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TRENDS IN WEED CONTROL IN WINTER CEREALS AND THE DEVELOPMENT OF TERBUTRYNE FOR PRE-EMERGENCE APPLICATION TO CONTROL BROAD-LEAVED WEEDS AND SOME ANNUAL GRASSES

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Summary Autumn pre-emergence applications of 1.5 kg terbutryne/ha controlled a wide range of annual broad-leaved weeds in winter cereals including *Aphanes arvensis, Lamium purpureum, Matricaria spp., Papaver rhoeas, Sinapis arvensis, Stellaria media, Tripleurospermum maritimum* and *Veronica persica*. *Poa annua* and *Poa trivialis* are of increasing importance and were also sensitive to pre-emergence treatment with terbutryne. *Galium aparine* and *Veronica hederifolia* were not controlled, whilst in trials spring germinating weeds were never a problem. By using terbutryne pre-emergence in the autumn the farmer is able to relieve his spring spraying workload and at the same time increase crop yields relative to growth regulator herbicides applied in the spring.

INTRODUCTION

There has been a marked change in cereal husbandry since the introduction of growth regulator herbicides in the early 1940s. Cereal varieties have undergone a progressive development with major emphasis on improving yield potential, whilst cropping patterns have tended towards continuous cereal growing often with minimal or sometimes no cultivation after the previous crop. As farming has become more highly mechanised so too, the size of agricultural machinery has increased in the drive towards greater efficiency.

Weed problems also seem to have altered in this period and although the evidence suggests little change in the range of species encountered (Way and Chancellor, 1976) their relative importance appears to have shifted. Some of the changes have involved broad-leaved species but the increased incidence of annual grass weeds in winter cereals, particularly *Alopecurus myosuroides* and *Avena spp* has been spectacular and the acceptance of effective pre-emergence herbicides by farmers followed in the late 1960's e.g. triallate, terbutryne and chlortoluron.

It soon became apparent that the majority of annual broad-leaved weeds in winter cereals were also controlled where terbutryne was used before crop emergence to control *A. myosuroides*, so that only rarely was a spring hormone follow-up treatment necessary. Until the boom in cereal prices of the early 1970's such a treatment, even at a reduced dose, was too costly in comparison to the long established and cheap hormone materials, but with the increased profits to be obtained from growing cereals the development of a recommendation for broad-leaved weed control using pre-emergence residual herbicides became a viable proposition, particularly if crop yields could be improved by the early removal of weed competition.

A full recommendation for the use of a reduced dose of terbutryne to control most of the important annual broad-leaved weeds of winter cereals was subsequently issued in 1975, soon after the introduction of a similar recommendation for methabenzthiazuron (Clark et al, 1974), another autumn - applied residual herbicide originally developed for the control of *A. myosuroides*.

The remainder of this paper considers not just the technical justification for an autumn herbicide spray to control broad-leaved weeds but also its impact on farm operations.

MATERIALS AND METHODS

Terbutryne, originally marketed as a 50% wettable powder, was subsequently modified and since 1975 has been available as a 50% w/v water-based liquid formulation. Broad-leaved weed control is achieved using a dose of 1.5 kg ai/ha.

Weed control data from farm-scale applications (table 1) was collected both during the development of this product and also after its commercial introduction.

The weed control and crop yield information summarised in tables 2 and 3 was collected from small-plot trials undertaken in the period 1973-1977. Treatments were applied using a precision plot sprayer fitted with Teejet 8002 nozzles operating at 2.1 bar and delivering 210 litres spray liquid/ha and were replicated four times. Plot size was 2.8 x 12 metres.

Weed control was evaluated using quadrat counts in treated and untreated plots on small-plot trials, and assessed using the EWRC 1-9 scale on farm scale sites.

Crops were harvested in the small-plot experiments using a modified Claas combine harvester and grain yields corrected to 16% moisture content.

RESULTS AND DISCUSSION

Weed spectrum

Data from a large number of observations (table 1) illustrate the wide range of weeds controlled by a pre-emergence application of terbutryne. The frequency of occurrence of each species reflects the extent of the problem commercially, the commonest being *Stellaria media, Tripleurospermum maritimum ssp inodorum, Matricaria spp* and *Poa annua*. All of these weeds were well controlled. Information from small-plot experiments (table 2) whilst indicating a poorer control of *Poa annua* than the two broad-leaved species, must also be related to the high incidence of acceptable results in table 1. Data in table 2 also give some idea of the low activity to be expected from growth regulator herbicides used under difficult conditions. It should be noted that control of *Poa annua* (and *P. trivialis*) was often mentioned by farmers as an important factor in their decision to use an autumn residual treatment (Ciba-Geigy 1978), since grasses are not controlled by hormone based materials.

Table 1

Summary of weed susceptibility ratings from some commercial applications of 1.5 kg terbutryne/ha during the period 1974-78

Weed species	Total no.of sites	No. of sites in EWRC rating categories 1 - 3	4 - 5	6 - 7	8 - 9
Aethusa cynapium	3	3			
Anagallis arvensis	3	2			1
Aphanes arvensis	13	11	2		
Atriplex patula	1				1
Capsella bursa-pastoris	9	9			
Chenopodium album	2	2			
Chrysanthemum segetum	1	1			
Fumaria officinalis	5	3			2
Galium aparine	5				5
Lamium purpureum	13	12	1		
Lolium perenne	3	2		1	
Mayweeds	35	32	2		1
Myosotis arvensis	9	7	1	1	
Papaver rhoeas	11	10	1		
Poa annua	33	28	3	1	1
Poa trivialis	7	6			1
Polygonum aviculare	10	5		2	3
Polygonum convolvulus	6	1	1		4
Polygonum persicaria	4	3	1		
Volunteer oil-seed rape	7	7			
Senecio vulgaris	5	4	1		
Silene alba	1				1
Sinapis arvensis	14	12	1		1
Sonchus spp	2	2			
Stellaria media	47	39	5	2	1
Urtica urens	3	2			1
Veronica hederifolia	10	4		1	5
Veronica persica	17	14	2	1	
Viola spp	11	9	1	1	

Table 2

Percentage control of individual weed species by autumn or spring herbicide treatments (mean results from trials in 1974 and 1975)

Weed species	Pre-emergence application		Spring application		
	No. of sites	terbutryne 1.5 kg ai/ha	No. of sites	mecoprop 2.24 kg ai/ha	dicamba + MCPA + mecoprop 5.6 litres product/ha
Poa annua	5	66	2	0	0
Stellaria media	5	87	3	61	60
Tripleurospermum maritimum	7	89	4	47	41

Other important species sensitive to terbutryne included *Aphanes arvensis*, *Lamium purpureum*, *Papaver rhoeas*, *Sinapis arvensis* and also *Veronica persica*, a common species poorly controlled by growth regulator herbicides.

Early weed removal assists vigorous crop growth in the spring, and in 5 years of trials and in commercial usage late germinating species such as *Anagallis arvensis*, *Polygonum spp.*, *Chenopodium album* and *Urtica urens* have only rarely been a problem despite the lack of terbutryne persistence into late spring.

Two other autumn germinating species *Galium aparine* and *Veronica hederifolia* were both resistant to terbutryne and although the former species in particular can be a serious problem, it was of irregular distribution.

Weather limitations in the spring

The continuing trend to greater acreages of winter cereals and particularly barley at the expense of spring cereals, can only compound the difficulties for farmers relying solely upon spring hormone treatments to control weeds in winter crops. Such materials should be applied to crops after the main tiller has five leaves but before the onset of jointing, which in most years covers a three week period from mid April onwards. But adverse weather conditions, particularly excessive wind and/or rainfall in that time may limit the number of days available for spraying. Tottman and Phillipson (1974) concluded that as few as one day in four may be classed as suitable spraying days during this period. If so, it is probable that the statistics collected by Evans in 1969 showing that more than one third of fields were sprayed incorrectly, are still indicative of a high incidence of late spraying of growth regulator herbicides. Indeed, it is sometimes suggested that over half of the acreage sprayed with broad-spectrum growth regulator products is treated after the start of jointing, the exact figure varying from season to season.

By utilising the autumn period for herbicide treatment, growers have the opportunity to spread their workload and help ensure that whatever material is used, it is applied at the optimum time. However this is not the only consideration and whilst the use of an autumn pre-emergence herbicide treatment may ease the spring workload, in the eyes of many cereals growers the major criterion by which a cereal herbicide should be judged is its effect on final grain yield.

Yield benefit from an autumn pre-emergence treatment

Perhaps the major contribution of those people who have promoted one or other of the systems of cereal growing in which such great interest has been shown during the past few seasons, has been their emphasis on a critical appraisal of all facets of cereal husbandry in the search for higher yields. In the case of herbicide usage, two aspects are of interest.

Firstly, the use of an autumn-applied product such as terbutryne has generally given a small yield increase averaging 0.23 tonnes/ha relative to untreated areas (table 3) and whilst this improvement has more than paid for the chemical costs it casts some doubt upon the competitive nature of the weed populations in many UK cereal fields.

