SESSION 7A

GRASS WEEDS IN CEREALS: TRENDS, COST PENALTIES AND SOLUTIONS

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A SURVEY OF COMMERCIALLY GROWN HIGH YIELDING WHEAT AND BARLEY CROPS FROM 1977 TO 1981

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Summary. A survey of 4900 crops of winter wheat and winter barley was carried out by Imperial Chemicals Industries PLC between 1977 and 1981. Detailed records were kept of the operations on one field per farm involving normal commercially grown crops. Analysis of grass weed problems and their control revealed the importance of avoiding competition from the previous crop stubble and through the growing crop to harvest in terms of yield and gross margin. The frequency of occurrence of different weed species and the yield trends associated with them was noted. The range of efficiency of chemical control of *Avena spp*. and *Alopecurus myosuroides* was examined in relation to yield and gross margin.

INTRODUCTION

A programme of cereal surveys was initiated in Autumn 1976 amongst farmers seeking to achieve high yields of winter wheat. They formed a series of '10 Tonne Clubs' the aims of which were the collection and co-ordination of data and the exchange of ideas and techniques in order to improve yields and margins. In the surveys, field scale commercial crops were recorded in order to identify the results of different husbandry practices. Recording was carried out by the farmers and technical representatives and the general results have been published elsewhere (1).

METHOD

The husbandry of invididual fields was recorded in some detail and related to yield and yield components. Farms were selected on the basis of farmers' interest in the crop and their ability to record the data required. The sample was biased to higher yielding crops as shown by Table 1 comparing survey average yields with national average yield. In most cases one field per farm was recorded and frequently the fields with the greatest potential were nominated. The sample of fields changed each year. No replication was included as the objective was to involve a large sample from which broad trends might be seen and to encourage farmers to examine their crops and their husbandry more closely and adopt a more systematic approach to cereal growing. It was not intended that statistical relationships should be derived and thus this work compliments experimental work rather than substituting for it. The size of the sample is shown in Table 1.

Crops throughout England and Wales were recorded but the distribution followed the pattern of importance of winter cereals across the country. Soils were identified by a simple 12 texture description and ranged from fen soils to chalk black puffy soils and light loams to clays.

Most of the cereal crops surveyed were grown in arable rotations consistent with the pattern in the country as a whole. Both the wheat and the barley tended to be the second or more cereal crop in the rotation. Only 25% were first cereal crops after a break.

In 1980 and 1981 financial data was added to the physical data recorded.

Information recorded on weeds and their control included the following:

- level of grass weeds in previous crop stubble
- identification of grass weed species present in previous crop stubble
- previous crop stubble treatment in respect of herbicides and cultivations
- presence or absence of grass weeds as a problem in the crop
- herbicide policies employed
- level of grass weeds at harvest
- identification of grass weed species at harvest

The method of analysis permitted these aspects to be related to any of the other aspects of crop management recorded and to the crop performance in terms of yield and yield components.

Some subjective assessment of data was inevitable in a survey of this type in respect of factors such as "general state of the stubble" which was defined as clean, slightly weedy, moderately weedy or very weedy.

RESULTS

Table 1

Cereal surveys - sample size and yields

	Winter Wheat				Winter Barley	
	1977	1978	1979	1980	1980	1981
No. of crops recorded	669	1110	1027	899	472	723
Average yields t/ha	6.3	7.0	6.9	7.3	6.2	5.5
National average yield t/ha(1)	4.87	5.89	5.22	5.89	4.46	4.3

Stubble weeds from previous crop

The majority (80%) of previous crop stubbles were "clean" or only "slightly weedy" with little variation over the 5 year period (Table 2). 37% of the stubbles preceding winter barley were described as "clean" compared to 43% "clean" stubbles preceding winter wheat. This possibly reflects the longer run of cereal cropping preceding barley crops and the earlier drilling of these crops compared to wheat leaving less time for any cleaning operations after harvesting the previous crop. However, there was no greater occurrence of moderately or very weedy stubbles preceding barleys compared to wheats. Overall 20% of previous crop stubbles fell into these more weedy categories.

Table 2

Level of weeds in previous crop stubble
% of total crops recorded

	Winter Wheat 1977	Winter Wheat 1978	Winter Wheat 1979	Winter Wheat 1980	Winter Barley 1980	Winter Barley 1981	Av. of all crops
Very weedy	5	5	3	4	4	3	4
Moderately weedy	16	15	13	15	17	17	16
Slightly weedy	39	38	39	38	43	47	40
Clean	40	42	46	42	36	33	40

Crops established from clean stubbles achieved a higher yield than those associated with weedy stubbles. Whilst the yield penalty was small (6% comparing crops following clean stubbles with those following very weedy stubbles - see Table 3) it is interesting that any yield effect followed right through all the subsequent crop management.

Table 3

Grass weeds in previous crop stubble

Previous Stubble	Yields t/ha: Wheat Crops 77-80	Yields t/ha: Barley Crops 80-81	Index for all Wheat and Barley Crops: Yield	Index: Ears/m^2 at harvest	Index: Grains ears	Index: 1000 grain weight(g)
Very weedy	6.73	5.65	94	91	104	100
Moderately weedy	6.69	5.65	94	94	102	100
Slightly weedy	6.80	5.75	96	96	101	100
Clean	7.14	6.00	100	100	100	100

The main effect appeared to derive from weed competition resulting in lower spring plant numbers (as a % of seeds sown) and lower ear numbers at harvest.

The method of establishment had little effect on this yield trend although direct drilling was not normally practised where previous crop stubbles were very weedy.

The main grass weeds in the previous crop stubble are shown in Table 4.

Agropyron repens, A. myosuroides and Poa spp. were the most common three grass weeds in stubbles preceding wheat. The same weed groups were found ahead of the barley crops but Poa spp. occurred with considerably higher frequency.

Table 4

Occurrence of grass weeds species in previous crop stubble as % of situations where grass weeds were noted

Weeds in previous Crop Stubble	Wheat Crops	Barley Crops
Agropyron repens	28	24
Agrostis stolonifera	3	2
Alopecurus myosuroides	24	19
Poa spp.	25	36
Lolium spp.	8	8
Volunteer cereals	2	4
Others	10	7

There was little difference between the yields achieved according to the presence of different weeds in the previous stubble. It was not possible to analyse for any yield trends from different levels of individual weeds.

Weed competition during crop growth

The grass weeds causing a problem during crop growth were recorded but no levels of severity were identified. The weed pattern was very similar for both wheat and barley crops during the years of the survey. Avena spp. was the commonest problem followed by A. myosuroides and Poa spp. (Table 5). Additional data collected in winter barley in 1981 only, indicated that the majority of these problems were being identified in the Autumn.

Table 5

Occurrence of grass weed species causing a problem in the crop as a % of total crop recorded

	Wheat Crops	Barley Crops
Avena spp.	43	38
Alopecurus myosuroides	31	30
Poa spp.	18	17
Agropyron repens	12	7
Lolium spp.	9	6
Bromus sterilis	8	9

Whilst the definition of "a problem in the crop" is subjective and gives no indication of the level of infestation, it did reflect the farmers own identity of grass weed competition and analysis on this basis suggested yield penalties as in Table 6.

Table 6

Grass weed problems and associated yields

Grass Weed Problem in Crop	Wheat Crops	Barley Crops
Avena spp.	6.9	6.3
Poa spp.	6.4	5.9
Agropyron repens	6.4	NA
Lolium spp.	6.4	5.4
Bromus sterilis	7.1	6.2
Total sample - all crops	6.9	6.2

NA = Insufficient data

Thus yields associated with Poa spp., Lolium spp. and A. repens presence were between 5-13% lower than for crops without these weed problems. Infestations of B. sterilis were generally patchy or restricted by headlands and especially in the earlier years of the wheat investigations this was only identified by the more informed farmers whose general level of husbandry was above the average for the group as a whole.

Weed problems recognised in the crop were variously influenced by husbandry factors such as sowing date, previous stubble treatment, soil type, previous cropping establishment system and nitrogen top dressing level.

Husbandry factors associated with weed problems in the crop

Earlier sowing appeared to be associated with higher frequency of Avena spp. Poa spp. and A. myosuroides problems whilst competition from Lolium spp. and A. repens tended to increase with later drilled crops.

Where previous crop stubbles were burnt, a "good" burn (as subjectively defined by the farmers) was associated with lower occurrence of all grass weed problems except B. sterilus, compared to situations where only a "poor" burn had been achieved.

Grass weeds were recorded with varying frequencies on different soil types but a strong trend appeared to exist with Avena spp. which occurred on 54% of heavy soils and 34% of lighter soil types. Poa spp. and to a lesser extent Lolium spp. occurred more frequently on lighter soils, whilst B. sterilis was associated with chalky boulder clays and Cotswold brash reflecting the frequency of winter cereal cropping and the more advanced build-up of this weed grass in such situations.

Trends of grass weed problems associated with previous cropping are shown in Table 7. Predictably Avena spp. and B. sterilis problems were more frequent in longer runs of cereals, whilst there was little evidence of Poa spp., Lolium spp. building up in these situations. Cereals grown after grass tended to have fewer Avena spp. and B. sterilis infestations but more frequent presence of Poa and Lolium spp. The occurrence of Avena spp. after potatoes was lower than in most cropping situations but this weed showed a surprising frequency after other arable break crops. Peas, beans, oilseed rape and sugar beet generally appeared to provide a useful break effect in respect of the other grass weeds recorded.

Table 7

% of wheat crops recorded with grass weed problems according to previous crop

Previous Crop	Avena spp.	Poa spp.	Lolium spp.	Bromus sterilis	Agropyron repens
1st wheat	39	20	10	8	4
2nd wheat	43	24	9	13	15
3rd or more wheat	60	21	9	20	15
Other cereal	40	16	6	6	14
Grass	28	22	26	5	11
Sugar beet	54	16	4	-	-
Potatoes	36	18	4	-	6
Peas/beans	53	9	3	5	7
Oilseed rape	56	10	6	6	8

Grass weed problems were generally more frequent under regimes of nearer optimum nitrogen top dressing (Table 8).

Table 8

% of wheat crops recorded with grass weed problems according to nitrogen top dressing level

N Top Dressing	% Weed Problems				
	Avena spp.	Poa spp.	Lolium spp.	Bromus sterilis	Agropyron repens
Nearer optimum (185 kg/ha)	46	15	10	12	12
Below optimum (97 kg/ha)	37	9	9	4	11

The establishment system followed appeared to produce particular trends in the weed competition in the crop. The frequency of *Avena spp.* and *B. sterilis* was considerably less in crops that had been ploughed. The latter problem appearing to relate directly with the amount of soil disturbance before drilling. Few problems of *Poa spp.* and *Lolium spp.* were recorded after minimum cultivations or direct drilling. *A. repens* appeared least frequently with minimal cultivated crop but no record of rhizome density is available to examine this further.

Table 9

% of wheat crops recorded with grass weed problems according to method of establishment

Establishment System	Avena spp.	Poa spp.	Lolium spp.	Bromus sterilis	Agropyron repens
Ploughed, cultivated and drilled	37	21	11	5	13
Minimum cultivations and drilled	55	13	6	12	9
Direct drilled	50	16	9	13	15

Efficiency of herbicide control

These surveys were not intended to identify optimum individual treatments for particular crops but the efficiency of chemical control was recorded. Table 10 examines the efficiancy of control of Avena spp. and A. myosuroides. Over 95% control was achieved with Avena spp. herbicides in more than 50% of treatments and around 40% of treatments gave the same excellent control of A. myosuroides. However, it is salutary that nearly 20% of treatments against these weeds produced only medium or poor control. Herbicides can obviously give very high levels of control but in practice there are situations where this is not achieved.

Table 10

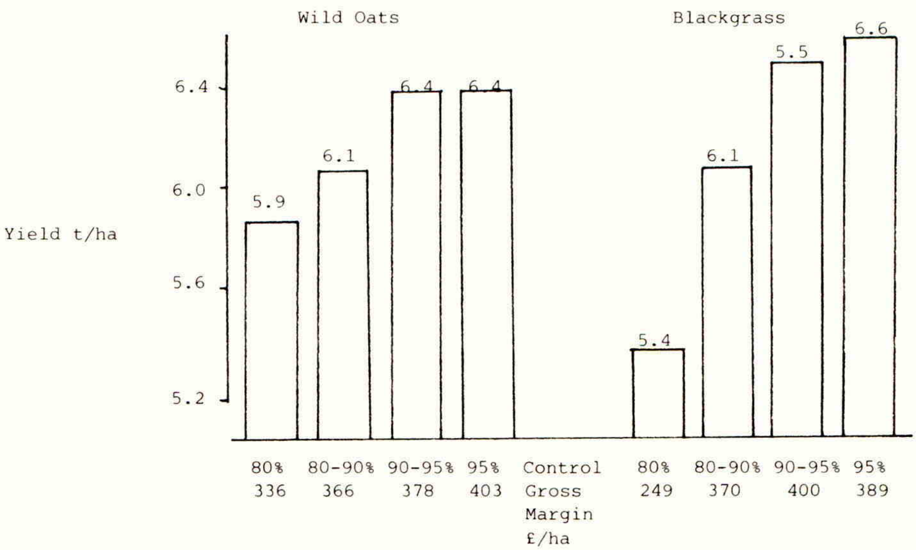
% of crops treated for control of Avena spp. and A. myosuroides by efficiency of control

Efficiency of Control	Avena spp. Winter Wheat	Avena spp. Winter Barley	Control of A. myosuroides Winter Wheat	Control of A. myosuroides Winter Barley
95%+	51	58	38	39
90-95%	30	30	43	45
80-90%	15	15	13	13
Less than 80%	4	2	5	3

There appeared to be a strong yield trend associated with the efficiency of control of these predominant weeds which was reflected in financial terms in the gross margin. Table 11 indicates a direct cost penalty of inefficient control of Avena spp. of £67/ha and £140/ha in the case of A. myosuroides.

Table 11

Influence of % control of Avena spp. and A. myosuroides



Weeds at harvest

The final measurement of weed competition was the level of weeds remaining in crops at harvest. The pattern was very similar to the proportion of clean and weedy fields found in the analysis of previous crop stubble as shown in Table 12.

Table 12

Level of weeds at harvest % of total crops recorded

	Winter wheat	Winter barley
Very weedy	4	3
Moderately weedy	15	12
Slightly weedy	39	42
Clean	42	43

The grass weed species present were similar to those identified in the growing crop (Table 5). The occurrence of most grass weeds had been reduced with the exception of *Poa spp.* in winter barley which was identified on more fields at harvest than had been recorded earlier.

Yield trends appeared to be closely associated with the degree of weed competition persisting through to harvest as might reasonably have been expected. It was not possible to identify varying yield effects of different grass species owing to the presence of more than one species. Table 13 indicates clearly the trend of yield and weed populations.

Table 13

Yields and grass weeds at harvest

Grass Weeds at Harvest	Yield t/ha	Yield Index	Spring plant numbers as % of seed sown	Ears/m^2 at harvest	Grain/ ear	1000 grain weight (g)
Very weedy	5.90	83	60	440	40.3	46.5
Mod. weedy	6.30	88	61	472	40.7	46.8
Slightly weedy	6.80	95	65	489	40.7	47.8
Clean	7.15	100	67	505	41.0	48.5

The main effects upon yield appeared to be from weed competition restricting ear numbers. This was a feature of lower plant survival over winter and the retention of fewer tillers per plant. The effects on 1000 graan weight and grains per ear were small.

