ANNUAL BROAD-LEAVED WEED CONTROL IN WINTER WHEAT AND WINTER BARLEY

AUTUMN AND SPRING TREATMENTS COMPARED

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Summary In 1977/78 and 1978/79 ADAS carried out a trial series comparing autumn weed control and spring weed control in winter wheat and winter barley. The yields and weed control obtained in 11 trials for winter wheat and 7 trials for winter barley are reviewed.

Significant yield responses were obtained where there was early emergence of crop and weed, particularly *Stellaria media*. The severe winter of 1978/79 may have restricted yield responses, this being particularly relevant to winter barley, all but one of the trials being carried out in that particular year.

Weed control at the time of assessment in the summer, was most satisfactory from spring treatments in the winter wheat trials but the situation was not clear in the winter barley trials. In the winter wheat series, early post-emergence treatments in the autumn often gave superior weed control to pre-emergence treatments. These offer a cheaper alternative to residual herbicides.

INTRODUCTION

At the 1978 BCPC Weed Conference (Evans and Harvey, 1978), ADAS trials on the comparison of annual broad-leaved weed control in winter wheat in the autumn or spring were reviewed. Experimental work has continued with an expanded range of herbicides and times of application on both winter wheat and winter barley. This paper outlines the results obtained in the 1977/78 and 1978/79 seasons.

METHOD AND MATERIALS

The series of trials has included a range of pre-emergence, early post-emergence herbicides and herbicides applied at the pseudostem erect stage (Zadoks Growth Stage 30 - Zadoks *et al*, 1974) and the 1-2 node detectable stage (Zadoks Growth Stage 31-32).

The results (tables 1-4) only include those herbicides that feature in a high proportion of trials. The autumn pre-emergence herbicides included in the tables for both winter wheat and winter barley are chlortoluron, isoproturon and terbutryne. The results from the pre-emergence application of methabenzthiazuron and linuron + trifluralin are quoted for winter barley only.

The early post-emergence treatments included in the tables for both winter wheat and winter barley are bromoxynil + ioxynil + mecoprop esters and mecoprop salt. The results from the early post-emergence use of methabenzthiazuron + mecoprop salt are given for winter wheat only. For the spring treatments, the results from the mecoprop salt, bromoxynil + ioxynil + mecoprop esters and 2,3,6-TBA + dicamba + MCPA + mecoprop salts treatments are tabulated.

The trials were carried out on farm crops and the dose of the various herbicides appears in the tables (tables 1 and 3). Weed control was assessed in various ways and is presented as percentage reduction due to treatment. Yields were assessed differently at different sites. At some, small samples were taken and threshed in the laboratory (ADAS Eastern Region, 1980); in other cases a combine harvester was used.

The dry autumn of 1978 and the subsequent very severe winter resulted in the early post-emergence treatments in some trials being applied in the very early spring of 1979.

RESULTS

The yields for winter wheat (table 1) and winter barley (table 3) have been tabulated. The average yield response is calculated only from the trials in which each herbicide is featured. If the herbicide was not included in every trial, the average yield response is quoted in brackets.

The control of weeds was recorded at all sites (tables 2 and 4). Where additional assessments were made in the winter or early spring, they generally showed that the initial level of weed control from the autumn treatments was in most cases satisfactory. However, with subsequent weed germination and/or recovery in the spring there was usually an apparent decline in effectiveness by the time the main assessments of weed control were made in the summer.

DISCUSSION

Only 3 out of the 11 trials on winter wheat gave significant yield responses to broad-leaved weed removal (table 1). In the 1978 trial at High Mowthorpe EHF, autumn pre-emergence and the early post-emergence treatments outyielded significantly those treatments applied at the pseudostem erect stage (Zadoks Growth Stage 30).

Early post-emergence treatments often gave superior weed control to the pre-emergence treatments at the time of the main assessment in the summer (table 2). The spring treatments gave the best overall weed control.

The yields of some of the winter barley trials (table 3) were disappointing because they were on extremely light soils and were affected by the severe winter of 1978/79. In the East Midlands 1979 (a) trial, all the pre-emergence treatments gave significant yield increases over the untreated control. In the same trial, the pre-emergence treatments gave higher yields than the treatments applied at the early post-emergence and pseudostem erect stage (Zadoks Growth Stage 30) but the differences were not statistically significant. In general, autumn and early post-emergence treatments gave similar yields to those treatments applied at the pseudostem erect stage (Zadoks Growth Stage 30).

Weed control in the winter barley series (table 4) from the various times of application was more variable than for the winter wheat series. The competitiveness of winter barley in the spring may have aided the relative efficacy of the autumn treatments in some trials by preventing weed growth in the spring.

The yield responses to weed control occurred where there was early emergence of both weed and crop, which usually occurred on the lighter textured soils. Large responses were obtained from the control of high populations of autumn germinating *S. media*.

The dry autumn of 1978 and the subsequent severe winter may have considerably influenced the results. The dry autumn would have been to the disadvantage of the pre-emergence treatments which are soil-acting. Crop and weed growth in the autumn and winter period was reduced which may have restricted yield responses. Additionally the restricted growth of weeds in the autumn and winter would have aided the efficacy of spring applied sprays. However, there was some evidence from the East Midland 1979 (a) winter barley trial to suggest that autumn application of herbicides controlled autumn germinating *S. media* that was too advanced to be controlled adequately in the spring.

The results of these trials agree with earlier ADAS results in winter wheat (Evans and Harvey, 1978) that generally, autumn broad-leaved weed control does not show significant yield advantage over spring treatments. Also, the efficacy of the autumn use of growth regulator and/or contact herbicides was confirmed. These offer a cheaper alternative to pre-emergence herbicides, as well as the opportunity of selecting a specific herbicide for the weed species present, if their levels are sufficient to warrant spraying. However, the crop could be predisposed to frost damage and they could be difficult to apply if the land is wet. The development of the low ground pressure vehicle for spray application would remove the latter restriction (Elliott, 1978).

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Table 1 (1978)

Winter wheat series - crop yields (tonnes/ha)

	Region/EHF	E (a)	E (b)	High Mowthorpe	SE
Autumn pre-emergence	Dose a.i. (kg/ha)				
chlortoluron	1.8	7.1	1.7	6.1	8.2
isoproturon	1.25	7.7	2.5	6.0	8.2
terbutryne	1.5	7.2	1.6	6.0	8.3
Crop 2-3 leaves (Zadoks 12-13)					
methabenzthiazuron + mecoprop	1.6/1.6 - 2.1	7.5	2.9	5.8	8.1
mecoprop salt	2.1-2.2	7.1	2.6	5.8	8.4
bromoxynil + ioxynil + mecoprop	1.3	7.1	2.8	-	-
Crop pseudostem erect (Zadoks 30)					
bromoxynil + ioxynil + mecoprop	1.8	6.8	2.6	-	8.6
2,3,6-TBA + dicamba + MCPA + mecoprop	1.65	5.8	2.9	4.8	8.4
mecoprop salt	2.1-2.7	5.8	3.1	5.3	8.7
Crop 1-2 node detectable (Zadoks 31-32)					
bromoxynil + ioxynil + mecoprop	1.8	-	-	-	-
2,3,6-TBA + dicamba + MCPA + mecoprop	1.65	5.0	1.1	-	-
mecoprop salt	2.2	6.6	2.8	-	-
Untreated		7.1	2.2	4.9	8.2
Standard Error ±		0.47	0.20	0.11	0.16

Table 1 (1979)

Region/EHF	Winter wheat series - crop yields (tonnes/ha) E (a)	E (b)	E (c)	E (d)	High Mowthorpe	Terrington (a)	Terrington (b)	Average yield response ± (1978 & 1979)
Autumn pre-emergence								
chlortoluron	4.7	5.4	5.8	7.2	-	-	-	(- 0.1)
isoproturon	5.4	5.3	6.3	7.7	-	-	-	(+ 0.2)
terbutryne	5.3	5.4	6.2	7.3	7.5	6.2	7.0	+ 0.3
Crop 2-3 leaves (Zadoks 12-13)								
methabenzthiazuron + mecoprop	4.8	4.9	6.4	7.2	7.2	6.9	6.8	+ 0.3
mecoprop salt	4.9	5.6	6.2	7.4	7.6	7.0	6.9	+ 0.4
bromoxynil + ioxynil + mecoprop	5.3	5.6	5.8	7.1	-	7.0	6.9	(0.0)
Crop pseudostem erect (Zadoks 30)								
bromoxynil + ioxynil + mecoprop	4.8	5.6	5.9	7.3	7.6	7.0	7.0	(+ 0.3)
2,3,6-TBA + dicamba + MCPA + mecoprop	4.9	5.3	6.0	7.0	7.1	6.8	6.8	+ 0.1
mecoprop salt	4.8	5.6	6.1	7.0	7.2	6.8	6.8	+ 0.2
Crop 1-2 node detectable (Zadoks 31-32)								
bromoxynil + ioxynil + mecoprop	5.5	5.0	5.8	7.0	-	6.9	7.0	(- 0.2)
2,3,6-TBA + dicamba + MCPA + mecoprop	4.9	5.6	6.1	6.8	-	6.7	6.9	(- 0.5)
mecoprop salt	5.8	5.3	6.3	7.3	-	7.2	6.9	(+ 0.1)
Untreated	5.0	5.8	6.7	7.4	4.2	6.3	7.0	5.9
Standard Error ±	0.27	0.30	0.44	0.37	0.17	0.26	0.09	

Table 2

Winter wheat series - percent weed control (1)