Table 3

Crop yields as % of untreated

Harvest year	Site no.	Autumn pre-em: 1.5 kg terbutryne/ha	Spring post-em: Crop stage at application	Spring post-em: 2.24 kg mecoprop/ha	Spring post-em: dicamba ± TBA +mecoprop + MCPA recommended rate	untreated yield (tonnes/ha)
1974	500	97				4.12
	501	94				5.10
	503	109				3.52
	504	104				3.62
	560		26	102	113	4.05
	561		26	93	95	5.10
	563		31	97	79	4.05
	564		30-31	124	94	3.04
	565		47	102	95	5.94
1975	791	97				5.15
	794	110				3.29
	795	100				8.13
	796	110				8.19
1976	164	114	30		104	3.59
	166	104	30		91	3.26
	167	101	31		88	4.80
	170	109	31		89	5.70
1977	423	106	30-31	104	98	4.01
	426	120	30-31	100	104	3.73

Crop stages according to Zadoks, Chang and Konzak

However the more important comparison is between an autumn treatment with terbutryne and the effect of spring-applied products with an equally wide broad-leaved weed spectrum. The most commonly used herbicides of this type contain dicamba and/or 2,3,6 - trichlorobenzoic acid (2,3,6 TBA) both of which can be phytotoxic and have been shown to reduce yield when used too late (Munro, 1972).

Although the characteristic effects of such treatments applied after the onset of jointing were not always seen (shrivelled grain, blackened ears) experimental data (table 3) indicated that products containing benzoic acid derivatives reduced yield relative to untreated plots by 2 to 5% at four sites and 9 to 21% at another four sites out of a total of eleven treated in the period 1974-1977.

It was intended that spring hormone treatments in these experiments should be applied within the recommended timings, but adverse weather delayed treatments until the first node stage at some sites, when the greatest depressions were observed. Similar results were noted in ADAS experiments during the period 1975-1977 (Evans and Harvey, 1978). Mecoprop used alone (table 3), although not always the most appropriate standard, was generally well tolerated by the crops with yields depressions of 3 and 7% at only two sites.

Thus is would appear that the large yield increases commonly seen thirty years ago after using hormone materials are no longer to be expected and in fact the data quoted here confirm the serious doubts already raised about the relative safety of late applications of those spring hormone treatments containing benzoic acid derivatives. At the very least they reinforce the views of Tottman (1976) regarding the need to accurately identify the stages during which cereal crops may be safely treated with hormone materials.

The density at which populations of the various weed species become competitive also merits further study since yield improvements following the successful use of terbutryne have generally been of a low level although still providing an economic return to the farmer. In particular, the distribution and significance of annual grasses such as *Poa annua* and *Poa trivialis* are not easily quantified, although apparently an increasing problem. Certainly a large number of the farmers using terbutryne to control broad-leaved weeds also had *Poa annua* problems which in their view warranted chemical treatment.

Acknowledgement

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PENDIMETHALIN FOR BROAD SPECTRUM WEED CONTROL IN WINTER BARLEY

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Summary Pendimethalin was applied pre-emergence on winter barley at 2.0 kg a.i./ha in 21 grower application trials and at 2.0 to 6.0 kg a.i./ha in six replicated trials. Results of weed control assessments demonstrated usually excellent control of a range of broadleaved species frequently present in winter cereals including Galium aparine, Stellaria media, Veronica spp. and Tripleurospermum maritimum. Control of the two grass weeds most frequently present in trials, Alopecurus myosuroides and Poa annua was good to excellent.

Comparisons with five standard pre-emergence herbicides showed pendimethalin to be equal or superior in efficacy for the control of the weed species present in these trials.

No damaging effects were observed on the treated crops from dosages up to 6.0 kg a.i./ha in replicated trials.

INTRODUCTION

Pendimethalin (trade names STOMP, PROWL and HERBADOX), formerly designated AC 92,553, is a dinitroaniline herbicide discovered and developed by American Cyanamid Company. It selectively controls annual broadleaved weeds and grasses in many agricultural and horticultural crops (Sprankle 1974). The activity of pendimethalin on important grass and broadleaved weeds in winter cereals in West Germany has been described by Hopp, Behrendt and Menck (1976).

Pendimethalin is generally more active when applied pre-emergence than when applied post-emergence. Pendimethalin acts by inhibiting early seedling development of sensitive species; therefore, post-emergence applications are effective only when made at an early stage. Following pre-emergence application of pendimethalin weed mortality occurs shortly after germination or following emergence from the soil.

The chemical is formulated as an emulsifiable concentrate containing 33% active ingredient, and has been under evaluation as a broad-spectrum herbicide for use in winter barley in the U.K. since 1974. Observations up to 1977 were not extensive but suggested that pendimethalin should be used at 2.0 kg a.i./ha for effective weed control and that this dosage was selective in winter barley with no indications of varietal susceptibility.

The two trials projects described here were established in the autumn of 1977 and were designed (a) to evaluate the herbicidal activity of pendimethalin in grower application trials and (b) to measure the effects, if any, of pendimethalin on winter barley at dosages up to 6.0 kg a.i./ha in replicated trials. It was not possible to find weed-free sites for these replicated trials and assessments of herbicidal activity were obtained incidentally on those species present.

Table 1 Details of Sites and Applications at Grower Trials

Trial No.	Location	Soil Type	Winter barley Variety	Pendimethalin appn. date	Soil tilth	Standard
1	Bridgwater, Somerset	clay loam	Astrix	25/10/77	medium, some large clods	isoproturon
2	Greinton, Somerset	clay loam	Sonja	12/10/77	fine, few clods	isoproturon
3	Shepton, Somerset	clay	Sonja	14/10/77	cloddy	none
4	Petworth, Sussex	clay	Sonja	20/10/77	cloddy	methabenzthiazuron
5	Abingdon, Oxon.	clay loam	Sonja	1/11/77	fine	isoproturon
6	Faringdon, Oxon.	clay	Sonja	23/10/77	cloddy	none
7	Tamworth, Staffs	loam	M. Otter	11/10/77	fine	triallate
8	Sawbridgeworth, Herts	clay loam	M. Otter	19/10/77	cloddy	terbutryne
9	Stansted, Herts	loam	M. Otter	10/10/77	fine-medium	terbutryne
10	Foulness, Essex	loam	Sonja	1/11/77	medium	chlortoluron
11	Sudbury, Suffolk	loam	Astrix	17/10/77	fine	chlortoluron
12	Felsted, Essex	clay loam	Sonja	25/10/77	fine	chlortoluron
13	Tollesbury, Essex	clay loam	Sonja	26/10/77	cloddy	isoproturon
14	Stowmarket, Suffolk	chalky clay	M. Otter	14/10/77	medium	isoproturon
15	Framlingham, Suffolk	clay loam	M. Otter	20/10/77	fine	none
16	Hardwick, Norfolk	clay	M. Otter	25/10/77	fine-medium	none
17	Kings Lynn, Norfolk	light loam	M. Otter	13/12/77	fine	methabenzthiazuron
18	Corby, Northants	clay	Sonja	13/10/77	cloddy	chlortoluron
19	Ulceby, S. Humberside	loam	M. Otter	22/10/77	cloddy	none
20	Bucknall, Lincs	clay loam	Malta	5/11/77	cloddy	none
21	Ilmington, Warks	clay loam	Sonja	20/10/77	fine	chlortoluron

METHOD AND MATERIALS

Grower Application Trials

Details of sites and applications are presented in Table 1. No special instructions on the preparation of seedbeds were given to growers. Where standard products were applied in the same field the same seedbed cultivations were applied over all treated areas.

Pendimethalin at 2.0 kg a.i./ha was applied at all sites using the grower's spray equipment within the 10 days following drilling. Sites were free of emerged weeds at the time of application except at site no. 2 where some A. myosuroides had emerged.

Treatments were applied in 225 to 335 l/ha at a pressure of 2.1 to 2.8 bar.

The size of treated plots was 1 to 2 ha. Untreated plots were laid out either as a 2 - 3 m strip between treated plots or by placing 10 to 12, 1 x 1 m polyethylene sheets on the ground at the time of application in each treated plot to give protection from the spray.

Observations on the trials during the period up to ear emergence of the crop were recorded to detect any effects of treatments on crops and each weed species present. The establishment and subsequent vigour of crops was assessed visually to detect any difference between treated and untreated areas.

The weed control effects of treatments were assessed on broadleaved species and on Poa annua by visual estimate of % control by comparison with the untreated area or areas. Control of Alopecurus myosuroides and Poa trivialis was assessed by head counts in 10 to 15 quadrats in each plot.

Replicated Trials

Details of the six replicated trial sites are given in Table 2. Trials were located on contrasting soil types and varying seedbed tilths. Pendimethalin was applied at doses of 2.0, 4.0 and 6.0 kg a.i./ha and at 2.0 kg a.i./ha in mixture with paraquat at 0.54 kg a.i./ha at four of the six sites. Chlortoluron was applied as the standard at 3.6 kg a.i./ha. Each of the five treatments was applied each on two dates at each site; i.e. between 0 and 3 days after drilling and between 10 and 12 days after drilling.

Table 2

Details of sites at replicated trials

Site No.	Variety	Soil type	Drilling date	Soil tilth
i	M. Otter	calcareous clay loam	6/10/77	medium
ii	Astrix	sandy loam	10/10/77	fine
iii	M. Otter	clay loam	10/10/77	cloddy
iv	Sonja	sandy loam	15/10/77	fine
v	M. Otter	calcareous clay loam	7/11/77	fine
vi	M. Otter	loam	11/10/77	medium

Applications were by knapsack sprayer at 225 l/ha and 2.8 bar pressure on plots of 3 x 15 m. There were four replicates in a randomised block design in each trial.

The effects of treatments on crops were assessed at three growth stages. Seedling establishment counts from 10 random quadrats of 25 x 25 cm in each plot were conducted at the time of full emergence. The vigour of crops was assessed visually in March or April, and scored on a 0-9 scale where 0 = no effect and 9 = 100% crop mortality. Grain yield was measured by plot combine in a 27 m^2 area from the centre of each plot.

