CHEMICAL CONTROL OF ALOPECURUS MYOSUROIDES IN WINTER CEREALS

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Summary A number of herbicides applied in autumn, winter or spring was compared for effect on A. myosuroides in seven winter wheat, and five winter barley crops in 1977 and 1978. Crop yields were measured and margins over chemical costs calculated. At high infestations of A. myosuroides isoproturon and chlortoluron gave excellent control, high yield responses and wide margins over chemical cost, at pre-emergence, early post-emergence, and mid-winter timings. Terbutryne, a terbutryne tri-allate sequence, and AC92553 were equally effective at the earliest timing. Clofop-isobutyl and diclofop-methyl were both effective and profitable at the midwinter timing. Clofop-isobutyl gave excellent A. myosuroides control when applied in the spring but isoproturon gave a better return. At present chemical costs and current grain prices of winter wheat or winter barley with moderate infestations of A. myosuroides can easily withstand the cost of grass weed herbicides, providing they can effectively control such infestations.

INTRODUCTION

This series of trials is a continuation of a programme undertaken by ADAS Eastern Region Agronomy Department, to test a wide range of herbicides applied at different times, for the control of A. myosuroides in winter wheat and winter barley.

The large number of trials gives good coverage of seasonal, soil, and weed variation, and provides the experience and information necessary for reliable advice to farmers and the industry generally.

1977 was a difficult season with very little germination of grass weed in the autumn of 1976. For that reason, most of the results in this paper refer to trials carried out in 1978, a year of heavy, A. myosuroides infestations.

METHOD AND MATERIALS

Two trials were completed in 1977, one each on winter wheat and winter barley, and ten trials in 1978, six on winter wheat and four on winter barley. All the trials were superimposed on commercial crops where naturally occurring infestations of A. myosuroides were expected.

The herbicide treatments are listed in Table 1. Site details, treatment application dates, stage of growth of the crop and A. myosuroides are given in Table 2.

Plot size was 10m x 2.7m and all treatments were applied using a modified van der Weij sprayer with size '00' fan jets at a pressure of 2.2 bar. Application rate was 225 l/ha. A randomised block with three replicates was used.

The effect of the treatments on A. myosuroides was assessed by removing all the plants in a number of quadrats in June or July and measuring the total length of seed heads. This gave a measure of seed return and weed control. In relation to spring plant population, 10m seed head length/m^2 is roughly equivalent to 50 plants/m^2, a light infestation, where an economic response to herbicide application becomes likely. An infestation of 10-30 m/m^2 could be considered moderate, and more than 30 m/m^2, heavy.

RESULTS

At the time of writing statistical analyses of the results (Tables 3-4) were not available due to the late harvest of 1978. They may be sought from the authors at a later date.

The appearance a dash (-) in any table indicates that the information, or data are not available.

Table 1

Treatments

	Common name	Rate a.i. kg/ha	Trial series 1976/77	Trial series 1977/78
Pre emergence				
1	Chlortoluron	3.6	✓	✓
2	Isoproturon	2.5	✓	✓
3	Terbutryne	2.8	✓	✓
4	Nitrofen	2.1	✓	✓
5	Methabenzthiazuron	3.2	✓	✓
6	Tri-allate + methabenzthiazuron	2.5 + 2.5	✓	✓
7	Tri-allate + terbutryne	2.5 + 1.4	✓	✓
8	AC92553	2.0		✓
Early post emergence				
9	Chlortoluron	3.2	✓	✓
10	Isoproturon	2.5	✓	✓
Post emergence, winter				
11	Chlortoluron	3.2	✓	✓
12	Isoproturon	2.5	✓	✓
13	Clofop-isobutyl	0.5	✓	✓
14	Barban + metoxuron/simazine	0.3 + 2.0		✓
15	Diclofop-methyl	1.1		✓
16	Isoproturon + difenzoquat	2.1 + 0.5		✓
Early spring				
17	Chlortoluron	2.7	✓	✓
18	Isoproturon	2.1	✓	✓
19	Clofop-isobutyl	0.5	✓	✓
20	Diclofop-methyl	1.1	✓	✓
21	Clofop-isobutyl + diclofop-methyl	0.25 + 0.8		✓
22	Difenzoquat	1.0		✓
23	Difenzoquat	0.5		✓
24	Flamprop-isopropyl	0.6		✓
25	Flamprop-isopropyl	0.3		✓
26	Metoxuron	4.4	✓	✓
Late spring				
27	Clofop-isobutyl	0.5	✓	✓

Table 2

Site Details : Winter Wheat and Winter Barley

	1977	1978						1977	1978			
Site:	1	2	3	4	5	6	7	1	2	3	4	5
Soil texture	ZL	SCL	VFSL	ZL	FSL	SCL	CL	SCL	ZL	ZL	ZL	ZL
Variety	Bouquet	Flanders	Flanders	Hobbit	Bouquet	Bouquet	Flinor	M. Otter	Sonja	M. Otter	M. Otter	M. Otter
Drilling Date	16 Oct	13 Oct	13 Oct	20 Oct	15 Nov	11 Nov	8 Nov	Oct	1 Nov	15 Oct	8 Oct	31 Oct
Seedbed at first spray	-	Very cloddy	Dry cloddy	Wet	Moist	Moist	Dry cloddy	-	Dry	Very Dry Good	Very Dry	-
Treatment Nos.	**Dates and growth stages (Zadoks) of crop and weed**											
Pre.em 1-8	27 Oct	19 Oct	20 Oct	8 Nov	23 Nov	23 Nov	18 Nov	-	12 Nov	19 Oct	13 Oct	9 Nov
Early p.em 9-10	15 Nov	22 Nov	28 Nov	28 Nov	3 Feb	3 Feb	29 Dec	-	27 Nov	4 Nov	4 Nov	17 Nov
Crop	10	10	10-11	11	12	12	11		11	11	11	11
A.myosuroides	10	10-12	11-12	11-12	12	12	12		-	11	10	-
P.em.winter 11-15	21 Jan	31 Dec	29 Dec	7 Mar	6 Mar	4 Mar	7 Mar	-	8 Jan	21 Dec	14 Dec	15 Dec
Crop	13	13	13	22	13	13	13		12	12-13	12	12
A.myosuroides	12	13	12	20	13	13	13		-	-	-	-
E. spring	18 Apr	30 Mar	30 Mar	17 Apr	3 May	10 May	19 Apr	9 Apr	6 Mar	7 Mar	6 Mar	7 Mar
Wheat 17-26												
Barley 17-21,26												
Crop	22-30	24	24	23-24	24	30	15.23-24	15.26	15.23	15.22	14.22	-
A.myosuroides	24	25	23-24	23	25	30	26	25	23	21	21	-
L. spring	26 May	14 Apr	10 May	9 May	-	16 May	17 May	-	13 Apr	9 May	9 May	10 May
Wheat												
Barley 22-25,27												
Crop	37	25-26	32	30		30-31	31		19.27	31	31	30
A.myosuroides	45-50	25	25-45	30		30	30		27	30	50	50

