SESSION 7C

WEED CONTROL AND PLANT GROWTH REGULATOR USE IN NON-CEREAL ARABLE CROPS

SESSION ORGANISER MS P. H. MOULT

POSTERS 7C-1 to 7C-12

GRASS WEED CONTROL IN UK WITH UBI C4874 - A NEW POST-EMERGENCE HERBICIDE

D.H. BARTLETT, C.D. JESSOP, D.R. SHRIMPTON

Uniroyal Chemical Ltd., Brooklands Farm, Cheltenham Road, Evesham, Worcs. WR11 6LW.

ABSTRACT

In 1988 and 1989, small plot replicated trials were carried out on a range of grass weeds to evaluate UBI C4874 (2-tetrahydrofuranyl methyl (+)-2-[4-(6-chloro-2-quinoxalinyloxy)-phenoxy] propanoate) at different rates, with and without surfactants.

The most effective surfactants were found to be refined paraffinic oils. C4874 30-45 g a.i./ha plus paraffinic oil was highly effective against volunteer cereals and annual grass weeds such as *Avena fatua*, *Alopecurus myosuroides* and *Bromus sterilis*. Rates of 45-90 g a.i./ha were required to control the perennial *Elymus repens.*

Earlier timings (GS 12-30) were generally more effective than the later timings of application for the control of *E. repens.*

Tank mixes of C4874 with bentazone had no obvious effects on grass or broad-leaved weed control.

No phytotoxicity was observed on any of the crops tested with C4874 at rates up to 240 g a.i./ha.

INTRODUCTION

UBI C4874 (2-tetrahydrofuranyl methyl (+)-2-[4-(6-chloro-2-quinoxalinyloxy)-phenoxy] propanoate (C4874) is a new post-emergence herbicide currently being developed internationally by Uniroyal Chemical Co. Inc. to control annual and perennial grass weeds in broad-leaved crops. Chemical and physical properties and efficacy data from the U.S.A. and other countries are published elsewhere (Bell and Peddie, 1989)

The work in the U.S.A. established that C4874 required the addition of a surfactant to optimise the control of grass weeds. This paper presents results from trials in the U.K. with C4874 at a range of rates with various surfactants, on volunteer cereals and annual and perennial grass weeds in such crops as pea, field bean, sugar beet, linseed and oilseed rape.

MATERIALS AND METHODS

Formulations used were UBI C4874 120 g a.i./l EC, sethoxydim 'Checkmate' 193 EC, fluazifop-P 'Fusilade 5' 125 EC, quizalofop 'Targa' 100 EC (1988 trials) 'Pilot' 500 SC (1989 trials), bentazone 'Basagran' 480 SL, propyzamide 'Kerb' 50 WP.

Surfactants used were UBI 9078, 'Chiltern Cropspray 11 E' (CSO) and 'Sifren' - refined paraffinic oils, 'Agral' - non-ionic wetter, 'LI 700'- acidified soya lecithin, 'Crodamet T/15' and 'ABM + 8'-ethoxylated tallow amines, 'Codacide Oil' - vegetable oil with encapsulated emulsifier.

All trials were applied with a propane powered small plot sprayer with Lurmark tips 02-F80 in 1988 and 02-F110 in 1989 giving 200 l/ha at 3.5 bar.

Trials were of a randomised block design with 3 or 4 replicates. Plot size was 6 x 2m.

Herbicide activity and crop tolerance were assessed visually by comparison of treated with untreated plots. Letters appearing in results tables refer to Duncans multiple range test where values with no letters in common are significantly different (p=0.05).

Weather conditions at times of application in 1988 were generally cool and damp and in 1989 were hot and dry.

RESULTS

Weed Control

The results in Table 1 show that against Avena fatua and Alopecurus myosuroides C4874 and quizalofop worked equally well applied at the later as at the earlier timing. However, sethoxydim gave better control at the later than at the earlier timing. On Elymus repens (Table 2) C4874 worked best, at both sites, when applied at the mid-stage of GS 23.

