 1.01
Mean		38.8	38.1	36.7	37.8
			S.E.± 1.24		
tri-allate Mean of 5% and 10%	2	39.3	37.9	36.4	37.9
	4	38.2	38.0	36.6	37.6
			S.E.± 1.24		S.E.± 0.71
Mean		38.7	38.0	36.5	37.7
			S.E.± 0.87		

Table 3

Experiment B The influence of wheat cultivar and time of treatment

Grain yields in cwt/ac corrected to 85% dry matter

Wheat cultivar	dose of tri-allate in 10% granules lb a.i./ac	Time of treatment: Pre-emergence 13/11/69		Post emergence 5-6 main stem leaves 30/4/69	Mean
Cappelle Desprez	0	45.6		44.0	44.8
	4	41.0		44.2	42.6
Maris Ranger	0	43.7		43.1	43.4
	4	42.8		45.1	44.0
Champlein	0	46.9		44.6	45.7
	4	41.8		44.9	43.3
Joss Cambier	0	45.8		48.7	47.3
	4	45.0		47.5	46.2
			S.E.± 1.94		S.E.± 1.37
Mean cultivars	0	45.5		45.1	45.3
	4	42.6		45.4	44.1
			S.E.± 0.97		S.E.± 0.69

Analysis of variance of the data in Table 3 again showed that none of the differences were significant, although the interaction between dose of herbicide and time of treatment approached significance at the 5% level suggesting that the post emergence treatments were safer. The data also suggested that the cvs. Cappelle and Champlein might be more susceptible to the pre-emergence treatment than the other two cultivars but this would require substantiation in further experiments. Analysis of the data in Table 4 showed that the plant counts on the plots treated by mixing the tri-allate granules with the soil before drilling were very significantly less than those on the other plots, the populations being almost halved. The grain yields at harvest were however only slightly reduced and differences from control were not significant.

Table 4

<u>The influence of concentration of tri-allate in the granule and position in relation to the crop seed</u>

Treatment	Concn. herbicide in granule	Plant counts mean no./ft length of row	Grain yield in cwt/ac corrected to 85% dry matter
Control		15.6	35.5
Mixed in pre-drilling 2 lb a.i./ac	5% w/w	7.1	31.3
	10% w/w	7.0	33.9
Emulsion pre-drilling incorporated 1 lb a.i./ac	-	12.3	31.3
Surface post drilling 2 lb a.i./ac	5% w/w	13.5	35.6
	10% w/w	13.9	32.8
		S.E.± 0.55	S.E.± 1.37

DISCUSSION

Early observations on experiment B indicated that shortly after emergence and during the winter months, the cvs. Maris Ranger and Joss Cambier were checked by the pre-emergence treatment with 4 lb/ac of tri-allate granules. Digging showed that plants arising from relatively shallow sown seed (0.5-0.75 in. deep) were the most severely affected. Adjacent but unaffected plants were found to arise from seed at about twice the depth (1.0-1.25 in.).

In experiment C (Table 4) when the tri-allate granules were mixed into the soil before drilling, plant mortality was also high.

Thus the crop seed must be isolated from the higher concentrations of tri-allate even when a granular formulation is used. Parker (1963) showed that part of the selectivity of tri-allate emulsion applied pre-emergence, depends on the growing point of the <u>Avena</u> spp. moving near to the soil surface relatively early in development, whereas with wheat it remains near to the seed for a longer period of time. This same factor seems likely to be involved in the selectivity of the granular formulation.

These experiments emphasise the well known powers of recovery of winter wheat. A crop may be quite severely damaged by adverse weather or soil conditions, or herbicide treatment, but if the set back occurs before active growth begins in the spring, recovery may be almost complete and grain yields normal.

In the present instances the combination of Eyespot infection with setback due to the herbicide did not appear to interact to the detriment of crop yield. However it should not always be assumed that occurrence of other types of stress situation together with temporary tri-allate toxicity will not be reflected in more permanent damage.

The main conclusion from these experiments is that winter wheat is relatively resistant to the granular formulations of tri-allate but that at least temporary damage and a reduction in plant population may occur. The risk is greatest if the seed is exposed to too high a concentration of herbicide shortly after germination by shallow drilling or mixing the herbicide with the soil.

One of the main advantages of the granular formulation is that Avena spp. are susceptible to surface applications, either pre-emergence or post-emergence, if these are not too long delayed (Holroyd, 1968, Holroyd and Bailey, 1970).

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THE PERFORMANCE OF TRI-ALLATE IN GRANULAR FORM FOR CONTROL OF AVENA SPP. & ALOPECURUS MYOSUROIDES

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Summary The granular formulation of tri-allate represents a new concept in the U.K. in herbicide applications to cereal crops. Some of the problems associated with the e.c. formulations and the need for incorporation of tri-allate have been overcome. Effective control of *Avena fatua* and *Alopecurus myosuroides* was obtained at rates of 1.5 lb/ac when applied immediately post seeding and pre-emergence to the weeds. Post-emergence applications to wild oats have given encouraging results with some variability in performance which appears to be related to the state of the crop and weather at application. Observations were made at 55 trials during the Autumn of 1969 and Spring 1970.

INTRODUCTION

The pre-emergence use of tri-allate for the control of *Avena spp.* and *Alopecurus myosuroides* is well known (Hannah, et al 1960, Lush and Mayes 1964, Lush, et al, 1968). The post-emergence effect of tri-allate in granular form on *Avena fatua* was reported in 1968 (Holroyd, 1968).

Since tri-allate is a volatile chemical it has been necessary to incorporate it in the soil when formulated as an emulsifiable concentrate. Incorporation of chemicals require certain physical conditions of the soil at the time of incorporation, which is not always possible to achieve especially on some of the heavier soils in wet conditions. Incorporation often requires extra operations by the farmer. It was felt, therefore, that if incorporation could be eliminated, one of the major problems in the commercial use of the product would be overcome. This has therefore led to the development of the granular formulation. Trials have been undertaken to compare applications of granular tri-allate with the emulsifiable concentrate for pre-emergence use. The post-emergence effect of the granular formulation has also been investigated further.

The use of granular formulations of pesticides is not new and granular herbicides have been used for spot and band treatment for some years, however, treatment of the soil with granules on a broadcast basis represented a new method of herbicide application.

The tests were therefore designed to include the use of available granular applicators on large plots to assess the practicability of this new concept.

METHOD AND MATERIALS

A total of 55 effective trials spread throughout the wild oat region of the U.K. were laid down in 1969-70 season by staffs of both Boots Pure Drug Co. and Monsanto Chemicals Ltd. to determine the effectiveness of the granular formulation of tri-allate applied pre-drilling, post-drilling and post-emergence to *Avena spp.*

Plot size included ¼ acre, 1/8th acre and small plots in the order of 270 sq.ft. The large plot applications were made with the Horstine Farmery TMA 4,32 ft and TMA 2,16ft airflow applicators and with the suitably modified Vicon varispreader. Small plots were applied by hand using a pepper pot type applicator.

Experimental design was normally a simple randomised block with 2-4 replications using where possible, an untreated control between each treatment. This layout seemed to function well in wild oat and blackgrass work where infestations often vary considerably over relatively short distances.

Rates from 1.5 lb ai/ac to 4.0 lb ai/ac were used in winter wheat and winter barley and from 1.2 lb ai/ac to 6.4 lb ai/ac in spring barley.

Pre-drilling applications were made from 3 weeks up to immediately before drilling. Post drilling applications were made from immediately after drilling up to 3 weeks after drilling. Applications made after crop emergence but before *Avena fatua* germinated were also tested.

Post-emergence applications were to be made as near to 1st March and 4 weeks later as possible to compare time effect. However, most of the first applications were made from mid to end of March because of the late season with the late stage of application being 4 weeks later.

In some of the post-emergence plots a sample of the *Avena spp.* plants were coded with rings of coloured wire related to their stage of growth at the time of application and these were then marked by stakes for observation throughout the trial.

Standard 40% w/v emulsifiable concentrate formulation and 10% w/w granules were used. The emulsifiable concentrate was always incorporated using straight tined zigzag harrows.

The granular formulation was applied to the soil surface and comparisons made of incorporation with non incorporation, the incorporation usually being carried out with a light harrow. Pre-drilling granules would normally get some incorporation with the seed drill.

Assessments were made by counting *Avena Spp*. panicles per yd^2 and *Alopecurus myosuroides* by counting the heads per ft^2 in sample quadrats thrown at random. Visual assessments were made where weed populations were low or variable.

Residue analyses have been carried out in cereal crops treated with granules both pre and post-emergence showing no detectable residues.