Table 3 Grain yield as percentage of control yield (15% moisture content) 1978

Treatment		Winter wheat sites							Winter barley sites					
		2	3	4	6	7	Mean	*Margin £/ha over herb	2	3	4	5	Mean	*Margin£/ha over herb.
Control	t/ha	4.39	2.52	4.27	3.26	3.48	3.58		3.44	3.76	2.35	3.70	3.31	
Pre emergence														
1 Chlortoluron		132	227	106	135	124	145	99	111	122	139	129	125	16
2 Isoproturon		131	215	107	125	116	139	80	128	118	140	118	126	18
3 Terbutryne		151	184	124	127	126	142	105	119	114	137	124	124	29
4 Nitrofen		110	184	120	139	112	133	81	110	116	124	122	118	19
5 Methabenzthiazuron		95	144	108	121	102	114	12	101	80	120	114	104	-23
6 Tri-all. + methabenz.		142	154	128	130	115	134	70	121	126	137	104	122	15
7 Tri-all. + terbutryne		138	183	123	144	128	143	97	136	117	156	116	131	35
8 AC92553		133	204	102	127	125	138	88	118	124	137	115	124	26
Early post emergence														
9 Chlortoluron		143	207	125	143	104	144	96	107	124	159	132	130	29
10 Isoproturon		147	198	115	147	119	145	98	130	121	143	148	136	41
Post emergence, winter														
11 Chlortoluron		132	103	129	140	116	124	34	122	117	150	135	131	31
12 Isoproturon		122	221	119	145	122	146	101	98	114	151	146	127	21
13 Clofop-isobutyl		122	173	108	111	115	126	57	113	123	168	129	133	52
14 Barb. + metox/sim.		137	205	115	140	106	141	97	131	120	122	128	125	29
15 Diclofop-methyl		110	201	109	139	129	138	94	107	115	179	136	134	55
16 Isopro. + difenz ½		139	198	112	116	-	141	71	117	123	125	140	126	10
Early spring														
17 Chlortoluron		109	161	124	126	102	124	40	137	115	110	108	118	7
18 Isoproturon		131	208	118	125	113	139	87	141	114	-	153	136	57
19 Clofop-isobutyl		107	-	103	129	96	109	6	-	118	124	-	121	21
20 Diclofop-methyl		106	181	116	112	93	122	44	85	126	125	-	112	3
21 Clof. ½ + diclof. ⅔		135	196	119	113	109	134	78	106	-	92	91	96	-37
22 Difenzoquat		92	89	110	102	90	97	- 39	81	84	100	80	86	-62
23 Difenzoquat ½		98	128	104	109	90	106	4	98	95	127	99	105	- 3
24 Flamprop-isopropyl		97	145	101	111	97	110	4	106	97	112	-	105	-16
25 Flamprop-isopropyl ½		83	81	110	103	113	98	- 20	112	104	107	-	108	4
26 Metoxuron		95	-	119	119	118	113	13	122	123	133	123	125	27
Late spring														
27 Clofop-isobutyl		99	187	100	114	96	119	35	-	93	108	109	103	-17

*Wheat priced at £87/tonne and barley (feed) £70/tonne U.K. weighted ave. Aug. 1977 to July 1978.

Table 4 Alopecurus myosuroides, percentage control 1977-78

Treatment		Winter wheat sites								Winter barley sites					
		1	2	3	4	5	6	7	Mean	1	2	3	4	5	Mean
Control	Head length m/m^2	3	40	78	10	6	28	37	29	40	8	46	58	47	40
Pre emergence															
1 Chlortoluron		99	92	96	100	98	97	86	95	-	98	53	94	86	83
2 Isoproturon		93	95	96	99	88	78	70	88	-	85	26	96	85	73
3 Terbutryne		97	92	94	100	72	89	89	90	-	88	69	98	94	87
4 Nitrofen		71	56	74	100	97	90	62	79	-	69	52	-	-	60
5 Methabenzthiazuron		68	50	30	88	78	25	35	53	-	89	0	89	-	59
6 Tri-all. + methabenz		65	87	32	76	99	96	81	77	-	71	62	96	60	72
7 Tri-all. + terbutryne		-	86	96	100	87	95	96	93	-	92	99	99	95	96
8 AC92553		-	96	94	100	100	96	92	96	-	95	91	97	-	94
Early post emergence															
9 Chlortoluron		98	93	98	92	100	99	96	97	-	100	70	82	89	85
10 Isoproturon		96	93	94	96	100	100	93	96	-	91	83	77	-	84
Post emergence, winter															
11 Chlortoluron		98	88	96	94	85	95	90	92	-	88	81	84	-	84
12 Isoproturon		99	99	93	94	86	98	98	95	-	93	75	96	96	90
13 Clofop-isobutyl		99	100	99	99	98	100	95	99	-	100	100	99	100	100
14 Barb. + metox/sim.		-	74	95	74	88	80	57	78	-	98	40	82	-	73
15 Diclofop-methyl		-	100	96	92	96	99	83	94	-	100	99	86	-	95
16 Isopro. + difenz. ½		-	55	97	63	55	77	-	69	-	96	72	-	-	84
Early spring															
17 Chlortoluron		68	33	68	72	50	67	25	55	98	86	50	-	63	74
18 Isoproturon		95	79	74	68	52	47	67	69	99	90	83	-	89	90
19 Clofop-isobutyl		99	99	99	99	97	90	88	96	99	-	99	99	-	99
20 Diclofop-methyl		5	60	56	38	44	4	14	32	65	67	76	82	-	72
21 Clof. ½ + diclof. ⅔		-	94	88	55	80	73	71	77	-	79	25	-	80	61
22 Difenzoquat		-	0	0	9	0	0	11	3	-	0	0	-	-	0
23 Difenzoquat ½		-	33	0	76	0	0	17	21	-	0	0	-	-	0
24 Flamprop-isopropyl		-	20	0	49	9	38	4	20	-	89	38	-	-	64
25 Flamprop-isopropyl ½		-	18	0	58	48	37	0	27	-	0	75	-	-	38
26 Metoxuron		83	-	-	70	82	82	75	78	99	88	83	-	82	88
Late spring															
27 Clofop-isobutyl		44	87	86	97	-	57	-	74	-	-	99	99	78	92

Notes: Extra treatment barban + metoxuron/simazine, early spring, sites 1, wheat - 82%, barley 97%

DISCUSSION

Previous reports, North and Livingston (1970), Baldwin and Livingston (1974) and Hubbard, Livingston and Ross (1976) have given much comparative data on the efficiency of A. myosuroides herbicides in winter wheat.