Cost of weed problems

The survey showed that grass weed problems could have a strong impact upon yields. A more important measure is that of gross margin which takes account of both crop output changes and herbicide costs. Financial data were only available for 1980 and 1981 but for both wheat and barley the gross margin difference between clean crops and very dirty crops was around 25% - which would be highly significant in terms of ultimate profitability.

Table 14

Gross Margin and weeds at harvest

Grass weeds at harvest	Gross Margin £/ha Wheat	Barley
Very weedy	401	315
Mod. weedy	475	384
Slightly weedy	510	381
Clean	560	420

DISCUSSION

This study examined the importance of grass weed competition arising from the previous crop stubble, occurring during crop growth and remaining at harvest of the wheat and barley crops surveyed. Farmer practice should clearly attempt to maintain continual control of grass weeds throughout a rotation rather than allow a gradual build up and then expect a complete removal of the problem. Weed problems left over from the previous crop were shown to carry a penalty of around 0.4 t/ha regardless of subsequent treatment in the crop which equates to a cost penalty of some £40/ha. Treatment of a lighter infestation must also be an easier and less costly target to control compared to treatment of dense infestation albeit less frequently.

Avena spp. occurred in a large number of crops but showed little direct effect upon yield (either because of the level of infestation or through treatment). However, the problems of contaminated grain samples is another potential cost penalty which could be serious in particular situations. Other common grass weeds, A. myosuroides, Poa spp., A. repens and Lolium spp. all represented a cause of yield loss when recorded in the growing crop. B. sterilis like Avena spp. was not associated with yield loss in the years of the survey but suggested the potential for serious escalation and cost penalty together with the management headaches of control.

Whilst aspects such as soil type, which are outside the farmer's control, are conducive to certain weed build-up, the survey identified husbandry practices which affected weed presence. Recognition of these relationships must be worthwhile in overall weed control policies.

Recognition of species and application of chemical treatment cannot be regarded as a complete solution to weed problems. The study highlighted the importance of the degree of control of Avena spp. and A. myosuroides and showed that in about 25% of all cases where spray measures were applied the efficiency of control was poor. In such cases the cost penalties were sizeable (up to £140/ha) deriving from both the continued weed competition and the cost of the ineffective control measures.

Where weed competition persisted through to harvest, yield losses were significant (17% for the "very weedy" crops) and gross margins were reduced by 25%. In addition to these direct cost penalties there are additional costs of harvesting, drying and storing grain. An increase in 'matter other than grain' (MOG) has been shown to result from an increase in grass weeds in the crop and the additional costs of MOG, whilst frequently hidden, can be considerable[3].

REFERENCES

1. Jones, M. J.; Hollies, J. D. (1977, 1978, 1979 & 1980). Pointers to Profitable Winter Wheat.

   Hollies, J. D.; Perkin, G. J. (1980 & 1981). Pointers to Profitable Winter Barley.

2. MAFF. E & W Crop Production Statistics.

3. Elliott, J. G. (1980). The economic significance of weeds in the harvesting of grain. Proceedings British Crop Protection Conference - Weeds, - 3, 787-796.

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POPULATION TRENDS OF AVENA FATUA AND ALOPECURUS MYOSUROIDES ON A COMMERCIAL ARABLE AND DAIRY FARM

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Summary. Avena fatua and Alopecurus myosuroides are being surveyed annually on all cereal fields of a 173 ha arable and dairy farm. Since 1977 average populations have remained relatively stable, at low levels not affecting crop yields. A. fatua have declined from a farm average of 0.47 panicles m^2 in 1977 to $0.03/m^2$ in 1982, and A. myosuroides from 4.75 heads/m^2 in 1977 to $2.80/m^2$ in 1982. Weed containment has been achieved with high expenditure on herbicides and with hand roguing of A. fatua. Over the six years only 4 crops received no herbicide, 26 received one and 38 crops received two herbicides for the control of grass weeds. Some reduction in total expenditure has been achieved by changing to less costly herbicides. A. myosuroides is more of a threat than A. fatua, and poor herbicide performance in some fields has allowed A. myosuroides populations to increase. A three year grass ley allowed some seeds to persist, and A. myosuroides and A. fatua plants appeared in the wheat after the ley. Monitoring of weed populations and herbicide use is continuing. Weed containment, herbicide costs, seed return, persistence, roguing, leys, rotations.

INTRODUCTION

A.fatua and A.myosuroides continue to be threats to profitable cereal growing, even though reserves of viable seeds decline rapidly in cultivated soils (Wilson 1978, Moss and Cussans 1982).

This suggests that their continued presence on farms relates only partly to persistence of seeds in the soil and may be due largely to inadequate control measures, so that new seeds add to those already in the soil. To test this concept it was decided to study weed levels on a whole farm over a long period of commercial control measures.

The long term study reported here is being carried out jointly between the Weed Research Organization and The Agricultural Development and Advisory Service to monitor A. fatua and A. myosuroides annually, and to relate population changes to control measures. This is a commercial farm, with a history of bad infestations of grass weeds, where an integrated approach to control is adopted relying on chemical, rotational and cultural methods. The study is continuing and this is an interim report covering the first six years of the project.

METHODS AND MATERIALS

Neville's Farm near Wantage was selected in 1976 as typical of many heavy land cereal farms with a continuing problem of A. fatua and A. myosuroides. It is a mixed arable and dairy farm of 173 ha on heavy clay, managed by Mr Richard Smith (director) and Mr Tim Hickman. Prior to 1976 their control programme had brought originally heavy infestations down to low populations, generally too low to affect yields. Although herbicide costs cannot be offset by short term yield responses, a control programme is needed to prevent populations increasing and so threatening yields.

Rotation

Prior to 1976 cropping decisions were made on a year to year basis using break crops and leys. In 1977 a rotation was adopted for the main block of land of 121 ha. This was based on three years grass ley followed by five years of cereal crops, but management requirements have led to some flexibility with the grass break varying between fields from two to four years (Table 1). A 21 ha block remains in continuous cereal and the remaining area is permanent grass. All cereals are winter sown, and the cropping sequence is shown in Table 1.

Table 1

Field areas and cropping sequences for six years

Field	Area (ha)	76/77	77/78	78/79	79/80	80/81	81/82
Continuous cereals							
A Butterfly	8.7	W	W	B	W	W	W
B Collins	5.5	W	W	B	W	W	W
C Styles	6.7	W	W	B	W	W	W
Ley/arable							
D Barley Ground	6.5	Gr	W	Gr	Gr	W	W
E Bosleys East	6.9	W	W	B	Gr	Gr	W
F Bosleys West	5.7	W	B	Gr	Gr	Gr	W
G Canal Meadow	10.1	Gr	Gr	W	W	B	B
H Feeding Ground	8.9	B	B	Gr	Gr	Gr	Gr
I Little Meadow	2.4	W	W	W	W	B	Gr
J Lockhouse	10.9	W	W	W	B	B	B
K Long Meadow	13.6	W	W	W	W	B	Gr
L Long Ground	10.9	B	B/Gr	Gr	Gr	W	W
M Rowleaze	13.8	Gr	Gr	W	W	W	B
N Swingbridge	15.8	O/Be	W	W	B	Gr	Gr
O Windsor Down North	8.1	B	B	Gr	Gr	Gr	W
P Windsor Down South	7.7	Gr	Gr	Gr	W	W	W

W = Winter Wheat B = Winter Barley Gr = Grass
O/Be = half Oats, half Beans B/Gr = half Barley, half Grass

Straw disposal and cultivations

The straw in most fields was burnt, the remainder being baled to provide for the dairy herd. In autumn 1977 most fields were ploughed, but in the following three years more crops were established by reduced cultivations instead of by ploughing. This involved tine cultivation to about 12 cm sometimes preceded by subsoiling to 40-45 cm. In 1981 there was a return to more ploughing and over half the fields were ploughed, mostly those where wheat was sown.

Herbicide application

Most herbicide applications were made by a conventional farm sprayer with hydraulic nozzles and operating at 225 l/ha and 210 kPa. Tri-allate (granules) and trifluralin + linuron applications were by contractor using a low ground pressure vehicle. Most herbicide applications were for the control of grass weeds and Table 2 shows the herbicides (names are abbreviated) that were used in each field in each year.

Table 2

Herbicides used on individual fields for grass weed control. (- = grass)

Field	76/77	77/78	78/79	79/80	80/81	81/82
Continuous cereal						
A	flam-met.	isoprot.*[!] flam-met.	triallate flam-iso.	triallate methabenz.	chlort.[@]	chlort.*
B	chlort.* benzp-e.	iso/iox/b.* flam-met.	triallate flam-iso.	triallate methabenz.	chlort.[@]	chlort.*
C	chlort.* benzp-e.	isoprot.*[!] flam-met.	triallate flam-iso.	triallate methabenz.	chlort.[@]	chlort.*
Ley/arable						
D	-	isoprot.* flam-met.	-	-	none	triallate trifl/lin.
E	chlort.* benzp-e.	chlort.* benzp-e.	chlort.[@]	-	-	triallate trifl/lin.
F	chlort.* benzp-e.	isoprot.* flam-iso.	-	-	-	isoprot.*
G	-	-	isoprot.*	chlort.[@] benzp-e.	triallate[+] trifl/lin.	pendimeth. difenzo.
H	chlort.* flam-iso.	isoprot.* flam-iso.	-	-	-	-
I	none	chlort.*	methabenz.	chlort.[@]	triallate trifl/lin.	-
J	chlort.* flam-met.	chlort.* benzp-e.	triallate isoprot.*	chlort.[@] flam-iso.	triallate trifl/lin.	pendimeth. flam-iso.
K	benzp-e.	isoprot.*[!] benzp-e.	benzp-e.	chlort.[@]	triallate trifl/lin.	-
L	flam-iso.	isoprot.*" flam-iso.	-	-	triallate trifl/lin.	triallate trifl/lin.
M	-	-	isoprot.*	chlort.[@]	none	iso/iox/b.[@]
N	none	benzp-e.	triallate	chlort.[@]	-	-
O	chlort.* flam-iso.	isoprot.* flam-iso.	-	-	-	isoprot.*
P	-	-	-	chlort.* benzp-e.	isoprot.*	isoprot.*

* Spring applied, @ Autumn applied, + High dose, ! Half dose, " Half field treated

In order to compare annual expenditure on herbicides, herbicide costs have been standardised to the typical retail prices for 1981 (Ministry of Agriculture, Fisheries and Food 1981) as follows:

		£/ha		£/ha
Isoproturon + ioxynil + bromoxynil	- autumn	48	Trifluralin + linuron	25.8
	- spring	40	Pendimethalin	42.6
Isoproturon	- autumn	47.5	Methabenzthiazuron	40.9
	- spring	39.9	Difenzoquat	35.5
Chlortoluron	- autumn	46.9	Benzoylprop-ethyl	43.2
	- spring	36.8	Flamprop isopropyl	39.5
Tri-allate granules	- normal dose	25.6	Flamprop methyl	40.8
	high dose	38.4		

Table 3 shows the calculated average cost (1981 prices) of herbicides used per ha of cereals grown. Actual costs will have varied with price fluctuations, and for 1981/82 will be less than shown due to recent reductions in the cost of some herbicides.

Table 3

Total cost of herbicides used (at 1981 prices).

	76/77	77/78	78/79	79/80	80/81	81/82
Total cost herbicides £	5502	7193	4442	5997	3882	5224
Total arable area ha	104.1	110.6	94.4	95.2	96.8	101.5
Cost/ha £	52.9	65.0	47.1	63.0	40.1	51.5

Whole farm survey assessments

Surviving *A. fatua* and *A. myosuroides* have been assessed each summer. The farm was surveyed for *A. myosuroides* heads in June and for *A fatua* panicles in July (after roguing) when heads and panicles were obvious but before ripening, shedding and possible lodging. Each field was surveyed on an approximate 40 m square grid. Ideally 3 or 4 people walk in parallel, 40 m apart across the field using tractor tramlines as a guide for keeping parallel. Every 50 paces four random quadrats of 0.25 m^2 (*A. myosuroides*) or 2 m^2 (*A. fatua*) were assessed by each surveyor. The combined count of heads or panicles for the four quadrats was recorded as one survey point on an outline map of the field. The completed map with six to seven survey points/ha indicated the distribution of *A. myosuroides* and *A. fatua*. The average density for each weed was calculated for each field.

Mean values for each field will not show variations in distribution which occur. A computer map is in process of being drawn to show relative areas of different levels of infestation within each field. This programme has not been completed. However an analysis of the total survey points is an indication of relative areas at different levels of infestation for the whole farm.

Transect assessments

The reserves of *A. myosuroides* seeds in the soil have been assessed annually in six fields. This was not possible for *A. fatua* where populations were too low for the assessment technique. Soil samples were taken each September at 3 or 4 points 40-60 m apart on a transect line across each of the six fields. Fifteen cores 12 cm diameter and 20 cm deep were taken within a 10 m radius of each point. The soil was air dried and *A. myosuroides* seeds determined by washing to reduce the sample size, and allowing the seeds to germinate (Moss 1981a).

RESULTS

Herbicide use

Herbicides for grass weed control were applied to most of the cereal crops grown between 1977 and 1982 (Table 2). Of the 68 crops grown, 4 received no herbicide for grass weed control, 26 received one herbicide and 38 crops received two separate herbicides. The greatest expenditure on herbicides (at 1981 prices) was in 1977/78 when eleven out of thirteen fields were sprayed twice using a urea based herbicide (chlortoluron or isoproturon) for *A. myosuroides* followed by a herbicide against *A. fatua* (Table 3). In subsequent years fewer fields have been sprayed twice and the change to a less expensive sequence of tri-allate granules and trifluralin + linuron almost halved the relative herbicide cost in 1980/81. Costs/ha have increased again in 1981/82 with all cereal fields being sprayed.

A. fatua populations

A. fatua panicles were absent from over 60% of the survey points (Table 4). The proportion containing more than 1 panicle/m^2 varied from 0.4% (1981/82) to 14.6% (1978/79). At very few points were there more than 10 panicles/m^2.

Table 4

Percentage of total survey points at different infestation levels

Infestation	76/77	77/78	78/79	79/80	80/81	81/82
A. fatua panicles/m^2						
0	62.4	81.8	72.2	80.4	67.4	92.0
up to 1	24.2	12.6	13.2	12.4	25.1	7.6
1-10	12.2	5.7	14.6	6.3	7.3	0.4
> 10	1.1	0	0	0.9	0.2	0
A. myosuroides heads/m^2						
0	63.1	66.0	76.5	76.3	68.7	72.4
up to 5	14.5	14.7	8.3	9.2	13.8	13.2
5-50	20.0	16.1	13.1	12.1	15.1	13.2
> 50	2.5	3.2	2.1	2.4	2.4	1.2

A mean for the farm of 0.47 panicles/m^2 survived in the first year (Table 5). The mean value fluctuated between 0.13 and 0.33 between 1977/78 and 1980/81 and fell to 0.03/m^2 in 1981/82. Generally fewer *A. fatua* panicles have been found on the continuous cereal than on the ley/arable area. Field J was the worst infested field in 1976/77 after poor control in a previous crop of beans. Although no panicles were recorded in this field in 1979/80, a further bad infestation occurred in 1980/81, followed by very few panicles in 1981/82, fluctuations probably due to variations in herbicide performance. In fields G and M 1.43 and 0.14 panicles/m^2 survived isoproturon and hand roguing in 1978/79 in the first cereal after grass. In the following two years these remained two of the most seriously infested fields. .07 panicles/m^2 were recorded in 1981/82 in field O after three years of grass. Fields A, B, C, I and K have remained lightly infested since 1976/77.