Region/EHF	1978 E (a)	1978 E (b)	1978 High Mowthorpe	1978 SE	1979 E (a)	1979 E (b)	1979 E (c)	1979 E (d)	1979 High Mowthorpe	1979 Terrington (a)	1979 Terrington (b)
Autumn pre-emergence							TOO FEW WEEDS FOR RELIABLE ASSESSMENT				TOO FEW WEEDS FOR RELIABLE ASSESSMENT
chlortoluron	0	0	77	14	74	52		44	-	-	
isoproturon	14	0	60	18	26	26		16	-	-	
terbutryne	52	0	88	34	63	33		56	98	7	
Crop 2-3 leaves (Zadoks 12-13)											
methabenzthiazuron + mecoprop	81	3	69	68	67	36		87	96	95	
mecoprop salt	55	10	62	45	52	41		54	90	45	
bromoxynil + ioxynil + mecoprop	77	35	-	-	74	32		61	-	89	
Crop pseudostem erect (Zadoks 30)											
bromoxynil + ioxynil + mecoprop	89	54	-	75	92	74		90	97	99	
2,3,6-TBA + dicamba + MCPA + mecoprop	92	72	92	62	81	68		89	93	99	
mecoprop salt	89	40	83	62	65	36		54	86	96	
Untreated (Weed level)(1)	(90)	(72)	61	*	106	175		71	(82)	(27.5)	
Main weeds											
Stellaria media	x		x	x	x				x	x	
Veronica spp			x	x	x			x		x	
Galium aparine	x	x		x						x	
Polygonum spp		x		x	x	x				x	
Mayweed spp											
Sonchus arvensis		x									
Myosotis arvensis					x	x					
Papaver rhoeas			x								

(1) Percent weed control calculated from assessments of weed number/m^2 or percent weed cover () or by visual score*

Table 3

Winter barley series - crop yields (tonnes/ha)

	Region/EHF Year	E 1978	E 1979 (a)	E 1979 (b)	E 1979 (c)	W 1979	EM 1979 (a)	EM 1979 (b)	Average yield response ±
Autumn pre-emergence	Dose a.i. (kg/ha)								
chlortoluron	1.8	5.3	3.8	3.6	2.1	5.7	-	-	(+ 0.2)
isoproturon	1.25	5.7	3.6	3.9	2.3	6.4	-	-	(+ 0.5)
terbutryne	1.5	4.4	4.3	3.7	2.4	5.8	6.3	4.3	+ 0.3
methabenzthiazuron	1.6	-	4.0	3.7	2.2	5.6	6.1	4.6	(+ 0.3)
linuron + trifluralin	0.5/1.0 - 0.6/1.2	-	4.0	4.0	2.4	5.4	5.8	4.7	(+ 0.3)
Crop 2-3 leaves (Zadoks 12-13)									
mecoprop salt	2.1-2.2	5.1	3.9	3.7	2.6	5.8	5.4	4.8	+ 0.3
bromoxynil + ioxynil + mecoprop	1.3	5.0	3.4	4.1	2.5	5.2	-	-	(+ 0.1)
Crop pseudostem erect (Zadoks 30)									
bromoxynil + ioxynil + mecoprop	1.8	5.0	3.5	3.8	2.3	6.1	5.6	4.6	+ 0.3
2,3,6-TBA + dicamba + MCPA + mecoprop	1.65	4.7	3.9	3.7	2.4	5.1	5.1	4.6	+ 0.1
mecoprop salt	2.1-2.7	5.4	3.7	3.9	2.5	6.1	4.6	4.7	+ 0.3
Crop 1-2 node detectable (Zadoks 31-32)									
bromoxynil + ioxynil + mecoprop	1.8	-	3.8	3.6	2.3	5.4	5.0	4.6	(+ 0.1)
2,3,6-TBA + dicamba + MCPA + mecoprop	1.65	4.5	3.3	3.4	2.3	5.5	4.9	4.8	0.0
mecoprop salt	2.1-2.2	4.9	3.8	3.4	2.4	6.3	5.1	4.5	+ 0.2
Untreated		4.7	3.5	3.5	2.2	5.7	4.9	4.4	4.1
Standard Error		0.22	0.27	0.28	0.23	0.38	0.23	0.18	

Table 4

Winter barley series - percent weed control (1)

Region/EHF Year	E 1978	E 1979 (a)	E 1979 (b)	E 1979 (c)	W 1979	EM 1979 (a)	EM 1979 (b)
Autumn pre-emergence				WEED KILLED BY CROP COMPETITION	TOO FEW WEEDS FOR RELIABLE ASSESSMENT		
chlortoluron	38	40	78			-	-
isoproturon	18	0	67			-	-
terbutryne	91	43	88			70	74
methabenzthiazuron	-	50	88			78	78
linuron + trifluralin	-	62	95			97	90
Crop 2-3 leaves (Zadoks 12-13)							
mecoprop salt	26	32	58			65	86
bromoxynil + ioxynil + mecoprop	100	69	78			-	-
Crop pseudostem erect (Zadoks 30)							
bromoxynil + ioxynil + mecoprop	79	[83](2)	77			59	100
2,3,6-TBA + dicamba + MCPA + mecoprop	88	[56](2)	53			11	100
mecoprop	59	[37](2)	35			48	100
Untreated (Weed level)(1)	(85)	120 [235](2)	264			*	*
Main weeds							
Stellaria media	x	x	x	x		x	
Veronica spp	x	x	x	x			
Galium aparine							
Polygonum spp		x					
Mayweed spp							x
Viola arvensis		x					
Papaver rhoeas	x		x				
Aphanes arvensis			x				

(1) Percent weed control calculated from assessments of weed number/m^2 or percent weed cover () or by visual score*

(2) Assessment carried out at later date than for pre-emergence and early post-emergence treatments

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THE PERFORMANCE OF PENDIMETHALIN ALONE AND IN COMBINATION WITH OTHER HERBICIDES FOR CONTROL OF WEEDS IN WINTER CEREALS IN EUROPE

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Summary This paper reviews results obtained in five European countries with pendimethalin alone and in combination with other herbicides for control of weeds in winter cereals. Pendimethalin applied pre-emergence in winter barley, rye and wheat gave excellent control of major grass weed species including *Alopecurus myosuroides* and *Apera spica-venti* and a wide range of broad-leaved weeds including *Galium aparine, Veronica* spp. and *Viola* spp. which were not controlled by other pre-emergence cereal herbicides.

When cultural conditions did not permit use of pendimethalin at the full dose of 1.5 to 2.0 kg/ha, mixtures with other herbicides permitted application of pendimethalin at lower doses whilst still maintaining good weed control and crop selectivity.

Résumé Cet article revise les résultats obtenus des essais réalisés avec le pendimethalin employé seul et en combinaison avec d'autres herbicides dans cinq pays européens, en vue du control des mauvaises herbes dans la culture des céréales d'hiver.

L'emploie pre-emergente du pendimethalin dans la culture de l'orge, du seigle et du blé pourvoit à un excellent control des graminaciés majeures telles que l'*Alopecurus myosuroides* at l'*Apera spica-venti*, et une grande varieté d'autres mauvaises herbes telles que le *Galium aparine*, les éspèces, *Veronica* et *Viola*, qui ne sont pas controliés par d'autres herbicides à activité pré-levée.

Toutes les fois que les conditions culturelles ne permettent pas l'usage du pendimethalin aux doses completes de 1.5 a 2.0 kg/ha, des combinaisons avec d'autres herbicides telles que le linuron et le neburon rendent possible l'application du pendimethalin à des doses moindres, tout en maintenant un bon control des mauvaises herbes et une bonne sélection des cultures.

INTRODUCTION

Pendimethalin, formerly designated as AC 92,553 is a dinitroaniline herbicide discovered and developed by American Cyanamid Company. Development work began in 1972.

Pendimethalin is used on many different crops (Sprankle, 1974), and in Europe, its major use is in winter cereals (barley, rye and wheat).

In recent years, due to intensive cereal growing, grasses such as *Alopecurus myosuroides*, *Avena* spp., *Apera spica-venti*, *Poa* spp. and *Agropyron repens* have increased in importance. A number of specific herbicides are available for control of these weeds, but as a result of their widespread use, broad-leaved species such as *Galium aparine*, *Veronica* spp. and *Viola* spp. have become problem weeds. At the time of introduction of pendimethalin, these weeds could only be controlled by the use of post-emergence sprays in the spring. Pendimethalin not only controls these three weeds and a wide range of other annual broad-leaved weeds in winter cereals but also gives excellent control of *Alopecurus myosuroides*, *Apera spica-venti* and *Poa* spp. *Avena* spp. are not controlled.

Pendimethalin is applied pre-emergence in the autumn. Uptake by germinating weeds occurs through the seed coat, roots, hypocotyl and cotyledons. In common with other dinitroaniline herbicides, pendimethalin inhibits cell division in meristematic tissues so that most weeds die before they emerge from the soil. Weeds which do emerge remain stunted in their growth and eventually die.

The duration of activity of pendimethalin is such that sensitive spring-germinating weeds are usually controlled thus obviating the necessity for post-emergence sprays.

Selectivity of pendimethalin, particularly in wheat, depends largely upon depth protection; a layer of soil must exist between the seed and herbicide. Recommendations are that winter cereals be drilled to a depth of 3 cm and that seed-beds are free of large clods. In some countries the dose required for effective weed control in wheat is restricted and combinations with other herbicides have been introduced or are under development. In practice, selectivity of pendimethalin has been excellent in barley and rye.

This paper is a summary of work carried out in the U.K., W. Germany, Sweden, France and Italy with pendimethalin alone and in combination with other herbicides. All experiments are not included but an attempt has been made to present representative data.

METHOD AND MATERIALS

Unless otherwise stated, results reviewed and presented are from replicated small-plot trials laid out on farmers' fields. Herbicide applications in the small-plot trials were made with a variety of knapsack sprayers delivering from 225 to 800 ℓ/ha at pressures ranging from 2 to 3 bars. Pendimethalin treatments alone and in combination with other herbicides were made pre-emergence of crop and weeds, generally within 5 days of crop drilling. Treatments were applied in randomized block designs with 3 or 4 replications.

Various methods were used to assess crop damage and weed control. These will be indicated in the relevant tables when data are presented.

Selectivity trials were replicated 5 times and were laid out on weed-free sites. Harvesting was carried out with a small-plot combine harvester.

RESULTS

U.K. (a) winter barley

Results from 6 replicated and 21 grower trials with pendimethalin in winter barley were presented at the 1978 British Crop Protection Conference (Winfield *et al.*). Excellent control of a range of broad-leaved species commonly found in winter cereals including *Galium aparine, Stellaria media, Veronica* spp. and *Tripleurospermum maritimum* was obtained with 2.0 kg/ha pendimethalin. Control of the two grass weeds most frequently present in trials, *Alopecurus myosuroides* and *Poa annua* was good to excellent at this dose. In these replicated trials, no phytotoxicity to barley was observed with doses up to 6.0 kg a.i./ha.