RESULTS

The results can be divided into pre-emergence and post-emergence applications. Both crop safety and weed control were examined relating to application technique. *Alopecurus myosuroides* and *Avena Spp* varied in intensity of infestation, but in the majority of the trials there was a high population. Soil conditions in the autumn were generally dry and seedbeds were often poor. The conditions would, in many cases, have been considered unsuitable for the application of triallate in the emulsifiable concentrate form.

In general pre-emergence post-drilling applications of granules gave better control of *Alopecurus myosuroides* than the equivalent rate of the emulsifiable concentrate and equivalent *Avena Spp* control in the winter sown crops. Performance in spring sown crops showed slightly reduced control of *Avena Spp* compared with the emulsifiable concentrate.

Applications of granules made before drilling of the crop caused slight to moderate thinning at use rates, whereas when applied immediately post drilling phytotoxicity was reduced to negligible proportions even at rates as high as 4.0 lb ai/ac. Surprisingly, *Avena Spp* and *Alopecurus myosuroides* control was also less effective with the pre-drilling applications of granules.

Incorporation of granules tended to increase phytotoxicity to the wheat and gave reduced weed control.

On a few sites the soil was extremely cloddy and the seed lay on the surface. Application of granules made post-drilling therefore were in contact with the seed consequently causing some damage. However, where the seed was adequately covered no damage occurred. In one trial where the seed was broadcast and harrowed in, only 5% thinning in the initial stand occurred at the use rate of 1.5 lb ai/ac which was adequately compensated by extra tillering by harvest.

On most soil types 1.5 lb ai/ac gave adequate *Avena Spp* and *Alopecurus myosuroides* control without any adverse effect on the crop when applied immediately post drilling. On sandy soils with very low organic matter or clay content, however, this rate was a little too high for safety to wheat.

Previous work would suggest 1.25 lb/ac as being the optimum rate for wheat on these soils. Three trials on black peat soils applied to spring barley gave disappointing wild oat control probably due to inactivation of the chemical.

With the pre-drilling treatments, increased delay between application and seeding appears to increase safety to the crop, but weed control is not as good.

Results from post crop emergence but pre-emergence to *Avena fatua* showed complete safety to the crop at all rates. *Avena fatua* control appeared to be adequate, but infestations were very light and further data is required before a recommendation could be made.

Applications made post-emergence to *Avena fatua* have given very interesting results. Control has varied quite considerably, but a careful examination of the data shows that the effectiveness of the product is very closely associated with the micro-climate in the crop. The best control was achieved in crops having a good leaf cover at the time of application where the micro-climate was relatively static. In poor and open crops control was not as good dropping to about 50% control. Applications made before the end of March were generally more effective than those made 4 weeks or more later.

Control of *Avena fatua* at the 1-2½ leaf stage was better than at tillering. The colour coded plants showed that the small *Avena fatua* plants were normally killed. A few escapes occurred with the small tillered *Avena fatua* but more where the plants were large and well tillered.

There was also a rate response at both times of application indicating that 2 lb ai/ac might be the optimum cost/performance rate.

Observations of the effect on *Avena fatua* of tri-allate applied post-emergence showed that, at first, there was a slight change in colour from the normal green to a yellowish green gradually extending from the leaf base along the leaf to the tip. The first signs of this occuring 7 to 10 days after treatment. This was accompanied by the disappearance of the cuticular wax.

The next stage observed was a further colour change to dark green accompanied by a distortion of the leaf. This effect has been previously described (Holroyd 1968).

In a few trials observations were made on control of *Alopecurus myosuroides* with post-emergence applications. In general the weed kill was not as good as with pre-emergence applications. This confirms previous observations made in various European countries.

There appeared to be no varietal differences. Seven wheat and six barley varieties were used in the field trials and there was one varietal trial in which 15 wheat and 4 barley varieties were tested. Wheat appeared to be slightly more susceptible than barley as is the case with the emulsifiable concentrate.

Summary of Results

Rate ai/ac and Treatment	Total No. Sites		No. Sites showing Control 90%+	75%+	below 75%	Sites showing Crop thinning Nil	Up to 20%	Over 20%
Pre-drilling e.c.								
1.5	11	Av.	6	2	0	8	3	0
		Al.	1	0	1			
2.0	7	Av.	4	1	0	3	3	1
		Al.	1	0	1			
3.0	8	Av.	5	0	0	3	2	3
		Al.	1	0	1			
Pre-drilling granular								
1.5	18	Av.	7	5	3	6	5	7
		Al.	0	2	2			
2.0	18	Av.	8	4	3	7	5	6
		Al.	0	2	2			
3.0	18	Av.	10	4	0	7	1	10
		Al.	2	2	0			
Post-drilling granular surface								
1.5	35	Av.	18	3	0	31	3	1
		Al.	8	3	1			
2.0	33	Av.	18	3	0	24	8	1
		Al.	9	2	1			
3.0	35	Av.	20	1	0	16	9	10
		Al.	10	2	0			
Post-drilling granular incorporated								
1.5	10	Av.	1	2	0	6	3	1
		Al.	0	1	1			
2.0	9	Av.	2	1	0	5	3	1
		Al.	1	0	1			
3.0	10	Av.	3	0	0	4	3	3
		Al.	1	1	0			
Post-emergence early applications								
1.5	9	Av.	0	6	3	8	0	0
2.0	11	Av.	4	5	2	11	0	0
2.5	10	Av.	5	2	3	10	0	0
3.0	9	Av.	5	2	2	9	0	0
Post-emergence late applications								
1.5	16	Av.	1	2	13	16	0	0
2.0	19	Av.	4	6	9	19	0	0
2.5	17	Av.	2	8	7	17	0	0
3.0	19	Av.	7	10	2	19	0	0

Av. = *Avena spp.*
Al. = *Alopecurus myosuroides*

Note: *Avena fatua* and *Alopecurus myosuroides* did not occur on every site. Post-emergence early applications were made in February and March and the late applications during later half of April and May.

DISCUSSION

The granular formulation of tri-allate is effective for controlling *Avena fatua* and *Alopecurus myosuroides* in wheat and barley crops when used post seeding. Performance of this formulation against *Alopecurus myosuroides* is superior to the emulsifiable concentrate form giving control in excess of 90%. *Avena Spp* control is also good although, in general, slightly less than with the e.c.

It appears necessary to apply the granules after the seed has been drilled in order to avoid phytotoxicity to the crop and, happily, weed control is also better with this application.

The large scale trials have proved the viability of applications through farmers equipment on a practical scale. However, it is vitally important that accurate and even distribution is obtained. This means the equipment must be in good order and properly calibrated. The machines used in these trials appeared to function satisfactorily. In general the machines gave better results than those from hand application, which would suggest greater accuracy from the machine.

Post-emergence applications to *Avena fatua* have given interesting and encouraging results and a greater degree of reliability was obtained in this year's trials compared to the previous year. We believe that further work to elucidate the factors involved will lead to a successful method being evolved for post-emergence applications. Indications from the data so far obtained show that activity is in both the vapour phase and in soil solution. The activity would seem to be governed by the condition of the micro-climate in the crop at the time of application, to allow exposure of the *Avena fatua* plant to tri-allate vapour for an unspecified period of time and concentration. Most of the applications which were made early in crops giving good cover gave better wild oat control than applications made later and in thin crops. There is also a suggestion that temperature may be involved since the higher temperatures might cause loss of chemical too quickly. At this stage one might hypothesise that under higher temperatures it is more important to have a thick crop.

The introduction of the granular formulation will offer another method of using tri-allate to help those farmers who have difficulty in using the emulsifiable concentrate because of soil incorporation requirements or other reasons.

The granular concept for broadcast applications of herbicides is new in the U.K. and will undoubtedly raise some problems in relation to machinery for application. However, suitable machinery is available and several machinery manufacturers are interested in developing suitable applicators.

Acknowledgements

Thanks are due to David Hodkinson of Monsanto Chemicals Ltd for the considerable amount of work that he has put into the development programme on tri-allate granules. I would also like to acknowledge the collaboration of the staff of Boots Pure Drug Co.Ltd who contributed significantly to the trials programme and for giving me access to their trials data. The assistance of Horstine Farmery Ltd and Vicon Ltd with machinery modifications and adjustment is gratefully acknowledged.

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AN EVALUATION OF METOXURON FOR THE CONTROL OF AVENA FATUA IN CEREALS IN THE UNITED KINGDOM

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Summary Metoxuron applied at 4.8 lb/ac pre-emergence in winter cereals, gave 50 to 60% control of A. fatua. This was generally inferior to the level of control obtained with the same dosage applied post emergence in the spring. Under suitable conditions 4.0 lb/ac applied post emergence in winter cereals gave acceptable control. In spring cereals acceptable control was obtained with 4.0 lb/ac applied either pre- or post emergence.