They have established the reliability of chlortoluron and isoproturon applied just post-emergence of crop and weed, both in terms of weed control and enhanced crop yields from early removal of A. myosuroides competition.

The large number of sites in the 1977/8 programme, as in previous years, enable consistent effects to be seen and conclusions drawn with reasonable confidence.

At various A. myosuroides infestation densities in winter wheat and winter barley good control, accompanied by useful returns on investment in chemical were obtained with chlortoluron, isoproturon, terbutryne, and a terbutryne tri-allate sequence applied pre-emergence of crop and weed. A new material AC92553 also performed well, despite some damage symptoms in winter wheat, which seemed not to affect yields. The margins over chemical cost ranged from £70 to £105/ha for winter wheat and £15-£41/ha for winter barley. The poorer returns from winter barley are probably a combination of poorer A. myosuroides control, poorer crop tolerance (e.g. chlortoluron with Maris Otter) and the lower value allocated to the grain.

Isoproturon was more effective applied just post-emergence. This improved the margin, compared with the pre-emergence treatment, from £80-£98/ha in wheat, and from £18-£41/ha in winter barley. While in theory it would be desirable to exploit the better activity of isoproturon, and from previous years' work, chlortoluron, applied at this timing, ground conditions in practice are often unsuitable for spraying at this time.

Clofop-isobutyl, diclofop-methyl and a barban, metoxuron, simazine mixture applied in mid-winter were also successful with margins of £57-£97/ha in winter wheat and £29-£55/ha in winter barley. Control of A. myosuroides was good with the first two chemicals, and the improved margins (£52 and £55/ha) in winter barley over earlier treatments may reflect better crop tolerance as well as lower chemical costs of the two materials.

Isoproturon gave good returns in both crops in the mid-winter and spring applications, although the control of A. myosuroides was poorer in spring. Chlortoluron, on the other hand, was not so effective in the spring, and this is reflected in a smaller yield response and poorer margins than isoproturon. The greater residual activity and lesser contact activity of chlortoluron compared with isoproturon makes it more suitable for the early pre-emergence application and vice versa.

A. myosuroides control from the spring treatments with the exception of clofop-isobutyl was inferior to the better autumn treatments. Even with this material the return was low, most of the weed competition having taken place by the time of spraying. L-flamprop-isopropyl was not very active on A. myosuroides with a low or negative return, and there were indications of yield loss with difenzoquat, a probable crop damage effect.

In general, for reliable A. myosuroides control and return on investment in chemical, autumn or mid-winter applications of the suitable herbicides are preferred, and spring treatments resorted to only when really necessary.

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NOTES

MIXTURES OF DIFENZOQUAT AND DICHLORPROP FOR THE CONTROL OF AVENA FATUA AND BROAD-LEAVED WEEDS IN SPRING BARLEY

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Summary In five field experiments in 1975 and 1976 the activity of difenzoquat alone or in mixtures with the potassium salt or the iso-octyl ester of dichlorprop (with or without the octanoates of bromoxynil and ioxynil) on *Avena fatua* in spring barley was studied. The potassium salt of dichlorprop at doses of 0.42 kg a.i./ha and 2.8 kg a.i./ha reduced the activity of difenzoquat when in mixture; the reduction was particularly marked at the higher dose. At the same doses, the ester of dichlorprop, alone or in mixture with bromoxynil and ioyxnil, had little effect on the activity of difenzoquat on either the crop or *A. fatua*. The advantages to the farmer in economic and practical terms of being able to apply herbicides in mixture rather than separately are discussed.

Résumé Cinq expériences de plain-champ ont été mises en place en 1975 et 1976 pour etudier l'activité du difenzoquat seul on en mélanges avec le sel de potassium ou l'ester d'iso-octyl du dichlorprop (avec on sans les octanoates de bromoxynil et d'ioxynil) dans la lutte contre *Avena fatua* en orge d'été. Le dichlorprop sel de potassium à 0,47 kg m.a./ha et 2,8 kg m.a./ha, mélangé au difenzoquat, a diminué l'activité de celui-ci, surtout à la dose plus élevée. Le dichlorprop ester aux mêmes doses, seul ou mélangé au bromoxynil ou à l'ioxynil, a eu peu d'influence sur l'activité du difenzoquat, aussi bien vis-à-vis de l'orge que de l'*A. fatua*. Les avantages économiques et pratiques pour l'agriculteur d'une application d'herbicides en mélange plutôt que séparément sont discutés.

INTRODUCTION

Economic and logistic factors are of increasing importance in the use of herbicides in spring cereals. Applications need to be made at the optimum time if maximum benefit is to be obtained. There are therefore obvious advantages if herbicides can be applied in mixture rather than as individual treatments. However the compounds to be mixed must be compatible both biologically and physically if they are to remain effective.

Gruenholz *et al* (1974) in Spain found that difenzoquat could be applied in mixture with ester formulations of 2,4-D and MCPA with little or no reduction in the effectiveness of difenzoquat on *Avena* spp. Arnold and O'Neal (1973) in Canada showed that amine salts of the same compounds reduced activity whereas Miller and Nalewaja (1973) reported that the dimethylamine salts did not reduce difenzoquat activity on *Avena fatua*.

The five experiments described in this paper invesigate the effect of salt and ester formulations of dichlorprop and a commercial mixture of dichlorprop, ioxynil and bromoxynil esters on the activity of difenzoquat on *A. fatua* in spring barley.