Recently, progress has been made in determining the dose of pendimethalin required to control specific weeds in winter barley. Results from 7 trials in the 1979/80 season are summarized in Table I.

Pendimethalin at 1.0 kg/ha gave consistently good control of all weeds present except for *Matricaria* spp. and *Galium aparine*. These spp. were controlled by 1.32 kg/ha in these experiments but normally require 2.0 kg/ha. Terbutryne, methabenzthiazuron and trifluralin + linuron did not control *Galium* and gave inconsistent control of *Matricaria* spp. and *Viola arvensis*. Terbutryne and methabenzthiazuron gave poor control of *Veronica persica* and *Stellaria media* respectively. No phytotoxicity was seen with any treatment.

Results of this and other trials are summarized in Table II which groups weeds according to the dose of pendimethalin required for consistent control.

U.K. (b) winter rye

Trial results have indicated that pendimethalin does not damage winter rye at 4.0 kg/ha which is twice the maximum intended dose. Trial work is continuing in this crop.

W. Germany

In W. Germany, pendimethalin is used pre-emergence in winter barley and winter rye at 1.5 and 2.0 kg/ha. The 2.0 kg/ha dose is necessary where *Galium aparine, Matricaria* spp. and *Alopecurus myosuroides* are dominant weeds.

Trial work in winter wheat indicates that use of pendimethalin alone may be possible under carefully controlled conditions of seedbed preparation and seeding depth. Mixtures of reduced rates of pendimethalin with other herbicides are unlikely to be successful in Germany because of the importance of *Galium aparine*.

Hopp *et al.* (1977) and Luening and Klaassen (1977) have reviewed some of the German work with pendimethalin in winter barley, rye and wheat. Their results, as well as extensive commercial experience in barley and rye, showed that pendimethalin had a broader spectrum of activity than other pre-emergence herbicides. Major weeds occurring in the trials reported by Hopp *et al.* were *Alopecurus myosuroides, Apera spica-venti, Galium aparine, Lamium purpureum, Matricaria* spp., *Polygonum persicaria, Stellaria media and Veronica* spp. Yield increases up to 66% compared with untreated control plots were obtained in winter barley following treatment with pendimethalin at 2.0 kg/ha. Pendimethalin gave greater yield increases than those obtained with either chlortoluron or methabenzthiazuron.

Sweden

In Sweden, pendimethalin at a dose of 2 kg/ha in winter wheat and winter rye has given excellent control of *Apera spica-venti, Alopecurus myosuroides,* and a range of broad-leaved weeds including *Matricaria* spp., *Stellaria media, Viola arvensis, Lamium* spp., *Veronica* spp. and *Polygonum aviculare*. Selectivity in both crops has been excellent.

Table 1. The effects of pendimethalin on broad-leaved and grass weeds in replicated trials in winter barley in the U.K.

Control of broad-leaved and grass weed species
(Estimated % reduction*)

Trial No.	Dose (kg/ha)	*Matricaria* spp. I	III	IV	V	VI	*Stellaria media* I	III	IV	*Veronica persica* II	*Aphanes arvensis* III	V	*Viola arvensis* VI	III	*Polygonum aviculare* VI	*Galium aparine* VII	*Poa annua* IV	VI
Plants/m^2-untreated		(35)	(6)	(3)	(11)	(16)	(33)	(24)	(34)	(21)	(25)	(9)	(5)	(73)	(8)	(16)	(50)	(20)
Herbicide																		
pendimethalin	1.0	98^{a}	61^{ab}	98^{b}	94^{b}	91^{ab}	99^{b}	100^{b}	100^{b}	100^{b}	93^{ab}	97^{a}	88^{b}	97^{c}	100^{a}	52^{abc}	100^{c}	96^{a}
pendimethalin	1.32	97^{a}	100^{c}	100^{b}	100^{b}	91^{ab}	100^{b}	97^{b}	100^{b}	100^{b}	98^{b}	100^{a}	100^{b}	97^{c}	96^{a}	98^{cd}	100^{c}	99^{a}
pendimethalin	2.0	99^{a}	92^{bc}	100^{b}	100^{b}	100^{b}	100^{b}	100^{b}	100^{b}	100^{b}	98^{b}	100^{a}	100^{b}	97^{c}	96^{a}	99^{c}	100^{c}	100^{a}
terbutryne	1.5	86^{a}	96^{bc}	87^{b}	70^{a}	54^{a}	88^{a}	90^{b}	98^{b}	80^{b}	100^{b}	100^{a}	94^{b}	52^{ab}	86^{a}	17^{a}	77^{b}	94^{a}
methabenz-thiazuron	1.58	80^{a}	49^{a}	90^{b}	99^{b}	90^{ab}	90^{ab}	28^{a}	55^{a}	40^{a}	76^{a}	100^{a}	46^{a}	21^{a}	78^{a}	27^{a}	57^{a}	79^{a}
trifluralin + linuron**	0.93 to 1.08 + 0.47 to 0.54	93^{a}	83^{abc}	50^{a}	92^{b}	90^{ab}	98^{b}	84^{b}	90^{b}	100^{b}	95^{ab}	100^{a}	58^{a}	63^{bc}	86^{a}	34^{ab}	85^{b}	99^{a}
CV %(transformed data)		17	31	17	10	29	9	21	12	23	15	4	26	29	17	41	9	16

*Assessments made at crop growth stages 30-69 (Zadoks 1974) as visual estimates of % reduction, following 1.0 x 0.1 m quadrat counts on untreated plots. Means with common superscripts are not significantly different at P=0.05 by Duncan's New Multiple Range Test.

** Chandor

Results with pendimethalin in Sweden have been presented by Aamisepp (1977, 1978, 1979, 1980).

Table II. Doses of pendimethalin for weed control in winter barley - U.K.

Dose kg/ha	Weeds controlled	
1.0	*Aphanes arvensis*	*Stellaria media*
	Lamium spp.	*Veronica* spp.
1.32	*Atriplex patula*	*Poa annua*
	Chenopodium album	*Polygonum aviculare*
	Myosotis arvensis	*Viola arvensis*
	Papaver rhoeas	
2.0	*Alopecurus myosuroides*	*Matricaria* spp.
	Fumaria officinalis	*Polygonum convolvulus*
	Galium aparine	

France

Extensive trials carried out since 1972 showed that wheat and barley in France could not tolerate consistently more than 0.5 kg/ha pendimethalin. At this dose, control of some broad-leaved weeds, e.g. *Stellaria media*, *Papaver rhoeas* and *Veronica* spp. was good under French conditions, but grass control, particularly of *Alopecurus myosuroides* was poor. To extend the spectrum of weeds controlled at this low dose of pendimethalin, mixtures with other herbicides have been investigated.

A wettable powder formulation containing 10% pendimethalin and 46% neburon applied at 4-5 kg/ha product in wheat and 5 kg/ha product in barley gave good results (Ribrioux *et al.* 1979). The combination gave a better spectrum of weed control than either material used alone at the equivalent dosage. Extensive testing of pendimethalin + linuron has also shown this to be an effective combination with good selectivity in both wheat and barley.

Selectivity of pendimethalin + neburon in both wheat and barley was good, provided seeding depth and seedbed preparation were adequate; that is a seeding depth of 2 to 3 cm and a seedbed free of large clods.

Results from selectivity trials in wheat and barley carried out by Cyanamid France are presented in Table III.

In wheat, pendimethalin + neburon at 2.5 times the recommended dose did not reduce yield compared with the untreated control. Similarly the standard material chlortoluron, at normal and twice normal dose had no effect on this crop.

In barley, both doses of pendimethalin + neburon and the higher dosage of chlortoluron caused a significant yield reduction in one trial. The reasons for this are unclear.

Italy

In Italy, winter barley is a relatively unimportant crop. Hence all trials have been carried out in winter wheat. Kovacs (1974) showed that control of *Alopecurus myosuroides* with pendimethalin + linuron at 0.4 + 0.5 kg/ha a.i. applied pre-emergence was as good as with pendimethalin alone at 1.05 kg/ha.

Table IV summarizes trial results from 4 years' work with pendimethalin + linuron at 0.8 + 0.5 kg/ha a.i. compared with pendimethalin alone at 1.27 to 1.59 kg/ha. Pendimethalin + linuron gave comparable control of the most commonly occurring weeds in these trials and was better than pendimethalin alone in controlling *Matricaria* spp., *Capsella bursa-pastoris* and *Viola* spp.

Table III. Selectivity of pendimethalin + neburon in wheat and barley in France 1976/1977
Yields in kg/ha

		Dose kg/ha					
		Pendimethalin + Neburon		Chlortoluron			
Trial No.	Crop	0.4 + 1.84	1.0 + 4.6	2.5	5.0	Untreated	CV %
1	Wheat	3250^{a}	3730^{a}	3643^{a}	3606^{a}	3190^{a}	10
2		6283^{a}	6430^{a}	6573^{a}	6563^{a}	6513^{a}	3
3		7349^{a}	6896^{a}	7236^{a}	7208^{a}	7366^{a}	4
4		6602^{a}	6648^{a}	6661^{a}	6597^{a}	6111^{a}	4
5		6641^{a}	6819^{a}	6840^{a}	6722^{a}	6778^{a}	3
6		5396^{a}	5522^{a}	5582^{a}	5514^{a}	5814^{a}	7
7		4808^{a}	4690^{a}	4910^{a}	4814^{a}	4970^{a}	4
1	Barley	6486^{a}	6786^{a}	6474^{a}	6210^{a}	6470^{a}	11
2		7213^{a}	7079^{a}	7158^{a}	6987^{a}	7000^{a}	3
3		7572^{b}	7494^{b}	7951^{a}	7462^{b}	7987^{a}	2
4		5310^{a}	5290^{a}	5266^{a}	5226^{a}	5253^{a}	5
5		4880^{abc}	4818^{bc}	5149^{a}	4954^{ab}	4608^{c}	4
6		5250^{a}	5300^{a}	5293^{a}	4956^{a}	5230^{a}	4

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

Table IV. The control of broad-leaved and grass weeds with pendimethalin + linuron in replicated trials in winter wheat in Italy. (EWRC Scale)