The weed control effects of treatments were assessed by visual estimates of % reduction of each broadleaved species, and by head counts of A. myosuroides and Avena spp. in 10 x (25 x 25 cm) quadrats in each plot.

RESULTS

Herbicidal Effects

The effects of treatments on weeds are presented in Tables 3 and 4.

Pendimethalin at 2.0 kg a.i./ha gave between 90 to 100% control of the four broadleaved species most frequently present in trials, i.e. Galium aparine, Stellaria media, Veronica spp., Tripleurospermum maritimum, in the majority of trials. Similar levels of control were observed also on Papaver spp., Aphanes arvensis, Polygonum spp., Spergula arvensis and Lamium purpureum in the 1 to 4 trials where these weeds were present.

Observations of herbicidal activity on Geranium spp. and Myosotis arvensis were limited to 2 and 3 sites respectively and showed slightly less conclusive results. The chemical had, as expected, low efficacy on Sinapis arvensis in two trials (Table 4) and had no visible effect on Senecio vulgaris in two trials (Table 3).

Comparisons between pendimethalin and the standard products in these trials showed that in most cases pendimethalin was more effective particularly in grower applications trials, where Galium aparine and Veronica spp. were present.

The two grass weed species most frequently present in trials were A. myosuroides and P. annua. Pendimethalin gave greater than 90% control of A. myosuroides in 10 of the 14 grower trials where the species was present and equally good control of P. annua in seven trials, but was less effective in two replicated trials.

Good control of P. trivialis was observed in one grower trial and very good control of Avena spp. in two replicated trials.

Admixture with paraquat had no apparent effect on the herbicidal activity of pendimethalin.

Crop Establishment and Vigour Effects

There were no observed effects of pendimethalin on crops in 19 of the total 21 grower trials. In two trials, nos. 2 and 3, a proportion of the winter barley seed germinating in the top 2.5 cm of soil, was observed to suffer stunted root systems when examined at the seedling/1-2 leaf stages. However, there was no apparent effect on crop vigour at this stage or any later stage.

Trial No.	Control of Broadleaved Weeds (estimated % reduction)*												Control of Grass Weeds (% reduction)**			Standard Herbicide comparison of efficacy†		
	Galium aparine	Stellaria media	Veronica spp.	Tripleurospermum sp.	Polygonum sp.	Sinapis spp.	Senecio vulgaris	Spergula arvensis	Aphanes arvensis	Lamium purpureum	Geranium spp.	Myosotis arvensis	A. myosuroides	Poa annua	Poa trivialis		B	G
1	90	-	99	-	-	-	-	-	-	-	-	-	98	-	-	isoproturon	[illegible]	>
2	99	99	99	-	-	-	-	-	-	95	-	-	83++	-	76	isoproturon	>>	=
3	-	99	99	-	-	-	-	-	-	-	-	-	70	-	-	-	-	-
4	-	95	-	80	-	-	-	100	99	-	99	70	-	95	-	methabenzthiazuron	=	>
5	-	-	99	-	-	-	-	-	-	-	80	80	-	-	-	isoproturon	>>	-
6	-	90	-	-	-	-	-	-	-	-	-	-	-	95	-	-	-	-
7	-	99	-	80	-	-	-	-	-	-	-	-	93	-	-	triallate	-	>
8	-	-	80	-	-	-	-	-	-	-	-	-	99	-	-	terbutryne	>>	>>
9	99	99	50	90	-	-	0	-	-	-	-	-	97	90	-	terbutryne	>	>
10	-	-	99	99	-	-	-	-	-	-	-	-	97	-	-	chlortoluron	>>	=
11	90	50	75	80	-	-	-	-	-	-	-	-	91	90	-	chlortoluron	>	>
12	99	-	99	-	90	-	0	-	-	-	-	90	99	-	-	chlortoluron	>	>
13	-	95	95	90	-	-	-	-	-	-	-	-	98	90	-	isoproturon	>	>
14	99	99	-	-	95	-	-	-	95	-	-	-	97	90	-	isoproturon	>	=
15	-	-	99	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	99	-	99	99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	-	99	95	-	99	-	-	-	-	-	-	-	-	-	-	methabenzthiazuron	>	-
18	-	99	-	99	-	-	-	-	-	-	-	-	88	-	-	chlortoluron	>	>
19	-	99	-	99	99	-	-	-	-	-	-	-	-	95	-	-	-	-
20	-	-	-	99	-	80	-	-	-	-	-	-	82	-	-	-	-	-
21	80	-	-	-	-	-	-	-	-	-	-	-	96	-	-	chlortoluron	>	<

**Control of grass weeds assessed by head counts (A. myosuroides + P. trivialis) or visual estimate (P. annua)
* Visual estimate of % reduction of infestation in comparison to untreated plots.
† Efficacy comparison summary on all broadleaved species present (B) and grass species present (G). Greater efficacy of pendimethalin is shown by > ; much greater by >> ; approx. equal by =, and lower efficacy by < .
++Some A. myosuroides were emerged at the time of application.

Table 4 The Effects of Pendimethalin on Broadleaved and Grass Weeds in Replicated Trials

	Application		Control of broadleaved and grass weed species (Estimated % Reduction[+])												(% Reduction[++])			
	Dose (kg a.i./ha)	Timing (days after drilling)	*Stellaria media*			*Tripleurospermum* sp.		*Veronica* spp.		*Papaver* sp.	*Sinapis arvensis*		*Aphanes arvensis*		*Alopecurus myosuroides*		*Avena* spp.	
Trial No.			i	iv	vi	ii	iv	ii	iv	iv	i	iii	ii	iv	i	ii	i	iii
Plants/m² - untreated:			(32)	(16)	(30)	(4)	(57)	(25)	(3)	(64)	(18)	(45)	(127)	(118)	(112)	(417)	(50)	(22)
Herbicide	untreated		0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a
pendimethalin	2.0	0-3	100^b	100^b	100^c	99^b	91^b	100^c	100^c	100^b	16^{bc}	0^a	100^c	99^{bc}	78^b	54^{bc}	82^c	96^{bc}
pendimethalin	4.0	0-3	100^b	100^b	100^c	100^b	100^d	100^c	100^c	100^b	21^{bcd}	2^{bc}	100^c	100^c	81^b	53^{bc}	93^c	100^c
pendimethalin	6.0	0-3	100^b	100^b	100^c	100^b	100^d	100^c	100^c	100^b	71^e	65^e	100^c	100^c	99^b	62^{bcd}	95^c	100^c
chlortoluron	3.6	0-3	99^b	100^b	72^b	99^b	96^c	100^c	96^b	100^b	2^b	3^{bc}	98^b	98^b	5^a	92^d	25^b	99^{bc}
pendimethalin + paraquat	2.0+0.54	0-3	100^b	100^b	100^c	99^b	92^b	100^c	99^c	100^b	29^{bcde}	0^a	100^c	99^{bc}	78^b	54^{bc}	78^c	96^{bc}
pendimethalin	2.0	10-12	100^b	100^b	100^c	99^b	96^c	100^c	100^c	100^b	25^{bcde}	35^{de}	100^c	100^c	92^b	52^{bc}	90^c	93^{bc}
pendimethalin	4.0	10-12	100^b	100^b	100^c	100^b	99^d	100^c	100^c	100^b	52^{cde}	19^{bcd}	100^c	100^c	94^b	65^{bcd}	93^c	75^{bc}
pendimethalin	6.0	10-12	100^b	100^b	100^c	100^b	100^d	100^c	100^c	100^b	64^{de}	31^{cde}	100^c	100^c	97^b	68^{bcd}	92^c	100^c
chlortoluron	3.6	10-12	100^b	100^b	100^c	99^b	93^{bc}	99^b	99^c	100^b	18^{bcd}	0^a	95^b	99^{bc}	87^b	78^{cd}	84^c	67^b
pendimethalin + paraquat	2.0+0.54	10-12	100^b	-	100^c	100^b	-	100^c	-	-	52^{cde}	0^a	100^a	-	81^b	40^b	86^c	-
	CV % (transformed data)		3.6	1.3	16	6.1	4.7	2.6	4.8	1.3	56	107	5.0	4.0	119	43	56	29

[+]Mean visual estimate of % reduction in comparison with the untreated plots in each replicate (statistical analysis as angular transformed data).

[++]Mean reduction of spikes or panicles in 10(25x25 cm) quadrats per plot (statistical analysis as log (x+1) surviving spikes or panicles).

Means are compared by Duncan's New Multiple Range Test. Means with common superscripts are not significantly different at p = 0.05.