METHOD AND MATERIALS

Details of the experiments are given in Table 1. In 1975 the herbicide treatments were:- difenzoquat (65%w.s.p) at 0.00, 0.50, 0.75 and 1.00 kg a.i./ha, with or without a mixture of iso-octyl esters of dichlorprop, bromoxynil and ioxynil (550 g/l e.c.), (Oxytril-P) at 0.77 kg a.i./ha (equivalent to 0.42 kg a.i./ha dichlorprop). In 1976 the treatments were:- difenzoquat (65%w.s.p) at 0.00, 0.5, 1.0 and 1.5 kg a.i./ha with or without dichlorprop potassium salt (500 g/l a.e.) and dichlorprop iso-octyl ester (300 g/l e.c.) at 0.42 and 2.80 kg a.i./ha. The difenzoquat was also used with or without the mixture of iso-octyl esters of dichlorprop, bromoxynil and ioxynil as in 1975. All the treatments with difenzoquat (alone or in mixture) included 500g/l Agral 90 and 6 g/l anti-foam. The tank mixtures were made up just prior to application and were apparently physically and chemically compatible, i.e. there was no sedimentation or flocculation.

The experiments were on commercially grown crops of spring barley with natural populations of *A. fatua* and broad-leaved weeds. Treatments were applied with a modified Oxford Precision Sprayer at a volume of 250 l/ha and a pressure of 2.1 bar, through four matched 8002 Teejets. The plots were 2 m x 6 m. The experimental design was a randomised block with three replicates.

In the 1975 experiments, *A. fatua* was assessed just prior to harvest by counting the number of panicles in three quadrats of 1 m^2 on each plot. In 1976 four quadrats per plot were counted. In addition, panicles were graded for size and the numbers of spikelets on each plot estimated from this data (Holroyd, 1972). Effects on the broad-leaved weeds were scored and any effects on the crop noted.

RESULTS

1975 The normally recommended dose of difenzoquat is 1 kg a.i./ha but all the treatments with difenzoquat alone gave good (over 90%) control of *A. fatua* except 0.5 kg a.i./ha sprayed at the earlier date on site 1 (Knighton)(Table 2). The later treatments were the more effective (over 98% control).

The addition of the mixture of dichlorprop, bromoxynil and ioxynil (esters) reduced the effectiveness of difenzoquat slightly at both times of application at site 2 (Notgrove) (up to 10%) but the reductions were only significant statistically at the second date. At site 1 the dichlorprop mixture reduced effectiveness slightly (up to 6%) at the earlier date but had no effect later. The dichlorprop mixture without difenzoquat had no significant effect on the *A. fatua*. None of the treatments had any noticeable effect on the crop except for an increase in vigour due to weed removal.

1976 In 1976, treatments were applied on only one date. The stages of growth of the crops and *A. fatua* were similar to those at the first date of treatment in 1975 (table 1). All the treatments with difenzoquat alone gave better than 90% control of the *A. fatua* (table 3). It was most effective on site 4 (Crudwell) where the lowest dose gave 100% control.

The addition of the dichlorprop mixture very slightly reduced the effectiveness of difenzoquat at all three sites, but the reduction was only significant statistically at site 4 where the numbers of *A. fatua* surviving any of the treatments were very small. The ester of dichlorprop without bromoxynil and ioxynil also had very little effect on the activity of difenzoquat, even at the higher dose of 2.8. kg a.i. /ha. In contrast the potassium salt of dichlorprop, particularly at the higher dose, reduced difenzoquat activity at all three sites. The antagonism between the two products was particularly noticeable at site 5 (Kennet) where *A. fatua* control from a recommended dose of difenzoquat (1 kg a.i./ha) was reduced from 98% to 68% by the addition of the higher dose of the dichlorprop salt. At the lower dose of dichlorprop antagonism was less severe. The effectiveness of the dichlorprop, and its mixture, on the broad-leaved weeds was not noticeably reduced by the presence of the difenzoquat.

None of the treatments containing dichlorprop but no difenzoquat had any significant effect on the A. fatua, in fact the A. fatua and the crop benefitted to some extent by the removal of the broad-leaved weeds.

DISCUSSION

Economic benefits can result from the tank mixing of herbicides, which are compatible, and although these may be difficult to quantify in economic terms they are nevertheless very real. There is the saving in cost from reducing the number of applications. Even if a farmer has his own equipment this can amount to £6/ha. Also the crop is subjected to one less pass with the tractor and sprayer. The effect on crop yield of an additional pass is variable, being dependent on such factors as soil type and condition, weather and crop growth stage. Accurate measurement is difficult, but investigations by MAFF Experimental Husbandry Farms in recent years (UK Min. Ag. Fish and Food 1973-77) have shown that an extra pass with tractor and sprayer between growth stages 4 and 6 (FeekesLarge), can reduce the yield of a cereal crop by up to 9%. A 5% reduction of a good spring barley crop could represent a loss of £15-£20/ha.

Probably the most important factor and one of the least easily quantified is the saving in time which tank mixing allows. An extra spraying day gained could make all the difference between a treatment being applied at the correct time and either at the wrong time or possibly not at all. A wrongly timed treatment can have a marked effect on crop yield due to crop damage and/or poor weed control. Pessala (1976) found that delaying treatment for A. fatua in spring barley by 5-15 days reduced yields by 10% or more. Lallukka (1976) had similar results when he delayed the control of broad leaved weeds.

Losses from not tank mixing can be £50-£60/ha but as our experiments show, the herbicides being mixed must be compatible. Mixing incompatible products can eliminate all the potential gains. The potassium salt of dichlorprop for example seriously reduced the activity of difenzoquat but the iso-octyl ester did not. Lutman and Thornton (1978) found that when mixed with diclofop-methyl the iso-octyl ester of dichlorprop could cause severe ear deformity in spring barley but there was no evidence of this in our experiments.

The reasons for the antagonism between salts of dichlorprop and difenzoquat are unknown. Physical reasons seem unlikely although it is tempting to speculate about the significance that difenzoquat is water soluble and in the water phase, whereas esters are in the oil phase of a formulation. Sharma et al (1976) in Canada found that ester formulations of 2,4-D and a bromoxynil/MCPA mixture increased the penetration of C_{14} labelled difenzoquat into A. fatua leaves nearly three fold whereas an amine salt of 2,4-D had no effect on penetration. The problem of the compatibility of biologically active compounds is complex and it seems likely that for absolute reliability each individual mixture will need to be tested, for not only must the active ingredients be compatible, but also the various formulating agents.