Weed species	No. of trials	pendimethalin 1.27-1.59 kg/ha	pendimethalin + linuron 0.8 + 0.5 kg/ha
Alopecurus myosuroides	15	2.5	2.1
Lolium italicum	14	4.0	3.3
Poa spp.	8	3.3	3.3
Capsella bursa-pastoris	8	2.3	1.2
Matricaria spp.	14	2.6	1.8
Papaver rhoeas	22	1.0	1.0
Polygonum spp.	25	1.7	1.5
Stellaria media	14	1.1	1.5
Veronica spp.	23	1.0	1.0
Viola spp.	8	3.3	1.5

DISCUSSION

The experiments with pendimethalin in winter cereals, carried out in a number of European countries over the last five or six years, which have been reviewed here show that doses of 1.0 to 2.0 kg/ha a.i. applied pre-emergence were safe in barley, rye and wheat where cultural conditions allowed. For effective control of *Alopecurus myosuroides, Galium aparine* and *Matricaria* spp., 2.0 kg/ha pendimethalin are required but for other susceptible weeds, doses can be reduced. Where cultural conditions (predominantly seeding depth and seedbed preparation) do not allow use of effective rates of pendimethalin, mixtures with herbicides such as neburon and linuron give good results. In France, pendimethalin + neburon is used successfully in wheat and barley and in Italy, good results have been obtained with pendimethalin + linuron. This would not be possible in areas where *Galium aparine* is a major problem, since the full rate of 2.0 kg/ha pendimethalin is required for control of this weed and no other herbicide is available which could compensate for the lower dosage of pendimethalin.

No varietal tolerance differences to pendimethalin in barley, rye, or wheat have been found. Wheat is, however, less tolerant than either barley or rye.

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A NEW PRE-EMERGENCE HERBICIDE MIXTURE FOR WEED CONTROL IN WINTER CEREALS.

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Summary Hoe 16 410 5 H is a formulated mixture of isoproturon and trifluralin developed by Hoechst A.G. for broad-spectrum pre-emergence weed control in winter cereals. In two years of field trials in Germany, England, France and Italy, Hoe 16 410 5 H has given good control of annual grasses including *Alopecurus myosuroides* and *Apera spica-venti*. Control of a wide spectrum of broad-leaved weeds has included *Stellaria media*, *Matricaria spp*, *Lamium purpureum* and the urea tolerant *Veronica hederifolia*. On light soils good control has been achieved with 2000 g.a.i./ha. and on heavier soils with 2400 g.a.i./ha. The mixture has no varietal restrictions and with conventional drilling has shown excellent crop tolerance.

Resumee Le Hoe 16 410 5 H est une association d'isoproturon et de trifluraline, developpée par Hoechst A.G. pour son large spectre d'efficacité, en pré-levée sur les adventices des cultures de céréales d'hiver. Dans les essais en cultures realises depuis 2 ans en Allemagne, Angleterre, France et Italie, le Hoe 16 410 5 H a fait preuve d'une bonne activité sur les graminées annuelles dont *Alopecurus myosuroides* et *Apera spica-venti*, de même que sur de nombreuses dicotyledones dont *Stellaria media*, *Matricaria spp.*, *Lamium purpureum* et *Veronica hederifolia*, plante resistante aux urées. Une bonne efficacité a été obtenue avec 2 000 g ma/ha en sols légers et avec 2 400 g en sols lourds. Dans les conditions traditionelles de semis, l'association a révélé une excellente selectivité a l'égard des cultures. Il n'y a pas eu de problème de sensibilité varietale.

INTRODUCTION

For a number of years, the European winter cereal area has been increasing whilst spring cereals have been declining. The long growing period of the winter crop favours the development of very competitive weeds, such as *Apera spica-venti*, *Alopecurus myosuroides*, *Viola tricolor* and *Galium aparine*. Control of these weeds by pre-emergence materials is important to avoid yield losses by competition with the crop in the early stages of growth.

Many commercially available herbicides for autumn use have limited efficacy against some grass and broad-leaved weeds. Additionally some are associated with limited crop tolerance. Hoe 16 410 5 H is a new herbicide mixture, developed by Hoechst A.G., which overcomes these limitations With this mixture the good activity of isoproturon against grasses (Schwerdtle et.al., 1975) and broad-leaved weeds is added to and extended by trifluralin so that late germinating weeds are also controlled.

The paper describes the activity of Hoe 16 410 5 H as determined by field trials during 1979 and 1980 in Germany, England, France and Italy.

METHOD AND MATERIALS

The formulation of Hoe 16 410 5 H used in all trials was a 40% wettable powder containing the active ingredients isoproturon (20%) and trifluralin (20%). The treatments described in this paper were applied at dose rates of 5 and 6 kg formulated product/ha (2000 and 2400 g.a.i./ha.). The standard products for comparison with Hoe 16 410 5 H were pendimethalin (330 g.a.i./l) at 1980 g.a.i./ha, linuron plus trifluralin (120 + 240 g.a.i./l) at 1800 g.a.i./ha., and chlortoluron (500 g.a.i./l) at 2500 g.a.i./ha. All trials were carried out with plot sizes of 10-15 m^2 in a randomized block design with three replicates. Applications were made, with Azo, Van der Weij precision plot sprayers at a pressure of 3 bars delivering 300 l/ha through eight or nine 110015 Tee Jets, mounted 25 cm. apart on 2-2.25 m. spray booms.

Grass weed control was assessed by counting the seed heads in two 0.5 m^2 quadrats per plot. Control of broad-leaved weeds was assessed between 5 and 8 months after treatment (late spring) using the EWRS 1-9 scale (Bolle, 1964) and the scores transformed into percentage. Crop vigour assessments were also made using the EWRS scale at 100% emergence and at the beginning of tillering in the autumn and in late spring. Yields were taken with Hege small-plot combines and the results presented on the basis of 86% dry matter.

RESULTS

Results for weed control and yield are summarised together for each year and crop (Tables 1-6)

Grass weed control

Control of A. myosuroides and A. spica-venti was very good with average percentage control for A. myosuroides varying between 87 and 97% for the 2000 g.a.i./ha rate and 92 and 98% for the 2400 g.a.i./ha rate. Control of this species in 1979 was slightly better than in 1980. The three winter cereal crops provided different conditions for the development of these grass weeds. The fact that there were only small differences between the activity of Hoe 16 410 5 H in these crops demonstrates the long persistence of this material, similar to that of chlortoluron and superior to that of the linuron plus trifluralin mixture. Pendimethalin also tended to be less effective against grass weeds than Hoe 16 410 5 H particularly in 1980.

Broad-leaved weed control

The activity of Hoe 16 410 5 H against broad-leaved weeds can be summarised in terms of those for which control was good to very good:- Stellaria media, Matricaria spp., Lamium spp., Veronica hederifolia, Polygonum aviculare and Myosotis atrensis. Those for which control was satisfactory to good were:- Viola spp., Galium aparine, Thlaspi arrense, Polygonum persicaria and Polygonum convolvulus. Control of the difficult weeds Viola tricolor and Galium aparine was in most cases sufficient to prevent serious weed competition. In all trials the broad-leaved weed activity of Hoe 16 410 5 H was superior to the standard chlortoluron and similar to the linuron plus trifluralin mixture. Results against *V. hederifolia* were outstanding compared with chlortoluron although the overall broad-leaved weed activity of Hoe 16 410 5 H was not equal to pendimethalin.

Crop Tolerance and Yield

Applications of Hoe 16 410 5 H in winter rye caused no crop effects. In winter barley and winter wheat slight crop effects were noted in only two out of 105 trials but at harvest these effects were not noticeable. This high level of selectivity was similar to that of the linuron plus trifluralin mixture. At the time of writing yield results were not available from all 1980 trials and thus most of the yield results presented were obtained in 1979. The good crop selectivity of Hoe 16 410 5 H was reflected in the good yield increases, compared with the untreated controls in all winter cereals tested. These ranged from 9 to 10% in winter rye with the highest yields from barley and wheat of 15 to 20%. The tendency for pendimethalin to give lower yields compared with Hoe 16 410 5 H may have been caused by lower levels of grass weed control and slightly more noticeable crop effects.

DISCUSSION

As the results show, the mixture of isoproturon and trifluralin (Hoe 16 410 5H) gives very good control of the grasses *A. myosuroides* and *A. spica-venti.* It also controls a wide spectrum of broad-leaved weeds including those tolerant to current urea herbicides. Under conventional drilling conditions no harmful crop effects occurred.

Hoe 16 410 5 H reaches its highest level of activity on moist soils with a good seed bed. On light soils excellent weed control will be achieved with 5 kg of formulated product per hectare and on heavy soils with 6 kg product per hectare.

This mixture is a further advance in the field of pre-emergence herbicides and compared with current standards offers more reliability, a broader spectrum of weed control and good selectivity.