Table 5

Mean *A. fatua* panicles/m^2 for individual fields (- = grass).

Field	76/77	77/78	78/79	79/80	80/81	81/82
Continuous cereals						
A	0.12	0	0	0.04	0.15	0.01
B	0.03	0	0	0.01	0	0
C	0.04	0.01	0	0.01	0.02	0.01
Mean	0.06	0	0	0.02	0.06	0.01
Ley/arable						
D	-	0	-	-	0	0
E	0.25	0.03	0.01	-	-	0.01
F	0.44	0.03	-	-	-	0.01
G	-	-	1.43	0.31	0.82	0
H	0.15	0.12	-	-	-	-
I	0.02	0	0	0.07	0.04	-
J	2.61	0.60	1.42	0	0.37	0.01
K	0.03	0.01	0.01	0.01	0.03	-
L	0.63	0	-	-	0	0
M	-	-	0.14	0.11	0.73	0.04
N	n.a.	0.64	0.28	1.76	-	-
O	0.83	0.27	-	-	-	0.07
P	-	-	-	0.05	0.12	0.16
Mean	0.62	0.17	0.47	0.33	0.26	0.03
Mean (whole farm)	0.47	0.13	0.33	0.23	0.21	0.03

A. myosuroides populations

A. myosuroides heads were absent from a large proportion of the survey points (Table 4). At most of the remaining points less than 50 heads/m^2 were recorded, but on a small proportion of points (varying from 1.2% to 3.2%) more than 50 heads/m^2 were found.

Average *A. myosuroides* populations for the whole farm have declined from 4.75 heads/m^2 in 1976/77 to 2.80/m^2 in 1981/82 (Table 6). Generally good control was achieved, but herbicides performed poorly in some fields especially in the early years e.g. high populations in H and O (1977/78) where *A. myosuroides* was suppressed but not killed; K in 1976/77 and 1978/79 where only a *A. fatua* herbicide was applied. Fields J and K have remained the worst infested fields, field J despite the continued use of *A. myosuroides* herbicides. In four fields *A. myosuroides* was recorded in the cereal crop following the grass ley: E 1981/82 (0.69 heads/m^2), F 1981/82 (0.20), G 1978/79 (6.54) and O 1981/82 (2.23 heads/m^2). This overall decline for the whole farm appears to be due to a generally improved herbicide performance in the later years in the arable/ley part of the rotation; in contrast there has been a trend for increasing populations in the continuous cereal fields from 1978/79 onwards.

Table 6

Mean A. myosuroides heads/m^2 for individual fields (- = grass).

Field	76/77	77/78	78/79	79/80	80/81	81/82
Continuous cereals						
A	1.68	0.38	0.01	0.67	0.46	3.63
B	0.53	1.78	0.03	1.35	1.57	3.53
C	2.32	1.81	0.10	5.24	5.54	4.78
Mean	1.51	1.32	0.05	2.42	3.86	3.98
Ley/arable						
D	-	0.04	-	-	0.02	0
E	8.51	2.20	0.08	-	-	0.69
F	9.21	4.37	-	-	-	0.20
G	-	-	6.54	2.15	4.29	2.85
H	0.93	14.26	-	-	-	-
I	0.21	0.11	0.40	0	1.00	-
J	7.36	0.32	6.40	12.58	5.42	11.46
K	19.35	1.37	22.82	11.66	18.02	-
L	5.56	0.11	-	-	0.09	0.73
M	-	-	0	0	0.80	0.01
N	0.46	2.90	4.02	4.40	-	-
O	0.90	43.50	-	-	-	2.23
P	-	-	-	0.04	0.12	3.47
Mean	5.83	6.92	5.75	4.40	3.72	2.40
Mean (whole farm)	4.75	5.63	4.04	3.81	3.76	2.80

Table 7

Mean viable A. myosuroides seeds/m^2 found in soil at transect points in six fields

Field	No. of points	'76	'77	'78	'79	'80	'81
Continuous cereals							
C	4	650	496	259	258	333	71
J	3		273	131	220	130	144
G	3			412	532	140	126
K	3			381	147	831	2313
Cereals 1976-78 Grass 1979-81							
O	3	87	77	157	49	6	24
H	3		160	155	144	55	12

Numbers of viable A. myosuroides seeds in the soil are shown in Table 7. In four fields under continuous cereals, seed reserves, although fluctuating, were generally maintained over the 4-6 year period. In two fields where grass replaced cereals from 1979 onwards viable seeds declined but were not eliminated in the latter three years.

DISCUSSION

The system at Neville's farm, with occasional ploughing and grass breaks, is unlikely to favour *A. myosuroides* and *A. fatua* as much as one with continuous cereals established with reduced cultivations. This farm is typical of many cereal farms where infestations of *A. myosuroides* and *A. fatua* are too low to reduce crop yields, and yet regular treatment is needed to prevent them increasing to levels where yields suffer. To what extent can economies be made in the cost of herbicides without weed populations increasing? This will be governed by the cost effectiveness of the herbicides, and the influence of cultural factors on herbicide performance and the decline of seed reserves.

This report gives the results of the first six years of a survey of the whole cereal area of a farm based on weed population records from about 700 survey points each year. It has been carried out against a background of improving husbandry standards. Wet autumns in some of the earlier years resulted in poor seedbeds, late sowings and difficulties in correctly timing residual herbicides. However, crop yields have generally improved (Table 8) reflecting the benefit of a comprehensive drainage programme, as well as modern varieties and chemical fungicides.

Table 8

Farm crop yields since 1979

Year	Field	Crop	Yield t/ha	Year	Field	Crop	Yield t/ha
1979	I & J	Wheat	4.9	1981	G, I, J & K	Barley	5.5
	G & M	Wheat	4.0		A, B & C	Wheat	8.1
	K	Wheat	6.4		D, M & P	Wheat	7.5
	N	Wheat	5.2		L	Wheat	7.0
	Mean/field		4.9				6.9
1980	A, B & C	Wheat	6.0	1982	G, J & M	Barley	6.2
	G	Wheat	7.8		A, B & C	Wheat	7.5
	I	Wheat	8.8		D	Wheat	7.6
	K	Wheat	8.1		E	Wheat	9.0
	M	Wheat	7.6		F	Wheat	7.9
	P	Wheat	8.2		L	Wheat	8.0
					O	Wheat	6.5
	Mean/field		7.3		P	Wheat	8.5
					Mean/field		7.4

Experiments have shown that reserves of both *A. myosuroides* and *A. fatua* seeds in cultivated soils decline to low levels after three years where new seeding is prevented (Wilson 1978, 1981a, Moss and Cussans 1981). The stability of populations over the first six years of this study indicates the influence of survivors in shedding seeds to maintain seed reserves. Containment has been achieved at a high cost of herbicide input with most fields being sprayed for one or both weeds. *A. fatua* levels appear to be reducing, probably due to the additional benefit of hand roguing backing up the herbicide. Roguing has been carried out where possible, but there have usually been some fields with too many survivors from the herbicide to be successfully rogued by hand. In 1982 all fields were roguable following good control with herbicides. Where herbicides have worked well and minimised seed return, *A. fatua* have recurred in the following year from seed reserves. Seed return will have to be prevented for several successive years before herbicides may be dispensed with. The results of a similar project in Cambridgeshire (Large 1981) show that this is a realistic objective. Here A. fatua were successfully reduced to roguable levels after 8 years of continuous treatment with specific A. fatua herbicides. A gradually increasing area is now being controlled by hand roguing alone at a lower cost than chemical treatment.

A. myosuroides represents more of a threat because of its faster potential rate of build-up than A. fatua (Wilson 1981b, Moss 1981b) and the inability to hand rogue. Generally herbicide control has been less successful than against A. fatua and with poor control populations have increased in some fields. In one minimum tillage experiment at the Weed Research Organization it was estimated that 95% control of A. myosuroides was needed to prevent an increase in viable seeds in the soil in the following year (Moss and Cussans 1982). Clearly more reliable control over several successive years is needed to effect a real decline in populations.

The dependence on herbicides to safeguard crop yields is indicated by the analysis of the survey data. This suggests that 2-3% of the cereal area may be suffering some yield loss with over 50 A. myosuroides heads/m^2 surviving herbicide use. A further 10-20% of the area (at present between 5 and 50 heads/m^2) would be at immediate risk of yield loss if herbicides were not used.

In the ley/arable rotation, three years in grass did not prevent a recurrence of both A. myosuroides and A. fatua in the first cereal crop after the ley. It is possible but unlikely that some seed heads may have formed in the grass which was cut early for silage each year. The decline of A. myosuroides seed reserves on the treatments is probably a true reflection of seed persistence. This is supported by experiments in which A. myosuroides seed reserves under grass declined by approximately 65%/annum (Moss pers. comm.). Failure to control both weeds in the first cereal crop allowed new seeds to enter the soil with the prospect of a further long programme of control on those fields.

Herbicide costs have been reduced by changing to cheaper alternative products which have given satisfactory control and not allowed populations to build up. It is considered by the farm management that the cost of containment cannot at present safely be reduced much more. A further saving may follow if A. fatua can be reduced sufficiently to be controlled by roguing alone. In 1981 herbicides cost £40/ha and yields averaged 6.9 t/ha. It is suggested that a realistic target for the cost of containment (to include application and roguing costs) of 5% of the value of the gross output should be achievable.

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REFERENCES

Large, J. W. (1981). Wild-oat control on a farm scale. Association of Applied Biologists Conference on Grass Weeds in Cereals in the United Kingdom, 363-366.

Ministry of Agriculture, Fisheries and Food. (1980). Weed control in cereals 1981. Booklet 2253 (81).

Moss, S. R. (1981a). Techniques for the assessment of Alopecurus myosuroides. Association of Applied Biologists Conference on Grass Weeds in Cereals in The United Kingdom, 101-107.

Moss, S. R. (1981b). The response of Alopecurus myosuroides during a four year period to different cultivation and straw burning systems. Association of Applied Biologists Conference on Grass Weeds in Cereals in the United Kingdom, 15-21.

Moss, S. R.; Cussans, G. W. (1982). Black-grass - some results of recent WRO research. Rep. Weed Res. Org. 1980-81.

Wilson, B. J. (1978). The long term decline of a population of Avena fatua L. with different cultivations associated with spring barley cropping. Weed Research, 18, 25-31.

Wilson, B. J. (1981a). The influence of reduced cultivations and direct drilling on the long-term decline of a population of Avena fatua L. in spring barley. Weed Research, 21, 23-28.

Wilson, B. J. (1981b). A review of the population dynamics of Avena fatua L. in cereals with special reference to work at the Weed Research Organization. Association of Applied Biologists Conference on Grass Weeds in Cereals in the United Kingdom, 5-14.

CONTROL OF ALOPECURUS MYOSUROIDES IN UK BY AUTUMN APPLICATION OF CHLORSULFURON PLUS METHABENZTHIAZURON IN WINTER WHEAT

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Summary. The development of a product containing chlorsulfuron plus methabenzthiazuron is described. In three seasons of trials, 1979-81, autumn application made either pre-emergence or post-emergence to winter wheat, gave control of the flowering heads of Alopecurus myosuroides equivalent to the standard, isoproturon. Chlorsulfuron plus methabenzthiazuron further reduced the length of seed head of surviving plants and showed good control of broad-leaved weeds including Veronic persica and Galium aparine. The mode of action of chlorsulfuron resulted in stunted plants of A. myosuroides being present in February but these did not compete with the crop and soon died when plant growth recommenced in spring. The product used in sequence with triallate granules gave control of A. myosuroides, Avena fatua and also many broad-leaved weeds. Pre-emergence, post-emergence, yield, broad-leaved weeds, triallate, Veronica, Galium, Avena.

INTRODUCTION

In the UK, the development of intensive winter cereal rotations, reduced cultivation systems and earlier sowing, have increased the occurrence of grass weeds and in particular A. myosuroides. As a result, many farmers are totally reliant upon herbicides to control grass weeds; their farming systems could not otherwise be sustained. (Clare, 1980). Effective control of A. myosuroides has been reported using chlortoluron (Barnes, 1981) and isoproturon (Ingram and Kyndt, 1981) and these products are widely used. A range of broad-leaved weeds is also susceptible and may increase to levels where crop yields are reduced if chlortoluron and isoproturon are used continually (Wilson, 1980).

Hence there is a need for an autumn herbicide effective against A. myosuroides and broad-leaved weeds including G. aparine and V. persica.

The properties and early development of chlorsulfuron (formerly DPX 4189) were described by Palm, et al, (1980). The herbicide is active at low rates (10 - 25g ai/ha) against most broad-leaved weeds and some annual grasses and is selective in cereals. The herbicide shows little or no activity against A. fatua and Bromus sterilis. Following uptake by both foliage and root system, the mode of action is to inhibit growth of sensitive plants by stopping cell division in shoot and root tips (Ray, 1982). Chlorsulfuron shows additive activity with a number of commonly used herbicides and this paper describes the development of a fomulated wettable powder containing chlorsulfuron and methabenzthiazuron ("Glean C").

METHODS AND MATERIALS

All trial plots were sprayed using a modified hand-held Oxford Precision Sprayer operating at approx. 200k Pa. pressure and applying 200 l/ha. Plots for weed control evaluations were generally 5m x 2m, replicated three times in randomised blocks and were not taken to yield. Weed assessments were made in February or May by counting weed populations or by visual assessment of weed growth compared with untreated control plots. In addition, the numbers of flowering heads and head lengths of A. myosuroides were assessed in June.

Plots used for crop tolerance and yield comparisons were on sites with few weeds and were generally 12-15 m x 2-3 m, replicated four times in randomised blocks and harvested with a mini-combine.

The herbicide treatments used were chlorsulfuron as DPX 4189 Dry Flowable (20% and 75% water dispersible granule), chlorsulfuron + methabenzthiazuron (70% w.p.), isoproturon (500 g/litre s.c.), methabenzthiazuron (70% w.p.) and triallate (10% granule).

Preliminary work in autumn 1979 evaluated herbicide mixtures on winter barley and winter wheat crops infested with A. myosuroides and some broad-leaved weeds. Eight replicated trials were made and also two large plot non-replicated log-dose-rate trials. Herbicides were applied alone and in tank-mixes and applications were made at pre-em. and early post-em. stages of the crop. These trials were used for weed control evaluations and no yields were taken.

In autumn 1980, replicated and fully randomised weed control trials were made on eight sites infested with high levels of A. myosuroides (mean 357 flowering heads/m^2 on untreated plots) and some broad-leaved weeds. Most sites used a minimum cultivation system of seedbed preparation and were not ploughed; ash from stubble burning was present on some sites. Herbicide tank-mixes were applied at pre-em., early post-em. (GS 11-12) and late post-em. (GS 14-15) stages of winter wheat. In addition applications were made on four winter wheat crops with few weeds present and these crop tolerance trials were harvested to provide yield data. Applications were also made to a wide range of commercially available wheat and barley varieties and these were assessed for visible crop damage.