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Table 1

Experiment Details

Site	1 Knighton	2 Notgrove	3 Knighton	4 Crudwell	5 Kennet
Barley variety	Berac	Golden Promise	Armelle	Hassan	Mazurka
Sowing date	15.3.75	15.4.75	28.3.76	15.3.76	3.3.76
Treatment date(1)	19.5.75	20.5.75	30.4.76	6.5.76	13.5.76
date(2)	3.6.75	4.6.75			
Stage of growth*					
Crop date (1)	13.21-14.23	14.21-14.23	14.21-15.23	14.21-15.22	15.21-16.22
date (2)	15.31-16.31	15.31-16.31			
A. fatua date (1)	10-14	10-14	10-15	10-15	10-14
Mean	12-13	-	13-14	13-14	13-14
date (2)	12-17	12-17			
Mean	14-15	-			
Assessment date					
Crop damage	27.6.75	27 6.75	8.76	8.76	8.76
Panicle counts	29.7.75	7.8.75	29.6.75	2.7.76	7.7.76
B.ld. weed scores	31.7.75	7.8.75	14.7.76	-	15.7.76

* As defined by Zadoks, Chang and Konzak (1974)

Table 2

Effect of difenzoquat alone or in mixture with dichlorprop bromoxynil and ioxynil (iso-octyl esters) on *A. fatua* spikelet production

Spikelets/m^2 - transformed log (10x+1), detransformed data (in parentheses)

1975 Experimental Sites		1. Knighton		2. Notgrove	
Treatments	Date	1	2	1	2
	dose kg/ha				
difenzoquat alone at	0.50	3.48 (302)	2.28 (19)	3.22 (166)	1.21 (1)
	0.75	2.65 (45)	1.57 (4)	2.50 (32)	0.64 (0)
	1.00	2.40 (25)	1.30 (2)	1.89 (8)	0.00 (0)
	Mean	2.84 (69)	1.72 (5)	2.54 (35)	0.62 (0)
difenzoquat at	0.50	3.64 (436)	2.29 (19)	3.38 (240)	2.41 (26)
+ 0.77 kg/ha	0.75	3.06 (115)	1.20 (2)	1.64 (4)	1.89 (8)
dichlorprop mix	1.00	2.83 (68)	1.11 (1)	2.32 (21)	1.06 (1)
	Mean	3.18 (151)	1.53 (3)	2.45 (28)	1.79 (6)
dichlorprop mix at	0.77	4.05 (1122)	4.22(1659)	3.71 (513)	3.51 (323)
	0.38	4.10 (1259)	4.24(1738)	3.45 (282)	3.76 (575)
Control		4.24 (1738)		3.68 (479)	
S.E. treatments		± 0.22		± 0.32	
dates		± 0.11		± 0.16	

Table 3

Effect of difenzoquat alone or in mixture with different formulations of dichlorprop on A. fatua spikelet production

Spikelets/m^2 - transformed log (10x+1) and detransformed data (in parentheses)

1976 Sites

3. Knighton

difenzoquat dose kg/ha	0	Mixture 0.77	dichlorprop salt 2.80	dichlorprop salt 0.42	dichlorprop ester 2.80	dichlorprop ester 0.42
0	4.04 (1096)	4.17 (1479)	4.32 (2089)	4.07 (1175)	4.08 (1202)	4.02 (1047)
0.5	2.90 (79)	3.24 (174)	3.76 (575)	3.76 (575)	2.48 (30)	3.36 (229)
1.0	1.77 (6)	2.04 (11)	3.63 (426)	2.72 (52)	1.26 (2)	1.69 (5)
1.5	0.41 (0)	1.47 (3)	2.82 (66)	1.75 (6)	1.74 (5)	1.45 (3)
Overall Mean	2.28 (19)	2.73 (54)	3.63 (426)	3.08 (120)	2.39 (24)	2.63 (43)
Treated Mean	1.69 (5)	2.25 (18)	3.40 (251)	2.74 (55)	1.83 (7)	2.17 (15)

S.E. treatments ± 0.39, treated means ± 0.22

4. Crudwell

difenzoquat dose kg/ha	0	Mixture 0.77	dichlorprop salt 2.80	dichlorprop salt 0.42	dichlorprop ester 2.80	dichlorprop ester 0.42
0	4.11 (1288)	3.89 (776)	3.83 (676)	3.98 (955)	4.06 (1148)	4.04 (1096)
0.5	0 (0)	1.46 (3)	1.35 (2)	1.83 (7)	1.19 (1)	0.36 (0)
1.0	0 (0)	0 (0)	1.75 (6)	0 (0)	0.82 (1)	1.07 (1)
1.5	0.36 (0)	0.72 (1)	0.46 (0)	0.52 (0)	0.46 (0)	0 (0)
Overall Mean	1.12 (1)	1.52 (3)	1.85 (7)	1.58 (4)	1.63 (4)	1.34 (2)
Treated Mean	0.12 (0)	0.73 (1)	1.19 (1)	0.78 (1)	0.82 (1)	0.48 (0)

S.E. treatments ± 0.25, treated means ± 0.14

5. Kennet

difenzoquat dose kg/ha	0	Mixture 0.77	dichlorprop salt 2.80	dichlorprop salt 0.42	dichlorprop ester 2.80	dichlorprop ester 0.42
0	3.56 (363)	3.48 (302)	3.57 (371)	3.49 (309)	3.79 (616)	3.39 (245)
0.5	2.01 (10)	2.08 (12)	3.34 (219)	2.94 (87)	2.18 (15)	2.65 (45)
1.0	1.50 (3)	1.51 (3)	3.10 (126)	2.08 (12)	1.23 (2)	0.47 (0)
1.5	0.66 (0)	0.56 (0)	3.04 (110)	1.06 (1)	1.09 (1)	1.07 (1)
Overall Mean	1.93 (8)	1.91 (8)	3.26 (182)	2.39 (24)	2.07 (12)	1.90 (8)
Treated Mean	1.39 (2)	1.38 (2)	3.16 (144)	2.03 (11)	1.50 (3)	1.40 (2)

S.E

S.E. treatments ± 0.34, treated means ± 0.19

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THE CONTROL OF AVENA FATUA AND BROAD-LEAVED WEEDS IN SPRING BARLEY WITH HERBICIDE MIXTURES CONTAINING DICLOFOP METHYL AND ITS ECONOMIC SIGNIFICANCE

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Summary In nine experiments between 1975 and 1977 the performance of several doses of diclofop methyl alone and in mixture with a number of broad-leaved weed herbicides, against Avena fatua in spring barley, has been studied. A formulated mixture of ioxynil, bromoxynil and dichlorprop esters (0.77 kg/ha) did not adversely affect the performance of diclofop methyl but mecoprop salt (2.24 kg/ha), dichlorprop salt and ester (2.8, 0.42 kg/ha) were antagonistic. There were indications that the salt formulation of dichlorprop was more antagonistic than the ester. The reasons for the lack of antagonism from the ioxynil, bromoxynil and dichlorprop product, when dichlorprop on its own was antagonistic are discussed. In 1977 diclofop methyl alone damaged the barley but these symptoms were alleviated when it was mixed with the broad-leaved weed herbicides. The economic significance of mixtures is also discussed.