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Table 1

Percentage control of grass and broad-leaved weeds and relative yields in winter barley 1979 (30 trials)

	No. of trials	Hoe 16410 2000 g. ai/ha	5H WI 2400 g. ai/ha	Pendimethalin 1980 g. ai/ha
Yield	20	117	120	113
Alopecurus myosuroides	21	94	96	92
Apera spica-venti	5	99	100	99
Stellaria media	11	97	98	100
Veronica hederifolia	12	96	96	99
Viola tricolor	1	75	87	95
Galium aparine	13	77	85	96
Matricaria spp.	10	96	96	99
Lamium purpureum	6	99	99	99
Thlaspi arvense	3	44	60	98
Myosotis arvensis	3	98	99	100

Mean untreated yield = 4.46 t/ha

Mean no. of seed heads/m^2 for *A. myosuroides* = 442/m^2

Mean no. of seed heads/m^2 for *A. spica-venti* = 162/m^2

Table 2

Percentage control of grass and broad-leaved weeds and relative yields in winter barley 1980 (21 trials)

	No. of trials	Hoe 16410 2000 g. ai/ha	5H WI 2400 g. ai/ha	Pendimethalin 1980 g. ai/ha
Yield	12	110	112	106
Alopecurus myosuroides	17	88	92	80
Apera spica venti	5	98	99	95
Stellaria media	15	86	92	98
Veronica hederifolia	6	74	92	98
Veronica persica	2	99	98	97
Viola tricolor	5	49	58	98
Galium aparine	8	41	53	87
Matricaria spp.	3	96	96	95
Lamium purpureum	7	97	98	98
Thlaspi arvense	6	74	83	97
Myosotis arvensis	4	98	99	99

Mean untreated yield = 5.98 t/ha

Mean no. of seed heads/m^2 for *A. myosuroides* = 303/m^2

Mean no. of seed heads/m^2 for *A. spica-venti* = 166/m^2

Table 3

Percentage control of grass and broad-leaved weeds and relative yield in winter rye 1979 (15 trials)

	No. of trials	Hoe 16410 2000 g. a.i./ha.	5H WI 2400 g. a.i./ha.	Pendimethalin 1980 g.a.i./ha
Yield	12	110	109	104
Alopecurus myosuroides	2	96	97	94
Apera spica venti	11	99	100	99
Stellaria media	5	97	98	99
Veronica hederifolia	5	79	82	98
Viola tricolor	2	90	92	99
Galium aparine	5	67	80	98
Matricaria spp.	2	87	87	97
Myosotis arvensis	2	100	100	100
Thlaspi arvense	2	86	86	97

Mean untreated yield = 4.39 t/ha
Mean no of seed heads/m^2 for *A myosuroides* = 165/m^2
Mean no of seed heads/m^2 for *A spica-venti* = 256/m^2

Table 4

Percentage control of grass and broad-leaved weeds in winter rye 1980 (10 trials)

	No of trials	Hoe 16410 2000gai/ha	5H WI 2400gai/ha	Linuron + Trifluralin 1800gai/ha
Alopecurus myosuroides	4	97	98	84
Apera spica venti	5	95	98	94
Stellaria media	5	91	95	97
Veronica spp	3	91	95	95
Viola tricolor	1	65	65	75
Galium aparine	2	70	75	72
Thlaspi arvense	2	87	92	98
Lamium spp.	4	99	99	99
Matricaria spp.	1	100	100	100

Mean no of seed heads/m^2 for *A. myosuroides* = 230/m^2
Mean no of seed heads/m^2 for *A. spica-venti* = 226/m^2

Table 5

Percentage control of grass and broad-leaved weeds and relative yield in winter wheat 1979 (32 trials)

	No. of trials	Hoe 16410 5H WI 2000 g. a.i./ha	Hoe 16410 5H WI 2400 g. a.i./ha.	Chlortoluron 2500 g.a.i/ha
Yield	20	115	116	110
Alopecurus mosuroides	20	91	93	93
Apera spica venti	7	100	100	99
Stellaria media	6	93	94	80
*Veronica persica**	2	84	87	57
Viola spp.	7	76	77	42
Galium aparine	7	58	77	40
Matricaria spp.	4	98	98	98
Lamium purpureum	1	100	100	100
Polygonum aviculare	4	86	86	52
Polygonum convolvulus	5	79	81	66
Polygonum persicaria	3	75	84	58
Myosotis arvensis	2	92	92	90
**Veronica hederifolia*	9	95	96	48

Mean untreated yield = 4.85 t/ha

Mean no. of seed heads/m^2 for *A myosuroides* = 274/m^2

Mean no. of seed heads/m^2 for *A spica-venti* = 70/m^2

Table 6

Percentage control of grass and broad-leaved weeds and relative yield in winter wheat 1980 (22 trials).

	No.of Trials	Hoe 16410 5H WI 2000 g. a.i./ha.	Hoe 16410 5H WI 2400 g. a.i./ha	Linuron + Trifluralin 1800 g.a.i/ha.
Yield	3	108	110	107
Alopecurus myosuroides	15	87	92	71
Apera spica venti	5	98	100	99
Stellaria media	9	96	98	98
Veronica hederifolia	7	92	96	93
Veronica persica	3	97	97	97
Viola arvensis	3	88	88	90
Galium aparine	12	63	70	70
Matricaria spp.	3	99	99	99
Lamium purpureum	4	89	94	88
Polygonum aviculare	3	99	99	99
Polygonum convolvulus	3	91	94	82
Myosotis arvensis	1	97	97	100

Mean untreated yield = 5 79 t/ha

Mean no of seed heads/m^2 for *A myosuroides* = 343/m^2

Mean no of seed heads/m^2 for *A spica-venti* = 165/m^2

TRIALS WITH METOXURON FOR THE CONTROL OF BROMUS STERILIS IN WINTER CEREALS

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Summary Metoxuron has been evaluated over two years for the control of Bromus sterilis, an extremely competitive annual grass weed which has recently become a serious problem in winter cereals. Results have demonstrated that metoxuron is effective when applied at the 1 to 3 leaf stage of the weed but once the seedlings have begun tillering, they are more difficult to control. B. sterilis is known to have a long period of germination and after an initial flush in the autumn can germinate through to the spring. In these situations single treatments are often not sufficient to give effective control. Metoxuron applied at the early post-emergence stage of the crop, followed by a second application in the spring or in sequence with triallate applied pre-crop emergence, will give the most reliable control. Yield response from these treatments can be considerable where heavy B. sterilis infestations occur.

Résumé Pendant deux ans, métoxuron a été testé contre Bromus sterilis, une mauvaise herbe annuelle très compétitive qui recémment a causé un sérieux problème dans les céréales d'hiver. Les résultats ont démontré que métoxuron utilisé au stade 1 à 3 feuilles de la mauvaise herbe est efficace mais au début du tallage la lutte est plus difficile. Il est connu que Bromus sterilis possède une longue période de germination après une première poussée en automne la germination peut continuer jusqu'au printemps. Dans cette situation un seul traitement est souvent insuffisant pour obtenir un contrôle effectif. Par conséquent métoxuron appliqué au stade post-émergence précoce de la culture, suivi d'une deuxième application au printemps ou consécutivement avec triallate appliqué en pré-émergence de la culture, donnera de meilleurs résultats. Dans de fortes infestations de Bromus sterilis ces traitements peuvent entraîner des augmentations de rendement considérables.

INTRODUCTION

Bromus sterilis, barren or sterile brome, is an annual grass weed which has become a serious problem in winter cereal crops in most parts of the country. It has always been widespread in bottoms of hedgerows and on the edge of some headlands and was first reported as a weed of economic significance in Warwickshire in the 1930's. The recent growth in infestation levels appears to have arisen due to a combination of reduced cultivation techniques, successive dry autumns and an increase in winter cereal crops. These factors have meant that there has been little opportunity to kill the seedlings by either chemical or mechanical methods prior to drilling the next crop.

In 1976 a number of grass weed herbicides were evaluated against B. sterilis in pot trials by the Weed Research Organisation (Richardson 1976). Metoxuron, discovered by Sandoz Ltd., Basle, Switzerland and used successfully for the post-emergence control of Alopecurus myosuroides for many years (Berg 1968, Glenister and Griffiths 1968) was included. The material gave promising results when applied at the 1 to 3 leaf stage of the weed. A number of trials were therefore conducted under field conditions to determine the optimum timing for application and to compare a single treatment with sequential treatments in situations where germination of B. sterilis was prolonged.

METHOD AND MATERIALS

Eight trials were carried out in 1978/79 and a further eight trials in 1979/80. These covered a wide range of winter cereal varieties and geographical locations (Table 1). 1978/79 trials were designed to determine the optimum time for application of metoxuron against B. sterilis and the 1979/80 trials to compare efficacy of single and sequential treatments which included metoxuron and triallate. Metoxuron was applied throughout as the commercial formulation Dosaflo, a water dispersible concentrate containing 500g a.i./l. Triallate was used either as a 10% granular or 40% liquid formulation. The reference treatment in the 1978/79 series of trials, isoproturon, was a commercial formulation containing 500g a.i./l. applied at the recommended rate for control of Alopecurus myosuroides.

Spray treatments were applied using either a Van der Weij Azo sprayer or a CO_2 knapsack sprayer at a pressure of 2.0 to 3.0 bars giving a spray volume of 200 to 333 l /ha. Triallate granules were applied with a Fischer small plot granule applicator, apart from site 11 where the granules were farmer applied using Horstine Farmery equipment on a field scale. All trials were of a randomised block design, generally with three replications. Plot size varied between 20 and 40 m^2.

The effect of the treatments on B. sterilis was assessed by counting the panicles in a number of $0.1m^2$ quadrats placed at random in each plot or as visual % control where infestations were very high ($>$1000 panicles/m^2). Crop vigour was difficult to assess due to heavy weed infestations. However, in 1979/80, two unreplicated trials were laid down on weed-free crops in East Anglia to observe the effects of 4.4 kg a.i./ha and 8.8 kg a.i./ha metoxuron applied early post-emergence in the autumn, followed by a late post-emergence application in the spring. 27 varieties of winter wheat and 11 varieties of winter barley were treated and phytotoxicity was scored by assessing visual % damage approximately 50 days after the last application.

Yield data was obtained from five of the 1979/80 trials using a Hege, small plot combine harvester. All grain yields were then adjusted to 85% dry matter.

RESULTS

Control of Bromus sterilis

1978/79

In this series of trials, good control of low to moderate infestations of B. sterilis was achieved when metoxuron was applied at the early post-emergence stage of the crop, Zadoks stage 12-20, the weed being at the 1-3 leaf stage (Table 2). Later applications in the spring, applied when B. sterilis had commenced tillering, generally gave poorer control though some good results were recorded. At sites 1 to 3, where comparisons were made, early treatments were clearly superior. Applications of metoxuron tended to give superior control to the reference treatment isoproturon.