INTRODUCTION

Metoxuron is manufactured by Sandoz Ltd., Basle, Switzerland. Evaluation of the commercial product (DOSANEX) containing 80% a.i. commenced in the United Kingdom in 1968 when Farm Protection Ltd., initiated field trials. The present report describes trials which were carried out during 1969 and 1970.

METHOD AND MATERIALS

All trials reported within have been sprayed with the Oxford Precision Sprayer using a spray volume of 40 gal/ac. Plot size was 45.5 ft x 6 ft = 1/160 ac and the treatments were replicated six times in 1969 and four times in 1970. All dose rates are quoted as lb. a.i./ac, and L.S.D. calculated for P 0.05.

During 1969 visual assessments of the control of A. fatua were carried out in accordance with the following scale.

Score	% control of A. fatua	Score	% control of A. fatua
1	100	6	75 - 85
2	97.5 - 100	7	65 - 75
3	95 - 97.5	8	32.5 - 65
4	90 - 95	9	0 - 32.5
5	85 - 90		

During 1970 visual assessments were made of the percentage control of A. fatua, and in addition the number of plants and fresh weight of A. fatua per unit area were recorded. The latter data has been transformed to % control.

The following trials were carried out during the two seasons.

Treatments	Number of Trial Sites 1969	1970
Pre-emergence in Winter Cereals	-	4
Early and Late post emergence in winter cereals	5	3
Pre- and post emergence in spring cereals	-	12

Pre-emergence treatments were applied between one and nine days after sowing the crop and compared with barban and metoxuron applied post emergence. Early post emergence treatments were applied between the one and four leaf stage of growth of A. fatua and compared with barban applied at the same time. Late post emergence treatments were applied between the 4 leaf stage and commencement of tillering of A. fatua.

RESULTS

Pre-emergence control of A. fatua

Table 1 (1969/70)

Control of A. fatua

Treatment	Rate lb/ac	Percentage control of A. fatua: Visual Assessment	% reduction in number	% reduction in weight
Metoxuron	4.0	56.0	41.5	46.5
Metoxuron	4:8	55.0	50.8	61.8
Metoxuron	6.4	68.0	35.3	52.8
Metoxuron	9.6	80.2	63.5	56.8
Metoxuron (post-em.)	4.0	42.3	41.0	40.0
Barban	0.3	70.5	41.3	62.8
S.E.		1.1	3.6	1.5
L.S.D.		4.6	15.1	6.5

(Mean of 4 trials)

Although the visual assessments indicated acceptable control with 9.6 lb applied pre-emergence, this is not supported by the other methods of assessment. In these trials the pre-emergence applications of metoxuron were of superior performance to 4.0 lb applied post emergence, but generally inferior to barban. As A. fatua did not emerge until late March, in fact four to five months after treatment, it is not surprising that these treatments are of low efficacy. It suggests therefore, that the residual activity of metoxuron is not sufficient to control spring germinating A. fatua when application is made pre-emergence in the autumn. The post emergence treatments with metoxuron were disappointing but were probably greatly influenced by the lack of rainfall.

Post emergence control of *Avena fatua* in Winter Cereals.

Table 2

Visual Assessment (1-9 Scale) of Control of *A. fatua*: (1969)

Treatment	Rate lb/ac	Trial Code Number WO/1	WO/2	WO/3	WO/4	WO/6	MEAN
Early Post emergence							
Untreated		8.8	8.8	8.8	9.0	8.7	8.8
Metoxuron	2.4	7.0	8.7	4.8	2.7	5.7	5.6
Metoxuron	3.2	4.8	8.8	3.7	1.8	5.2	4.9
Metoxuron	4.0	4.0	8.3	2.8	2.7	4.2	4.4
Metoxuron	4.8	3.3	8.7	1.7	1.3	2.7	3.5
Metoxuron	6.4	3.7	7.2	1.2	1.3	1.3	2.9
Barban	0.3	7.3	7.8	4.7	6.0	5.8	6.3
Late Post emergence							
Metoxuron	2.4	7.7	8.3	2.7	3.5	5.5	5.5
Metoxuron	3.2	6.8	8.3	2.7	3.0	4.5	5.1
Metoxuron	4.0	5.0	8.7	1.8	2.8	3.8	4.4
Metoxuron	4.8	4.2	8.0	1.5	3.0	3.3	4.0
Metoxuron	6.4	2.7	7.8	1.2	2.0	2.2	3.2
S.E.		0.7	0.5	0.7	0.6	0.8	1.7
L.S.D.		1.5	1.1	1.5	1.4	1.5	2.6

Table 3

Control of *A. fatua*: (1970)

Treatment	Rate lb/ac	Percentage control of *A. fatua*: Visual Assessment	% reduction in number	% reduction in weight
Early Post emergence				
Metoxuron	2.4	35.0	37.0	44.7
Metoxuron	3.2	46.3		
Metoxuron	4.0	63.8	43.0	68.3
Metoxuron	4.8	36.9		
Metoxuron	6.4	55.0		
Metoxuron	8.0	76.9	61.0	81.0
Barban	0.3	38.7	30.0	61.0
Late Post emergence				
Metoxuron	2.4	36.2	16.3	34.7
Metoxuron	3.2	61.3		
Metoxuron	4.0	71.9	36.3	42.0
Metoxuron	4.8	74.4		
Metoxuron	6.4	76.9		
Metoxuron	8.0	92.4	47.0	69.7
S.E.		4.7	9.6	6.2
L.S.D.		10.1	N.S.	26.5

(Mean of three trials)

All dose rates of metoxuron applied both early and late post emergence during 1969 produced an acceptable control of *A. fatua*. Dose rates in excess of 4.0 lb/ac produced over 90% control of *A. fatua* at both times of application. All treatments, however, produced unacceptable results at site WO/2. This may be partially due to the acidic nature (pH 5.2) and high organic content (15.4%) of this particular soil.

The results obtained during 1970 are very dependant upon a number of inter-relating factors. The main ones appear to be the stage of development of *A. fatua* at the time of application and the moisture status of the soil at that time and during the following two weeks. These factors must be considered before any general conclusions are made about the effectiveness of metoxuron for the post emergence control of *A. fatua* in winter cereals.

Dose rates at and below 4.0 lb/ac did not produce acceptable control at the majority of sites, but improved control was obtained with higher dose rates. When applied early post emergence 8.0 lb/ac produced acceptable control, but when applied late post emergence this dose rate did not result in an acceptable reduction in the number of plants, although the reduction in weight is considered nearly acceptable.

Whilst metoxuron did not kill a high percentage of *A. fatua* in the 1970 trials, it did, however, cause a large reduction in the weight of the surviving plants. In addition, metoxuron was found to cause considerable abortion of the basal spikelets and infertility of the apical spikelets in surviving plants.

Table 4

The inhibition of growth of *A. fatua* by metoxuron.

Treatment	Rate lb/ac.	Fresh weight per plant in gm.	% reduction in weight per plant.
Early Post emergence			
Untreated		4.1	0
Metoxuron	2.4	3.6	12
Metoxuron	4.0	2.5	38
Metoxuron	8.0	1.9	54
Barban	0.3	2.3	44
Late Post emergence			
Metoxuron	2.4	3.9	4
Metoxuron	4.0	3.1	23
Metoxuron	8.0	2.2	46

(Mean of three trials)

Table 5

Control of *A. fatua*

Treatment	Rate lb/ac	Percentage control of *A. fatua* * Visual	** % reduction in number	** % reduction in weight
PRE-EMERGENCE				
Metoxuron	2.4	48.3	44.4	48.4
Metoxuron	3.2	52.3	-	-
Metoxuron	4.0	63.5	64.6	64.0
Metoxuron	4.8	70.1	-	-
Metoxuron	6.4	77.1	-	-
Metoxuron	8.0	81.2	78.0	75.8
POST EMERGENCE				
Metoxuron	2.4	49.3	49.2	48.4
Metoxuron	3.2	54.2	-	-
Metoxuron	4.0	66.5	68.6	59.8
Metoxuron	4.8	70.5	-	-
Metoxuron	6.4	75.5	-	-
Metoxuron	8.0	78.4	71.8	80.0
Barban	0.3	25.7	33.0	31.8
S.E.		0.6	3.0	2.5
L.S.D.		2.4	12.1	10.2

* Mean of 11 trials
** Mean of 5 trials

Both the pre- and post emergence treatments produced similar control of *A.fatua*. An application of 4.0 lb/ac resulted in 60-70% control on both occasions, whilst 8.0 lb/ac produced approximately 80% control. Results were variable from site to site but these inconsistencies were mainly related to the moisture status of the soil at the time of application and rainfall occurring soon after application. Superior results were obtained when adequate soil moisture was present at the time of application or where reasonable rainfall occurred within two weeks of application.