Resume Entre 1975 et 1977 il a été étudié le comportement de plusieurs doses du diclofop méthyl, soit seul, soit en association à certains herbicides d'activité sur dicotylédones, dans la lutte contre Avena fatua en cultures d'orge du printemps. Un produit commercial associant des esters de l'ioxynil, du bromoxynil et du dichlorprop (0.77 kg/ha) n'a pas nui au comportement du diclofop méthyl, par contre, le sel du mécoprop (2.24 kg/ha) et le sel, ainsi que l'ester du dichlorprop (2.8 et 0.47 kg/ha) ont fait preuve d'antagonisme, plus marqué peut-être de la part du sel du dichlorprop. Les raisons de l' absence d'antagonisme de la part du produit ioxynil + bromoxynil + dichlorprop sont discutées. En 1977 le diclofop méthyl seul a provoqué des dégâts dans l'orge mais les symptômes on disparu lorsqu'il a été associé aux herbicides anti-dicotylédones. On considère l'importance, economique de l' emploi d'associations de désherbants.

INTRODUCTION

The use of herbicide mixtures to widen the range of species controlled in one operation is well established with compounds for broad-leaved weed control. However, the control of grass and broad-leaved weeds in one operation is less well established although some mixtures are now available. There are clear economic advantages in the use of this type of mixture in spring cereals. As the spraying season in the spring is often very short, it is difficult for the farmer to spray grass and broad-leaved weeds at the correct time, particularly if each field has to be sprayed twice. Inevitably many fields are sprayed too late or not at all, resulting in yield depression through increased weed competition and/or crop damage. These difficulties can be alleviated by using herbicide mixtures that control the weeds in one operation.

Although some broad-leaved weed herbicides mix readily with those for the control of <u>Avena</u> spp. with no adverse effects on performance, others do not. Diclofop methyl [2(4-(2,4-dichlorophenoxy) phenoxy) methyl propionate], a post-emergence herbicide for the control of <u>Avena</u> spp. in barley, wheat and some broad-leaved crops (Schumacher & Schwerdtle 1975; Hewson, 1976), has been reported by Todd and Stobbe (1974) and by O'Sullivan <u>et al</u>. (1977) to mix satisfactorily with ester formulations of benzonitriles but not with growth regulators (e.g. 2,4-D). Thus mixtures of diclofop methyl with some broad-leaved weed herbicides may be practicable.

Bearing in mind the economic and logistic advantages of mixtures we have studied the effects of several doses and formulations of growth regulator and benzonitrile broad-leaved weed herbicides on the performance of diclofop methyl against <u>A. fatua</u> in spring barley. In addition we have monitored the influence of these mixtures on the crops and on the broad-leaved weeds.

METHOD AND MATERIALS

Nine field experiments were carried out between 1975 and 1977. All were of factorial design with three replicates, each plot measuring 2 x 6 m. Details of the experimental sites, dates of treatment and the stages of growth of <u>A. fatua</u> and barley, together with the dates of assessment are given in Table 1. The treatments were all applied with a modified Oxford Precision Sprayer with a 2 m boom delivering 250 l/ha at a pressure of 2.1 bars. Herbicide doses are expressed in terms of active ingredient (a.i.). <u>A. fatua</u> was assessed as described by Holroyd (1972), from which the numbers of spikelets/m^2 were calculated.

<u>Table 1</u>

<u>Experimental Details</u>

Site	Barley variety	Herbicide application date	Barley Lvs/plant	Barley Tillers/plant	*A. fatua* lvs/plant Range	*A. fatua* lvs/plant Mean	Dates of Assessment: Crop damage	Panicle counts	Blw* scores
1 Notgrove	Golden Promise	20 May 75	4	1-3	em^{+}-4	2-3	27 June	7 Aug	7 Aug
		4 June 75	$5\frac{1}{2}-6\frac{1}{2}$	2-5	$2\frac{1}{2}-6\frac{1}{2}$	4-5	27 June	7 Aug	7 Aug
2 Knighton	Berac	19 May 75	$3\frac{1}{2}-4\frac{1}{2}$	1-3	em-4	-	27 June	29 July	31 July
		3 June 75	$5-6\frac{1}{2}$	2-5	$2-6\frac{1}{2}$	-	27 June	29 July	31 July
3 Crudwell	Lofa	11 June 75	$3-4\frac{1}{2}$	0-3	em-$4\frac{1}{2}$	$3-3\frac{1}{2}$	3 July	12 Aug	13 Aug
	Abed	18 June 75	$4-5\frac{1}{2}$	1-4	$1-5\frac{1}{2}$	$3-4\frac{1}{2}$	3 July	12 Aug	13 Aug
4 Knighton	Armelle	27 April 76	4	0-3	em-5	$2\frac{1}{2}-3$	Aug	29 June	14 July
5 Crudwell	Hassan	28 April 76	$3\frac{1}{2}-4$	0-2	em-$4\frac{1}{2}$	2-3	Aug	2 July	-
6 Kennet	Mazurka	29 April 76	$3-3\frac{1}{2}$	0-2	em-$3\frac{1}{2}$	2-3	Aug	7 July	15 July
7 Bicester	Proctor	13 May 77	4-5	0-2	em-$4\frac{1}{2}$	2-3	26 July	18 July	-
8 Knighton	Aramis	18 May 77	$5-5\frac{1}{2}$	1-5	em-5	3-4	25 July	20 July	-
9 Crudwell	Hassan	24 May 77	3-5	0-3	$\frac{1}{2}-4\frac{1}{2}$	$3-3\frac{1}{2}$	-	2 Aug	-

*Blw = broad-leaved weeds $^{+}$em = emerging

1975

The performance of diclofop methyl (36% e.c.) alone or with mecoprop salt (64% a.c.), dichlorprop salt (55% e.c.) or a formulated mixture of ioxynil, bromoxynil and dichlorprop esters (55% e.c.) on A. fatua and broad-leaved weeds was assessed. The nine herbicide treatments (Table 2) were applied either when the barley had approximately 4 main stem leaves or when it had approximately 5½ leaves and was beginning to joint (Table 1). During the summer any damage to the barley crop was noted and in late July or early August the density of A. fatua was determined. At the same time the degree of control of broad-leaved weeds was determined subjectively using a 0-10 scale (0 = complete control, 10 = no control).