Table 1

Trial Site Details

Year	Trial No.	Location	Variety	Drilling Date	Application Dates		
					Pre-em.	Early post-em.	Late post-em.
1978/79	1.	Ruddington, Notts.	Sportsman	2.11.78	-	5. 2.79	27. 4.79
	2.	Great Ponton, Lincs.	Bounty	1.11.78	-	8. 3.79	18. 4.79
	3.	Great Gonerby, Lincs.	Flanders	21.10.78	-	20.11.78	20. 4.79
	4.	Fullready, Warwicks.	Mardler	17. 9.78	-	-	1. 5.79
	5.	Lighthorne, Warwicks.	Malta	1. 9.78	-	-	1. 5.79
	6.	Holwell, Beds.	Flanders	28. 9.78	-	-	26. 2.79
	7.	East Leach, Glos.	Igri	7.10.78	-	-	31. 3.79
	8.	East Leach, Glos.	Igri	11.10.78	-	-	31. 3.79
1979/80	9.	Turvey, Beds.	Igri	30. 9.79	4.10.79	9.11.79	14. 2.80
	10.	Skeffington, Leics.	Flanders	16.10.79	19.10.79	22. 1.80	3. 3.80
	11.	Stetchworth, Cambs.	Flanders	4.10.79	6.10.79	16.11.79	18. 2.80
	12.	Great Ponton, Lincs.	Bounty	23.10.79	29.10.79	15. 2.80	5. 4.80
	13.	Scampton, Lincs.	Sonja	19.10.79	19.10.79	23. 3.80	5. 4.80
	14.	East Leach, Glos.	Igri	29. 9.79	-	15.10.79	13. 3.80
	15.	Bourton-on-the-Water, Glos.	Flanders	18.10.79	15.10.79	23.11.79	18. 3.80
	16.	Grandborough, Warwicks.	Flanders	17.10.79	15.10.79	13.12.79	13. 3.80

Table 2

Percentage control of Bromus sterilis panicles in 1978/79 trials

Treatment	Rate (kg.ai./ha)	Crop Stage	Weed Stage	% control Site 1	2	3	4	5	6	7	8
Metoxuron	4.4	early post-em (12-20)	1-3 lvs (11-13)	96	81	97	-	-	-	-	-
Isoproturon	2.5	early post-em (12-20)	1-3 lvs (11-13)	95	65	63	-	-	-	-	-
Metoxuron	4.4	late post-em (20-30)	2 lvs to tillering (12-24)	75	60	90	92	45	48	91	44
Isoproturon	2.1	late post-em (20-30)	2 lvs to tillering (12-24)	65	33	91	85	36	13	53	40
Untreated control (no. of panicles / m^2)				(63)	(25)	(6)	(-)	(-)	(-)	(52)	(286)

Figures in parentheses relate to growth stage (Zadoks et al 1974)

1979/80

Both metoxuron applied at an early post-emergence stage of the crop and triallate applied pre-crop emergence, appeared during the winter to have been very effective in reducing the population of B. sterilis. However, by the spring, it could be seen that at most sites less than 50% control had been achieved. This appeared to be due to prolonged germination possibly caused by variable depth of planting and some induced dormancy. The early applications of metoxuron were again generally superior to those made in the spring (see Table 3).

The most reliable and effective control in these trials was achieved by the sequential treatments - metoxuron (early post-emergence) followed by metoxuron (late post-emergence, Zadoks crop stage 20-30) and triallate (pre crop-emergence) followed by metoxuron (early post-emergence).

Both these sequences were clearly superior to triallate (pre crop-emergence) followed by metoxuron (late post-emergence). At the three sites, 9 to 11, where infestations of B. sterilis were particularly high (> 1000 panicles / m^2), triallate (pre crop-emergence) followed by metoxuron (early post-emergence) and metoxuron (late post-emergence) gave excellent control and, as expected, was clearly superior to any other treatment.

Table 3

Percentage control of Bromus sterilis panicles in 1979/80 trials

Treatment			% control							
Pre-em	Early post-em	Late post-em	Site 9	10	11	12	13	14	15	16
Triallate	-	-	12	15	0	-	-	-	25*	28*
-	Metoxuron	-	38	26	-	72	81	45	-	-
-	-	Metoxuron	32	45	-	31	33	22	53	37
Triallate	Metoxuron	-	60	65	73	86	98	-	-	-
Triallate	-	Metoxuron	68	57	48	54	80	-	58	70
-	Metoxuron	Metoxuron	80	85	-	71	94	-	92	80
Triallate	Metoxuron	Metoxuron	89	94	96	-	-	-	-	-
Untreated control (no. of panicles / m^2)			(>1000)	(>1000)	(>1000)	(560)	(830)	(65)	(151)	(47)

Metoxuron 4.4 kg a.i./ha   Triallate Granular 2.25 kg a.i./ha
* Triallate liquid 1.7 kg a.i./ha

Crop Phytotoxicity

Crop damage was difficult to establish due to the competitiveness of B. sterilis. However no obvious effects were observed from any treatment. In the two variety trials, all varieties of winter wheat known to be safe to treat with metoxuron showed no unusual effects, either from sequential applications of 4.4 kg a.i./ha or from 8.8 kg a.i./ha. The winter barley varieties were not affected by two applications of 4.4 kg a.i./ha of metoxuron, but at one site were clearly more sensitive to 8.8 kg a.i./ha applied in the autumn.

Crop Yield

Large increases in yield due to control of B. sterilis were obtained at all trial sites. The better treatments at the more heavily infested sites (> 1000 panicles/m^2) increased the grain yield by approximately a factor of 2 when related to untreated control plots. (Table 4).

Table 4

Grain yields as a percentage of control yield (15% moisture content)

(1979/80)

Treatment			Grain yield				
			Site				
Pre-em	Early post-em	Late post-em	9	10	11	12	13
Triallate	-	-	101	136	100	-	-
-	Metoxuron	-	150	149	-	146	137
-	-	Metoxuron	166	151	-	145	99
Triallate	Metoxuron	-	230	172	145	158	142
Triallate	-	Metoxuron	206	177	139	145	107
-	Metoxuron	Metoxuron	190	185	-	144	122
Triallate	Metoxuron	Metoxuron	266	196	166	-	-
Untreated control t/ha			(2.34)	(1.99)	(1.86)	(5.94)	(4.63)

DISCUSSION

Trial results have demonstrated that metoxuron can be used effectively for the control of *Bromus sterilis* but that the product is unlikely to give good control when applied in the spring at the normal time for the control of *Alopecurus myosuroides*. Optimum control will be achieved when the weed is at the 1-3 leaf stage. However, in situations where heavy infestations occur and prolonged germination is likely, sequential treatments will probably give the most reliable results as there appears to be little control of the weed by residual activity.

It has been shown that applications of metoxuron early post-emergence, October - February, followed by metoxuron late post-emergence in the spring have generally given good control of *B. sterilis*. Whilst it has been evaluated in three trials only, a sequence of triallate, applied pre-crop emergence followed by metoxuron, early post-emergence and metoxuron again late post-emergence appears to give the most effective control of very heavy infestations. *B. sterilis* is still mainly confined to headlands and it is possible that this treatment, although costly, could be used primarily as a barrier spray.

B. sterilis has been shown in trials to be highly competitive and all sequential treatments have resulted in large yield increases which would more than repay the cost of the herbicide programme.

Farmers who have a known heavy infestation are advised to check their crops during the autumn and winter for the initial flush of *B. sterilis* and apply metoxuron 4.4 kg a.i./ha at the 1-3 leaf stage of the weed. The crop should again be checked in the spring and, if further germination has occurred, another application of metoxuron 4.4 kg a.i./ha should be applied Where particularly heavy infestations of *B. sterilis* are known to occur farmers may be advised to carry out an initial treatment with triallate liquid applied pre-drilling or triallate granules applied pre-crop emergence. Trials experience has shown that it is safe to apply metoxuron in sequence to the metoxuron tolerant varieties provided there is a minimum period of six weeks between the two applications.

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NOTES

THE INFLUENCE OF TEMPERATURE ON THE HERBICIDAL ACTIVITY OF DICLOFOP-METHYL AGAINST DIFFERENT WEED GRASS SPECIES

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Summary The influence of temperature on activity of diclofop-methyl against *Avena fatua*, *Phalaris minor*, *Echinochloa crus-galli*, *Eleusine indica* and *Setaria viridis* was studied in growth chambers under the temperature regimes of 18/10°C, 25/17°C and 32/24°C day/night temperatures respectively, whilst all other environmental factors such as light intensity, daylength and relative air humidity were maintained constant. It was noted that the temperature range at which diclofop-methyl is most active varied amongst species. In general, the most effective control of the species tested was achieved by diclofop-methyl at temperatures best suited for their most vigorous growth.
Control of *Avena fatua* and *Phalaris canariensis* was better at 18/10°C than at higher temperatures, whereas *Eleusine indica* and *Setaria viridis* were most susceptible to diclofop-methyl at 32/24°C. *Echinochloa crus-galli* showed highest susceptibility and highest dry matter production at 25/17°C.

Resumé L'influence de la température sur l'activité du diclofop-methyl, efficace contre *Avena fatua*, *Phalaris minor*, *Echinochloa crus-galli*, *Eleusine indica* et *Setaria viridis*, a été étudiée en chambres de climatisation aux différentes températures de jour et de nuit (18/10°C, 25/17°C et 32/24°C) tandis que les autres facteurs comme la durée de la lumière du jour, son intensité et l'humidité de l'air sont restés constants. On a ainsi observé que l'efficacité du diclofop-methyl à diverses températures varie selon les espèces.
Le meilleur contrôle étudié a été obtenu généralement aux températures convenant à leur végétation optimale.
L'efficacité contre *Avena fatua* et *Phalaris canariensis* a été meilleur à 18/10°C qu'aux températures plus élevées. Par contre *Eleusine indica* et *Setaria viridis* ont été sensibles à diclofop-methyl à 32/24°C. *Echinochloa crus-galli* montre la plus grande sensibilité et la plus importante production de matière sèche à 25/17°C.

INTRODUCTION

Diclofop-methyl is a selective herbicide for post-emergent control of annual grass weeds such as wild oats (*Avena fatua*, *A. sterilis* and *A. ludoviciana*), *Phalaris* species and several millets such as barnyard grass (*Echinochloa crus-galli*) and green foxtail (*Setaria viridis*). The product is mainly used in wheat, spring barley and sugar beet but also in flax, rape and soyabeans. The relevant biological data concerning this herbicide were presented by Langelüddeke *et al.* (1975), Schumacher and Schwerdtle (1975), Hewson (1976) and Breidert *et al.* (1977).

When field results of several years were compared, it was seen that environmental factors had an influence on the degree of Avena fatua control (Manning and Hewson, 1978). One important factor in this respect may be temperature. To evaluate the influence of temperature on herbicidal activity of diclofop-methyl the following study was performed with 5 grass species under controlled environmental conditions.