In autumn 1981, weed control evaluations were continued by replicated trials in randomised blocks in winter wheat treated pre-em. (13 sites) and post-em. (14 sites). Most sites were under a minimum cultivation system, some with ash present and all were severely infested with A. myosuroides (mean 711 flowering heads/m^2 in untreated plots). A similar series of 17 replicated trials was done on sites infested with broad-leaved weeds and in addition, 7 crop tolerance trials on winter wheat growing on a range of soil types (light, medium and heavy), were taken to yield.

RESULTS

1979-80 Season

The mean percentage control of flowering heads of A. myosuroides in the replicated wheat trials is shown in Table 1. Chlorsulfuron was applied alone at 15 and 30 g/ha and in tank-mix with a reduced rate of methabenzthiazuron (recommended rate 3150 g/ha). Chlorsulfuron is known to have little or no activity against A. fatua and triallate was applied at the recommended rate (2250 g/ha) as a granule with chlorsulfuron being applied by sprayer on the same day.

Chlorsulfuron at both rates showed moderate control of A. myosuroides when applied alone but gave additive activity and increased the control with both other herbicides. In addition control of broad-leaved weeds present in these trials (Stellaria media, Veronica persica, Polygonum aviculare and Aphanes arvensis) was also improved by the addition of chlorsulfuron, being in the 85-100% range with both mixes.

No crop damage effects were noted with any of the treatments applied pre-em. or post-em. on winter wheat but visible crop damage occurred with some chlorsulfuron treatments in winter barley.

Table 1

Percentage Control of Flowering Heads of *A. myosuroides* 1979-80

Winter Wheat (3 trials)

Treatment	g/ha	Mean Pre-em. and Post-em. Applications
chlorsulfuron	15	49.7
chlorsulfuron	30	68.0
chlorsulfuron + methabenzthiazuron	15 + 2100	88.3
chlorsulfuron + methabenzthiazuron	30 + 2100	97.1
chlorsulfuron + triallate	15 + 2250	76.5
chlorsulfuron + triallate	30 + 2250	81.6
methabenzthiazuron	2100	70.6
triallate	2250	57.4

1980-81 Season

The mean percentage control of flowering heads of *A. myosuroides* following applications at pre-em., early post-em. (GS 11-12) and late post-em. (GS 14-15) is shown in Table 2. Chlorsulfuron at 15 and 20 g/ha was tank-mixed with two reduced rates of methabenzthiazuron and showed additive activity, improving considerably on the control of *A. myosuroides* obtained with methabenzthiazuron (3150 g/ha) used alone. Similarly, chlorsulfuron at 20 g/ha markedly improved the control obtained with triallate granules at all three times of application. Isoproturon was included in these trials as a standard and gave more effective control when used post-em. of the crop. The tank-mix of chlorsulfuron + methabenzthiazuron (20 + 2400 g/ha) gave consistent control of *A. myosuroides* in all trials and at all three application times when assessed by numbers of flowering heads in June.

Plant counts in February showed higher numbers of *A. myosuroides* present in plots treated with chlorsulfuron mixtures than in isoproturon treated plots (Table 3). However surviving weeds were markedly stunted and yellowed following chlorsulfuron treatment, when compared with untreated plants and with surviving plants on isproturon treated plots. When crop and weed growth recommenced in spring, the majority of these surviving *A. myosuroides* plants on chlorsulfuron treated plots, died quickly and resulted in a marked improvement in the degree of control assessed by counting flowering heads. This slow killing action of chlorsulfuron is the result of the unique mode of action in stopping cell division but not directly affecting other plant processes (Ray, 1982).

Other grass weeds occurring in some trials (*Poa trivialis*, *Lolium multiflorum*) were well controlled (over 90% reduction of flowering heads) by all the chlorsulfuron treatments and broad-leaved weeds including *S. media* and *Veronica hederifolia* were similarly controlled. *Galium aparine* occurred in some trials and the number of plants of this weed was reduced by 75% but surviving plants were severely stunted and confined to the base of the crop.

Table 2

Percentage Control of Flowering Heads of A. myosuroides, 1980 - 81
(Winter Wheat 6 trials, Winter Barley 2 trials)

Treatment	g/ha	Crop Stage at Application Pre-em.	GS 11-12	GS 14-15
chlorsulfuron + methabenzthiazuron	15 + 2100	78	93	93
chlorsulfuron + methabenzthiazuron	15 + 2400	91	91	63
chlorsulfuron + methabenzthiazuron	20 + 2100	88	94	83
chlorsulfuron + methabenzthiazuron	20 + 2400	89	90	88
chlorsulfuron + triallate	20 + 2250	97	97	81
isoproturon	2500	84	96	91
methabenzthiazuron	3150	56	54	64
triallate	2250	79	56	60

Table 3

Percentage Mortality of A. myosuroides Plants, February 1981

Treatment	g/ha	Crop Stage at Application Pre-em.	GS 11-12
chlorsulfuron + methabenzthiazuron	20 + 2100	59	67
chlorsulfuron + methabenzthiazuron	20 + 2400	64	55
chlorsulfuron + triallate	20 + 2250	85	82
isoproturon	2500	87	89
triallate	2250	83	46

The crop tolerance trials on winter wheat showed no adverse crop effects or significant ($P = 0.05$) yield reductions in the absence of weeds following treatment with chlorsulfuron mixed with methabenzthiazuron or applied with triallate. Application of higher rates of these mixtures up to four times recommended rate (chlorsulfuron + methabenzthiazuron, 80 + 9600 g/ha, chlorsulfuron + triallate, 80 + 9000 g/ha) to a range of winter wheat varieties showed no adverse effects on any variety.

1981 - 82 Season

The results for control of A. myosuroides are shown in Table 4. Chlorsulfuron + methabenzthiazuron was applied as a formulated product to give 20 + 2400 g/ha or, when used in combination or sequence with triallate, a lower rate was used to give 15 + 1800 g/ha. The results confirmed that chlorsulfuron + methabenzthiazuron showed additive activity with triallate even when the spray application was made four weeks after the triallate granules. As in the previous season, counts of plant mortality in February showed poor control (59-63%) from chlorsulfuron + methabenzthiazuron treatment compared with isoproturon. The survival of stunted plants was less evident when triallate granules were used in the treatment. Assessment of flowering heads in June revealed a marked improvement in control of A. myosuroides with the chlorsulfuron + methabenzthiazuron product used either pre-em. (93% control) or post-em. (92% control). The standard isoproturon was more effective post-em. (95% control) than pre-em. (90% control).

Seed heads on surviving plants in chlorsulfuron + methabenzthiazuron treated plots were reduced in size (mean length 3.8 cm) compared with untreated (8.1 cm), isoproturon (6.3 cm) and triallate (7.5 cm). Using this measurement, the control of total head length of A. myosuroides has been calculated and this is also shown in Table 4. Results with the chlorsulfuron + methabenzthiazuron product are generally improved by this assessment whereas results with isoproturon were generally poorer reflecting the larger size of surviving seed heads. The effectiveness of chlorsulfuron + methabenzthiazuron did not appear to be affected by the presence of ash.

Table 4

Effects of treatments on A. myosuroides in Winter Wheat, 1981-82

(14 Trials)

Treatment (g/ha)	% Plant Mortality February	% Control of Flowering Heads	Mean Head Length * (cm) of Survivors	% Control of Total Head Length
Pre-emergence Application				
chlorsulfuron + methabenzthiazuron w.p. (20 + 2400)	63	93	3.7	96
chlorsulfuron + methabenzthiazuron w.p. (15 + 1800) applied same day as triallate granules (2250)	93	98	4.6	99
isoproturon (2500)	89	90	6.7	86
triallate (2250)	82	69	7.3	58
Post-emergence Application				
chlorsulfuron + methabenzthiazuron w.p. (20 + 2400)	59	92	3.9	92
chlorsulfuron + methabenzthiazuron w.p. (15 + 1800) applied same day as triallate granules (2250)	76	97	5.1	96
chlorsulfuron + methabenzthiazuron w.p. (15 + 1800) applied four weeks after pre-em. triallate granules (2250)	96	99	4.8	99
isoproturon (2500)	92	95	5.8	93
triallate (2250)	67	55	7.6	59

In some of these trials, other grass weeds occurring were Poa annua and P. trivialis and all treatments gave a high level of control (99-100%). A fatua occurred in two trials only and poor control (28 and 34.5% pre-em. and post-em. respectively) was given by the chlorsulfuron + methabenzthiazuron product whereas good control was obtained where triallate was added (96 and 90%) and with isoproturon (89.5 and 99%).

* Untreated plots mean head length 8.1 cm.

Chlorsulfuron + methabenzthiazuron and isoproturon gave excellent control of S. media, Tripleurospermum maritimum and Myosotis arvensis. V. persica occurred in two trials only and was well controlled (99%) by chlorsulfuron + methabenzthiazuron, but not by isoproturon (47%) or triallate (60%). V. hederifolia was similarly well controlled by chlorsulfuron + methabenzthiazuron but not by isoproturon (73%).

G. aparine occurred in six trials and visual assessment of reduction of plant numbers and size indicated good control with chlorsulfuron + methabenzthiazuron particularly with post-em. application (94%; pre-em. 85%). Isoproturon gave 14% (pre-em) and 53% (post-em) control.

The series of broad-leaved weed trials confirmed the effectiveness of chlorsulfuron + methabenzthiazuron against a wide range of weeds as reported by Swann (1982). Results with some commonly occurring weed species are shown in Table 5.

Table 5

Effect of Chlorsulfuron + Methabenzthiazuron on Broad-leaved Weeds in Winter Wheat, 1981-82

(Mean % control in 17 trials)

Weed Species	Mean No Weeds/m^2	Crop Stage at Application Pre-em.	GS 10-12
Chenopodium album	6	100	-
Lamium purpureum	29	99	95
Stellaria media	45	100	99
Tripleurospermum maritimum	77	100	100
Veronica hederifolia	17	89	-
Veronica persica	16	100	100
Viola arvensis	117	92	92

Relative yields of a range of varieties of winter wheat treated at various growth stages on sites with few weeds present are shown in Table 6. No visible crop damage was noted during the growing season and the yield data indicate no consistent adverse effects with pre-em. or early post-em. application of chlorsulfuron + methabenzthiazuron (20 + 2400 g/ha).

Table 6

Effect of Chlorsulfuron + Methabenzthiazuron on Yield of Winter Wheat

1981-82

Yield Relative to Untreated (= 100)

Site No.	cv.	Untreated Yield (t/ha)	Crop Stage at Application Pre-em.	GS 9-10	GS 11-12
1	Hustler	8.19	-	115	106
2	Bounty	5.19	116	131*	136*
3	Bouquet	5.24	102	100	102
4	Vuka	6.78	101	100	101
5	Virtue	8.10	103	100	99
6	Avalon	4.62	96	107	100
7	Mardler	7.61	101	95	100

* Weeds present in some plots

DISCUSSION

The results presented here indicate that the product containing chlorsulfuron + methabenzthiazuron is an effective autumn herbicide against A. myosuroides and compares favourably with the standard, isoproturon for use on winter wheat. With both pre-em. and post-em. application in autumn, the product results in similar control of flowering heads of the weed, to that obtained with isoproturon. However, the head length of surviving plants following chlorsulfuron + methabenzthiazuron treatment, is markedly less than with isoproturon treatment and this may result in a greater reduction of seed return of A. myosuroides although Moss (1981) reported that weed viability was more important than head length in untreated plants.

The importance of controlling both A. myosuroides and broad-leaved weeds early in winter cereals has been demonstrated (Wilson, 1980) and a delay in control with isoproturon until the spring reduced yields compared with control in the autumn. The presence of some stunted A. myosuroides plants in February following autumn application of chlorsulfuron + methabenzthiazuron is not considered to reduce crop yields in view of the mode of action of chlorsulfuron. The rapid cessation of cell division in root and shoot tips of susceptible plants results in no further growth of the weed (Ray, 1982) and growth room studies have shown that the rate of tranpiration of sensitive weeds is markedly reduced within hours of treatment (Palm et al, 1982). This suggests that treated weeds are not competitive with the crop for water or nutrient uptake.

The broad-leaved weed activity of chlorsulfuron + methabenzthiazuron applied in autumn has already been described in detail (Swann, 1982) and the results in these grass weed control trials confirm the activity against V.persica and G. aparine in particular. The failure of isoproturon and chlortoluron to control these two species when used for control of A. myosuroides, has led to the use of additional herbicides, such as ioxynil + bromoxynil + mecoprop applied as a tank-mix in autumn or as a separate application in spring (Wilson, 1980). The development of chlorsulfuron + methabenzthiazuron enables A. myosuroides and some other annual grasses and broad-leaved weeds in winter wheat to be controlled by a single autumn application either pre-em. or post-em. of the crop. With the addition of triallate granules, the treatment also provides effective control of A. fatua.

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REFERENCES

Barnes, T.R. (1981). The use of chlortoluron for the control of Alopecurus myosuroides 1970 to 1980. AAB Conference on Grass Weeds in Cereals in the United Kingdom, 215 -222.

Clare, R.W. (1980). Cost effectiveness of weed control in British cereal growing. Proceedings 1980 British Crop Protection Conference - Weeds 3, 777 - 786.

Ingram, G.H.; Kyndt, C.F.A. (1981). Isoproturon - the control of black-grass (Alopecurus myosuroides) - a summary of its performance. AAB Conference on Grass Weeds in Cereals in the United Kingdom, 231-237.

Moss, S.R. (1981). Techniques for the assessment of Alopecurus myosuroides. AAB Conference on Grass Weeds in Cereals in the United Kingdom, 101-107.

Palm, H.L.; Riggleman, J.D.; Allison, D.A. (1980). Worldwide review of the new cereal herbicide - DPX 4189. Proceedings 1980 British Crop Protection Conference - Weeds, 1, 1-6.

Palm, H.L.; McKinley, N.D.; Sweetser, P.B. (1982). Determining rates of chlorsulfuron for use in cereal crops. Proceedings Weed Science Society of America Conference 1982, Boston.

Ray, T.B. (1982). The mode of action of chlorsulfuron: a new herbicide for cereals. Pesticide Biochemistry and Physiology, 17, 10-17.

Swann, N.B. (1982). Autumn application of chlorsulfuron for the control of broad-leaved weeds. Aspects of Applied Biology 1, Broad-leaved weeds and their control in cereals, 77-85.

Wilson, B.J. (1980). The effect on yield of mixtures and sequences of herbicides for the control of Alopecurus myosuroides Huds. and broad-leaved weeds in winter cereals. Weed Research, 20, 65-70.

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CONTROL OF ALOPECURUS MYOSUROIDES AND AVENA FATUA WITH A SINGLE GRANULAR HERBICIDE APPLICATION

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Summary Trials were conducted over three years with a 12% w/w micro-granular formulation of isoproturon plus triallate. Pre or post-emergence applications gave good control of Alopecurus myosuroides and Avena fatua in winter wheat and winter barley, although the most reiable results were achieved with pre-emergence applications. Good yield responses were also obtained. As expected, treatment of the highest infestations gave the biggest increases.

Using commercial applicators micro-granules are much quicker, and therefore cheaper, to apply than comparative spray treatments. The use of isoproturon plus triallate granules is therefore an effective and economical strategy for the control of a mixed population of blackgrass and wild oats in winter wheat and barley. Isoproturon plus triallate, micro-granules, pre or early post-emergence, speed of application.