DISCUSSION

Pre- and post emergence treatments applied to spring cereals were of equal effectiveness in controlling *A. fatua*, but this was not so for winter cereals. This suggest that metoxuron does possess a degree of residual activity which is sufficient to control *A. fatua* when application is made pre-emergence in the spring, but is not sufficient when applied pre-emergence in the autumn. In general satisfactory control was obtained with 4.0 lb applied post emergence in winter cereals and pre- or post emergence in spring cereals. Soil moisture however appears to be a factor which greatly influences the degree of control obtained.

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CONTROL OF AVENA SPP. IN WHEAT WITH WL 17,731

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Summary WL 17,731 (ethyl-N-benzoyl-N-(3,4 dichlorophenyl)-2 aminopropionate) has been field tested at doses from 0.5 - 8.0 kg/ha as a post-emergence herbicide, specifically for the control of *Avena fatua* and *A. ludoviciana* in wheat. When applied between the commencement of crop tillering and the appearance of the nodes, WL 17,731 has given up to 100% control of *Avena* spp. at 1.5 kg/ha and 95% control at 1 kg/ha. No yield reductions have been found at doses in excess of four times those required for weed control, although reductions in crop height have sometimes been recorded.

INTRODUCTION

An introductory paper (Chapman et al, 1969) has described the use of WL 17,731 (ethyl-N-benzoyl-N-(3,4 dichlorophenyl)-2 aminopropionate) for control of *Avena* spp. in wheat in 1968 - 1969. This report records the results of the 1970 field evaluation of the chemical in 80 trials conducted in the cereal growing areas of Britain, France and the prairie provinces of Canada.

METHOD AND MATERIALS

The trials were located in Great Britain in East Anglia and Kent, in France around Paris, Bordeaux and Avignon, and in Canada in Saskatchewan and Manitoba. The trials were in commercial crops. Trial sites were selected with two objectives, (a) to assess the activity of WL 17,731 on high natural infestations of *Avena* spp. at different doses and times of application and (b) to establish the crop effect of the compound on wheat grown in situations free of weed competition. The infested areas contained *Avena fatua* or *Avena ludoviciana*, or both species together.

Randomised block designs with either 4 or 6 replicates were used, with plot sizes varying from 30 to 50 m^2.

An e.c. formulation was used in most trials (occasionally a w.p.). This was applied using a knapsack sprayer fitted with Allman '00' nozzles to deliver doses from 0.5 to 8.0 kg/ha. The application volume was 500 litres/ha (145 litres/ha in Canada) and the spraying pressure was 2.1 kg/sq cm The stages of crop growth (Chancellor, 1966) at the time of application are recorded in the tables of results.

Growth stages of *Avena* spp. corresponded closely with the stage of the crop. Trials were carried out in winter and spring wheats. Assessments of weed control were made by counting the number of panicles present in at least 3 quadrats (0.5 x 0.5 m) per plot when the majority of panicles had fully emerged. Crop yield

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data were obtained with a modified Class Colombus and Hege combines.

Broad-leaf weeds were controlled where necessary by separate applications of appropriate herbicides.

RESULTS

The degree of control achieved with WL 17,731 is dependent upon the time of application with the later treatments (during the final phase of tiller production through shooting and node production) being more effective than earlier treatments. This is shown in Figures 1 and 2. The action of WL 17,731 applied to wheat under varying intensities of infestation are recorded in Table 1 and Figure 3. The yield results in Table 1 were all obtained from trials where there was no infestation of Avena spp. and so clearly indicate the minimal crop reaction to WL 17,731. Figure 3 shows the yield increases obtained after treatment with 1 kg/ha of WL 17,731 applied between the tillering and node production stages on sites of varying weed infestations. Figure 4 shows the inter-relationship between yield and Avena spp. population density in the absence of chemical control.

DISCUSSION

The relationship between time of application and control of Avena spp. presented in Figures 1 and 2 confirms the activity pattern already given for WL 17,731 by Chapman et al (1969). Applications of WL 17,731 prior to the tillering stages of crop growth, result in poor wild oat control. In Britain and France, excellent weed control is obtained with doses as low as 1.0 kg/ha, applied during the growth period from the later stages of tiller production through to the formation of the nodes. In Canada, weed control following applications during tiller production and shooting is markedly superior to that obtained during the earlier stages of plant growth.

The reasons for this improved control at the later stages of application are not yet known. The effect of competition by Avena spp. on wheat yields is shown in Figure 4, which illustrates that increases in Avena spp. populations result in decreased yields. Other work by Thurston (1962) and Bowden and Friesen (1967) has shown the serious nature of wild oat competition in cereal crops. Applications of WL 17,731 have resulted in yield increases and such increases are dependent on the initial density of Avena spp. (Figure 3).

Crop reaction to WL 17,731 has been manifested as a shortening of straw length. Doses of up to 2 kg/ha were generally without effect on crop height, but a 10 - 15% reduction sometimes followed the use of 4 kg/ha. In some trials, this effect was reflected by a shortening of the stem inter-nodes being formed when WL 17,731 was applied, i.e. application of WL 17,731 at the 2nd node stage has resulted in a shortening of the inter-nodal distance between nodes 2 and 3. There were indications that the severity of effect was more pronounced when the cultivar Capitole was treated.

No yield reductions have been recorded in 15 trials where WL 17,731 had been applied at doses up to 8 kg/ha (Table 1). All these trials were on sites free from wild oat interference, and therefore do reflect the outstanding crop safety margin of WL 17,731 on wheat.

The coincident timing of application of WL 17,731 and other herbicides suggest that it may be possible to develop suitable mixtures. Studies to define and confirm herbicide compatibility are in progress. Work is also in progress to evaluate WL 17,731 in other crops, including barley and sugar beet.

The 1970 results therefore further substantiate the opinion of Chapman et al (1969) that this compound represents a considerable advance in the control of wild oat in wheat'.

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TABLE I. Results from 15 Trials in Gt. Britain and France (yields expressed as a % of the untreated plots)

WL 17,731 Dose (kg/ha)	Stage of Crop Growth at Time of Application														
	Mid-Tillering	End of Tillering		Shooting		1st Node Stage			2nd Node Stage				Appearance of Last Leaves		
1.0	104	102	96	102	104	98	96	102	100	100	101	101	103	105	101
2.0	109	104	101	110	96	-	93	103	98	105	99	98	100	100	98
4.0	110	106	105	102	93	95	92	-	-	105	99	-	-	98	-
6.0	-	-	-	-	-	-	88	108	94	103	99	94	97	-	89
8.0	-	-	102	-	-	-	90	-	-	105	98	-	-	-	-
Yield (m.tons/ha) untreated plots	5.9	4.7	4.8	4.7	5.3	5.0	5.2	5.8	5.4	5.7	4.2	5.1	4.8	4.7	4.2

All trials in absence of *Avena* spp.

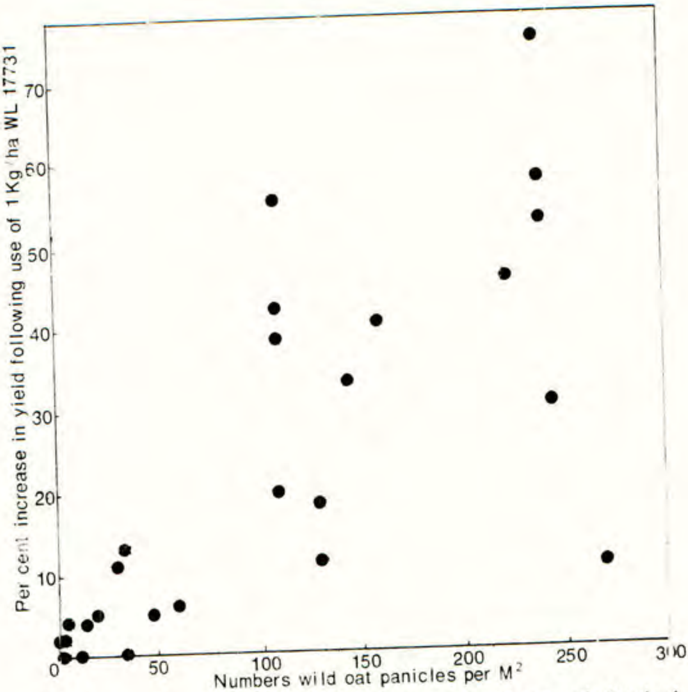

Fig 3 Inter-relationship between density of *Avena* spp and chemical control with WL 17731