The surfactant screen in 1988 (Table 3) showed that the activity of C4874, on both barley and E. repens, was improved by the addition of all the surfactants tested. The biggest improvement was given by the refined paraffinic oils - UBI 9078 and CSO which increased the level of control given by C4874 30 g a.i./ha up to that of the standards at perennial weed rate. Fluazifop-P gave poor control of barley.

Further evaluations of the refined paraffinic oils surfactants in 1989 (Table 4) showed that 1% (2 l/ha) of oil with C4874 was superior to 0.5% for the control of both A. fatua and E. repens. CSO was more effective than UBI 9078. C4874 + CSO (10 g a.i./ha + 1%) gave better control of A. fatua than quizalofop 125 g a.i./ha and C4874 40 g.a.i./ha was better than quizalofop 250 g a.i./ha on E. repens. However, all these differences were not statistically significant.

In 1988 (Table 6) C4874 + UBI 9078 (30 g a.i./ha + 1%) gave control of Bromus sterilis equal to the standards fluazifop-P and quizalofop (99%+) and superior to that given by propyzamide (60.6%).

TABLE 1. Effect of application timing of C4874 on the control of annual grass weeds <u>Avena fatua</u> and <u>Alopecurus myosuroides</u> in 1988.

treatment	rate g a.i./ha		% control (42 DAT) Northleach-Linseed *A. fatua*		Cirencester-Peas *A. myosuroides*	
		Appln. GS	12-13	31	30	39
		Date	13 May	6 June	13 May	6 June
Untreated	(no.heads/m^2)		(100)		(80)	
Untreated	-		6.7 c	0.0 c	0.0 c	0.0 b
C4874 + CSO	30 + 1.25%		92.5 b	95.8 b	87.5 ab	100 a
C4874 + CSO	60 + 1.25%		99.3 a	99.3 a	100 a	97.0 ab
fluazifop-P + Agral	188 + 0.1%		99.8 a	100 a	93.8 ab	99.5 ab
sethoxydim + CSO	338 + 1.25%		4.3 c	100 a	83.8 b	96.3 b
quizalofop + Sifren	125 + 1%		99.8 a	99.5 a	100 a	99.5 ab

TABLE 2. Effect of application timing of C4874 on the control of perennial grass weed <u>Elymus repens</u> in 1988.

treatment	rate g a.i./ha		% control *E. repens* 70 DAT Kemble-Peas		49 DAT Stourbridge-Sugar beet	
		Appln. GS	13	23	23	33
		Date	13 May	6 June	1 June	20 June
Untreated	(no.heads/m^2)		(95)		(120)	
Untreated	-		10.0 c	15.0 c	2.5 c	7.0 d
C4874 + CSO	30 + 1.25%		60.5 b	91.0 a	95.5 a	61.3 bc
C4874 + CSO	60 + 1.25%		97.5 a	95.8 a	98.0 a	64.8 abc
fluazifop-P + Agral	375 + 0.1%		94.5 a	78.8 ab	98.8 a	95.5 ab
sethoxydim + CSO	869 + 1.25%		55.5 b	53.8 b	78.0 b	52.5 c
quizalafop + Sifren	300 + 1.0%		98.0 a	98.0 a	-	98.5 a

TABLE 3. Control of volunteer w. barley cv. Panda and Elymus repens with C4874 with and without surfactants in 1988.

treatment	rate g a.i./ha		% control Evesham-W.barley		Hampton-E.repens
		Appln.	21 DAT	70 DAT	42 DAT
		GS	40		32
		Date	11 May		11 May
Untreated	(no.heads/m^2)		(410)		(100)
Untreated			5.0 g	0.0 e	21.3 b
C4874	30		10.0 fg	6.7 e	16.3 b
C4874	60		47.5 cde	25.0 d	15.0 b
C4874 + Agral	30 + 0.1%		30.0 ef	22.5 d	31.3 b
C4874 + UBI 9078	30 + 1.25%		82.5 a	99.8 a	81.3 a
C4874 + CSO	30 + 1.25%		67.5 abc	99.0 a	70.0 a
C4874 + LI 700	30 + 0.5%		37.5 de	58.8 c	16.3 b
C4874 + ABM +8	30 + 0.5%		57.5 bcd	87.8 ab	38.8 b
C4874 + Crodamet T 15	30 + 0.5%		60.0 bcd	81.3 b	42.0 b
C4874 + Codacide Oil	30 + 1.25%		42.5 de	33.8 d	16.3 b
fluazifop-P + Agral	375 + 0.1%		42.5 de	30.0 d	83.8 a
sethoxydim + CSO	869 + 1.25%		85.0 a	100.0 a	86.3 a
quizalofop + Sifren	300 + 1.0%		70.0 ab	96.7 ab	32.5 b