INTRODUCTION

Recent surveys (Anon 1977, Elliott et al 1979) have shown wild oats (A. fatua) to be widespread throughout the United Kingdom, infesting a mean of 61% of the cereal area. Blackgrass (A. myosuroides) was found to be confined to England infesting 30% of cereals in the South East, East and East Midlands but 11% or less of the rest of England. In Eastern England 83% of this area was also infested with wild oats.

The importance of these infestations has been demonstrated in many experiments where large yield increases have been obtained from controlling either blackgrass (Hubbard, Livingstone and Ross, 1978) or wild oats (Wilson & Cussans 1978).

The ability of blackgrass to produce many seed heads from a single plant and the prolonged dormancy of wild oat seeds in the soil often necessitate annual treatment against these weeds.

Isoproturon has been shown to give good control of blackgrass pre and post-emergence in trials conducted over several seasons (Ingram et al 1981) and triallate has proved similarly effective in controlling wild oats in either liquid or granular form (Holroyd et al, 1970; Hodkinson, 1972).

This paper describes trials undertaken over three years with a micro-granular formulation of isoproturon plus triallate for the control of wild oats and blackgrass. The cost effectiveness of micro-granule herbicide application is stressed.

METHOD AND MATERIALS

Small plot replicated and large plot farmer applied trials were carried out on winter wheat and winter barley between 1979 and 1982. The material under test was 12% w/w micro-granular formulation of isoproturon plus triallate sold since 1981 as

'Trigger'. Commercially available formulations of triallate 10% w/w micro-granules, chlortoluron 50% w/v s.c. and isoproturon 50% w/v s.c. were used as standard treatments.

Granular treatments in small plot replicated trials were applied with a self propelled precision small plot sprayer modified for use as a granule spreader. This was replaced in the 1980/81 season with a purpose built granule applicator. Spray treatments were applied using a precision sprayer at a volume of 293 L/ha and a pressure of 210k.Pa. Plot sizes were 30 - 36 m^2 replicated three times. Blackgrass and wild oats were assessed by counting the number and heights of plants in 3 x 0.5 m^2 quadrats 3 - 4 months after application. Yields were taken with a Claas small plot combine, percent moisture levels recorded and weights adjusted to 85% d.m.

In large plot user trials, granules were applied by the farmer using commercial micro-granule applicators. Sprays were applied through standard equipment at 200 - 400 L/ha. Plot size was 1 hectare unreplicated; untreated areas of at least 50 m^2 were present at each site. Assessments were made by counting plant numbers in 8 - 10 x 0.5 m^2 quadrats 3 - 4 months after treatment.

Weed levels varied between 7 - 503 m^2. Soil types ranged from sandy to 5% organic matter.

RESULTS

Table 1 shows that isoproturon plus triallate granules gave a high level of control of blackgrass and wild oats when applied pre-emergence in 1979-'80 and 1980-'81. Post-emergence application was generally as effective on blackgrass although control at one site was only moderate (77%). Post-emergence control of wild oats was very good in 1979-'80 but dropped in 1980-'81.

In 1981-'82 control of both weeds pre or post-emergence was moderate possibly reflecting the severe weather conditions over the winter period.

Results given by the standard treatments were similar to isoproturon plus triallate on blackgrass pre and post-emergence in 1979-'80, but on wild oats in the same year triallate was less effective pre-emergence and all the standards were inferior post-emergence. In 1980-'81, isoproturon plus triallate gave notably better results pre-emergence on blackgrass than the standard but post-emergence, all treatments were successful with the exception of triallate which gave a low level of control.

Farmer applied user trials (Table 2) supported the data from small plot trials, with the best results being obtained in 1979-'80. Results in 1980-'81 were also good with the exception of post-emergence application to blackgrass, the mean % control here was lowered by a failure at one site (33%) where the treatment was applied when the weed had 2-3 tillers.

Table 3 shows that the level of control given by isoproturon plus triallate was not influenced by the size of grass weed infestation whereas the control of blackgrass by triallate was reduced by high numbers. The only notable reduction in control has been in wild oats in 1980-'81 when infestations were less severe than the previous year.

Table 4 gives the yields from replicated trials. The sites with the largest infestations showed the greatest yield response from treatment. It is notable that the double dose of isoproturon plus triallate did not significantly depress yield in comparison with the standard rate.

Table 1

Control of annual grasses in winter wheat and barley - small plot trials

A) *Alopecurus myosuroides*

Mean % control of plant numbers

	Pre-emergence applications			Post-emergence (1lf-2tillers)		
	1979/80	80/81	81/82	1979/80	80/81	81/82
Isoproturon + triallate granules 3 Kg ai/ha	99.7 (5)*	93.0 (3)	82.2 (3)	100 (5)	92.3 (5)	93.4 (3)
	(97=100)	(84-98)	(78-88)		(77-99)	(84-99)
Triallate granules 2.25 Kg ai/ha	81.8 (5)	82.2 (3)	-------	94.0 (4)	56.0 (5)	-------
	(52-92)	(76-91)		(80-100)	(31-74)	
Isoproturon 2.5 Kg ai/ha	97.8 (5)	92.2 (3)	-------	98.2 (4)	96.9 (5)	-------
	(81-100)	(88-93)		(89-100)	(84-100)	
Chlortoluron 3.5 Kg ai/ha	98.6 (5)	95.3 (3)	-------	98.3 (4)	94.6 (5)	-------
	(97-100)	(91-99)		(90-100)	(74-100)	

B) *Avena fatua*

Mean % control of plant numbers

	Pre-emergence applications			Post-emergence (1lf-2tillers)		
	1979/80	80/81	81/82	1979/80	80/81	81/82
Isoproturon + triallate granules 3 Kg ai/ha	99.4 (5)	92.8 (4)	81.2 (2)	96.9 (2)	75.8 (4)	87.0 (3)
	(94-100)	(79-100)	(77-85)	(88-100)	(59-89)	(59-100)
Triallate granules 2.25 Kg ai/ha	93.1 (5)	84.5 (4)	-------	80.7 (2)	69.8 (4)	-------
	(69-100)	(77-93)		(60-95)	(31-88)	
Isoproturon 2.5 Kg ai/ha	92.4 (5)	74.1 (4)	-------	69.5 (2)	61.7 (4)	-------
	(91-97)	(36-89)		(67-72)	(49-72)	
Chlortoluron 3.5 Kg ai/ha	90.8 (5)	70.9 (4)	-------	50.0 (2)	60.4 (4)	-------
	(71-100)	(17-100)		(31-69)	(39-78)	

Note * - (x) - Number of occurrences
= - (x-x) - Range of % control

Table 2

Control of annual grasses in winter wheat and barley - farmer applied user trials

A) Alopecurus myosuroides

	Mean % control of plant numbers			
	Pre-emergence applications		Post-emergence (11f-2tillers)	
	79/80	80/81	79/80	80/81
Isoproturon + triallate granules 3.0 Kg ai/ha	98.0 (3)* (95-100)=	93.0 (5) (80-100)	98.7 (3) (94-100)	74.4 (5) (33-97)
Triallate granules 2.25 Kg ai/ha	-------	95.0 (1)	-------	-------
Isoproturon 2.5 Kg ai/ha	-------	93.0 (1)	-------	88.1 (2) (58-100)

B) Avena fatua

	Mean % control of plant numbers			
	Pre-emergence applications		Post-emergence (11f-2tillers)	
	79/80	80/81	79/80	80/81
Isoproturon + triallate granules 3.0 Kg ai/ha	91.3 (3) (86-97)	95.5 (4) (81-100)	100 (1)	-------
Triallate granules 2.25 Kg ai/ha	-------	61.4 (3) (10-89)	-------	-------

Note * - (x) - Number of occurrences

= - (x-x) - Range of % control

Table 3

Comparison of % control levels on both light and heavy infestations of *Alopecurus myosuroides* and *Avena fatua* pre-emergence applications

year	Pop. in unsprayed at assessment (m^2)	Isoproturon + triallate granules 3.0 Kg ai/ha	Triallate granules 2.25 Kg ai/ha	Isoproturon 2.5 Kg ai/ha	Chlortoluron 3.5 Kg ai/ha
		Alopecurus myosuroides % control of plant numbers			
79/80	11	97	85	81	97
	503	100	52	99	98
80/81	11	84	91	88	94
	59	94	78	95	91
		Avena fatua % control of plant numbers			
79/80	7	100	100	93	96
	310	98	78	79	80
80/81	7	100	81	87	100
	18	90	93	89	86

Table 4

Harvest yields from 14 small plot trials in Essex 1979/80 & 1980/81

Crop	Growth stage at application (Zadoks Scale)	No. plants m² Avena fatua	No. plants m² Alopecurus myosuroides	Yield of untreated t/ha	level of significance	Yield as % of untreated: Isoproturon + triallate granules 3 Kg ai/ha	Isoproturon + triallate granules 6 Kg ai/ha	Isoproturon 2.5 Kg ai/ha	Triallate granules 2.25 Kg ai/ha	Chlortoluron 3.5 Kg ai/ha
79/80										
WW	09-10	----	79	6.56 a	5%	99 a	98 a	----	98 a	59 b
WW	10-11	----	18	6.78	N/S	105	92	----	100	77
WW	03-05	14	----	6.74	N/S	101	113	106	102	118
WW	09-10	----	217	3.64 b	5%	210 a	224 a	202 a	190 a	205 a
WW	07	14	101	4.72 c	5%	142 ab	103 c	155 a	156 a	155 a
WW	09-10	310	----	0.77 d	5%	971 ab	1054 ab	871 b	624 c	514 c
WB	15-21	----	300	3.26 b	5%	200 a	184 a	198 a	177 a	179 a
WW	20-25	11	6	6.58 b	5%	99 b	127 a	102 b	117 ab	110 ab
WW	12-13	----	95	4.53 d	5%	186 a	173 a	188 a	150 bc	138 c
80/81										
WB	11-12	221	----	3.2 d	1%	163 abc	184 ab	188 ab	138 c	178 ab
WW	09-10	123	6	2.1 b	1%	233 a	243 a	214 a	181 ab	233 a
WB	07	----	59	4.5 b	1%	113 a	124 ab	107 b	116 b	131 ab
WW	02	11	165	5.1 d	1%	151 ab	153 ab	155 ab	116 c	151 ab
WW	10	7	----	7.8	N/S	109	95	108	105	104

i) N/S Not Significant
ii) All treatments having the same letters are not significantly different from each other

WW - Winter Wheat

WB - Winter Barley

DISCUSSION

The results show that isoproturon plus triallate granules give good control of blackgrass and wild oats pre or post-emergence in winter wheat and winter barley. The best results were obtained pre-emergence agreeing with earlier results on triallate granules (Hodkinson 1972). Late post-emergence treatments are likely to be less reliable because there is no foliar uptake; granules rely entirely on soil moisture for the release of chemical to plant roots and in some cases the weeds may have grown beyond the fully susceptible stage before this happens. This may explain the poorer post-emergence control of wild oats (small plot trial) and blackgrass (user trial) in the relatively dry late autumn of 1980-'81. In East Anglia, the Midlands and South East the mean rainfall was 74% of average in November and 70% of average in December (Meteorological Office Monthly Weather Reports).

All assessments of weed control were made 3-4 months after treatment thus taking into account late winter grass weed germination. Head counts taken just before harvest at some sites did not differ by more than 5% from the earlier assessments and were therefore not reported. This indicates that in most seasons an autumn treatment is sufficient to give season long control of blackgrass and wild oats.

The yield data confirm the importance of controlling blackgrass and wild oats in cereals; at one winter wheat site an infestation of 310 wild oats/m^2 led to a yield of only 0.77 L/ha in the untreated. This was increased tenfold in the plots treated with isoproturon plus triallate. The excellent crop safety of isoproturon plus triallate granules is demonstrated by the yields from the double rate treated plots. It is particularly notable that the crop was 'on emergence' at six of the sites taken to yield; this is a sensitive growth stage for many herbicides.

The control of wild oats and blackgrass in winter cereals with one application of a granular herbicide offers two major advantages:

Firstly, the ability to control both weeds with one early season application; Wilson (1979) demonstrated the need for broad spectrum grass weed control early in the life of the crop to safeguard yields. One treatment is cheaper to apply and more convenient than the two that were often considered necessary (Cussans 1981).

Secondly, the speed and convenience of micro-granule application. The time taken to apply granules compared with sprays was reported by Palmer (1976). At a rate of 22.5 Kg/ha with a fully filled 1 ton hopper it would take 3 hours 52 minutes to apply the contents of 47 ha at a forward speed of 6 m.p.h. At similar speed and with the same boom width it would take 5 hours 5 minutes to spray 47 ha with a 1500 litre capacity sprayer. In addition the sprayer needs supplying with 10 tons of water and no account had been taken of haulage time. Clearly the advantage of granular application is the ability to treat large areas without refilling. This is particularly important at a time of year when many operations e.g. seed bed preparation and fertilizer application have to be accomplished over a short space of time; it also represents a financial saving on fuel and wear and tear on machinery.

The disadvantages of granular applications are few. Compared with some spray treatments, isoproturon for example, granules have a shorter period of application; treatment pre or early post-emergence is necessary for optimum results. There is also a greater necessity for good seed bed preparation; granules bounce off soil clods that have broken down through weathering. Sprays, however, will penetrate small clods and give some control of germinating weeds. A further disadvantage is the inability to tank mix granules with other products for the control of aphids or autumn mildew.

These points are out-weighed by the advantage of controlling A. fatua and A. myosuroides and some broadleaved weeds (Rognon et al) by a single application of a granular herbicide.

This treatment enables quick application and economical control of the two most important grass weeds infesting cereals in the U.K.

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REFERENCES

Anon, (1977). Ministry of Agriculture, Fisheries and Food (1977 b) 1977 National Survey of Wild Oats and other grass weeds. Pinner Middlesex. MAFF (Publications)

Cussans, G. W.; (1981) Weed Control in Cereals - a long term view. Proc. Grass Weeds in Cereals in the United Kingdom Conference. 355-361

Elliot, J. G.; Church, B. M.; Harvey, J. J.; Hulls, R. H.; Waterson, H. A.; (1979) Survey of the presence and methods control of wild oats, blackgrass and couch grass in cereal crops in the United Kingdom during 1977. J. Agri. Sci.

Hodkinson, H. D.; (1972). Field experience of granular triallate for control of Avena spp in winter and spring cereals. Proc. 11th British Weed Control Conference

Holroyd, J.; Bailey, J. A.; (1970) Newer herbicides for control of Avena fatua in winter and spring cereals. Proc. 9th British Crop Protection Conference - Weeds 63-70

Hubbard, K. R.; Livingstone, D. B.; Ross, B. L. (1976) Chemical Control of Alopecurus myosuroides in winter cereals. Proc. 1976 British Crop Protection Conference - Weeds 63-70

Ingram, G. H.; Kyndt, C. F. A. (1981) Isoproturon - the control of blackgrass (Alopecurus myosuroides). A summary of its performance Proc. Grass Weeds in Cereals in the United Kingdom Conference 1981

Palmer, R. J.; (1976) Future requirements in micro-granule machinery Proc. British Crop Protection Counc. Monogr. No 18 128

Rognon, J. et al and Anon (1977) Technical Bulletin on isoproturon. Rhone-Poulenc Agrochemicals.