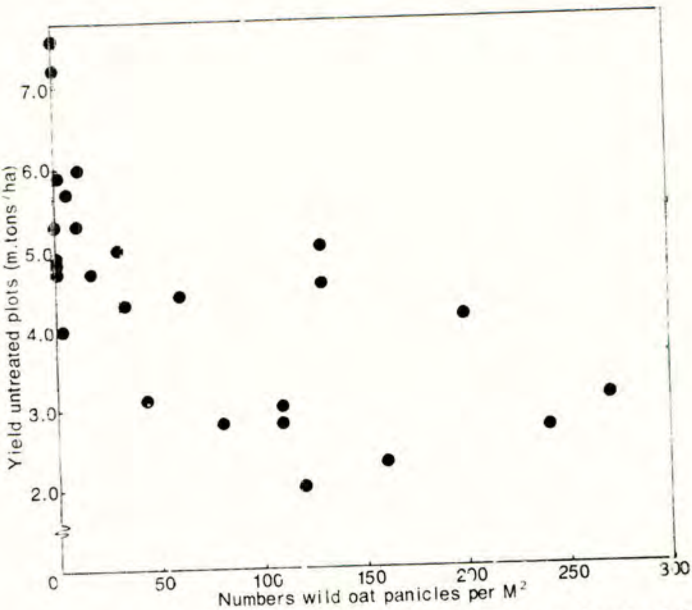

Fig 4 Inter-relationship between density of *Avena* spp and crop yield

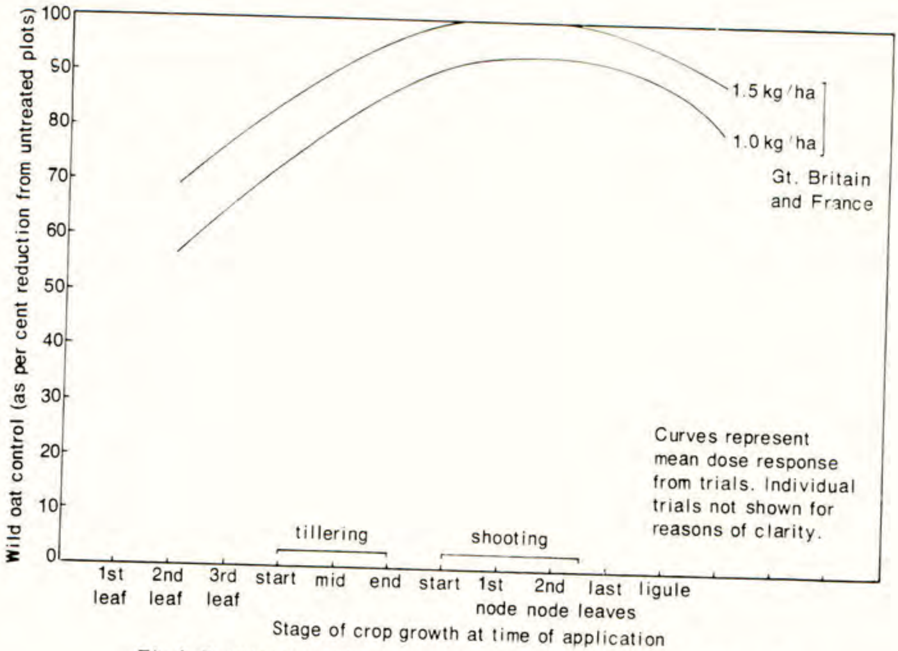

Fig 1 Relationship between time of application and wild oat control in Great Britain and France

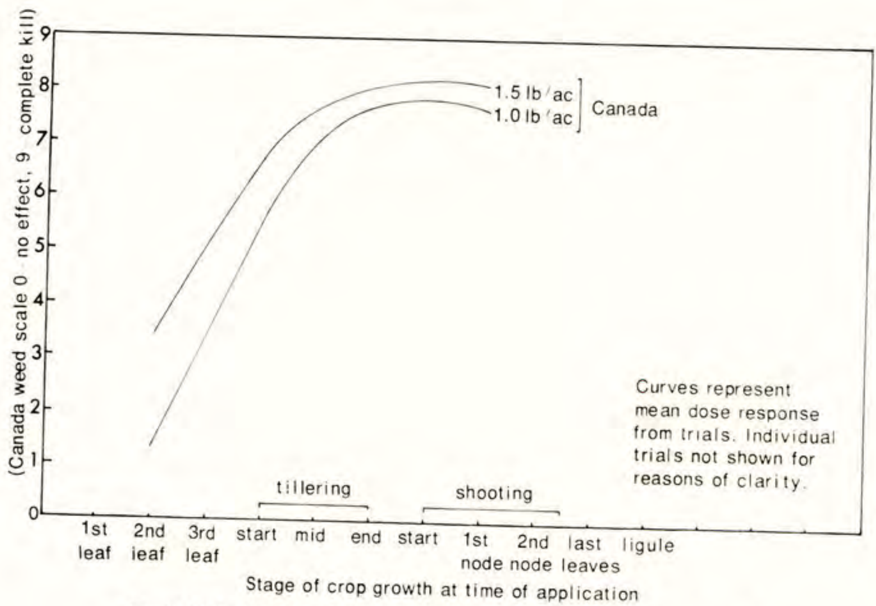

Fig 2 Relationship between time of application and wild oat control in Canada

Proc. 10th Br. Weed Control Conf. 1970

CHEMICAL CONTROL OF AVENA FATUA IN WINTER WHEAT

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Summary The effectiveness of 11 herbicides or mixtures of herbicides for the control of *Avena fatua* in winter wheat was examined in 5 field experiments. None of the chemicals gave a satisfactory control at all sites. Metoxuron applied in the spring (63%) and a pre-emergence application of chlortoluron (77%) gave the best control, being effective at 3 out of the 5 centres.

INTRODUCTION

Herbicide trials for the control of *Alopecurus myosuroides* in 1968/69, indicated that some of the newer herbicides also showed activity against *Avena fatua*. During the season 1969/70 the effectiveness of 11 herbicides, or mixtures of herbicides, were evaluated in 5 experiments on winter wheat in East Anglia.

METHOD AND MATERIALS

All of the experiments were superimposed on commercial crops where naturally occurring infestations of *Avena fatua* were expected. Relevant site details, treatment application dates, stage of growth of crop and weed are given in Table 1. Chemicals tested are listed below, all dose rates are in terms of active ingredient per acre.

Treatment	1	terbutryne	2.02 lb
	2	barban	0.35 lb
	3	methabenzthiazuron	2.82 lb
	4	nitrofen	2.11 lb
	5	metoxuron (pre-emergence)	4.27 lb
	6	metoxuron (spring)	3.23 lb
	7	metoxuron (spring)	3.63 lb
	8	chlortoluron (pre emergence)	3.23 lb
	9	chlortoluron (spring)	2.42 lb
	10	dichlobenil/ fluometuron 2:1	2.25 lb
	11	WL 19805	2.02 lb
	12	701	2.52 lb
	13	2440	1.34 lb
	14	lenacil + ioxynil	0.81 + 0.40 lb

WL 19805 = 2-(4-chloro-6-ethylamino-3-triazine-2-ylamino)-2-methyl proprionitrile

2440 = 1:1 mixture brompyrazone + isonoruron

701 = a substituted urea

Table 1

Site	1	2	3	4	5
Soil texture	ZyCL	ZyCL	ZyCL	ZyCL	ZL
Variety	Champlein	Cama	Cappelle	W.Desprez	Cappelle
Date drilled	5/11	10/11	20/11	20/11	20/10
Seedbed at first spray	dry	moist	moist	wet	moist
Treatment date					
1	13/11	13/11	24/11	4/12	28/10
2	28/3	28/3	27/3	27/3	27/2
3	13/11	13/11	24/11	4/12	28/10
4	13/11	13/11	24/11	4/12	28/10
5	13/11	13/11	24/11	4/12	28/10
6	28/3	28/3	27/3	27/3	27/3
7	17/4	17/4	10/4	15/4	7/4
8	13/11	13/11	24/11	7/12	28/10
9	17/4	17/4	2/4	15/4	7/4
10	28/3	28/3	27/3	27/3	27/3
11	17/4	17/4	2/4	15/4	7/4
12	28/3	28/3	27/3	27/3	27/3
13	17/4	17/4	10/4	15/4	7/4
14	17/4	17/4	10/4	15/4	14/4
Growth stage of crop (No. of leaves)					
Spray date 2	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	3
Spray date 3	Tillering	Tillering	Tillering	Tillering	Tillering
Growth stage of <u>Avena fatua</u> (No. of leaves)					
Spray date 2	$1\frac{1}{2}$	$1-1\frac{1}{2}$	1-2	2-3	N.R.
Spray date 3	$1-3\frac{1}{2}$	3-4	1-2	2-3	N.R.