Table 5 The Effect of Treatments on Crop Establishment, Vigour and Grain Yield in Replicated Trials

Herbicide	Dose (kg a.i./ha)	Timing (days after drilling)	i			ii			iii			iv			v			vi		
Trial No:			Establishment †	Vigour ††	Relative yield ‡	Establishment	Vigour	Relative yield	Establishment	Vigour	Relative yield	Establishment	Vigour	Relative yield	Establishment	Vigour	Relative yield	Establishment	Vigour	Relative yield
Untreated	-	-	100	0	100^{ab} (3.61 t/ha)	100^{ab}	0	100^{ab} (3.88 t/ha)	100	0	100^{a} (3.93 t/ha)	100	0	100 (5.70 t/ha)	100	0	100 (5.38 t/ha)	100	0^{a}	100 (4.94 t/ha)
pendimethalin	2.0	0-3	97	0	129^{d}	104^{ab}	0	106^{ab}	85	0	119^{bc}	99	0	104	101	0	100	113	0^{a}	102
pendimethalin	4.0	0-3	99	0	111^{abcd}	111^{a}	0	113^{bc}	107	0	122^{bc}	103	0	103	97	0	95	118	0.9^{ab}	101
pendimethalin	6.0	0-3	86	0	89^{a}	100^{ab}	0	118^{bcd}	85	0	120^{bc}	107	0	99	92	0	92	102	1.2^{b}	90
chlortoluron	3.6	0-3	103	0	94^{a}	116^{a}	0	147^{d}	87	0	130^{c}	120	0	101	92	0	96	116	0.4^{ab}	103
pendimethalin + paraquat	2.0+0.54	0-3	96	0	127^{d}	99^{ab}	0	108^{b}	89	0	123^{bc}	107	0	104	90	0	93	122	0^{a}	102
pendimethalin	2.0	10-12	86	0	124^{cd}	112^{a*}	0	109^{b}	93	0	126^{bc}	101	0	103	94	0	97	115	0^{a}	105
pendimethalin	4.0	10-12	84	0	117^{bcd}	106^{a*}	0	106^{ab}	88	0	118^{bc}	105	0	102	94	0	94	118	0.8^{ab}	96
pendimethalin	6.0	10-12	97	0	103^{abc}	88^{b*}	0	115^{bc}	89	0	121^{bc}	100	0	106	92	0	91	107	1.2^{b}	99
chlortoluron	3.6	10-12	92	0	126^{d}	110^{a*}	0	142^{cd}	87	0	115^{ab}	96	0	107	96	0	96	111	1.3^{b}	103
pendimethalin + paraquat	2.0+0.54	10-12	105	0	130^{d}	49^{c*}	0	76^{a}	-	-	-	-	-	-	97	0	98	115	0^{a}	103
	Sig. by 'F' test		NS	-	***	***	-	***	NS	-	***	NS	-	NS	NS	-	NS	NS	**	NS
	CV %		17.6	-	12.1	11.6	-	17.3	11.5	-	6.9	13.4	-	6.8	9.9	-	6.3	14.5	3.2	6.9

*applied at approximately 50% crop emergence

† Establishment of seedlings as % of untreated.

††Vigour scored 15-20 weeks after treatment on 0-9 scale where 0=no effect; 9=crop kill.

‡ Grain yield as % of untreated.

Mean data are compared by Duncan's New Multiple Range Test. Means with common superscripts are not significantly different at P=0.05.

There was no effect on crop establishment except in the one instance (trial ii) (Table 5) where the pendimethalin + paraquat treatment applied after partial emergence of the winter barley caused some damage. Other treatments at this site and in the five other replicated trials had no effect on establishment.

At five of the six replicated sites no vigour effects were apparent when assessed in March or April. At site vi the vigour reductions following six treatments were caused by selective grazing by rabbits or hares.

Grain Yield

Significant differences in yield were recorded in three of the six replicated trials - nos. i, ii and iii (Table 5). Significant yield increases of 6% to 29% were recorded following pendimethalin treatments at 2.0 kg a.i./ha.

Following pendimethalin treatments at doses of 4.0 and 6.0 kg a.i./ha yields were significantly greater than the untreated control in trial iii but were not significantly different to untreated in trials i and ii.

Yield differences between pendimethalin and chlortoluron treatments in trial ii were probably due to differences in control of *A. myosuroides* at this site.

DISCUSSION

Trials were situated in widespread locations throughout Southern, South Western and Eastern regions of England and were conducted on a range of soil types with various seedbed tilth conditions. Under these conditions pendimethalin was effective in controlling the weed species most frequently present. The spectrum of weed control and level of activity of pendimethalin demonstrated in these trials was on average greater than that of the standard herbicide products applied for comparison.

Assessments of control of *Avena* spp. were obtained from two replicated trials. The levels of efficacy observed in these two trials have been observed infrequently in previous trials, and the activity of pendimethalin on *Avena* species is considered unreliable following pre-emergence applications in winter cereals.

Results of crop tolerance assessments on winter barley at dosages two and three times those required for effective weed control indicated a high level of safety to the winter barley crop. The four varieties present in trials showed equally good tolerance of pendimethalin, supporting previous observations (unpublished) that all varieties commonly grown in the UK are equally tolerant of pendimethalin.

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THE EFFECT OF STRAW DISPOSAL METHOD AND CULTIVATION ON ALOPECURUS MYOSUROIDES POPULATIONS AND ON THE PERFORMANCE OF CHLORTOLURON

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Summary Three field experiments were set up to study the effects of combinations of straw disposal methods, stubble cultivations and chlortoluron application on the control of *A. myosuroides*. Straw was either burnt or removed by baling; plots were either left uncultivated or cultivated to 3-5 cm or 10-12 cm deep using a rotary cultivator; chlortoluron (3.6 kg a.i./ha) was applied in the absence of a crop in October.

Straw burning reduced the subsequent weed infestation compared with baling. Cultivations, in the absence of a herbicide application, had a variable effect. Chlortoluron was more effective at controlling *A. myosuroides* on land cultivated 10-12 cm deep than when applied to uncultivated land, irrespective of straw disposal method.

At all sites, the lowest infestation of *A. myosuroides* occurred after the straw was burnt, the land cultivated to 10-12 cm deep and chlortoluron subsequently applied.

INTRODUCTION

In winter cereals, *A. myosuroides* seeds are mainly shed during July and this seed is a potential source of infestation to any subsequent crop. After winter cereals have been harvested, the remaining straw and stubble may be treated in a variety of ways. Straw may be burnt or removed by baling; the land may be left uncultivated for direct drilling or alternatively be cultivated in some way. Early stubble cultivations may be carried out in the belief that they will stimulate *A. myosuroides* seeds to germinate so that the seedlings may be killed before the next crop is planted.

The effect of these different treatments on the subsequent infestation of *A. myosuroides* has not been fully studied. It was therefore decided to study the effect of straw disposal method and early stubble cultivations on the subsequent development of this weed.

Many of the soil acting herbicides used against *A. myosuroides* are applied in the autumn. The activity of these herbicides could be affected by the treatment of the stubble of the previous crop as this may influence the amount of straw residues or ash close to the soil surface. It was therefore decided to see if the method of straw disposal and stubble cultivation did affect the activity of an autumn applied herbicide against *A. myosuroides*.

METHOD AND MATERIALS

Three field experiments were started in August 1976 at the following locations near Oxford - Bucknell, South Weston, Waterperry. At all sites, the previous crop was a winter cereal which had been infested with A. myosuroides. The soils were all clay loams.

The experimental treatments were as follows:

		Uncultivated		
Straw baled	x	Cultivated 3-5 cm deep	x	Unsprayed
Straw burnt		Cultivated 10-12 cm deep		Sprayed with Chlortoluron (3.6 kg a.i./ha)

Each plot was 3 m x 2 m and all treatment combinations were fully randomised within each of the four replicates.

Dates of treatment and assessment for each site are given in table 1.

Table 1

Dates of treatments and A. myosuroides assessments

	Bucknell	South Weston	Waterperry
Straw burnt	4 August 1976	16 August 1976	17 August 1976
Cultivations	4 August	17 August	17 August
Chlortoluron application	25 October	25 October	29 October
Autumn seedling assessment	11 October	12 October	11 October
Spring tiller assessment	16 June 1977	15 June 1977	2 June 1977

Straw was removed by baling over the entire trial area and burning was carried out after straw (5,500 kg/ha) had been taken from bales and spread evenly over the surface of the relevant plots.

The ground was very dry and an excellent burn was achieved at all sites. Cultivations were done using a tractor mounted rotary cultivator with gears set to give a rotor speed of 122 r.p.m. at a tractor forward speed of 0.45 m/sec. Depth of cultivation was adjusted by means of depth wheels attached to the rotovator. Some difficulty was experienced maintaining the shallower depth of cultivation.

On 13 October 1976 at all sites, the entire trial areas were sprayed with paraquat (0.84 kg a.i./ha) to kill off all the seedlings present. The subsequent application of chlortoluron was not made until all the seedlings were visibly dead. Chlortoluron was applied as an 80% w.p. in approximately 225 l of water/ha. An Oxford Precision sprayer was used with a 2 m boom and all applications were made at 2.1 bar through Spraying Systems 'Teejet' 8002 nozzles. Propane was used as propellant.

A. myosuroides was assessed by counting all seedlings or tillers within a fixed 1 m^2 quadrat within each plot. The autumn assessment was made before paraquat or chlortoluron had been applied so for each combination of straw disposal and cultivation treatment, there were two identical plots per replicate.

RESULTS

October seedling assessment

The results are given in Table 2. On uncultivated land, straw burning significantly reduced (P = 0.05) the numbers of seedlings appearing at Bucknell and Waterperry. At Bucknell, cultivations masked the effect of burning whereas at Waterperry, the effect was still apparent after both cultivation treatments.

The effect of cultivations differed between straw treatments. At Bucknell and Waterperry, where straw was baled, the deeper cultivation treatment significantly reduced the numbers of seedlings appearing. After straw burning, cultivations did not significantly affect the numbers of seedlings emerging at Waterperry, whereas at Bucknell cultivations increased the numbers of seedlings.

At South Weston, the seedling populations were lower than at the other two sites and no clear pattern of the effects of burning or cultivation was apparent.