Wilson, B. J.; Cussans, G. W.; (1978) The effects of herbicides applied alone and in sequence, on the control of wild oats (Avena fatua) and broadleaved weeds, and on yield of winter wheat. Annals Applied Biology (1978), 89, 459-466.

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THE EFFECT OF SEQUENTIAL REDUCED RATES OF DICLOFOP-METHYL AND ISOPROTURON ON THE CONTROL OF ALOPECURUS MYOSUROIDES IN WINTER WHEAT

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Summary. In two experiments four sequential applications of diclofop-methyl at 0.29 kg a.i./ha and isoproturon at 0.53 kg a.i./ha were made between November 1981 and April 1982 to *Alopecurus myosuroides* growing in winter wheat. In addition on each occasion single applications of diclofop-methyl at 1.14 kg a.i./ha and isoproturon at 2.1 kg a.i./ha were also made. Repeated doses of diclofop-methyl at 0.29 kg a.i./ha, with and without surfactant, and single doses of 0.57 kg a.i./ha were also applied at the first two dates.

Poorer *A. myosuroides* control was obtained at the later application dates particularly with diclofop-methyl. Repeated low doses of diclofop-methyl were not as effective as the early single applications of either the intermediate or high rate, however the additional surfactant markedly increased the level of control. Repeated low doses of isoproturon gave control as good as that achieved from the best of the single applications. Early removal of *A. myosuroides* resulted in the greatest yield increases. Soil samples taken in April show isoproturon residue levels from the repeated low dose to be between those recorded from the first and the fourth single application. Surfactant, crop yield, herbicide residue.

INTRODUCTION

The timing of herbicide applications for the control of *Alopecurus myosuroides* (black-grass) in winter cereals has received considerable attention in recent years (Baldwin, 1981; Barnes, 1981; Ingram and Kyndt, 1981). It is now generally accepted that early removal of this weed is desirable not only because it leads to a greater crop yield response but also because *A. myosuroides* control tends to decline with later applications. *A. myosuroides* continues to be a serious weed problem and there is scope for improving both reliability and effectiveness of herbicide performance.

The technique of repeated low doses of herbicides has been used with good effect for controlling weeds in sugar beet (May, 1981) and the principle may have some relevance for weed control in cereals. Isoproturon kills *A. myosuroides* by acting predominantly through the soil although it can be taken up via the shoots. In addition, treatment timing is flexible and it is thus an interesting compound to study in the context of repeated low dose applications. Diclofop-methyl, also active against *A. myosuroides*, exhibits both root and foliar uptake and can be applied at a range of crop growth stages. The foliar activity of this herbicide is generally considered to be the most important and Chow and Dorrell (1979) and Taylor *et al.* (1980) have demonstrated increased biological activity of diclofop-methyl with surfactants.

This paper describes two experiments in which four repeated low doses of isoproturon and diclofop-methyl were compared with single doses applied at the recommended rate at each of four dates. Applications were made between November and April to *A. myosuroides* growing in winter wheat. In addition single half doses and repeated low doses of diclofop-methyl, with and without surfactant, were applied at the first two dates.

METHOD AND MATERIALS

Two experiments were set up on heavy clay sites during the autumn of 1981. Both were of randomised block design containing four replicates. Each replicate comprised 16 plots each measuring 3 x 10 m with a 2 m pathway between pairs of adjacent plots. Each replicate was separated by a 2 m pathway and the entire experiment measured 46 x 64 m.

Table 1

Crop variety, initial crop and A.myosuroides population, application dates and crop and A.myosuroides growth stages

Site	Variety	Population/m^2 Crop	Population/m^2 A.myosuroides	Application date		Growth stage Crop	Growth stage A.myosuroides
				1	24 Nov.	13	13
Long				2	1 Feb.	21	21-24
Crendon	Bounty	183	177	3	23 March	23	21-24
				4	15 April	30	Well tillered
				1	3 Dec.	13	13
				2	1 Feb.	21	21
Murcott	Brigand	204	44	3	23 March	23	23-28
				4	15 April	30	Well tillered

All treatments were applied using an Argocat '8' with modified boom allowing the herbicide to be delivered by independent CO_2 pressurised containers to two 3 m off-set sections. The boom was fitted with Spraying Systems 8003 'TeeJet' nozzles placed at 0.5 m spacing. Herbicide solution was delivered at a pressure of 210 kPa and at a forward speed of 6 km/h a spray volume rate of 200 l/ha was achieved.

Repeated applications of diclofop-methyl at 0.29 kg a.i./ha were made at four dates and on each occasion single treatments at 1.14 kg a.i./ha were also made for comparison. In addition single doses of 0.57 kg a.i./ha and two repeated applications of 0.29 kg a.i./ha, with and without surfactant, were applied at the first and second date. The surfactant, Ethylan* D256 a non ionic fatty alcohol ethoxylate, was added to the spray solution at 0.5% v/v. The four repeated applications of isoproturon were applied at a rate of 0.53 kg a.i./ha with single applications at 2.10 kg a.i./ha.

a. Biological assessments

At each site before the first treatments were applied densities of crop and A. myosuroides were determined using a number of 0.1 m^2 random quadrats (Table 1).

The effects of the first and second applications were assessed in March using ten 0.1 m^2 quadrats per plot to determine the number of A. myosuroides plants surviving. In June A. myosuroides heads were assessed before seed shedding commenced. All heads were counted in six random quadrats which measured 0.5 x 2 m on the treated plots and 0.25 x 1 m on the unsprayed plots.

* Trade mark of Diamond Shamrock.

b. Yield assessment

Crop yields were obtained by cutting a single swath of 2.1 m from the centre of each plot with a small plot combine harvester. The ends of the plots were first removed as discards. The grain from each plot was weighed and from this a sample of approximately 1 kg taken, dried at 100 C for 21 hrs and reweighed. The samples were sieved to remove trash and grain < 2.00 mm and from these data the yield of clean grain at 85% d.m. was determined.

c. Herbicide residue assessment

Following the fourth application soil samples were taken from all isoproturon treatments. Ten 15 x 2.5 cm diameter cores were taken to a depth of 15 cm on each plot and bulked into a single sample. The samples were sieved through a 6 mm mesh and analysed for isoproturon residue by the method previously described by Byast et al. (1977).

RESULTS

Table 2

Effect of herbicide treatments on numbers of *A.myosuroides* plants/m^2 (March)

Treatment	Dose (kg a.i./ha)	Application date(s)	Site Long Crendon	Site Murcott
Diclofop-methyl + surfactant	0.29	1, 2	3.8 (1.79)	2.3 (1.24)
Diclofop-methyl	0.29	1, 2	29.7 (5.35)	10.3 (3.09)
"	0.57	1	12.5 (3.50)	6.3 (2.46)
"	"	2	46.5 (6.59)	13.3 (3.56)
"	1.14	1	3.8 (1.81)	2.0 (1.35)
"	"	2	14.0 (3.69)	5.3 (2.29)
Isoproturon	0.53	1, 2	7.0 (2.46)	2.8 (1.60)
"	2.10	1	7.8 (2.68)	4.0 (1.95)
"	"	2	2.5 (1.57)	22.0 (4.51)
Unsprayed control			224.5 (14.91)	76.5 (8.67)
S.E.			± (0.543)	± (0.438)

Transformed data in parenthesis $\sqrt{n}$

a. Biological

The degree of *A. myosuroides* control obtained at the highest rate of diclofop-methyl shows a significant decrease in activity at the last two application dates (Table 3). *A. myosuroides* control from the first two applications was better than 99% at the final assessment (Table 3) although counts in March show more plants present after the second date at Long Crendon (Table 2). At the same site a similar trend was also recorded at the intermediate dose rate. At this rate the final level of control was significantly poorer than the high rate at both the first and second date at Long Crendon but only at the second date at Murcott. Repeated low doses of diclofop-methyl from both two and four applications gave similar levels of control to the immediate rate applied at the second date but were poorer than this dose at the first date and from both early applications at the highest dose rate. The addition of surfactant to the repeated low dose markedly increased A. myosuroides control to a level similar to that achieved from both early single applications at the highest dose rate.

Applications of the high rate of isoproturon show reduced level of control at the last date and also at the second date at Murcott (Table 3). Repeated low doses of isoproturon gave control similar to that achieved from the best of the single applications in both the assessment on plant numbers (Table 2) and the final assessment on head numbers (Table 3).

Table 3

Effect of herbicide treatments on numbers of A.myosuroides heads/m^2 (June)

Treatment	Dose (kg a.i./ha)	Application date(s)	Site: Long Crendon		Murcott	
Diclofop-methyl + surfactant	0.29	1, 2, -, -	6.6	(2.57)	6.0	(2.32)
Diclofop-methyl	0.29	1, 2, -, -	61.8	(7.78)	39.3	(6.20)
"	"	1, 2, 3, 4	67.8	(8.20)	32.5	(5.70)
"	0.57	1, -, -, -	21.4	(4.46)	12.6	(3.64)
"	"	-, 2, -, -	38.1	(6.14)	24.7	(4.90)
"	1.14	1, -, -, -	0.9	(1.35)	2.4	(1.76)
"	"	-, 2, -, -	3.8	(2.10)	0.8	(1.29)
"	"	-, -, 3, -	80.5	(8.90)	58.6	(7.48)
"	"	-, -, -, 4	272.8	(16.54)	97.5	(9.80)
Isoproturon	0.53	1, 2, 3, 4	5.2	(2.38)	0.4	(1.18)
"	2.10	1, -, -, -	5.7	(2.46)	3.5	(2.07)
"	"	-, 2, -, -	1.5	(1.52)	62.7	(7.77)
"	"	-, -, 3, -	8.0	(2.55)	7.0	(2.79)
"	"	-, -, -, 4	117.2	(10.82)	30.2	(5.57)
Unsprayed control			814.3	(28.65)	281.5	(16.58)
S.E. (treatments)			$\pm$	(0.767)	$\pm$	(0.726)
S.E.D. (treatments + control)			$\pm$	(0.939)	$\pm$	(0.889)

Transformed data in parenthesis $\sqrt{n + 1.0}$

b. Yield

There was a greater crop yield response to the control of A. myosuroides at Long Crendon than at Murcott (Table 4). At Long Crendon all treatments , with the exception of the single applications of the highest rate of diclofop-methyl and isoproturon applied at the last date gave significant increases over the untreated control. At Murcott only the repeated low doses of diclofop-methyl, the single intermediate rate of diclofop-methyl applied at the first date and the first and third single applications of isoproturon resulted in increased crop yields. At both sites crop yield from the repeated low dose of diclofop-methyl, with additional surfactant, was greater than those from the last two single applications of diclofop-methyl at the highest rate. In addition, at Murcott, this treatment also out yielded the second single application of the high rate of diclofop-methyl. Yield from the single third date application of isoproturon at Long Crendon was significantly lower than those recorded from the first and second dates and from the repeated low doses.

Table 4

Effect of herbicide treatment on cereal yield (clean grain >2.00mm) at 85% d.m. in t/ha.

Treatment	Dose (kg a.i./ha)	Application date(s)	Site Long Crendon	Murcott	Mean
Diclofop-methyl +surfactant	0.29	1, 2, -, -	5.83	8.46	7.14
Diclofop-methyl	0.29	1, 2, -, -	5.42	7.68	6.55
"	"	1, 2, 3, 4	5.23	8.00	6.62
"	0.57	1, -, -, -	5.33	7.82	6.58
"	"	-, 2, -, -	5.10	7.27	6.19
"	1.14	1, -, -, -	5.37	7.58	6.47
"	"	-, 2, -, -	5.13	7.27	6.20
"	"	-, -, 3, -	4.97	7.01	5.99
"	"	-, -, -, 4	3.41	6.41	4.91
Isoproturon	0.53	1, 2, 3, 4	5.48	7.30	6.39
"	2.10	1, -, -, -	5.69	7.83	6.76
"	"	-, 2, -, -	5.55	7.65	6.60
"	"	-, -, 3, -	4.61	8.26	6.44
"	"	-, -, -, 4	4.31	7.72	6.01
Unsprayed control			3.63	6.76	5.20
S.E. (treatments)			± 0.261	± 0.351	± 0.236
S.E.D. (treatments and control)			± 0.320	± 0.430	± 0.289

Table 5

Isoproturon residues (μg/g) measured in the top 15 cm of soil (April)

Dose (kg a.i./ha)	Application date(s)	Site Long Crendon	Murcott
0.27	1, 2, 3, 4	0.32	0.27
2.10	1, -, -, -	0.10	0.07
"	-, 2, -, -	0.25	0.04
"	-, -, 3, -	0.54	0.31
"	-, -, -, 4	0.65	0.44
S.E.		± 0.050	± 0.030

c. Herbicide residue

The isoproturon residue results (Table 5) show that at both sites the repeated reduced doses were intermediate between the first and fourth single applications. In general higher residue levels were recorded at Long Crendon but the rate of decline appears to be of the same order at both sites indicating that on these two experiments isoproturon had a half life of about six to seven weeks. This rate of decline for isoproturon is similar to that calculated by Moss (1979)

DISCUSSION

Timing had a considerable influence on A. myosuroides control with both herbicides showing a decrease in biological activity with later applications. This was more pronounced with diclofop-methyl where the best control and greatest yield response was achieved before the crop had reached two to three tillers and indicates that optimum time for control with this herbicide is when A. myosuroides has reached two to three leaves. However, degree of control may also be related to soil temperature as there is evidence with Avena fatua (wild-oats) that diclofop-methyl is more active at lower temperatures (Donn and Bieringer, 1980; Hewson and Jones, 1981). It also is likely that the moist soil conditions encountered during the winter may have enhanced activity (J.C.Caseley pers.com.). The half dose of diclofop-methyl also appears to be very effective when applied at this time although there is no advantage from repeated low doses with this herbicide. However additional surfactant markedly improved the performance with the low dose. Taylor and Chow (1980) suggest that increased activity on A. fatua was due to more spray being retained by the plant and this is certainly more likely than any increased root uptake as Hatfield and Sweet (1973) and Parochetti et al. (1977) demonstrated that surfactants did not significantly improve the performance of a number of soil-acting herbicides. Additional surfactant may increase the possibility of crop damage but in these experiments no phytotoxic symptoms were observed and yield response was shown to be as good or better than other diclofop-methyl treatments applied at the first two dates.

The high level of control achieved from the repeated low doses of isoproturon suggests the possibility of reducing either dose or number of applications although early post-emergence treatment would be required to be most effective. Repeated applications may improve the distribution in the soil as Fryer and Kirkland (1970) indicated that herbicide deposition was uneven from a single application. Certainly this technique is now feasible as low ground pressure spraying vehicles can give access to the land in all but extremes of environmental conditions. Crop scorch did occur following a frost after the third application at Long Crendon and although this resulted in a lower yield from the high rate of isoproturon the yield from the repeated low dose was not reduced. The herbicide residue measured from the repeated low doses did not exceed those amounts recorded from the highest of the single dose at either site (Table 5) indicating there was no significant build up of isoproturon to a level that may have affected crop tolerance.