Plot size was 30 ft x 6 ft, all treatments were applied by a modified Weij sprayer with fan jets. Application rate was 20 gal/ac. A randomised block design was used, treatments replicated 3 times.

The overall infestation of <u>Avena fatua</u> was assessed on the 6 control plots in mid-April and broadleaved weeds in early May. Treatment effects were made by the removal of all <u>Avena fatua</u> plants from a number of quadrats in each plot in late June/early July and crop yields measured by a sample harvest technique, avoiding areas where <u>Avena fatua</u> plants had been removed. The number of seed heads were counted, graded into three sizes and the total dry weight of the panicles measured.

RESULTS

Grain Yield cwt/ac 85% DM.

Treatment	Site 1	2	3	4	5	Mean*	%*
Control	37.5	42.4	38.0	27.8	27.6	39.3	100
1	43.3	41.5	36.6	30.2	36.0	40.5	103
2	50.0	38.8	40.0	28.8	30.5	42.9	109
3	48.1	43.5	38.5	36.2	37.5	43.4	110
4	51.2	42.4	40.0	37.0	38.2	44.1	113
5	50.5	43.2	36.2	29.6	38.2	43.3	110
6	43.8	42.8	36.5	36.1	38.6	41.0	104
7	48.3	40.4	37.9	32.0	39.8	42.2	107
8	45.5	41.4	39.8	27.5	38.9	42.2	107
9	50.8	39.3	36.1	35.6	40.2	42.1	107
10	49.0	41.0	37.5	30.3	36.4	42.5	108
11	43.0	38.9	39.1	30.4	30.4	40.3	103
12	51.4	42.3	40.3	34.9	35.0	44.7	114
13	45.1	40.4	40.6	26.3	36.1	42.0	107
14	47.3	40.4	38.8	31.0	34.8	42.2	107
s.e.	3.45	1.76	1.22	4.45	1.99	1.35	

*** excludes sites 1 and 4**

Dry Weight of Panicles g/m²

Treatment	Site 1	2	3	4	5	Mean*	% Control*
Control	32.5	10.3	21.0	4.9	8.2	18.0	0
1	37.2	9.3	9.9	4.5	5.9	15.6	13.3
2	2.8	9.4	1.0	7.8	8.9	5.5	69.4
3	37.5	15.9	11.5	9.7	7.3	18.1	0
4	32.5	6.8	6.1	0.9	2.6	12.0	33.3
5	24.2	6.7	3.5	5.8	3.5	9.5	47.2
6	19.8	1.9	1.4	0.7	0.8	6.0	66.6
7	20.6	1.5	2.6	8.9	1.9	6.7	62.8
8	9.7	4.9	0.8	3.4	1.0	4.1	77.2
9	21.[illegible]	3.5	4.3	0.8	1.2	7.6	57.8
10	12.3	3.9	8.2	6.2	4.9	7.3	59.4
11	38.7	3.6	1.2	8.7	10.3	13.5	25.0
12	15.6	2.0	0.3	1.3	6.2	6.0	66.6
13	33.3	6.5	4.1	4.7	4.5	12.1	32.8
14	37.4	13.9	2.1	20.4	2.9	14.1	21.7
s.e.	8.3[illegible]	2.77	5.25	3.53	1.88	2.60	

Avena fatua plants/m² in spring

	1	2	3	4	5
	44.13	60.28	29.06	38.75	N.R.

* excludes site 4.

The results from site 1 have been excluded from the grain yield mean as there was a competitive infestation of *A. myosuroides* present.

The results of site 4 have been excluded from the overall mean, as the standard errors were excessive. At site 1 only barban and chlortoluron (pre-emergence) gave significant reductions of Avena fatua; at site 2 both spring applications of metoxuron and 701 only gave significant reductions. In contrast at site 3 all herbicides except methabenzthiazuron gave a significant level of control; at the remaining site 5 nitrofen, metoxuron (all application dates), chlortoluron (both dates) and the lenacil/ioxynil mixture gave a significant reduction in the Avena fatua population. Overall the only chemicals failing to control Avena fatua were terbutryne, methabenzthiazuron WL 19805 and the lenacil/ioxynil mixture. Control levels on average ranged from 33% with 2440 and nitrofen to the best of 77% with a pre-emergence application of chlortoluron.

DISCUSSION

These results do not present a very clear picture regarding the effectiveness of the herbicides tested, due to variable performance from site to site. It is not possible from the data recorded to explain this variability, further experimental work will be necessary. In carrying out this further work, consideration must be given to the experimental design and methods to attempt to combat the natural variability of Avena fatua populations within very small areas. The data presented show that very large differences seldom reach significant levels, which suggests caution must be used in interpretation of results.

Acknowledgements

The authors wish to thank especially the farmers who provided the experimental sites for this work; NAAS colleagues who assisted and Rothamsted Experimental Station for the statistical analyses. In addition we would like to thank the firms who provided us with experimental materials.

NEWER HERBICIDES FOR THE CONTROL OF AVENA FATUA IN CEREALS

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Summary Ten different herbicides or herbicide formulations were tested for their effectiveness in controlling *Avena fatua* in six experiments on crops of winter and spring wheat and spring barley. Granular tri-allate was one of the most effective compounds, being more active pre-emergence in winter wheat and more active early post-emergence (*A. fatua* 0-2 leaves) in spring cereals. 1.5 lb a.i./ac gave 75%-90% control in the spring cereals with no crop damage. 4 lb a.i./ac of chlorfenprop-methyl gave 93-95% control in two of the spring cereal experiments when the majority of the *A. fatua* had 2-3 leaves, but was less effective at other times and in the other experiments. 2-4 lb a.i./ac of nitrofen applied in early February gave 80-90% control with little apparent permanent damage to winter wheat. Barban formulated with additional surface active agent had little or no advantage over the normal formulation. Other compounds were either unreliable or ineffective at selective doses.

INTRODUCTION

Barban and tri-allate are the herbicides most commonly used for the control of *Avena fatua* and *A. ludoviciana* in wheat and barley. Recently however a number of other herbicides and alternative formulations of barban and tri-allate have been suggested for this purpose.

During the season 1969-70 the effectiveness of ten herbicides or herbicide formulations were investigated in six experiments on crops of winter and spring wheat and spring barley.

METHOD AND MATERIALS

One experiment was in winter wheat, one in spring wheat and four in spring barley. All the experiments were on outside farms, in commercially grown crops where naturally occurring infestations of *Avena fatua* were expected, with the exception of one on spring barley which was located at Begbroke and relatively clean of weeds. This provided a useful check on crop tolerance, particularly as the soil at Begbroke is a light sandy loam and soil acting herbicides can be expected to be relatively active.

Details of the sites, dates of treatment, soil conditions and stage of growth of both crop and weed are given in Table 1. The herbicides used in these experiments and their formulations are listed below. All doses in this paper are in terms of active ingredient.

Ethyl 2-(n-benzoyl-3,4-dichloroanilin)propionate (WL 17731) 40% w/w, w.p. (When 'mixing up' the powder was mixed with Risella oil in the proportion 1 g powder to 5 ml oil before adding water); chlortoluron 80% w/w, w.p.: tri-allate on 24/48 mesh attapulgite granules 5% and 10% w/w; tri-allate, 40% w/v e.c.; barban, 12.5% w/v e.c.

and 25% w/v e.c.; chlorfenprop-methyl, 53.5% w/w w.p.; haloxydine, 20% w/v, aq.c.; metoxuron, 80% w/w w.p.; nitrofen 24% w/v e.c.

At Burmington and Begbroke all the herbicides except the granular tri-allate were applied at logarithmically reducing doses through a Fisons' Mini-Logarithmic Sprayer at a volume rate of 28 gal/ac, using a matched pair of Teejets (No. 6503) and a pressure of 40 p.s.i. Plots were 22 x 1 yd, the dose being halved every 5.5 yd. Equipment was not available to apply the granular formulation at a logarithmically reducing dose, so a strip of 4 sub-plots each 5.5 x 1 yd was treated using a small hand-held shaker, on the 'pepper-pot' principle. The doses were reduced progressively by a factor of 2 so that treatments more or less matched those of the 'logarithmic' plots. Both experiments were of a randomised block design, replicated 3 times on the winter wheat and 4 times on the spring barley, with 1 yd discard between each plot.

On the other experiments, finite doses of the herbicide were applied through an Oxford Precision Sprayer. The volume rate was 24 gal/ac using a 4 jet boom fitted with matched Teejets (No. 6502) spaced 18 in. apart and a pressure of 30 p.s.i. The pre-emergence treatments with tri-allate emulsion were mixed into the soil by raking to a depth of approx. 1 in. The plot size was 6 x 2 yd with no inter-plot discards. A randomised block design replicated 3 times was used in all these experiments.