METHOD AND MATERIALS

Seeds of Avena fatua, Phalaris canariensis, Echinochloa crus-galli, Eleusine indica var. africana and Setaria viridis were sown on pots (14 cm diameter) in a sandy loam and cultured in a growth chamber under the following conditions:

$25^{o}C$ and 65% relative air humidity in the light (12 h, 28000 lux) and

$17^{o}C$ / 90% relative air humidity in the dark.

When the third leaf of the plants had expanded, diclofop-methyl was applied as the commercial formulation (284 gms/litre diclofop-methyl) at the rates indicated in Table 2.

The volume of spray solution corresponded to 300 l water/ha. For each herbicide rate tested 18 pots per species were taken. In each pot six plants were grown. When the spray had dried, the plants were divided into three groups and placed in three growth chambers with the temperature regimes shown in Table 2. The conditions for light and air humidity remained the same as for cultivation before spraying.

On the day of herbicide application, thirty-six untreated plants from each species were harvested for dry matter determination. Twenty-two days later a further thirty-six untreated, and all herbicide treated plants, were harvested and for each pot the dry matter of above ground plant parts was determined. Based on these values the percentage control was calculated as follows:

$$\% \text{ control} = 100 - (\frac{mt}{mu} \cdot 100)$$

mt = dry weight of surviving treated plants at a given rate of herbicide

mu = dry weight of untreated plants

The log probit analysis was used for calculation of the ED_{80} values.

RESULTS

1. Growth of untreated plants under different temperatures

As indicated in Table 1 the different weed grass species have different optimum temperatures for growth. Growth index is defined as dry weight of plants at the end of the trial/dry weight of plants at the day of herbicide application.

For Avena fatua growth was best at $18/10^{o}C$, but at $25/17^{o}C$ dry weight production was not significantly different. The inverse was true for Phalaris canariensis. Both species showed a reduced dry weight production at $32/24^{o}C$. Within the tested species of the tribe Paniceae, Echinochloa crus-galli grows faster at $18/10^{o}C$ and $25/17^{o}C$ than the others and reaches its optimum at $25/17^{o}C$, even though at $32/24^{o}C$ the dry weight production is not significantly lower. Setaria viridis and Eleusine indica produce considerably more dry matter at $32/24^{o}C$ than at lower temperatures.

Table 1

Growth index of untreated plants within the trial period (22 days) at different temperature regimes

Tested species	Temperature regimes		
	18/10°C	25/17°C	32/24°C
Avena fatua	15.7	15.0	7.7
Phalaris canariensis	37.4	42.4	12.1
Echinochloa crus-galli	20.0	90.1	88.4
Eleusine indica var. africana	12.3	48.7	81.9
Setaria viridis	13.3	86.9	131.1

2. The influence of temperature on activity of diclofop-methyl

The activity of diclofop-methyl against Avena fatua was best at 18/10°C but at 25/17°C the percentage control obtained with comparable herbicide concentrations was only slightly weaker as shown in Table 3. Plants which were grown under 32/24°C in the post-application period were obviously less damaged than those which grew in cooler temperatures, even though the differences in control are only significant between 32/24°C and 18/10°C, as shown in Table 3. There seems to exist a correlation between growth of the Avena plants and their susceptibility to diclofop-methyl. The activity of diclofop-methyl against Avena fatua was the best under optimal growth conditions. This correlation was also observed with the other species tested.

Table 2 shows the best control of Echinochloa at 25/17°C, which is the temperature of maximal dry weight production of this species. Even 30 g a.i./ha diclofop-methyl allowed 89% control at 25/17°C, whereas at 32/24°C only 39% control and at 18/10°C, 78% control was achieved with the same rate.

The other wild millets which showed maximal weight production at 32/24°C were best controlled at this high temperature. At the sublethal rates of 0.03 kg a.i./ha the influence of the temperature on activity of diclofop-methyl was obvious with both Eleusine and Setaria. At higher concentrations of the herbicide the effect of temperature was not significant with Setaria viridis.

With Phalaris canariensis no clear cut influence of different temperatures on activity was observed. There was a tendency for better control at five of the six tested rates of diclofop-methyl at 18/10°C than at higher temperatures.

Table 2

Percentage control by diclofop-methyl under three different temperature regimes

Species	Temperature after application	Rate of diclofop-methyl (kg a.i./ha) 0.016	0.031	0.063	0.125	0.25	0.5	1.0
Avena fatua	18/10°C	-	-	38.9	62.7	75.6	84.2	91.2
	25/17°C	-	-	27.2	61.8	76.2	78.1	85.2
	32/24°C	-	-	12.2	50.7	58.8	70.1	75.0
Phalaris canariensis	18/10°C	-	9.7	27.8	36.1	76.4	86.2	99.1
	25/17°C	-	16.4	12.6	26.9	70.9	76.9	81.4
	32/24°C	-	13.4	9.0	32.6	54.1	81.3	91.7
Echinochloa crus-galli	18/10°C	12.0	78.4	92.4	97.9	100	100	-
	25/17°C	16.6	88.8	99.0	100	100	100	-
	32/24°C	7.7	39.0	79.3	95.1	99.3	100	-
Eleusine indica var. africana	18/10°C	4.3	32.3	77.5	90.3	97.4	100	-
	25/17°C	21.6	57.9	99.5	100	100	100	-
	32/24°C	22.8	91.8	99.9	99.9	100	100	-
Setaria viridis	18/10°C	2.3	26.1	82.9	87.5	95.7	99.2	100
	25/17°C	2.4	44.5	88.7	97.3	99.9	100	100
	32/24°C	39.7	65.4	88.7	94.4	98.4	99.9	100

The values are based on dry weight (0% control corresponds to dry weight of untreated plants).

DISCUSSION

The data presented here clearly show that the conditions for maximal activity of diclofop-methyl are different amongst species. Best control is achievable under conditions suited for optimal growth of a given species. Such a correlation is not restricted to diclofop-methyl as pointed out by Muzik (1976). Because diclofop-methyl severely damages the meristems of susceptible plants (Köcher and Lötzsch, 1975) it is probable that actively growing meristems are more susceptible than those of slower growing plants.

Under field conditions the influence of temperature on herbicidal activity may partially be due to temperature dependent differences in wax quantity and thickness of the cuticles, and therefore rates of retention and penetration of herbicides can be altered (Hull *et al*. 1975). These influences were minimized in the experiments

Table 3

Calculated ED_{80} values with the range of confidence ($p = 0.05$) for plants cultivated under different temperatures after treatment with diclofop-methyl. (All values in kg a.i./ha.)

Species	Temperatures		
	18/10°C	25/17°C	32/24°C
Avena fatua	0.28	0.63	1.60
	0.22	0.34	0.65
	0.15	0.18	0.38
Phalaris canariensis	0.56	1.0	1.20
	0.38	0.66	0.74
	0.29	0.49	0.41
Echinochloa crus-galli	0.051	0.031	0.076
	0.045	0.029	0.069
	0.041	0.027	0.063
Eleusine indica var. africana	0.10	0.036	0.030
	0.085	0.034	0.027
	0.073	0.032	0.024
Setaria viridis	0.102	0.062	0.054
	0.088	0.056	0.049
	0.076	0.051	0.044

reported here by culture of all test plants under identical environmental conditions before herbicide application.

Furthermore, high temperature in the field is often accompanied by water stress as a result of increased evaporation and transpiration at high temperatures. It is known that plants growing under water stress are less susceptible to diclofop-methyl than well irrigated plants (Dortenzio and Norris, 1980). Any interference of water stress and high temperatures was excluded here by a good water supply of the test plants.

Thin cuticles and a good water supply may be the reasons for excellent control of Echinochloa, Eleusine and Setaria by diclofop-methyl at rates higher than 0.125 kg a.i./ha irrespective of the temperature. A distinct influence of temperature on herbicidal activity was observed only at sublethal rates in the range of 0.015 - 0.063 kg a.i./ha diclofop-methyl.

The activity of diclofop-methyl against Avena fatua at 32/24°C was not satisfactory, but in regions where this is a serious weed, an average temperature of 28°C normally does not occur during the developmental stage (2 - 4 leaf stage) best suited for good control by diclofop-methyl.

Regarding Phalaris, there seems to be a tendency of slightly better control under temperatures of 18/10°C.

The results show that diclofop-methyl controls different grass species under a wide range of temperatures, provided the environmental conditions are suited for growth of the considered grass species.

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ETHYLENE AS A COMPONENT OF HEAT-TREATED WILD OAT SEEDS (AVENA FATUA L) AND THE EFFECT OF HEAT TREATMENT ON GERMINATION

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Summary Ethylene and certain other gaseous hydrocarbons emanating from heated wild oat seeds (Avena fatua L) were identified and determined by gas chromatographic analysis.

Heat-treated wild oat seeds were sown throughout the growing season in several cereal fields of different soil types. Percentage germination of the heat-treated seeds were found to be equal to or higher than pricked seeds.

Straw-burning experiments in the autumn on two barley fields densely populated with wild oats showed significantly greater germination on the burnt plots.

INTRODUCTION

The primary objectives of the work described in this paper were: to investigate the effects of heat treatment on the viability and subsequent germination of wild oat seeds in the field; and to link the results of the field observations to farming practice.

It is known that wild oat seeds can survive in the soil for periods of up to nine years (Chancellor, 1976) and that their survival and spread into virgin fields continues unchecked. Although much work has been carried out on wild oats, there is little information available to allow an understanding of the breaking of dormancy.

The effects of temperature on seed dormancy have been reported by a number of workers (Burdett and Vidaver, 1971 ; Chancellor et al, 1971; Egley, 1972; Esashi and Leopold, 1969; Katoh and Esashi, 1975; Ketring and Morgan, 1969; Kurth, 1965; Stewart and Freebairn, 1969; and Toole et al, 1964). In practice, straw or stubble burning in the fields is a means of either killing or breaking the dormancy of weed seeds. Investigations of this are thoroughly documented (Cussans and Wilson, 1976; Ellis and Lynch, 1977; Thurston, 1964 ; Viel, 1963; Watkins, 1970; Wilson and Cussans, 1975; and Williams and Thurston, 1964).