Table 2

Effect of straw disposal method and cultivation on *A. myosuroides* seedlings/m^2 in October 1976

Data square root transformed for analysis.
Untransformed data in parentheses

	Bucknell		South Weston		Waterperry	
	Straw baled	Straw burnt	Straw baled	Straw burnt	Straw baled	Straw burnt
Uncultivated	34.3 (1456)	18.8 (448)	15.3 (245)	14.5 (217)	63.6 (4146)	47.7 (2468)
Cultivated 3-5 cm deep	29.5 (919)	30.6 (946)	18.7 (367)	13.4 (190)	64.7 (4237)	42.8 (1873)
Cultivated 10-12 cm deep	24.1 (612)	28.4 (829)	16.7 (291)	17.4 (309)	54.1 (2972)	39.7 (1679)
S.E.	± 2.56		± 1.12		± 3.11	

June tiller assessment

The results are given in Table 3. The effect of straw burning in reducing the amounts of *A. myosuroides* was still evident on the uncultivated and unsprayed plots at Bucknell and Waterperry. As with the autumn assessment, cultivations masked the effect of burning at Bucknell but not at Waterperry. The effect of cultivation where straw was baled and in the absence of a subsequent chlortoluron application was to significantly decrease the tiller population at Bucknell and South Weston but there was no such effect at Waterperry. Where straw was burnt the only significant effect of cultivation was at South Weston where tiller numbers were decreased.

The effect of chlortoluron can most easily be studied by comparing the treated and untreated plots for each combination of straw disposal and cultivation treatment (Table 4).

Table 3

Effect of straw disposal method, cultivation and chlortoluron application on A. myosuroides tillers/m² in June 1977

Date square root transformed for analysis. Untransformed data in parentheses

	Bucknell				South Weston				Waterperry			
	Straw baled		Straw burnt		Straw baled		Straw burnt		Straw baled		Straw burnt	
	-ch	+ch	-ch	+ch	-ch	+ch	-ch	+ch	-ch	+ch	-ch	+ch
Uncultivated	19.1 (378)	18.3 (354)	8.8 (82)	4.7 (53)	27.9 (784)	11.3 (135)	26.3 (699)	8.9 (107)	28.9 (839)	23.0 (530)	20.6 (427)	18.2 (338)
Cultivated 3-5 cm deep	9.2 (92)	14.3 (245)	4.7 (40)	3.3 (12)	22.7 (548)	15.0 (248)	14.5 (225)	6.1 (37)	31.2 (997)	22.1 (530)	23.1 (535)	18.7 (353)
Cultivated 10-12 cm deep	9.5 (136)	2.9 (12)	5.9 (47)	2.5 (8)	13.6 (194)	4.0 (24)	8.1 (71)	1.7 (2)	29.8 (894)	16.8 (304)	22.9 (528)	13.4 (207)
S.E.	± 2.07				± 2.04				± 2.08			

ch = chlortoluron

Table 4

% control of A. myosuroides by chlortoluron

	Straw baled			Straw burnt		
	Uncultivated	Cultivated 3-5 cm deep	Cultivated 10-12 cm deep	Uncultivated	Cultivated 3-5 cm deep	Cultivated 10-12 cm deep
Bucknell	6	-166	91	35	70	83
South Weston	83	55	88	84	84	97
Waterperry	37	47	66	21	34	61
Mean	42	-21	82	47	63	80

In the absence of cultivation and with both straw disposal methods, chlortoluron significantly reduced the tiller population at South Weston but not at the other two sites. Where the deeper cultivations were made, chlortoluron application significantly reduced the tiller population at all three sites when straw was baled and at South Weston and Waterperry when straw was burnt. Following straw baling and the shallower cultivation, the application of chlortoluron significantly reduced the numbers of tillers at South Weston and Waterperry. After straw burning this reduction was only significant at South Weston.

DISCUSSION

In the absence of any cultivation, straw burning reduced the subsequent amount of A. myosuroides as compared with removing the straw by baling. The reduction in seedling numbers in the autumn was equivalent to a control of 69% at Bucknell, 11% at South Weston and 40% at Waterperry. This beneficial effect of burning on reducing subsequent weed infestations has been found in another experiment (Moss, 1978). It should be noted that burning conditions were excellent and that straw was spread over the entire plot. It is likely that on a field scale the degree of control achieved by burning would be poorer.

A rotary cultivator was used to simulate the type of shallow stubble cultivations commonly carried out in the belief that they will stimulate weed seed germination. Such cultivations are in practise, often made with disced or tined implements. However, the rotary cultivator used in these experiments was set to give the slowest rotor speed possible so that soil inversion was kept to a minimum.

The effect of the cultivations on the subsequent seedling population varied between sites and straw treatments. This may have been due to a difference in the relative proportions of seeds in the soil as compared to those shed in the previous crop, which would initially have remained on the soil surface. Thus at Bucknell, cultivations increased seedling numbers on burnt plots but reduced them where straw was baled. Cultivations may have brought up more viable seeds than they buried on burnt plots as burning would have reduced the numbers of viable seeds on the soil surface. Where straw was baled and there were consequently many fresh viable seeds on the soil surface, cultivations buried these but brought relatively fewer old seeds back up to the soil surface.

It has been established that most A. myosuroides seedlings are derived from seeds in the top 2.5 cm soil (Naylor, 1970) and thus cultivations are likely to influence the numbers of seeds in this surface layer by moving seeds up and down the soil profile.

No determinations of seeds in the soil was made in the series of experiments. We do not know how long seeds buried by cultivations will survive in the soil. They could be brought back to the surface by subsequent cultivations and cause a new infestation.

These experiments do not support the belief that shallow stubble cultivations are a means of stimulating germination although they may be useful for other purposes. However, ground conditions were very dry when the cultivations were made and this may have prevented the immediate germination of many seeds.

Chlortoluron was applied in October in the absence of any crop. If a crop had been drilled, then there would have been some cultivations by the passage of the drill even on 'uncultivated' plots. Also the absence of crop competition during the winter, may have influenced the survival of the weed.

Chlortoluron gave better control of the weed on land that had been cultivated 10-12 cm deep than on uncultivated land, irrespective of straw disposal method. The herbicide gave intermediate results on land cultivated 3-5 cm deep following straw burning but erratic results after straw baling, possibly because of the difficulty experienced in maintaining a constant depth of cultivation.

Although the herbicide was applied in somewhat artificial conditions in that no crop was present, the results are in agreement with those found on another experiment where winter wheat was sown (Moss, 1978).

The differences in herbicide activity between cultivation treatments could be due to the presence of straw and ash residues in the surface soil. The effect of burnt straw residues on the activity of chlortoluron and isoproturon is the subject of a paper presented elsewhere at this conference (Nyffeler and Blair, 1978).

On all the experimental sites, the lowest A. myosuroides population occurred after the following combinations of treatments were used - straw burning, cultivation to 10-12 cm, chlortoluron applied. At the other extreme, the highest populations followed the combination of straw baling, no cultivation or cultivation 3-5 cm, and no herbicide application.

These experiments demonstrate that an infestation of A. myosuroides can be greatly influenced by the stubble treatment adopted. Straw burning can effectively reduce the numbers of seedlings by destroying seeds and cultivations not only have a variable direct effect by moving seeds in the soil but can also influence the subsequent activity of a soil applied herbicide.

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THE INFLUENCE OF BURNT STRAW RESIDUES OR SOIL COMPACTION ON CHLORTOLURON AND ISOPROTURON ACTIVITY

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Summary A series of laboratory experiments was carried out to asssess possible reasons for the reported failures to control blackgrass (*Alopecurus myosuroides* Huds.) with urea-herbicides in direct-drill situations. Compaction over a bulk density range of 1.2 to 1.65 g/cm^3 did not seem to be an important factor in explaining the difference between direct drilled and ploughed sites. The activity of chlortoluron was not significantly influenced by compaction but the leaching of chlortoluron and isoproturon was slightly decreased. Ash (burnt straw) applied in amounts equivalent to 40, 80, 160, 320 and 640 kg/ha on the surface or incorporated into the top 2 cm decreased the activity of chlortoluron and isoproturon against *A. myosuroides*.

Résumé Une série d'essais en laboratoire ont été réalisés dans le but de trouver les raisons possibles au manque d'activité des herbicides du type urée contre le vulpin (*Alopecurus myosuroides* Huds.), des cas ayant été rapportés dans des situations de "semis-direct". Le sol a été rendu compact artificiellement dans un intervalle de densité de 1.2 a 1.65 g/cm^3. Ce facteur n'a pas permis d'expliquer la difference entre les deux methodes de culture: "semis-direct" et labour. On n'a pas pu prouver statistiquement une influence de la compacité du sol sur l'activité de Chlortoluron. Les valeurs de lessivage du Chlortoluron et de l'Isoproturon ont par contre été légèrement diminuées. Des cendres (pailles brulees) appliquées en quantités équivalentes à 40, 80, 160, 320 et 640 kg/ha, en surface ou incorporées aux 2 cm superficiels ont diminué l'activité de Chlortoluron et d'Isoproturon contre *A. myosuroides*.

INTRODUCTION

Direct drilling of cereal crops is increasing and this may at times lead to an increased grass weed problem (Bachthaler, 1974; Cussans, 1976). In some cases there appears to be inadequate weed control with pre-emergence applications of chlortoluron and isoproturon (Hubbard et al, 1976; Moss, 1978 a & b). When direct drilling it is important that there should be little or no crop residues present (Pollard, 1977) and many farmers now dispose of all excess straw by burning (Elliot, 1975). This means that there can be much ash on or near the soil surface at the time when herbicides are sprayed. It has been suggested that this ash could affect herbicide performance (Cussans, 1975).

This paper reports a series of experiments to study the effect of compaction on chlortoluron and isoproturon performance and movement in the soil, and to consider the influence of ash on the activity of these herbicides against Alopecurus myosuroides Huds. (blackgrass).