The winter wheat experiment was assessed just prior to crop harvest when most of the *A. fatua* panicles had emerged, by scoring on a scale of 0-10 (0 = no *A. fatua* panicles present, 10 = indistinguishable from the adjacent discards) every 2.75 yd along each plot. The distance at which the crop appeared to be normal was also noted. The clean spring barley crop at Begbroke was also assessed by scoring for vigour and density every 2.75 yd along each plot.

In the other four experiments, at the time of treatment 10 *A. fatua* plants (if available) of each growth stage were colour coded by placing a piece of suitably coloured wire in the soil beside each selected plant, on each plot. Just prior to harvest the fate of the colour coded plants was recorded and their panicles classified into 3 categories according to size.

The overall density of *A. fatua* panicles present on each plot was also recorded by counting the numbers of panicles present in 3 quadrats of 1 yd^2 on each plot when the majority of panicles were fully emerged. The panicles of these plants were also graded according to size. The average number of spikelets on panicles in each category were calculated for each experiment (Holroyd, 1968) and a figure for the number of spikelets/yd^2 obtained from the panicle counts. Effects on the crops were also noted.

RESULTS

The scores from the experiments at Burmington and Begbroke, where the doses were logarithmic are illustrated in Fig. 1 and 2. The overall numbers of spikelets on the plots in the other experiments (finite doses) are shown in Table 2 as a percentage of the mean controls. The data from the colour coded plants have still to be analysed. All the *A. fatua* populations were very variable in density as indicated by the range in the numbers of spikelets/yd^2 on the control plots, but the population at Mildenhall was particularly uneven.

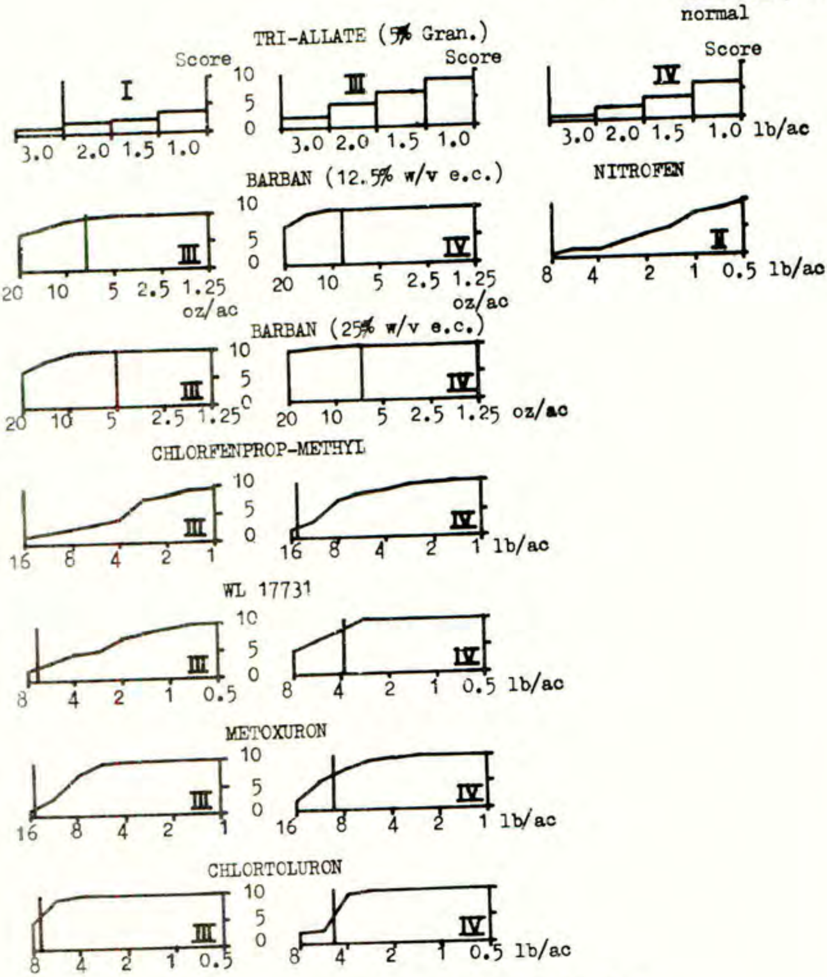
The granular formulation of tri-allate (5%w/w) was most effective on the *A. fatua* in the winter wheat experiment (Burmington) when applied pre-emergence although the maximum rate of 3 lb a.i./ac caused slight crop damage. The post-emergence treat-

Fig. 1 Control of <u>Avena fatua</u> in winter wheat (Cappelle Desprez) on plots treated logarithmically at various times of application.

Scores for no. of panicles - 0 = none; 10 = as control.

<u>Dates of Application</u> I 7.11.69 II 6. 2.70 III 14.4.70 IV 28.4.70

<u>Vertical bar</u> dose below which crop is normal



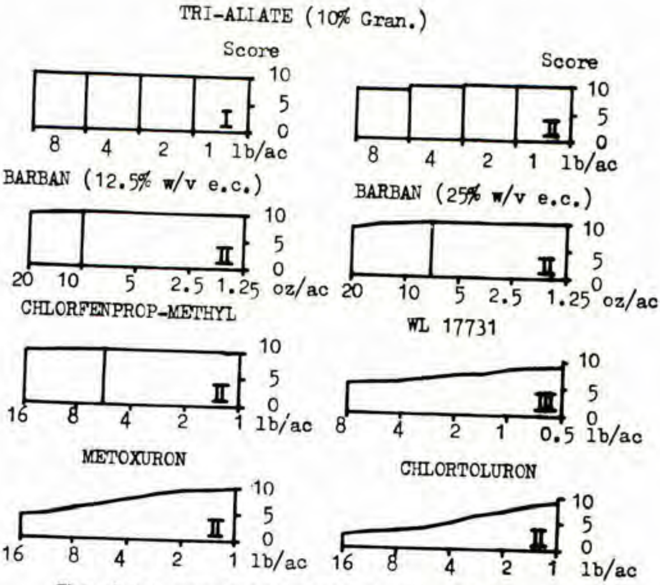
The above scores are means of 3 replicates

Fig. 2 Susceptibility of spring barley (Zephyr) to logarithmic doses of various herbicides applied at various times.

Scores for crop damage - 0 = none, 10 = as control

<u>Dates of Application</u> I: 27.4.70 II:29.5.70 III:11.6.70

<u>Vertical bar</u> Dose below which crop is normal



The above scores are means of 4 replicates

ments applied in April had no apparent effect on the crop even at the peak dose of 3 lb a.i./ac. Weed control was good at this peak dose but only moderate at lower doses.

In the experiments on spring cereals tri-allate granules (10% w/w) were most effective when applied just after emergence, when the <u>**A. fatua**</u> had 0-2 leaves. On three of the experiments 1.5 lb a.i./ac gave 89-90% control at this time.

None of the crops showed any apparent toxicity except for the spring barley at Begbroke (Fig. 2) which showed slight damage as a result of the 8 lb a.i./ac treatment post-emergence. Chlorfenprop-methyl was also one of the more effective compounds but the timing of the application appeared to be critical. Thus on three of the spring cereal experiments 8 lb a.i./ac gave 97-98% control when the <u>A. fatua</u> had up to 3 leaves and at two of these sites 4 lb a.i./ac gave 95% and 93% control. Earlier treatments were less effective. The spring crops appeared to be relatively resistant even to a dose of 8 lb a.i./ac except for some ephemeral scorch. In the winter wheat, treatments were not so effective with 8 lb a.i./ac giving only approximately 70% control of the <u>A. fatua</u>. WL 17731 was much less effective on the weed and showed marked crop toxicity. Wheat is known to be more resistant than barley (Chapman <u>et al</u>., 1970) but even the spring wheat at Abingdon showed some symtoms of damage at doses of 1 and 2 lb a.i./ac. The winter wheat at

Burmington was more resistant but A. fatua control was poor at doses below 4 lb a.i./ac.

Metoxuron gave moderate A. fatua control above 8 lb a.i./ac in the winter wheat at Burmington, when applied in mid-April but by late April the weed was considerably more resistant. Crop toxicity was less at the earlier date. In the spring crops, crop toxicity was also noticeable but A. fatua control was relatively poor except at Abingdon where 4 and 8 lb a.i./ac applied when the weed had 2-3 leaves gave over 90% control. The closely related compound chlortoluron was more toxic to the winter wheat and spring cereals but was only marginally more active on the A. fatua. Like metoxuron it was most effective at the Abingdon site.