The development of techniques for the identification and analysis of small quantities of gases by gas chromatography in the 1960's led to intensive investi--gations of ethylene and its function in the breaking of seed dormancy in inherently dormant seeds and allowed the gases emanating from germinating seedlings to be identified and determined. Evidence that ethylene stimulates the germination of dormant seeds and also emanates from germinating seeds has been presented by Burnett and Vidaver (1971), Egley and Dale (1970), Esashi and Katoh (1975), Esashi and Leopold (1969), Katoh and Esashi (1975), Stewart and Freebairn (1969), Ketring and Morgan (1969 and 1970), and Toole et al (1964).

The results given in this paper include the analysis of the hydrocarbon gases emanating from heated wild oat seeds,percentage seedling emergence of heat-treated wild oat seeds planted in the field and percentage seedling emergence after straw burning in the autumn.

METHOD AND MATERIALS

Fresh wild oat seeds (A. fatua L) have been collected yearly (1977 - 1980) from fields in Roxburghshire, Fife and Angus just prior to harvesting 'Golden Promise' barley. The seeds were stored in paper bags at room temperature and used when required.

Gas Analysis: A standard gas mixture containing known amounts of hydrocarbon gases was always used for calibration before running the experimental samples. 200 whole seeds, 200 denuded seeds and the husks from the denuded seeds were put in separate 170ml Pyrex conical flasks fitted with specially prepared sealed rubber caps. The flasks and caps had been previously thoroughly sterilised and washed several times in distilled water and oven dried before use.

The samples to be tested were heated in an oven at a temperature of 100°C for periods of over two hours. After heat treatment, the gases present were determined by Gas Chromatography (GLC). A gas sample of 1ml from each flask was drawn from each flask by a 1ml sterile plastic syringe and injected separately into the (GLC) apparatus, and the hydrocarbon gases were determined using a 1.5m by 6mm column of partially deactivated alumina at 110°C and a flame ionisation detector, the details of which are fully explained by Smith and Restall (1971).

Heat Treatment Germination Test: Samples of 100 seeds of A. fatua L were wrapped in paper towels and put in an electric oven kept at a temperature of 100°C (±2°C) for 6, 9 and 12 hours respectively. Four replicates of each heat treatment and, in addition, four samples of pricked seeds and untreated controls were planted in field soils on a randomized block design. Plot size was $1m^2$ with 100 seeds planted to a depth of 3cm. Seedling counts were made soon after emergence. The same procedure was repeated for each soil type.

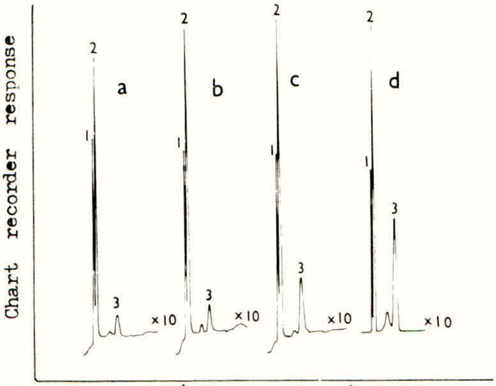
Straw Burning Germination Test: Two sites were selected in Fife and Angus respectively where the population of wild oat seedlings were greater than 2000 per m^2 in the spring of 1978. After harvesting 'Golden Promise' barley the straw was burnt and 10 plots of 1 m^2 from the burnt and unburnt areas respectively were marked out at random. The stubble from the unburnt plots was removed by hand to enable easy counting of the wild oat seedlings as they emerged. The same procedure was carried out for both sites and counts of the emerged seedlings were made on 25. 10. 78, - one month after burning.

RESULTS

The presence of small amounts of hydrocarbon gases after the hot flasks were allowed to cool to room temperature is shown by the results in Figure 1. Figure 2 shows that increased quantities of hydrocarbons were present when the contents were analysed in the hot state. The ethylene concentration in the hot gases were: Whole seeds = 7.5ppm, Denuded seeds = 6.0 ppm, Seed husks only = 1.5 ppm.

Figure 1

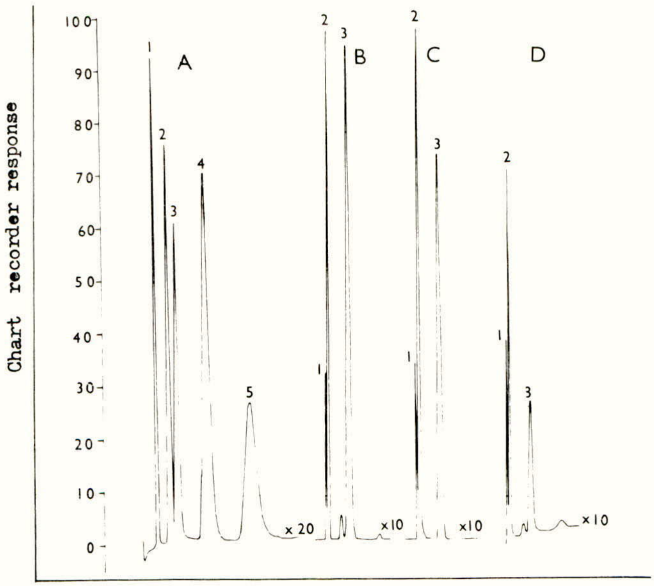
Chromatograms of gases emanating from wild oat seeds when heated to 100°C and cooled to room temperature (approx. 18°C) before analysis.



a) Empty flask and rubber cap. b) Husks only. c) Denuded seeds. d) Whole seed
Peak 1, methane. Peak 2, ethane. Peak 3, ethylene

Figure 2

Chromatograms of a standard gas mixture and those from hot wild oat seeds



A = Standard gas mixture. B = Whole seeds. C = Denuded seeds. D = Husks only.
Peak 1, methane. Peak 2, ethane. Peak 3, ethylene. Peak 4, propane. Peak 5 propy-lene.

Table 1 gives percentage germination of heat - treated seeds (12 h heat treatment) from two sites, which shows outstanding emergence compared with the other treatments.

Table 2 presents data from the stubble burning experiment and shows significantly better seedling emergence at P = 0.001 on the burnt areas.

Table 1

The Effect of Heat Treatment on the Germination of Wild Oat Seeds

Site 1 - a clay loam. Site 2 - a sandy clay loam.

Mean of percentage germination of heated seeds (100°C)

Treatments	Site 1. Fife % germination	Site 2. Roxburghshire % germination
Control	18.0	22.0
Pricked	78.3	66.6
6 hours heat	60.0	53.7
9 hours heat	73.4	63.7
12 hours heat	98.0	73.7
SED	4.82	5.94
P = 0.001		

The results show that all the treatments gave significantly greater germination that the untreated control. Pricked seeds germinated better than the 6 hour heat-treatment, but was not significantly different from the 9 and 12 hour treatments. The most surprising outcome of the experiment was the breaking of dormancy by the very high heat treatment used, which apparently had no detrimental effect on the seed embryo. There was good evidence for a linear increase in germination as the duration of the heat treatment increased over the 6 to 12 hour period.

Table 2

Analysis of wild oat data on burnt and unburnt barley fields

Mean number of wild oat seedlings per plot

Treatments	Site 1. Fife nos. of seedlings	Site 2. Angus nos. of seedlings
Burnt	104.3	113.1
Unburnt	11.4	34.9
SED	8.56	6.91
P = 0.001		

The results of the experiments show that significant differenc es at P = 0.001 occur between the burnt and unburnt areas. There was evidence that the seeds lying on the soil surface of the burnt areas were completely destroyed by the heat from the burning straw and stubble.

DISCUSSION

There is no published evidence for the presence of ethylene in wild oat seeds, or, on the survival of seeds heated at a temperature of 100°C for periods of 12 hours. The computed data for the percentage seedling emergence of different periods of heat treatment clearly demonstrate a linear response from the six to twelve hours. The most striking outcome of these experiments is the breaking of dormancy by the very high heat treatments for prolonged periods of time without affecting the viability of the embryo and subsequent germination.

These investigations indicate that on heating at 100°C ethylene and other hydrocarbons are emanated by the seeds and subsequently re-absorbed on cooling. Ethylene has been shown to break dormancy in some seeds and it seems likely that this is also the case with wild oat seeds. The experiments do not however rule out other possibilities, for example the breaking of physical barriers that prevent gaseous exchange in the seed.

The adsorption of volatile components when seeds were heated and cooled was observed by Taylorson (1979), and the role of ethylene in the germination processes were recorded by several researchers. Toole et al (1964), suggested that ethylene may mature the immature embryo, as in fruits; Ketring and Morgan (1969 and 1970) stated that the embryo of the peanut seed was the major site of ethylene production and its function must be to activate the quiescent cells into growth. Stewart and Freebairn (1969), felt that ethylene was the intermediate which caused germination, auxin and gibberellin having primarily induced the response by stimulating ethylene production. Esashi and Katoh (1975) on the other hand suggested that CO_2 is also an essential component, in association with the more avtive role of ethylene in the breaking of dormancy of cocklebur seeds. They concluded that, in the breaking of dormancy, ethylene provides for one of the essential increments of growth force, or 'thrust' required to exert radicle through the testa. These are a few statements indicative of the conflicting role ethylene may play in the breaking of dormancy in dormant seeds.

The results in Table 2 show significant seedling emergence after burning straw. This would however have no effect on the subsurface seeds, which would come up on the surface once the field was ploughed. The very heavily infested wild oat field in Fife - six hectares with more than 2000 seedlings per m^2-was offered for a long term eradication project and the programme is as follows: Immediately after the 'Golden Promise' barley harvest in 1978, the straw and stubble were burnt in the field. Later in the autumn of the same year, the field (Haig field) was rotary cultivated to a depth of 10cm, left for weeds to grow and chemically burnt at the end of May, 1979. The field was then direct drilled with a 3 year grass ley, and grazed in the autumn. In 1980, two cuts were made for silage, and this procedure would continue so as to cut off any wild oat plant which may emerge with the grass. After three years the field would be burnt off chemically and direct drilled with barley for the next five years, during which time the bank of stored seeds in the soil would be completely destroyed, thus leaving a wild oat free field.

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