1976

The effects of mixing dichlorprop salt (50% a.c.), dichlorprop ester (30% e.c.) or a formulated mixture of dichlorprop ester with ioxynil and bromoxynil esters (55% e.c.) on the activity of several doses of diclofop methyl were examined in three trials. The herbicides were applied in late April when the barley had 3-4 leaves. Panicles were counted in late June or early July and the influence of the 24 treatments on the height of the crop was recorded just before harvest. At the same time plants from 6 random 1 m lengths of row in each plot were collected and the barley heads were examined for the occurrence of deformities. Broad-leaved weed control was assessed at two of the sites (sites 4, 6) in mid July.

1977

In these three trials diclofop methyl (36% e.c.) at 0.62, 1.25 and 1.87 kg/ha was mixed with various combinations and doses of ioxynil, bromoxynil and dichlorprop esters. Two formulations of dichlorprop ester, a 38% e.c. and a 30% e.c. were studied. All the herbicides were applied when the barley crops had approximately 4-5 leaves. Their effects on A. fatua were noted in late July, and at sites 7 and 8 their influence on the height of the crops was recorded just prior to harvest.

RESULTS

1975

A. fatua control. Significant reductions in the number of spikelets of A. fatua were obtained at all three sites at the first application, with diclofop methyl alone at 1.0 and 1.5 kg/ha (Table 2). Control at the second date was poorer and few treatments reduced spikelet numbers significantly. The control by 1.0 kg/ha diclofop methyl, at the first application, when mixed with the ester formulation of ioxynil, bromoxynil and dichlorprop was just as good as its performance alone. However when mixed with the salts of mecoprop or dichlorprop its activity was severely reduced and spikelet counts did not differ significantly from the untreated controls. In general, control at site 3 (Crudwell) was not so good as that at the other two sites. The three broad-leaved weed herbicides had no effect on A. fatua.

Crop damage. The subjective assessments showed that barley head density and height were slightly reduced by 1.5 kg/ha diclofop methyl alone but not by any of the other treatments.

Broad-leaved weed control. Diclofop methyl alone had no effect on these weeds. The level of control from the three broad-leaved weed herbicides varied, being better at site 2 than at site 1 (Table 3). There were some indications that their overall level of weed control was poorer when mixed with diclofop methyl.

1976

A. fatua control. Diclofop methyl alone achieved significant reductions in spikelet numbers at all doses, but satisfactory levels of control were only attained

Table 2

Control of A. fatua by diclofop methyl alone and in mixtures with three broad-leaved weed herbicides, 1975 (spikelets/m^2).

(Treatments applied when the crop had 3 - 4½ leaves)

Herbicides	Dose (kg/ha)	Site 1	Site 2	Site 3
Diclofop methyl	0.5	431	274	1811
Diclofop methyl	1.0	207	25	1563
Diclofop methyl	1.5	166	35	797
Diclofop methyl + bromoxynil, ioxynil, dichlorprop (esters)	1.0 + 0.77	146	18	1489
Diclofop methyl + mecoprop (salt)	1.0 + 2.24	846	1118	2058
Diclofop methyl + dichlorprop (salt)	1.0 + 2.80	828	1291	2025
Ioxynil + bromoxynil + dichlorprop (esters)	0.77	978	1353	1912
Mecoprop (salt)	2.24	1062	2088	2162
Dichlorprop (salt)	2.80	1197	2033	2186
Control		1027	1844	2358
S.E. ±		204	267	220

Table 3

Control of broad-leaved weeds with three herbicides alone and in mixtures with diclofop methyl (0 = complete control; 10 = no control)

Herbicides	Dose (kg/ha)	Application 1 Site 1	2	3	Application 2 Site 1	2	3
Ioxynil, bromoxynil, dichlorprop + diclofop methyl	0.77 + 1.0	5	2	6	5	3	6
Ioxynil, bromoxynil, dichlorprop	0.77	4	2	4	2	2	3
Mecoprop + diclofop methyl	2.24 + 1.0	5	5	5	6	3	5
Mecoprop	2.24	3	1	3	4	2	4
Dichlorprop + diclofop methyl	2.80 + 1.0	4	3	6	2	1	3
Dichlorprop	2.80	3	1	4	2	1	7

at 1.25 and 1.87 kg/ha (Table 4). When the formulated mixture of ioxynil, bromoxynil and dichlorprop esters was added to diclofop methyl the performance of the latter was not significantly impaired. However dichlorprop alone as an ester and a salt, particularly at 2.8 kg/ha, decreased the performance of diclofop methyl, the antagonism being most marked at 1.87 kg/ha. There were some indications at all sites that the salt was more antagonistic than the ester but only at site 5 (Crudwell) were these differences significant. The broad-leaved weed herbicides had no effect on A. fatua.

Crop damage. The height of the crop was slightly reduced by dichlorprop at 2.8 kg/ha. This treatment also affected the growth of the barley ears (Table 5), a high percentage containing opposite and in some cases whorls of spikelets. These

Table 4

The control of A. fatua with diclofop methyl alone and in mixtures with several broad-leaved weed herbicides, 1976

(Log (10 x + 1) spikelets/m^2)

Broad-leaved herbicides	Dose (kg/ha)	Site 4 (Knighton)				Site 5 (Crudwell) Diclofop methyl (kg/ha)				Site 6 (Kennet)			
		0	0.62	1.25	1.87	0	0.62	1.25	1.87	0	0.62	1.25	1.87
0		4.03	2.17	1.46	0.68	4.10	3.22	2.08	1.92	3.47	2.88	2.11	1.42
Ioxynil + bromoxynil + dichlorprop	0.77	3.99	3.11	2.35	0.91	3.99	3.01	1.79	1.55	3.41	2.64	2.15	2.15
Dichlorprop K salt	2.8	4.06	3.96	3.24	3.59	4.05	3.88	3.69	3.29	3.49	3.39	3.08	2.97
Dichlorprop K salt	0.42	3.90	3.60	2.67	2.19	4.10	3.75	3.26	2.68	3.34	3.34	2.66	2.34
Dichlorprop ester	2.8	3.84	3.77	3.58	3.47	3.84	3.85	3.66	3.70	3.43	3.58	2.51	2.78
Dichlorprop ester	0.42	4.14	3.60	3.21	2.47	4.01	3.47	2.30	1.87	3.15	2.75	2.33	1.53
S.E. ±		0.39				0.25				0.34			