TABLE 4. Control of Avena fatua and Elymus repens with C4874 with surfactants at different concentrations at Evesham in 1989.

treatment	rate g a.i./ha + %		% control A. fatua		E. repens	
		Appln.	56 DAT		38 DAT	
		GS	32		13-22	
		Date	24 May		3 May	
Untreated	(no.heads/m^2)		(90)		(150)	
Untreated			0.0 c		0.0 d	
C4874 + UBI 9078	10 + 0.5		60.0 b)		-	
C4874 + UBI 9078	10 + 1		80.7 ab)	)78.0	-	
C4874 + UBI 9078	20 + 0.5		81.7 ab)		40.0 bc)	
C4874 + UBI 9078	20 + 1		89.7 a)		78.3 a)	)71.4
C4874 + UBI 9078	40 + 0.5		-		80.3 a)	
C4874 + UBI 9078	40 + 1		-		87.0 a)	
C4874 + CSO	10 + 0.5		77.3 ab)		-	
C4874 + CSO	10 + 1		72.3 ab)	)81.7	-	
C4874 + CSO	20 + 0.5		81.7 ab)		74.5 a)	
C4874 + CSO	20 + 1		95.3 a)		87.3 a)	)85.7
C4874 + CSO	40 + 0.5		-		89.8 a)	
C4874 + CSO	40 + 1		-		91.3 a)	
quizalofop + CSO	125 + 1		58.3 b		73.3 a	
quizalofop + CSO	250 + 1		-		87.3 a	

TABLE 5. Control of <u>A. myosuroides</u>, <u>A. fatua</u> and <u>E. repens</u> in spring sown crops with C4874 ± bentazone in 1989 (bent = bentazone; CSO at 1%).

treatment	rate g a.i./ha		% control			
			Watlington Field beans		Norcote Peas	Cirencester Peas
		Appln.	A.myosur.	A.fatua	E.repens	
		GS	24-60	31	12-21	32
		Date	22 May		19 May	17 May
Untreated	(no.heads/m^2)		(120)	(100)	(90)	(150)
Untreated	-		0.0 b	0.0 c	14.5 c	10.0 f
C4874 + CSO	30		92.8 a	85.0 b	88.3 a	61.7 cd
C4874 + CSO	45		99.3 a	94.0 ab	94.3 a	86.0 abc
C4874 + CSO	60		99.0 a	97.3 a	96.5 a	93.5 ab
C4874 + CSO	90		100 a	99.0 a	97.0 a	94.5 a
C4874 + bent. + CSO	30 + 1440		93.0 a	91.8 ab	91.3 a	59.3 d
C4874 + bent. + CSO	60 + 1440		99.0 a	96.5 a	94.0 a	87.5 ab
bentazone	1440		2.5 b	0.0 c	15.0 c	20.0 f
quizalofop + CSO	125		97.0 a	89.0 ab	70.0 ab	25.0 ef
quizalofop + CSO	250		-	-	96.0 a	68.8 bcd
sethoxydim + CSO	338		99.8 a	97.8 a	47.0 b	45.0 de
sethoxydim + CSO	869		-	-	69.3 ab	84.3 abc

1989 trials on <u>A. myosuroides</u> and <u>A. fatua</u> in spring sown beans (Table 5) showed C4874 to be slightly less active on <u>A. fatua</u> than in 1988 (Table 1), quizalofop 125 g a.i./ha was also less active and gave less control than C4874 45 g a.i./ha - statistically significant only at the Cirencester pea site. This difference in level of activity may have been due to the higher temperatures around application in 1989. The difference in the level of control of <u>E. repens</u> between Norcote and Cirencester (Table 5) may probably be explained by the earlier GS at application, but also by a much more competitive pea crop at Norcote.