METHOD AND MATERIALS

Compaction studies These were carried out using aluminium tubes (12.5 cm diameter, 10.0cm height). In experiment 1 samples from a field (clay loam) at Weed Research Organization (WRO) were collected by pushing the tubes into direct drilled (DD) or ploughed (PL) plots and then removing the ring with the soil core intact. In experiment 2 similar containers were filled with soil (sandy loam) which was compacted using a rack and pinion to exert a measured pressure of 0, 0.5, 1.25 and 3.125 kg/cm^2 on the soil via a pressure plate. Bulk densities obtained were 1.20, 1.40, 1.52 and 1.65 g/cm^3. The soil contained John Innes base fertilizer (4 g/kg soil), DDT (0.5 g/kg), fritted trace elements (0.25 g/kg) and $MgSO_4$ (1.0 g/kg).

A. myosuroides (collected from the farm at WRO in 1977), (25 seeds) or wheat (cv. Maris Huntsman), (10 seeds) were planted at a depth of approximately 0.625 and 2.5 cm respectively. For the field samples seed was pushed into the surface layer of the cores using tweezers. Herbicide treatments were applied as surface sprays using a laboratory sprayer fitted with an 8002 E "Teejet" nozzle delivering 378 l/ha at 2.1 bars. Chlortoluron and isoproturon were formulated as wettable powders (80% and 75% w/w a.i. respectively). After treatment the containers were kept in a glasshouse (mean temperature 15-20°C, mean r.h. 50-60%) and watered from overhead as required. After six weeks, shoot fresh weights (above soil surface) were measured and results are given in Tables 1 and 2. Data were analysed using analysis of variance techniques and standard errors (S.E.) are given as appropriate.

Leaching studies Leaching columns were constructed by cutting polyvinyl chloride tubes (7.75 cm diam.) into two longitudinal halves. Tubes 23 cm long were used for isoproturon and 15 cm long for chlortoluron studies. These columns were packed with the same sandy loam (no fertilizer) as used in compaction studies to a depth of 2.5 cm below the top of the column. Soil was compacted with pressures of 0, 1 and 3 kg/cm^2 as before. Herbicide treatments were then sprayed as described in compaction studies. The columns were then leached using 360 ml water/tube (corresponding to 76 mm rainfall) added by syringe in 10 ml aliquots distributed over a one day period.On completion of leaching the tubes were left undisturbed for 24 hours and then were cut into the longitudinal halves. The face of each half was then sown thickly with seed of Agrostis tenuis Sibth. These cores were watered very carefully from overhead to minimise any redistribution of herbicides or seed. Assessment of herbicide movement was made by (a) the leaching distance (mm) measured from start point to point of maximum damage and (b) the length of inhibited zone (mm). The results are presented in Table 3 and S.E. given as appropriate.

Ash studies The ash was prepared by burning wheat straw; for experiment 4, 15 kg of straw burned gave 1 kg of ash, and in experiment 5, 20 kg straw gave 1 kg ash. A yield of 10 tonne/ha straw thus corresponds to 0.4 (in experiment 4) and 0.3 g ash/pot respectively (in experiment 5). Pots (8.9 cm diam., 8.9 cm height) were filled with the same soil as was used in other experiments and 10 A. myosuroides seeds per pot planted at 0.625 cm depth. Where ash was mixed into the soil an ash-soil mixture was used to fill the top 2.5 cm of the pot. Where ash was applied to the surface, a weighed amount was applied to each pot. All pots were watered carefully from overhead to stabilise the ash prior to spraying. Herbicide treatments were applied as described in the other two studies. After treatment pots were returned to the glasshouse and were watered from overhead as required. After 5 weeks the shoot fresh weights (above soil surface) were measured and these data are in Tables 4 and 5, with S.E. given as appropriate.

RESULTS

Field samples The results of this experiment (Table 1) were very variable. The trend to better *A. myosuroides* control in the ploughed soil was statistically proved by a logarithmic transformation of the data. While both herbicides at the highest dose controlled *A. myosuroides* completely in the ploughed pots, some plants were left out in the direct-drilled treatment.

Table 1

Effect of pre-emergence treatments of chlortoluron and isoproturon on *A. myosuroides* planted in soil cores from direct-drilled (DD) and ploughed (PL) field plots

		chlortoluron(kg/ha)				isoproturon(kg/ha)			
	untreated	0.125	0.25	0.5	1.0	0.0625	0.125	0.25	0.5
DD	3.47[1] (2.44)[2]	3.08 (2.47)	2.72 (2.37)	0.38 (1.33)	0.25 (0.97)	2.18 (2.19)	2.46 (2.27)	1.24 (1.74)	0.54 (1.49)
PL	3.32 (2.34)	1.58 (2.05)	1.31 (2.06)	0.12 (0.83)	0.01 (0.15)	2.52 (2.40)	0.70 (1.76)	1.18 (1.82)	0.00 (0.00)
S.E.	$\pm$ 0.626 ($\pm$0.232)								

[1] fresh weight per pot in g

[2] $\log_{10}(100x + 1)$ of fresh weight per pot in g

Compaction Increasing the soil bulk density below seed level had no significant influence on chlortoluron activity against *A. myosuroides* (Table 2).

Table 2

Effect of compaction below seed level on the activity of chlortoluron (pre-emergence) against *A. myosuroides*

Plant fresh weight in mg

chlortoluron (kg/ha)	pressure exerted on soil (kg/cm^2) 0	0.5	1.25	3.125
untreated	150	174	177	195
0.25	97	111	141	123
0.5	62	34	84	64
1.0	28	35	20	6
S.E.	$\pm$ 17.4			
bulk density (g/cm^3)	1.20	1.40	1.52	1.65

Leaching Isoproturon is more mobile than chlortoluron (Table 3). As an average of both compaction levels it moved 41 mm compared with 29 mm for chlortoluron. With increasing bulk density the mobility of both herbicides was decreased. In the same way the zone of herbicide distribution in the soil column was narrower.

Table 3

The influence of soil compaction on the leaching of isoproturon (1 kg/ha) and chlortoluron (2 kg/ha)

	distance of movement[1]		width of inhibited zone[2]	
compaction level (kg/cm^3)	1	3	1	3
isoproturon	45.3	36.0	48.3	42.8
chlortoluron	31.8	26.0	58.0	41.3
S.E.	± 1.42		± 3.35	
mean	38.6	31.0	53.2	41.1
S.E.	± 1.01		± 2.37	

[1] herbicide movement from the point of application to the point of maximal activity

[2] width of zone of inhibited growth of the test plant

Ash An application of ash reduced the activity of both herbicides significantly. In the first experiment (Table 4) even the smaller amount of ash was sufficient to protect the plants almost completely against herbicide damage.

Table 4

The effect of superficially applied straw ash on the pre-emergence activity of chlortoluron and isoproturon against A. myosuroides

herbicide rate		Plant fresh weight in mg, ash (g/pot) 0	0.2	0.4
untreated		170	169	137
chlortoluron	0.125	152	169	137
	0.25	102	187	153
	0.5	32	136	174
	1.0	6	124	102
isoproturon	0.0625	217	191	139
	0.125	79	122	204
	0.25	10	173	147
	0.5	5	150	132
	S.E.		± 21.95	

In the second experiment (Table 5) a dose response to ash became very clear with increasing amount of ash showing a counteraction of higher herbicide rates.

Table 5

The effect of straw ash applied to soil surface or mixed into top 2.5cm on the pre-emergence activity of chlortoluron and isoproturon against A. myosuroides

	dose (kg/ha)	0	ash surface application[1] 0.025	0.05	0.10	0.20	ash incorporation[1] 0.10	0.20
		Weight per plant in mg						
no herbicide		152	160	180	152	122	146	180
isoproturon	0.25	16	142	114	120	148	164	174
	0.50	2	29	44	108	112	60	138
	1.00	0	0	10	16	109	10	64
chlortoluron	0.50	22	120	96	156	138	96	132
	1.00	10	49	62	62	144	102	92
	2.00	0	10	14	36	70	13	27
S.E. (surface only)				± 15.7				
S.E. (surface vs. incorporation)							± 17.0	

[1] ash dose in g/pot

The comparison of ash incorporation with surface application revealed only a slight trend to a higher adsorption with the surface treatment. These findings were confirmed by a further experiment which is not included in this report.

DISCUSSION

The trend for chlortoluron and isoproturon to give lower A. myosuroides control in the undisturbed direct drilled samples compared with ploughed cultivation is consistent with the results of Hubbard et al, (1976)and Moss, (1978 a & b.) The high variability could in part be due to the method of planting. The seeds were pushed into the surface with tweezers and some seed could have been damaged and the depth of planting variable.

Factors which could influence the performance of chlortoluron and isoproturon in the two cultivation regimes include first the effect of top soil compaction on plant growth and root development, on moisture content, water movement and herbicide leaching, and second an increase in organic matter and charcoal as trash and ash. The results in Table 2 show that soil compaction below seed level did not adversely affect the activity of the two herbicides. The conditions in the compaction experiment (Expt. 2) were similar to those of the first one (Experiment 1) with bulk densities of 1.65 g/cm^3 in direct drilled and 1.35 g/cm^3 in ploughed plots (Pollard, personal communication) although the soil used in experiment 2 was a lighter sandy loam.