Table 5

Barley ears with abnormal arrangements of spikelets (% abnormal)

		Site 4				Site 5 Diclofop methyl (kg/ha)				Site 6			
		0	0.62	1.25	1.87	0	0.62	1.25	1.87	0	0.62	1.25	1.87
No herbicide		0%	0	0	0	0	0	3	0	0	0	0	0
Dichlorprop ester	0.42	48	70	72	80	0	0	0	9	0	0	0	0
Dichlorprop ester	2.8	83	74	74	74	91	88	88	90	26	33	26	52

Symptoms were most severe at site 4 (Knighton) where even the low dose of the dichlorprop ester caused 50% or more of the heads to be deformed. The addition of diclofop methyl at 1.87 kg/ha to the dichlorprop appeared to increase slightly the number of deformed ears. Virtually no deformities were found in the ears of plants sprayed with the other broad-leaved weed herbicides.

Broad-leaved weed control. The scores for broad-leaved weed control at sites 4 and 6 (Knighton and Kennet) showed that the addition of diclofop methyl to the broad-leaved weed herbicides did not impair their activity. Few broad-leaved weeds were present at site 5 (Crudwell).

1977

A. fatua control. Diclofop methyl at 1.87 kg/ha achieved over 95% control alone and in all the mixtures at all three sites. Approximately 90% control was achieved by the 1.25 kg/ha dose, but there were indications, at this and the lowest dose, of interactions between the diclofop methyl and the broad-leaved weed herbicides (Table 6). Although the ioxynil and bromoxynil esters appeared to enhance slightly the performance of diclofop methyl and the dichlorprop ester at 0.84 kg/ha to inhibit it, only at site 8 (Knighton) was the activity of diclofop methyl affected significantly by the broad-leaved weed herbicides. However, the diclofop methyl mixtures with the ioxynil and bromoxynil esters achieved significantly better control of *A. fatua* than a number of the other mixtures. In general there was little antagonism of diclofop methyl from the broad-leaved weed herbicides. The latter on their own had no effect on *A. fatua*.

Table 6

The effect of ioxynil, bromoxynil and dichlorprop on the control of *A. fatua* by diclofop methyl, 1977

(Log (10 x + 1) spikelets/m^2)

Broad-leaved herbicide	Formulation (% e.c.)	Dose (kg/ha)	Diclofop methyl (mean 0.62 and 1.25 kg/ha) Site 7	Site 8	Site 9
-	-	-	2.52	1.92	2.24
Ioxynil, bromoxynil, dichlorprop (ester	55	0.77	2.60	1.53	2.52
Ioxynil, bromoxynil, dichlorprop (ester	55	1.54	2.74	1.92	2.66
Dichlorprop (ester)	38	0.42	2.42	2.28	2.62
Dichlorprop (ester)	38	0.84	2.77	2.25	2.47
Dichlorprop (ester	30	0.42	2.53	2.22	2.40
Ioynil + bromoxynil (ester)	44	0.35	2.24	0.56	1.97
Control (untreated)			3.48	3.91	3.55
S.E. of treatment means ±			0.12	0.24	0.24
S.E. of control means ±			0.08	0.15	0.15

Crop damage. At sites 7 and 8, particularly site 7 (cv. Proctor), diclofop methyl on its own at 1.25 kg/ha and 1.87 kg/ha, shortened the heads and stunted the crop. The highest dose at site 7 reduced crop height by 20%. This crop damage was less severe when the diclofop methyl was mixed with the broad-leaved weed herbicides.

DISCUSSION

These experiments have shown that excellent control of A. fatua can be achieved with diclofop methyl alone and when mixed with a commercial product containing ioxynil, bromoxynil and dichlorprop (Oxytril P). Thus it is possible to take advantage of the benefits of reduced application costs, improved timeliness of herbicide application and perhaps increased yield, resulting from the use of a mixture that will control both A. fatua and broad-leaved weeds in one operation. However, although this mixture was successful, others with mecoprop and dichlorprop alone were unsuccessful as they impaired the performance of the diclofop methyl. The severest antagonism was produced by dichlorprop at 2.8 kg/ha and mecoprop at 2.24 kg/ha, but the lower dose of dichlorprop (0.42 kg/ha) also caused some antagonism in 1976, although not in 1977. In the 1976 experiments the salt formulation of dichlorprop was more antagonistic than the ester. This agrees with data from O'Sullivan et al. (1977) which showed the amine salts of 2,4-D and MCPA to be more antagonistic than the esters. The addition of the product containing ioxynil, bromoxynil and dichlorprop esters did not affect the performance of diclofop methyl despite the presence of dichlorprop ester at 0.42 kg/ha. This suggests that the potential antagonism from the dichlorprop was being counteracted by the benzonitriles. The reasons for the antagonism by the growth regulator herbicides are not clearly understood but Todd & Stobbe (1976) and Walter et al. (1977) have shown that antagonistic herbicides decreased the translocation of diclofop methyl within the Avena spp.

As has been shown by O'Sullivan et al. (1977), the level of broad-leaved weed control was not seriously affected by the presence of the diclofop methyl.

In two of the three years some of the treatments damaged the barley. Dichlorprop ester at both 0.42 and 2.8 kg/ha in 1976 caused the production of deformed ears. There were slight indications that this was increased when the dichlorprop was mixed with diclofop methyl at the highest rate. In 1977 diclofop methyl alone at 1.25 and 1.87 kg/ha damaged the barley at two sites, but when mixed with the broad-leaved weed herbicides the level of injury was reduced. Poor tolerance by barley of diclofop methyl has been reported by Friesen et al. (1976) and O'Sullivan et al. (1977) but these workers did not report any alleviation of the symptoms by broad-leaved weed herbicides.

The trials were carried out in eight different spring barley varieties and there was no evidence of varietal interactions.

In conclusion, the economic benefits of controlling A. fatua and broad-leaved weeds in one operation can be utilised with mixtures containing diclofop methyl and some broad-leaved weed herbicides. However, with other broad-leaved weed herbicides the performance of diclofop methyl may be reduced. These experiments indicate some of the difficulties associated with the use of mixtures and suggest that prior testing is necessary to prevent an inadequate performance by one or more of the constituents.

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