Reduced rates of herbicides offer economic savings but only if biological efficacy is maintained. However the data presented in this paper represents only two experiments in one season and further examination is required. Nevertheless these results demonstrate that reduced rates of diclofop-methyl and repeated low doses of isoproturon can achieve high levels of control but additional inputs were necessary. The inclusion of extra surfactant in diclofop-methyl by tank mixing with a broad-leaved weed herbicide may increase the cost effectiveness of this treatment but comparative investigations would be required to confirm this. Repeated treatments of isoproturon while incurring additional application costs could lead to a reduction in dose by up to a half as indicated in the data from the March assessments (Table 2). Although volume rates need to be reduced in order to achieve maximum work rates, if additional applications are to be made, previous work (Ayres and Cussans, 1980) has shown this to be feasible with isoproturon. Low doses would also reduce the risk of possible crop damage that can result from increased concentrations of herbicide or the combination of herbicides applied at low volume rates.

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REFERENCES

Ayres, P.; Cussans, G. W. (1980). The influence of volume rate, nozzle size and forward speed on the activity of three herbicides for the control of weeds in winter cereals. British Crop Protection Council Monograph, 24, 57-64.

Baldwin, J. H. (1981). A review of trials by the Agricultural Development and Advisory Service on *Alopecurus myosuroides*. Association of Applied Biologists Conference. Grass weeds in cereals in the United Kingdom, 197-200.

Barnes, T. R. (1981). The use of chlortoluron for the control of *Alopecurus myosuroides* 1970-1980. Association of Applied Biologists Conference. Grass weeds in cereals in the United Kingdom. 215-222.

Byast, T. H.; Cotterill, E. G.; Hance, R. J. (1977). Methods of analysis for herbicide residues. 2nd Edition, Technical report. Agricultural Research Council Weed Research Organization, 15, pp 58.

Chow, P. N. P.; Dorrell, D. G. (1979). Response of wild oats (*Avena fatua*), flax (*Linum usitatissimum*) and rapeseed (*Brassica campestris* and *B. napus*) to diclofop-methyl. Weed Science, 27, 212-215.

Donn, G.; Bieringer, H. (1980). The influence of temperature on the herbicidal activity of diclofop-methyl against different grass species. Proceedings British Crop Protection Conference - Weeds, 283-288.

Fryer, J. D.; Kirkland, K. (1970). Field experiments to investigate long-term effects of repeated applications of MCPA, tri-allate, simazine and linuron. Report after six years. Weed Research, 10, 133-158.

Hatfield, H. H.; Sweet, R. D. (1973). Adjuvents for pre- and post emergence herbicide application. Proceedings 27th North Eastern Weed Control Conference, 170-176.

Hewson, R. T.; Jones, A. M. (1981). Early post-emergence control of *Avena* spp (Wild-oat) in winter cereals with diclofop-methyl. Association of Applied Biologists Conference. Grass weeds in cereals in the United Kingdom, 257-264.

Ingram, G. H.; Kyndt, C. F. A. (1981). Isoproturon - the control of blackgrass (*Alopecurus myosuroides*) - a summary of its performance. Association of Applied Biologist Conference. Grass weeds in cereals in the United Kingdom, 231-237.

May, M. J. (1981). Results of some WRO experiments on the overall application of Betanal E and Goltix using repeated low doses, low volumes and high pressure. British Sugar Beet Review, Spring 1981, 52-53, 56.

Moss, S. R. (1979). The influence of tillage and method of straw disposal on the survival of black-grass. *Alopecurus myosuroides* and its control by chlortoluron and isoproturon. Annals of Applied Biology, 91, 91-100.

Parochetti, J. V.; Wilson, H. P.; Beste, C. E. (1977). Effects of several adjuvents on pre-emergence and post-emergence herbicides in 1976. Proceedings 31st North Eastern Weed Science Society, 105-112.

Taylor, W. A.; Chow, P. N. P.; Owen, P. G. (1980). Influence of surfactants on spray deposition and biological activity of diclofop-methyl on wild oat (Avena fatua. L) British Crop Protection Council, Monograph, 24, 45-48.

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THE CONTROL OF AGROPYRON REPENS PRE-HARVEST OF WHEAT AND BARLEY WITH THE ISOPROPYLAMINE SALT OF GLYPHOSATE: ADAS RESULTS 1980 AND 1981

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Summary. The isopropylamine salt of glyphosate was applied in a formulated product, prior to harvest of wheat or barley at various rates, with and without additional surfactants, in seven trials in 1980 and six trials in 1981.

The highest rate tested, that recommended by the manufacturer for the control of *Agropyron repens*, gave the highest and most reliable control of rhizome buds. Half this rate resulted in a small loss of reliability and efficacy. There was a further small loss in control from reducing the rate from one half to one quarter of that recommended by the manufacturer when conditions were ideal for glyphosate activity. When conditions were not ideal there was a far larger loss of control.

Overall, additional surfactants appeared to improve the control and reliability of control of *A. repens*, particularly at the very low rates of glyphosate.

Rate, dose, surfactant, viable bud assessment.

INTRODUCTION

The use of the isopropylamine salt of glyphosate for the control of *A. repens* (common couch) and other perennial grass weeds in cereal stubbles and uncropped land was commercially introduced to the United Kingdom in 1974 (Evans 1972). It has subsequently become the standard for the control of perennial grass weeds throughout the United Kingdom. It is available as the 360 grammes/litre acid equivalent product 'Roundup', sold by Monsanto p.l.c. and recommended at the rate of 4 litres/ha product for the control of *A. repens*.

At the 1978 British Crop Protection Conference - Weeds, it was suggested that the application of 0.72 kg/ha acid equivalent of glyphosate rather than the 1.44 kg/ha rate that was currently recommended would result in only a small loss of control of *A. repens* and it might be more cost effective to apply two half rates in consecutive years (Harvey & Potts, 1978). Final results of these trials carried out by the Agricultural Development and Advisory Service and the Scottish Colleges were announced in 1981. These showed that the control of *A. repens* was more successful in the Midlands and South of England and in these areas there was little loss of control from using half the rate recommended. In the North of England and Scotland, poorer control of *A. repens* was achieved and there was a significant loss of control when half the recommended rate was used (Harvey, Attwood and Potts, 1981). This was probably due to the fact that by the time the susceptible growth stage of *A. repens* was achieved in the cereal stubble in the North of England and Scotland the rapid growth necessary for optimum control had ceased.

In the 1980 British Crop Protection Conference - Weeds, the application of glyphosate prior to harvest of wheat and barley was reported (O'Keeffe, 1980).

Application at this time ensures that A. repens is sprayed at a very susceptible growth stage and is likely to be growing actively if adequate soil moisture is present (Friesen, 1977). Additionally A. repens growing competitively with a cereal crop has a high green shoot : rhizome ratio and as the cereal crop ripens rapid rhizome growth commences (Cussans, 1968). Therefore good retention of spray per unit of rhizome is possible and with rapid rhizome growth a strong 'sink' for the translocation of glyphosate should be created.

The use of additional surfactants has been shown to increase the control of A. repens in cereal stubbles at very low rates of glyphosate (Turner and Loader, 1980). Due to commercial and farmer interest it was decided to investigate the role of such surfactants at the same time as investigating the effect of rate of glyphosate on the control of A. repens pre-harvest of wheat and barley. Such treatments were carried out under trials clearance issued by the Pesticide Safety Precautions Scheme. The publication of the results in this paper is not to recommend, directly or indirectly, the commercial use of surfactants with glyphosate prior to harvest of wheat and barley as at the time of writing no provisional commercial or commercial clearance has been granted. (Pesticides Branch, UK. Ministry of Agriculture, Fisheries and Food, 1979).

METHODS AND MATERIALS

The treatments were applied prior to harvest of wheat or barley according to product recommendations of glyphosate. The crops had a bulk grain moisture content of below 30% and the applications of the commercial product made at least seven days prior to harvest, using knapsack sprayers at a total volume of 200 litres/ha at 200k. Pa.

A. repens was assessed at the majority of sites by measuring the control of rhizome viable buds (Turner and Cussans, 1981). This method involved the digging up of the rhizomes two to four weeks after the application of glyphosate, cutting a known weight of a sub-sample into one node sections and germinating them in seed trays. The number of viable buds and the weights of the resulting shoots were recorded, but only the percentage control of viable buds is given in this paper. A. repens is a weed that grows in patches and this method overcomes the problem of a variable population over the site. In addition, collecting the samples before cultivation of the site negates risk of transfer of rhizomes from one plot to another. However, this method should only be recognised as a relative assessment of efficacy and it is difficult to relate results precisely to field performance in terms of control of shoots/m^2. On some sites additional assessments of shoots/m^2 were made in the following spring or summer. The apparent differences between treatments were so small compared to the variation of A. repens over the site that the results were meaningless. On one site seedling A. repens confounded an assessment made the following spring. At one further site A. repens was assessed only by shoot numbers in the spring following application. Average A. repens populations at the time of application exceeded 100 shoots/m^2 at all sites.

In 1980, one of the surfactants - Ethylan TT 15 caused problems in mixing with water, particularly at one site. This was re-formulated and featured as Ethylan T 158 in 1981. In both years a common source of fertilizer grade ammonium sulphate was used.

RESULTS

Table 1

Percentage survival of viable rhizome buds compared with untreated control, 1980

Rate of glyphosate (kg ae/ha)	Additional surfactants	South West 1	South West 2	South East	High Mowthorpe	Northern 1	Northern 2
1.44	-	1	0	0	0	0	1
0.72	-	12	5	0	1	5	2
0.36	-	17	3	11	1	8	15
1.44)	1.0 litre/ha	3	1	0	0	0	0
0.72)	Ethylan TF + 5 kg/ha	1	0	0	0	5	0
0.36)	ammonium sulphate	11	0	0	0	4	5
1.44)	1.0 litre/ha	-	2	0	0	0	0
0.72)	Ethylan TT 15	-	1	2	0	0	0
0.36)		-	1	0	1	2	8

Log.transformation data in Table 4.

At all the sites the weather at the time of application was warm and humid and the soil was moist with the A. repens rapidly growing. Overall the optimum level of control with or without additional surfactant was given by the 1.44 kg/ha acid equivalent of glyphosate, supporting the commercial recommendation. The treatment of 0.72 kg/ha acid equivalent of glyphosate with Ethylan TT 15 gave a similar level of control to 1.44 kg/ha acid equivalent glyphosate without the surfactant. At the South West 1 site, using logarithmic transformation analysis, 0.72 kg/ha acid equivalent of glyphosate with Ethylan TF and ammonium sulphate gave a significantly better control of viable buds than 0.72 kg/ha glyphosate alone.

Table 2

Percentage of A. repens shoots compared with untreated control, 1980.

Rate of glyphosate (kg ae/ha)	Additional surfactants	East Midlands *
1.44		4
0.72		6
0.36		21
1.44)	1.0 litre/ha	6
0.72)	Ethylan TF +	6
0.36)	5 kg/ha ammonium sulphate	8
1.44)	1.0 litre/ha	2
0.72)	Ethylan TT 15	3
0.36)		5
SED ±		6.06

A. repens population in untreated plots at the time of assessment - 433 shoots/m^2.

* Assessed January 1981.

The results of the East Midlands trial again indicate that the best treatments were the full recommended rate of 1.44 kg/ha acid equivalent of glyphosate with or without additional surfactants.

With the relatively high level control of A. repens achieved by 0.36 kg/ha acid equivalent of glyphosate in 1980, it was decided that in 1981 a rate of 0.18 kg/ha acid equivalent of glyphosate would be incorporated into the trials.

Table 3

Percentage survival of viable rhizome buds compared with untreated control, 1981.

Rate of glyphosate (kg ae/ha)	Additional surfactants	Boxworth	South West	High Mowthorpe	Northern 1	Northern 2	Northern 3
1.44	-	1	11	0	0	4	0
0.72	-	2	13	0	5	1	0
0.36	-	-	22	1	23	5	45
0.18	-	-	49	1	75	18	100
0.36)	1.0 litre/ha Ethylan TF	-	24	0.5	2	0	100
0.18)	+ 5 kg/ha ammonium sulphate	-	19	0	16	4	100
1.44)	1.0 litre/ha Ethylan T 158	-	1	0	0	16	3
0.72)		2	13	0	0	0	1
0.36)		1	36	0	15	21	36
0.18)		-	51	7	40	12	59
SED ± (between treatments)			11.8		12.6	11.1	17.7

log. transformation data in Table 4.

Conditions for glyphosate activity were not so ideal as in the previous year. At all the sites except Boxworth and High Mowthorpe, the soil was dry but the A. repens was not senescing. These conditions may explain the more variable results than those obtained in 1980, with slight variations of soil moisture over the trial sites leading to differences in efficacy.

The results show that overall the most consistent control of A. repens was achieved by the application of 0.72 - 1.44 kg/ha acid equivalent of glyphosate with or without the addition of surfactant. Using logarithmic transformation analysis, the addition of Ethylan T 158 significantly improved control of viable buds at the highest rate of glyphosate at the South West site and significantly reduced control at the Northern 3 site.

At the 0.36 kg/ha acid equivalent rate of glyphosate, using logarithmic transformation analysis, the addition of Ethylan TF and ammonium sulphate significantly improved control of viable buds in the Northern 1 and 2 trials.

At the very low rate of 0.18 kg/ha acid equivalent of glyphosate, the control of viable rhizome buds was improved significantly by the addition of a surfactant in three of the four trials where the soil was dry. The level of control achieved at this rate even with surfactants was generally less satisfactory than that achieved by rates of 0.72 kg/ha glyphosate. In the South West trial, under the dry soil conditions, there was a statistically significant advantage with the addition of 1.0 litre/ha Ethylan TF + 5 kg/ha ammonium sulphate to 0.18 kg/ha acid equivalent of glyphosate over the addition of Ethylan T 158. In the Northern 1 site, the difference approached significance. In the Northern 2 trial, using logarithmic transformation analysis, the rate of 0.36 kg/ha glyphosate with Ethylan TF and ammonium sulphate gave a significantly higher level of control than the equivalent rate with Ethylan T 158. At the Northern 3 site both treatments involving the addition of ammonium sulphate and Ethylan TF gave no control of rhizome buds.

At Boxworth and High Mowthorpe the soil was moist at the time of application and the results were similar to those obtained under similar conditions in 1980.

Table 4

No. of viable rhizome buds - logarithmic transformed data

Rate of glyphosate (kg ae/ha)	Additional surfactants	1980 South West 1	1981 South West	1981 Northern 1	1981 Northern 2	1981 Northern 3
1.44	-	0.641	0.973	0.000	0.725	0.000
0.72	-	1.462	1.002	0.426	0.159	0.000
0.36	-	1.613	1.189	1.397	0.692	1.634
0.18	-	-	1.629	1.986	1.273	2.168
1.44)	1.0 litre/ha Ethylan TF + 5 kg/ha ammonium sulphate	0.920	-	-	-	-
0.72)		0.608	-	-	-	-
0.36)		1.433	1.339	0.515	0.000	2.294
0.18)		-	1.038	1.330	0.813	2.272
1.44)	1.0 litre/ha Ethylan TT 15(1980) or Ethylan T 158(1981)	-	0.100	0.000	1.328	0.563
0.72)		-	0.830	0.000	0.000	0.282
0.36)		-	1.435	0.956	1.290	1.709
0.18)		-	1.594	1.655	1.165	1.905
Untreated control		2.409	1.949	2.088	2.139	2.084
ESE ± (between treatments)		0.128	0.197	0.213	0.218	0.164

At all sites, observations of necrosis of A. repens foliage made immediately prior to harvest generally showed a close association with the control of viable buds obtained.