Compaction has been reported to inhibit plant growth (Raghavan et al, 1978). The clearest effect is on the root development. The elongation of primary roots is less and lateral root growth greater and tending to be shallower (Ellis et al, 1977; Finney and Knight, 1973). This was also observed in the compaction experiments although the roots still could absorb sufficient water and nutrients to provide almost normal shoot weights. It was however a short term experiment with frequent irrigation and no water stress was apparent. Under field conditions the seeds are embedded in compacted soil which definately can affect plant vigour. But again this does not explain herbicide failures in a higher compacted direct drilled soil as weak plants are expected to be more susceptible to the attack of urea herbicides (Vez and Wurgler, 1970).

Both herbicides were less mobile in compacted soil as expected theoretically (Hamaker, 1975). This is because the quantity of soil and hence the adsorption capacity per unit volume increases. Hence, none of the factors considered in relation to a higher soil bulk density gave an adequate explanation of the differences in A. myosuroides control which were observed in experiment 1. The soil surface of the direct drilled field samples looked very different from the conventionally cultivated ones. On the direct drilled cores there was much straw, trash and a substantial algal growth, all of which increased the organic matter content in the top soil. Analyses revealed a higher value of 2.6% in direct drilled than of 2.1% in ploughed, both however very low levels.

As burning is the most common method of straw disposal in direct drilled situations the adsorption effect of the ash could be important (Hurle, 1978). In the joint WRO/Letcombe Laboratory tillage experiments the dry matter yield of winter wheat excluding grain has ranged from 5.47 to 9.51 tonne/ha (Pollard, 1977). These yields were the base for the calculation of ash in the experiments. In practice the straw is not distributed very uniformely and ash may also be blown around so there could be localised accumulations. The ash could also be mixed into the surface of the soil by cultivation or rainfall. The results of experiment 5 show that the ash mixed into the top 2 cm of the soil was still able to decrease the performance of the herbicides.

Another important factor could be the degree of straw burning. We anticipated a smaller adsorption coefficient of ash as final burning product than of non-totally burnt out charcoal. It is not known how the laboratory burning compared with practical conditions in terms of oxygen supply and temperature. A comparison of the data of experiment 5 in which the straw was burnt more completely and the experiment 4 suggested however that this effect may not be so important with regard to herbicide adsorption.

The reason for difference between ploughed and direct drilled plots is thus still not entirely clear. Compaction did not seem to be a factor in explaining the differences but the influence of ash was important. However, as these results were obtatained from trials using a sandy soil type with a low initial organic matter content, any slight enhancement of this factor may be more important than it would be in other heavier soil types. Further investigations have to show if in special situations the adsorptive effect of straw ash could be ocunteracted by higher herbicide rates.

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THE USE OF TRIFLURALIN + LINURON AS A COMBINATION PRE-EMERGENCE HERBICIDE FOR THE CONTROL OF BROADLEAF AND ANNUAL GRASS WEEDS IN WINTER CEREALS

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Summary The use of a commercial formulation of trifluralin plus linuron, has proved very successful on the continent of Europe as a pre-emergence treatment for the control of annual grasses and broadleaf weeds in winter cereals. This paper reports on trials undertaken to test the efficacy and selectivity of this combination in the United Kingdom. The results of the trials have demonstrated that an autumn treatment to winter wheat or barley will give season long control of certain annual weed grasses (*Poa* spp. and *Apera spica-venti*) and problem broadleaved weeds such as *Matricaria* spp., *Stellaria media*, *Aphanes arvensis*, *Veronica* spp. and *Viola arvensis*. In most cases a follow-up herbicide treatment in the spring would not be necessary. Safety to a wide range of winter wheat and barley varieties has also been demonstrated.

INTRODUCTION

As outlined by Clark, *et al* (1974) the principle objectives of weed control in winter cereals are:

1. The reduction or elimination of competition
2. Reduction in harvest contamination
3. Ease of harvesting and drying.

Until recently this has been achieved in winter cereals by the use of post-emergence spring applications of 'hormone'-type herbicides. However, early competition from broadleaved weeds is not reduced with such treatments and neither are annual grass weeds controlled.

The benefits of an early weed-free environment became apparent when farmers began to use pre-emergence herbicides against *Alopecurus myosuroides*. In addition to grass control, certain of these chemicals, including methabenzthiazuron, gave control of some broadleaf weeds. Much of the United Kingdom winter cereal acreage does not have an *Alopecurus* problem, yet the practice of applying an autumn pre-emergence herbicide for weed control is of increasing interest as farmers then do not have to rely upon being able to spray in the variable spring conditions when the crop or weeds are at the correct stage.

The herbicidal properties of the combination of trifluralin plus linuron were first reported by Snel, M., *et al* (1974) and the combination was tested at that time in the United Kingdom. Trials showed that, although proving generally very effective for broadleaf weed control, the combination lacked sufficient activity in the spring to control deep-germinating *Alopecurus myosuroides*. With the practice of autumn applied herbicides for weed control gaining in interest, the combination was re-appraised in 1977/78 in replicated and farmer-applied trials, the results of which are summarised in this paper.

METHODS AND MATERIALS

The trifluralin plus linuron combination used throughout was the commercial formulation (CHANDOR®) used on the continent, an emulsifiable concentrate containing 240 g a.i. trifluralin and 120 g a.i. linuron per litre. The treatments were applied at the recommended dose rate of 4 litres formulated product/ha (960 g a.i. trifluralin + 480 g a.i. linuron/ha), except GB77-88 where application was made at 640 + 320 g a.i./ha. The full properties of this formulation are described by Snel, M., et al (1974). The reference treatments were methabenzthiazuron at 3136 and 1568 g a.i./ha and isoproturon at 2030 g a.i./ha. The trials were carried out at several locations in the United Kingdom cereal growing areas (Table 1). The replicated trials were of a randomised block design with four replications. Applications were made with an Azo-propane unit at a volume of 225 litre/ha. The phase III trials were comprised of unreplicated 1 hectare blocks, sprayed with farmers' own sprayers at 200-300 litre/ha. Comparisons were made with untreated areas and/or farmer applied pre-emergence autumn or spring post-emergence herbicides.

TABLE 1

Trials Details

Trial No.	Reference Product, and dose	Sowing Date	Variety	Location
Replicated Trials				
GB77-88	Methabenzthiazuron 3136 g ai/ha	22.10.77	Nimrod	Mixbury, Northants.
GB77-90	"	17.11.77	Huntsman	Ilsley, Berks.
GB77-91	"	19.10.77	Sportsman	Wokingham, Berks.
GB77-92	"	26.10.77	Hobbit	Beenham, Berks.
GB77-96	"	29.11.77	Huntsman	Much Birch, Hereford
GB77-93	1568 g ai/ha	30.9.77	Huntsman	Elmham, Norfolk
GB77-94	"	4.10.77	Huntsman	Ryburgh, Norfolk
GB77-95	Isoproturon 2030 g ai/ha	20.10.77	Otter	Elmham, Norfolk
Phase III Farmer Trials				
GB77-113	Methabenzthiazuron 1568 g ai/ha	19.10.77	Sportsman	Wokingham, Berks.
GB77-114	"	15.11.77	Hobbit	Maidenhead, Berks.
GB77-115	"	28.10.77	Hobbit	Windsor, Berks.
GB77-116	"	10.10.77	Otter	Elmham, Norfolk
GB77-117	"	20.10.77	Otter	Dereham, Norfolk
GB77-118	"	27.10.77	Huntsman	Grimston, Norfolk
GB77-119	"	9.11.77	Atou	Ashwicken, Norfolk
GB77-120	"	9.11.77	(wheat)	Hillington, Norfolk
GB77-122	"	28.10.77	Flanders	Holbeach, Lincs.
GB77-123	"	2.11.77	Huntsman	Holbeach, Lincs.
GB77-124	"	25.10.77	Bouquet	Holbeach, Lincs.
GB77-125	"	25.10.77	Atou	Gedney, Lincs.
GB77-121	"	27.10.77	Huntsman	Steeple Barton, Oxon.

Assessments were made as follows:

Selectivity - crop emergence, vigour and stand were assessed on a 0-10 linear scale where 0 represented complete crop failure and 10 represented the condition of the untreated plot.

Weed control was assessed as % soil surface covered using the Barratt-Horsfall visual scale and the mean ratings may be converted to either % control or % cover as required. The replicated trials were analysed using Analysis of Variance and then the means were subjected to Duncan's Multiple Range Test. The range for each assessment is given in the tables as a letter sequence following the mean value.

RESULTS

The combination of trifluralin plus linuron has been tested on a wide range of current and new varieties of winter wheats and barleys at a rate of 960 + 480 g ai/ha and also at twice this rate. The detailed results are not reported here but at 960 + 480 g ai/ha no perceptible damage was seen on any variety although at twice this rate some reduction in stand was seen with a few winter wheat varieties. No effect, even at double rate, was seen on any of the varieties of winter barley tested. In the replicated trials reported in this paper, of which only one was winter barley, no effect was seen on crop emergence or crop vigour from treatments of trifluralin plus linuron at the 960 + 480 or the 1920 + 960 g ai/ha rate (Table 2). These trials contained a selection of the currently popular varieties of winter wheat and winter barley.

TABLE 2

The Selectivity of Trifluralin + Linuron to Winter Cereals in the 1977/78 Replicated Trials with Respect to Crop Emergence and Crop Vigour

	Crop Emergence			Crop Vigour		
Trial No.	Reference	Trif.+Lin.	Untreated	Reference	Trif.+Lin.	Untreated
GB77-88	100.0 a	100.0 a	100.0 a	10 a	10 a	10 a
GB77-90	100.0 a	100.0 a	100.0 a	-	-	-
GB77-91	100.0 a	100.0 a	100.0 a	10 a	10 a	10 a
GB77-92	100.0 a	100.0 a	100.0 a	-	-	-
GB77-96	100.0 a	97.4 a	100.0 a	10 a	10 a	10 a
GB77-93	100.0 a	100.0 a	100.0 a	10 a	10 a	10 a
GB77-94	100.0 a	100.0 a	100.0 a	10 a	10 a	10 a
GB77-95	100.0 a	100.0 a	100.0 a	10 a	10 a	10 a

Each trial was subjected to Duncan's Multiple Range Test, the difference between means is significant at the 5% level if followed by a different letter.