Two formulations of barban were used in the winter wheat. The newer more concentrated (25% w/w) formulation (CR 6809) with additional surface active agent (Pfeiffer and Holmes, 1969) was more toxic to the crop but unfortunately did not show any increased toxicity to the A. fatua. In the spring cereals only this newer formulation was used and although the A. fatua control was generally variable, 0.156 lb a.i./ac gave 95% and 80% control at Olverston and Abingdon respectively. At Mildenhall where the barley cultivar was Proctor, not surprisingly, there was severe crop damage and control of the A. fatua was very poor.

Haloxydine showed a high degree of activity but unfortunately relatively little selectivity between the crop and the weed.

Nitrofen applied in early February to the winter wheat gave good A. fatua control at doses above 2 lb a.i./ac with little evidence of persistent crop damage.

DISCUSSION

In the winter wheat at Burmington there were two distinct flushes of A. fatua, one in the autumn and one in the spring. The autumn applications of tri-allate granules controlled the autumn germination and apparently many of the spring germinating plants. The spring applications on the other hand controlled the spring germinating plants but were less effective on the more established autumn plants. However in the spring crops the tri-allate granules were one of the more successful treatments although the results were variable at Mildenhall. The optimum time for treatment in these experiments was early post-emergence.

Chlorfenprop-methyl again proved to be very effective but the timing still appears to be very critical, and in agreement with earlier work which indicated that A. fatua was most susceptible at the 1.5-2.5 leaf stage (Holroyd, 1968).

The two closely related substituted urea compounds metoxuron and chlortoluron were variable in their control of A. fatua but have the added advantage that they control Alopecurus myosuroides and a number of dicotyledonous weeds.

WL 17731 is primarily intended for the control of Avena spp. in wheat crops but in the winter wheat at Burmington and spring wheat at Abingdon its selectivity appeared to be marginal.

Haloxydine also lacked selectivity and the new formulation of barban showed little or no advantage over the old.

Thus on the basis of these experiments a herbicide for the control of Avena spp., which is reliable and effective under all conditions at an economic dose, has yet to be found.

Acknowledgements

We are grateful to M.E. Thornton and M.R. Nowakowski for their assistance with the experiments, to the farmers who supplied the experimental sites and the manufacturers for the supply of the herbicides.

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Table 1

Details of sites and stages of growth of crops and Avena spp. at time of treatment

Site, crop and soil type	Date of treatment	Soil condition	Stage of growth (no. of leaves on main stem and presence of tillers) Crop	Weed	Weed density no./ft^2
Burmington, Warwicks					
winter wheat	7.11.69	knobbly, moist	20% emerged, 0.5 leaves	0.5 leaves	0-1
cv. Capelle Desprez	6.2.70	closed, wet	3-3.5	0-2.5	0-2
sown 22.10.70	14.4.70	closed, moist	5-5.5, 1-2 tillers	(2-5.5, 1-2 tillers (0-1.5	1-5
clay loam	28.4.70	closed, moist	6-6.5, 1-3 tillers	(3-7.5, tillering (1-2.5	1-5
Mildenhall, Wilts					
spring barley	2.4.70	fine and fluffy but wet	0 - chitted	0-1	0-1
cv. Proctor	24.4.70	moist	2-2.5	0-2.5	dense but patchy
sown 17.3.70	7.5.70	moist	6-7 tillering	0.5-4.5 some tillers	dense but patchy
clay loam and flints	9.6.70	dry, compact	jointing	4.5-7.5	dense but patchy
Olverston, Gloucs					
spring barley	17.4.70	moist - dry, closed	0 - chitted	-	-
cv. Julia	5.5.70	dry, moist below	3-3.5	0-2.5	
sown 24.3.70	13.5.70	moist	4.5-5.0 tillering	0-4.5	
sandy loam	28.5.70	dry, slight cracking	7-8 tillered	3-8	
	9.6.70	dry, cracking	8.5-9, 3 joints	4.5-8.5	3-4
Fifield, Gloucs					
spring barley	20.4.70	fine, fluffy, dry	chitted	0-0.5	very few
cv. Sultan	6.5.70	dry, moist beneath	2-2.5	0-2	
sown 22.3.70	18.5.70	dry	4.5-5 tillering	0-5 some tillers	
medium loam	3.6.70	very dry	6-7 tillered	1.5-6 + tillers	
over brash	10.6.70	very dry	7-7.5, jointing	3-7, jointing	1-10

Table 1 continued

Site, crop and soil type	Date of treatment	Soil condition	Stage of growth (no. of leaves on main stem and presence of tillers) Crop	Weed	Weed density no./ft^2
<u>Abingdon, Berks</u>					
spring wheat	16.4.70	moist, fine	-	-	-
cv. Kolibri	1.5.70	dry, wet below	1.5-2	0 - 1	
sown 2.4.70	12.5.70	wet	4-5.5, tillering	0 - 5	
silty loam	1.6.70	dry, slight cracking	6-7, jointing	2 - 7	
	10.6.70	dry, cracked	3 joints	4 - 7, jointed	2 - 11
<u>Begbroke, Oxon</u>					
spring barley	27.4.70	wet, closed	0	-	-
cv. Zephyr	29.5.70	dry, cracking	5-5.5, 2-3 tillers	-	-
sown 25.4.70	11.6.70	dry and dusty	9, 4-5 joints	-	-
light sandy loam					

Table 2

Percentage reduction in the numbers of spikelets of *Avena fatua*

Site		Mildenhall				Olverston					Fifield					Abingdon				
Control spikelets/yd^2		464 (range 15-1082)				742 (range 418-1030)					310 (range 23-1306)					758 (range 182-1985)				
Date of application		2/4	24/4	8/5	9/6	17/4	5/5	13/5	28/5	9/6	20/4	6/5	18/5	3/6	10/6	16/4	1/5	12/5	1/6	10/6
Stage of growth of majority of *A. fatua*		0	1-1.5	2	6-7	0	1-2	2-3	4-5	6-7	0	1-1.5	2-3	4-5	5-6	0	1	2-3	4-6	6-7
	dose lb a.i./ac																			
Tri-allate 10% granules	0.75	58	0	0	-	62	78	61	-	-	50	63	58	-	-	25	35	32	-	-
"	1.5	5	75	0	-	86	89	83	-	-	58	89	57	-	-	49	90	77	-	-
"	3.0	86	54	62	-	93	99	96	-	-	79	84	89	-	-	94	95	70	-	-
tri-allate emulsion	1.25	-	-	-	-	88	-	-	-	-	66	-	-	-	-	52	-	-	-	-
WL 17731	0.5	-	29	8	-	-	-	1**	0*	9	-	-	0*	0*	0	-	-	31	3*	29
"	1.0	-	7	6	-	-	-	36**	20**	7*	-	-	31*	43**	42	-	-	56*	67*	56
"	2.0	-	41*	55*	-	-	-	42**	39**	17**	-	-	27**	0***	19	-	-	58**	30**	39
chlorfenprop-methyl	2.0	-	0	0	-	-	0	67	-	-	-	0	61	-	-	-	54	70	-	-
	4.0	-	11	54	-	-	9	95	-	-	-	42	69	-	-	-	77	93	-	-
"	8.0	-	82	57	-	-	63	98	-	-	-	80	97	-	-	-	85	97	-	-
metoxuron	2.0	-	0	15	-	-	35	30*	-	-	-	33	0*	-	-	-	3	64	-	-
"	4.0	-	39	54*	-	-	10	25*	-	-	-	56**	40	-	-	-	35	92*	-	-
"	8.0	-	60*	45	-	-	65**	85***	-	-	-	25***	73**	-	-	-	96	91**	-	-
chlortoluron	1.0	-	55	0	-	-	31	5	-	-	-	0	17	-	-	-	64	29	-	-
"	2.0	-	45*	7*	-	-	37**	7*	-	-	-	47**	0*	-	-	-	80	63	-	-
"	4.0	-	47**	38**	-	-	81**	48**	-	-	-	39**	36**	-	-	-	86	89**	-	-
barban (25% e.c.)	0.078	-	-	27	-	-	-	37	-	-	-	-	35	-	-	-	-	50	-	-
	0.156	-	-	53	-	-	-	95*	-	-	-	-	44	-	-	-	-	80	-	-
"	0.312	-	-	1***	-	-	-	91	-	-	-	-	75	-	-	-	-	84**	-	-
haloxydine	0.125	0	-	0	0***	0*	-	77*	17	-	30	-	1*	-	-	0	-	90*	76**	-
"	0.250	38*	-	58*	0***	73*	-	59**	68*	-	83	-	55*	0	-	64	-	93**	56**	-
"	0.500	60**	-	61**	55***	98***	-	95**	90**	-	49**	-	70**	39*	-	60	-	85***	79***	-
		S.E. ± 37				S.E. ± 12					S.E. ± 30					S.E. ± 21				

* slight crop damage; ** moderate crop damage; *** severe crop damage