DISCUSSION

When considering glyphosate alone, the optimum rate of those tested in 1980 was 1.44 kg/ha acid equivalent. There was using logarithmic transformation analysis a significant loss of efficacy in the South West trial from a reduced rate of 0.72 kg/ha acid equivalent and an apparent loss of efficacy in some of the remaining trials. A further apparent loss of efficacy was recorded in all but two trials at the rate of 0.36 kg/ha acid equivalent. In 1981 there was overall little difference between the 1.44 kg/ha and 0.72 kg/ha acid equivalent rates but the higher rate appeared a little more reliable. There was a large drop in efficacy from further reductions in rate. Conditions in 1980 and 1981 were different for the majority of trials. All the trials were carried out under ideal conditions for glyphosate activity in 1980 but in 1981 only those at Boxworth and High Mowthorpe were carried out in moisture conditions adequate for rapid growth.

The results where there was adequate moisture were similar between the years. In the South West trial in 1981 there was a fairly severe moisture stress on a light soil and the highest rate of glyphosate gave disappointing results. In this same year the Northern trials were carried out when the soil was dry and the relative humidity at application was low but the weed was not suffering heavily from moisture stress. On two of these three sites there was a large fall in efficacy between the 0.72 kg/ha and 0.36 kg/ha acid equivalent rates. Such a large drop in efficacy was not noted on sites adequately supplied with moisture.

The addition of surfactants in 1980 and 1981 appeared to increase the reliability of glyphosate at a rate of 0.72 kg/ha acid equivalent. Additionally the results indicate that 0.72 kg/ha acid equivalent of glyphosate with surfactant was giving similar control of A. repens as 1.44 kg/ha without additional surfactant. In 1980 under good conditions for glyphosate activity the level of control of 0.36 kg/ha acid equivalent with additional surfactant was equivalent to 0.72 kg/ha without additional surfactant. However this was not the situation in trials suffering from some measure of drought stress in 1981. In the South West trial of that year the addition of a surfactant significantly increased efficacy of 1.44 kg/ha acid equivalent of glyphosate in a drought stress situation. At the very low rate of 0.18 kg/ha acid equivalent in 1981, in trials where there was some drought stress, the surfactants ammonium sulphate with Ethylan TF gave a higher level of control than Ethylan T 158 except in one trial where the former treatment failed completely. It is difficult to explain the failure as there was apparent herbicidal action on the foliage.

In conclusion, these trials reinforced the recommendation of the manufacturers, that for the control of A. repens the rate of 1.44 kg/ha acid equivalent gave the most reliable results. However, there was in most trials little loss of efficacy from halving this rate. These results are very similar to those published by the manufacturers recently for the 1979 harvest (O'Keeffe 1981). There was a greater loss of efficacy when rates were further reduced to 0.36 kg/ha acid equivalent, particularly where the soil and weather conditions were not conducive to rapid growth of A. repens but where it was not senescing due to drought. With the very low populations of A. repens frequently experienced and the desire of some farmers to spray pre-harvest on a fairly regular basis, for example to control annual weeds to encourage a more efficient straw burning operation, lower rates can be contemplated. These rates would depend on the frequency with which the farmer is prepared to spray his crop pre-harvest and the state of growth of the A. repens, but based on these trials may vary between 0.36 - 0.72 kg/ha acid equivalent of glyphosate.

At rates below 0.72 kg/ha acid equivalent lower volumes of application may prove an advantage (Turner and Loader, 1980). Such an approach may not save on herbicide and application costs but may contain A. repens at uncompetitive levels with the additional potential benefits of the control of annual weeds. A farmer, conscious of costs is reluctant to spray the full rate of 1.44 kg/ha acid equivalent on very low populations of A. repens and is more likely to allow the weed to build up to competitive levels. The level at which A. repens competes with a cereal crop requires further definition. At the 1970 British Crop Protection Conference - Weeds, results were reported that indicated that a population of 45 primary shoots/yard^2 did not affect the yield of spring wheat or barley (Cussans, 1982). However, it would be wise to incorporate a significant safety margin even if this level is acceptable for current conditions.

The use of additional surfactants gave an apparent increase of reliability at rates of 0.72 kg/ha acid equivalent and below in 1980. However, in 1981 where the activity of glyphosate fell appreciably between 0.72 kg/ha and 0.36 kg/ha acid equivalent on sites suffering from a degree of drought stress these surfactants, particularly Ethylan T 158, did not always retrieve the situation. These wetters only improved the control of A. repens significantly in some trials at the rates of 0.18 - 0.36 kg/ha when the control of A. repens was unsatisfactory in some cases, even with their addition.

Unlike previous Agricultural Development and Advisory Service and Scottish Colleges results on application of glyphosate to cereal stubbles there was no variation of control of A. repens according to geographical location. This explains why the practice of pre-harvest application of glyphosate is having such a profound effect on perennial grass weed control in Northern Britain giving the farmer in these areas greater flexibility in choice of crop.

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REFERENCES

Cussans, G.W. (1968). The growth and development of Agropyron repens (L) Beauv in competition with cereals, field beans and oilseed rape. Proceedings British Weed Control Conference - 1, 131-136.

Cussans, G.W. (1970). A study of the competition between Agropyron repens (L) Beauv. and spring sown barley, wheat and field beans. Proceedings British Weed Control Conference - 1, 337-343.

Evans, D.M. (1972). Field performance of glyphosate derivatives in the control of Agropyron repens and other perennial weeds. Proceedings British Weed Control Conference. 1, 64-70.

Friesen, H.A. (1977). Effect of growth stage on quack grass (Agropyron repens) (L) Beauv.) control with glyphosate. Weed Sci.Soc.Am., Abstr., 1977 Meeting., Abstr.No. 5.

Harvey, J.J., Potts, R.J. (1978). A cost effective approach to the control of Agropyron repens in cereal stubbles with glyphosate. Proceedings British Weed Control Conference. 1, 49-55.

Harvey, J.J., Attwood, P.J., Potts, M. (1981). The control of Agropyron repens in cereal stubbles with glyphosate. Proceedings Association of Applied Biologists - Weed Group Conference, Grass Weeds in Cereals in the United Kingdom, 155 - 165.

U.K. Ministry of Agriculture, Fisheries and Food, Pesticide Branch, Great Westminster House, Horseferry Road, London SW1P 2AE (1979). Pesticides Safety Precautions Scheme.

O'Keeffe, M.G. (1980). The control of Agropyron repens and broad-leaved weeds pre-harvest of wheat and barley with the isopropylamine salt of glyphosate. Proceedings British Weed Control Conference. 1, 53-60.

O'Keeffe, M.G. (1981). The control of perennial grasses by pre-harvest applications of glyphosate. Proceedings Association Applied Biologists - Weed Group Conference, Grass Weeds in Cereals in the United Kingdom, 137 - 144.

Turner, D.J., Cussans, G.W. (1981). Techniques for the assessment of perennial grass weeds. Proceedings Association Applied Biologists - Weed Group Conference, Grass Weeds in Cereals in the United Kingdom, 109 - 114.

Turner, D.J, Loader, M.P.C. (1980). Effect of ammonium sulphate and other additives upon the phytotoxicity of glyphosate to Agropyron repens (L) Beauv. Weed Research 20, 139 - 146.

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CHEMICAL CONTROL OF *PHALARIS PARADOXA* IN WINTER CEREALS

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Summary. A number of herbicides applied in autumn, winter or spring, were compared for effect on *Phalaris paradoxa* in three winter wheat crops and one winter barley during 1981 - 1982. Natural weed populations varied with a very high count in the winter barley. All pre-emergence treatments bave some control with terbutryne, a tri-allate, terbutryne sequence, triallate followed by diclofop-methyl, and pendimethalin being outstanding. The higher rate of diclofop-methyl performed better than the other early post-emergence treatments. The spring applications of three herbicides gave disappointing results. Pre and post-emergence, treatments, terbutryne, tri-allate, diclofop-methyl, pendimethalin, herbicides.

INTRODUCTION

In the last few years, *P. paradoxa*, commonly known as Canary grass, has been an increasing problem in winter cereal crops on farms situated on the coastal areas of Essex and Suffolk. Like *Bromus sterilis* the infestations have usually been confined to the field headlands but in some cases have spread out into the field. This series of trials was designed to study the chemical control of *P. paradoxa* using existing *Alopecurus myosuroides* and *Avena fatua* herbicides alone and in sequence. Similar techniques to those employed in *A. myosuroides* herbicide experiments were used for this one year series.

METHOD AND MATERIALS

Commercial crops of winter cereals sown with various cultivation systems and with a history of *P. paradoxa* infestation were sought within ADAS Eastern Region. These were found on the coastal strips of Essex and Suffolk. Highest populations of the weed were on the headland in three of the four sites chosen, plot size was therefore restricted to include the heaviest *P. paradoxa* populations. Three randomised blocks were used.

Plot size was 7m x 3m and liquid treatments were applied using a modified van der Weij sprayer with size '00' Allman fan jets at a pressure of 220k Pa. Application rate was 225 l/ha. Granules were mixed with fine sand and applied using the 'pepperpot' method.

Trial areas were laid down at time of drilling and three herbicide timings used; pre-emergence, early post-emergence, and spring. Plant counts were carried out during the winter and a final assessment of *P. paradoxa* head numbers was made in June to enable calculation of a percentage control against untreated plots. Continuous germination of the weed throughout the season was expected but did not occur, hence only one plant count was considered necessary.

The herbicide treatments are listed in Table 1. Site details, treatment application dates, also growth stages of crop and *P. paradoxa* are given in Table 2. Table 3 shows percentage control of the weed.

Table 1

Treatments

		Rate a.i. kg/ha
Pre-emergence		
1	Methabenzthiazuron	3.2
2	Terbutryne	2.8
3	Tri-allate (gran)	2.3
4	Trifluralin + linuron	1.2 + 0.6
5	Trifluralin + linuron (gran)	1.3 + 0.6
6	Tri-allate (gran) followed by	2.3
	diclofop-methyl (early post emerg)	1.1
7	Tri-allate (gran) + terbutryne (sequence)	2.3 + 1.5
8	Pendimethalin	2.0
Early post-emergence		
9	Diclofop-methyl	1.1
10	Diclofop-methyl	1.7
11	Isoproturon	2.4
12	Flamprop-methyl (wheat)	0.5
	1-flamprop-isopropyl (barley)	0.6
13	Isoproturon tank mix with	2.5
	diclofop-methyl	0.6
14	Isoproturon + tri-allate (gran)	3.0
15	Isoproturon + ioxynil + bromoxynil	2.9
16	Diclofop-methyl + methabenzthiazuron	0.6 + 1.6
Spring		
17	Flamprop-methyl (wheat)	0.5
	1-flamprop-isopropyl (barley)	0.6
18	Diclofop-methyl	1.1

Table 2

Site Details

Site	1	2	3	4
Soil texture	ZyCL	ZyL	ZL	ZyCL
Variety	Armada	Mardler	Igri	Virtue
Drilling date	29 Sept	3 Oct	14 Oct	24 Oct
seedbed at first spray	Good	Good	Cloddy	Good
Treatment Nos.Dates of Herbicide Application, Growth Stage(Zadoks) Crop and Weed				
PRE-EMERGENCE				
Treatments 1 - 8	30 Sept	6 Oct	16 Oct	30 Oct
EARLY POST-EMERGENCE				
Treatment 14	22 Oct	3 Nov	3 Nov	19 Nov
Crop G.S.	11	12	11	11
P. paradoxa GS	11	11	11	11
Treatments 6, 9, 10, 11, 12, 13, 15, 16.	1 Dec	2 Dec	4 Feb	5 Feb
Crop G.S.	13	13	21	13
P. paradoxa GS	11 - 21	13	14	13
SPRING			(17) (18)*	
Treatments 17, 18.	3 Apr	3 Apr	3 Apr 22 Apr	3 Apr
Crop G.S.	30	26	26 29	26
P. paradoxa GS	27	23	30 27	14

Weed Population

Plants per m^2	1 Dec	2 Dec	7 Dec	5 Feb
P. paradoxa	92	506	1045	179
Heads per m^2 (July)				
P. paradoxa	143	520	2675	214

* In the case of barley treatments 17 and 18 were applied on separate dates.

RESULTS

Table 3

Phalaris paradoxa, Percentage control

Treatment					
Site		1	2	3	4
Control heads per m^2		143	520	2675	214
Pre-emergence					
1	Methabenzthiazuron	87.3	25.5	67.4	0.
2	Terbutryne	99.7	94.6	98.1	96.5
3	Tri-allate (gran)	64.4	52.9	66.7	89.4
4	Trifluralin + linuron	23.4	57.5	58.8	0.
5	Trifluralin + linuron (gran)	79.6	80.0	82.3	62.7
6	Tri-allate (gran) + diclofop-methyl (post)	100.0	98.7	88.2	100.0
7	Tri-allate (gran) + terbutryne (sequence)	99.1	93.4	97.3	100.0
8	Pendimethalin	92.6	87.2	98.1	92.1
Early post-emergence					
9	Diclofop-methyl	52.6	92.8	63.0	89.8
10	Diclofop-methyl	100.0	99.5	89.7	88.2
11	Isoproturon	71.0	41.1	60.0	22.0
12	Flamprop-methyl (wheat)	20.4	53.9	-	40.2
	1-flamprop-isopropyl (barley)	-	-	37.3	-
13	Isoproturon with diclofop-methyl	99.4	100.	73.3	68.9
14	Isoproturon + tri-allate (gran)	49.7	53.4	74.1	81.5
15	Isoproturon + ioxynil + bromoxynil	58.3	50.9	64.2	58.7
16	Diclofop-methyl + methabenzthiazuron	100.	95.4	76.9	80.3
Spring					
17	Flamprop-methyl (wheat)	78.3	0.	-	64.2
	1-flamprop-isopropyl (barley)	-	-	28.6	-
18	Diclofop-methyl	6.3	0.	34.0	0.

At the time of writing yield figures from sites 2 and 4 have not been processed but may be sought from the authors at a later date.

From field observation and this trial series the following provisional conclusions can be drawn:-

1. Ploughing will assist greatly the control of P. paradoxa.

2. Of the pre-emergence herbicides tested, terbutryne, tri-allate granules plus terbutryne (sequence), and pendimethalin gave very good control of the weed.

3. Of the pre-emergence plus post-emergence or post-emergence treatments, tri-allate followed by diclofop-methyl and the high rate of diclofop-methyl alone gave similar very good control.

DISCUSSION

P. paradoxa is a grass of Mediterranean origin which was first identified in East Anglia cereal crops about 1978 when it was found to survive applications of chlortoluron and isoproturon applied for control of A. myosuroides. The mode of introduction of the grass into the United Kingdom is unclear but it is thought that it may have arrived as a contaminant of other phalaris species imported to be sown as bird cover or for seed. In addition to East Anglia the weed has been found in Warwickshire, Buckinghamshire and Glamorgan.

The seedling grass resembles that of A. myosuroides but a diagnostic feature at this stage is that the lower pink area of stem will exude a pink/red sap when broken or crushed. The mature spike resembles that of Phalaris, canariensis minor but can be distinguished from this grass in that one floret only of each spikelet produces seed.

Although the weed has been observed in both autumn and spring crops its main germination appears to be in the autumn when infestations in a cereal crop can be almost as competitive as A. myosuroides. Minimum cultivation techniques for establishing cereals encourage an explosion of the weed.

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