Trif.+Lin represents trifluralin + linuron

Weed control with the combination was extremely good and figures are given showing total weed control at two and six months after treatment (Table 3). These figures are calculated from ratings of percentage total broadleaf and grass weed infestations in the plots. The total control of weeds was very similar to that seen with the reference material, methabenzthiazuron, at the recommended rates. The only difference in the materials being in the control of *Matricaria* spp. in some locations where methabenzthiazuron was superior and *Veronica* spp. where trifluralin plus linuron proved superior. The combination gave superior overall weed control to isoproturon at 2030 g ai/ha.

TABLE 3

The Efficacy of Trifluralin + Linuron against Total Weed Flora in the 1977/78 Replicated Trials Expressed as % Control

Trial No.	2 Months Post-Drilling: Reference	2 Months Post-Drilling: Trif.+Lin.	2 Months Post-Drilling: % Cover in untreated	6 Months Post-Drilling: Reference	6 Months Post-Drilling: Trif.+Lin	6 Months Post-Drilling: % Cover in untreated
GB77-88	74.9 b	54.1 ab	9.6	91.8 b	88.5 b	28.9
GB77-90	-	-	-	55.3 b	62.8 b	3.9
GB77-91	100.0 b	95.1 b	12.2	99.0 b	99.0 b	31.5
GB77-92	89.9 b	88.0 b	55.4	85.9 b	64.6 ab	26.5
GB77-96	-	-	-	59.4 b	75.6 b	3.6
GB77-93	0.0 a	28.0 a	1.5	75.6 b	83.7 b	3.6
GB77-94	89.9 b	88.7 b	0.3	91.8 b	93.9 b	14.5
GB77-95	67.5 b	92.5 b	7.9	64.6 b	97.3 c	22.3

The principle weeds present were Stellaria media, Galium aparine, Veronica spp., Matricaria spp., Aphanes arvensis, Viola spp., Polygonum spp. and Papaver rhoeas.

Each trial was subjected to Duncan's Multiple Range Test, the differences between means is significant at the 5% level if followed by a different letter.

Weed control in untreated plots was 0.0 a.

Only low infestations of annual grasses (P. annua and P. trivialis) were seen in the replicated trials (Table 4) and under these conditions all treatments gave good control. Good control of autumn germinating A. myosuroides has also been observed, but the combination appears to lack sufficient activity to contain heavy infestations germinating in the spring. Limited activity against wild oats (Avena spp.) has also been seen in these trials. Any wild oat seeds germinating below the treated area are not controlled.

TABLE 4

The Efficacy of Trifluralin + Linuron against Poa annua and Poa trivialis in the 1977/78 Replicated Trials Expressed as % Control

Trial No.	2 Months Post-Drilling: Reference	2 Months Post-Drilling: Trif.+Lin.	2 Months Post-Drilling: % Cover in untreated	6 Months Post-Drilling: Reference	6 Months Post-Drilling: Trif.+Lin.	6 Months Post-Drilling: % Cover in untreated
GB77-88	100.0 b	66.6 b	0.9	-	-	-
GB77-91	100.0 b	100.0 b	2.8	94.6 b	94.6 b	3.3
GB77-92	100.0 b	100.0 b	2.6	-	-	-
GB77-93	-	-	-	75.6 b	82.7 b	3.6
GB77-94	-	-	-	100.0 b	100.0 b	2.1
GB77-95	-	-	-	42.6 b	88.0 b	2.6

Each trial was subjected to Duncan's Multiple Range Test, the difference between means is significant at the 5% level if followed by a different letter.

Weed control in untreated plots was 0.0 a.

The most common weed throughout the trials was Stellaria media and this particular weed was well controlled by the combination (Table 5). In addition to those already mentioned, Aphanes arvensis, Chrysanthemum segetum, Lamium purpureum, Polygonum convolvulus, Fumaria officinalis, Cerastium arvense, Viola arvensis, Galeopsis tetrahit and Polygonum aviculare were present in these trials and proved to be very susceptible to the combination. The control of Senecio vulgaris, Urtica urens and Galium aparine was variable and no control of Ranunculus spp. was seen.

TABLE 5

The Efficacy of Trifluralin + Linuron Against Stellaria media in the 1977/78 Replicated Trials Expressed as % Control

Trial No.	2 Months Post-Drilling Reference	2 Months Post-Drilling Trif.+Lin.	2 Months Post-Drilling % Cover in untreated	6 Months Post Drilling Reference	6 Months Post Drilling Trif.+Lin.	6 Months Post Drilling % Cover in untreated
GB77-88	89.4 b	47.4 b	2.8	-	-	-
GB77-91	100.0 b	100.0 b	6.1	-	-	-
GB77-92	89.4 b	78.9 b	2.8	-	-	-
GB77-93	-	-	-	83.3 b	83.3 b	1.8
GB77-94	-	-	-	87.5 b	100.0 b	2.4
GB77-95	-	-	-	55.8 b	91.1 c	3.3

Each trial was subjected to Duncan's Multiple Range Test, the difference between means is significant at the 5% level if followed by a different letter.

Weed control in untreated plots was 0.0 a.

The results seen in the grower applied trials again reflected the results seen in replicated trials (Table 6). No significant reduction in crop stand was seen and good control of P. annua and P. trivialis was again obtained. The principle difference between trifluralin plus linuron at 960 + 480 g ai/ha and the main reference material methabenzthiazuron, was in the control of Veronica spp. and Matricaria spp. (Table 7). In eight of the trials, trifluralin plus linuron showed superior control of Veronica spp. but methabenzthiazuron gave a better reduction in the population of Matricaria spp.

TABLE 6

Summary of the 1977/78 Farmer-Applied Phase III Trials 5 Months after Application Crop Stand and % Weed Cover

Trial No.	Crop Stand Reference	Crop Stand Trif.+Lin.	Crop Stand Untreated	Annual Grass Weeds Reference	Annual Grass Weeds Trif.+Lin.	Annual Grass Weeds Untreated
GB77-113	10.0	10.0	10.0	0.0	0.0	1.9
GB77-114	-	9.9	10.0	-	1.2	9.4
GB77-115	9.8	9.7	10.0	0.5	0.2	4.7
GB77-116	9.9	10.0	-	1.6	0.2	-
GB77-117	10.0	10.0	10.0	0.2	0.7	2.3
GB77-118	9.9	10.0	-			
GB77-119	10.0	10.0	-	0.9	0.2	-
GB77-120	-	9.9	10.0	-	0.0	0.5
GB77-122	10.0	10.0	-			
GB77-123	9.9	9.7	-			
GB77-124	9.9	9.9	10.0	0.0	0.0	3.0
GB77-125	10.0	10.0	-	0.0	0.0	-
GB77-121	10.0	10.0	-	0.0	0.0	-

Annual grass weed data are expressed as % Cover due to the lack of an untreated area in the field in some trials.

TABLE 7

Summary of the 1977/78 Farmer-Applied Phase III Trials - 5 Months After Application
% Cover of *Veronica* spp. and *Matricaria* spp.

	Veronica spp.			*Matricaria* spp.		
Trial No.	Reference	Trif.+Lin.	Untreated	Reference	Trif.+Lin.	Untreated
GB77-114				-	0.2	1.4
GB77-115	0.0	0.0	2.8	0.0	0.2	1.9
GB77-116	3.0	2.5	-			
GB77-117	0.2	0.2	2.3			
GB77-118	5.6	1.6	-			
GB77-119	1.9	0.7	-	0.5	2.3	-
GB77-120	-	0.9	3.5	-	0.5	0.9
GB77-122	0.7	0.2	-	0.5	0.7	-
GB77-123	1.6	0.7	-	2.6	3.5	-
GB77-124	1.9	1.2	4.2			
GB77-125	4.7	1.6	-			
GB77-121	3.5	1.4	-			

Data are expressed as % cover due to the lack of an untreated area in the field in some trials.

DISCUSSION

The trials reported above have demonstrated that the combination of trifluralin plus linuron at 960 + 480 g ai/ha will give good control of important weed species when applied as a pre-emergence surface application to winter wheat and barley. This control is sufficient to carry right through into the spring when the crop is likely to smother any further weeds. The only likely hormone treatment required could be mecoprop if *Galium aparine* is present in significant numbers.

The combination of trifluralin plus linuron has also been shown to be safe to the crop at the rates tested and may be safely used on all mineral soils. It is not, however, suitable for use on soils with an organic matter of 8% or more.

The use of this combination satisfies the principle objectives of cereal weed control and also possesses additional advantages to the farmer over conventional spring weed control measures, viz.:

1. Poor spring weather can delay spraying and in the meantime the crop or weeds can grow beyond the critical stage.

2. Conventional hormone sprays do not control annual grass weeds.

3. Damage to cereals from late hormone applications can occur, and there is the danger of drift onto neighbouring crops.

4. Mixtures of two or three hormone materials are required to control a wide range of broadleaf weeds.

5. Leaving weeds until the spring allows competition from autumn germinating weeds to occur and wastes expensive fertilisers.

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