In all three 1989 trials the tank mix of C4874 with bentazone did not appear to reduce the level of grass weed control.

<u>Crop Safety</u>

C4874 at rates up to 240 g a.i./ha caused no observed phytotoxicity on any of the crops tested.

TABLE 6. Control of Bromus sterilis in winter oilseed rape with C4874 in 1988.

treatment	rate g a.i./ha + %		% control B. sterilis 90 DAT Cirencester	Watlington
		Appln. GS	22-24	12-14
		Date	17 October	25 October
Untreated	(no.plants/m²)		(100)	(250)
Untreated			0.0 c	7.5 c
C4874 + UBI 9078	20 + 1		98.0 a	98.3 a
C4874 + UBI 9078	30 + 1		99.3 a	99.3 a
C4874 + UBI 9078	50 + 1		99.1 a	99.4 a
fluazifop-P + Agral	125 + 0.1		99.1 a	99.3 a
quizalofop + Sifren	75 + 1		99.3 a	99.5 a
propyzamide	700		67.8 b	53.3 b

DISCUSSION

The results of these trials show that C4874, in combination with the most effective surfactant tested - a refined paraffinic oil at 1%, gave a high level of control of grass weeds which was equal or better than that given by the standards at higher rates of use.

C4874 30-45 g a.i./ha gave excellent control of volunteer barley and annual grass weeds. Size of weeds did not appear to influence the level of control but sethoxydim gave poor control of small A. fatua and quizalofop was less effective than C4874 on A. fatua at all timings. Fluazifop-P gave poor control of barley. However, the size of E. repens at application did affect the level of activity of C4874. On young, actively growing E.repens GS 12-30 C4874 45-90 g a.i./ha gave excellent control but when applied at GS 50 or beyond it was much less effective (unpublished results).

More work is required to determine the desirability of tank mixing C4874 with other products.

REFERENCES

Bell, A.R.; Peddie, A.S. (1989) UBI C4874, a new post-emergence herbicide for control of annual and perennial grassess. Brighton Crop Protection Conference - Weeds 1989. 1,(In print)

DEPTH AND DATE OF EMERGENCE OF VOLUNTEER OILSEED RAPE (BRASSICA NAPUS L) AND ITS CONTROL WITH HERBICIDES USED IN PEAS, BEANS, POTATOES AND SUGAR BEET

H. J. GARRETT

Department of Agricultural Botany, Whiteknights, University of Reading, Berkshire, RG6 2AS*

J. H. ORSON

ADAS, Block B, Government Buildings, Brooklands Avenue, Cambridge, CB2 2DR

ABSTRACT

Current products used in potatoes, peas, beans (Vicia faba) and sugar beet were assessed for control of volunteer oilseed rape (Brassica napus L) in randomised block field trials on light soils. Factors affecting product efficacy, notably depth of rape emergence, rape variety and growth stage were investigated. An observation plot assessed vernalisation requirements of rape and a pot trial investigated depth of emergence of rape.

INTRODUCTION

Brassica napus L possesses ruderal strategies of survival which contribute to its successful weed status (Hodgson, 1978). In addition, the nature and amount of glaucous leaf surface wax contributes to rape tolerance of many herbicides (Baker, 1980). Volunteer rape will emerge whenever conditions are favourable. Depth and date of emergence may be important variables of their success, for rape has been observed in the field to emerge in flushes in the spring.

MATERIALS AND METHODS

For all experiments, a single batch of seed was used for each variety of Ariana, Bienvenu, Cobra and Libravo. Seed lots were similar in germination and seed weight.

Field experiments were on a sandy loam soil at Anstey Hall, Cambridge with the exception of one trial at Terrington EHF, Norfolk which was on a silt loam. Air dried, shredded and sieved (5 mm) soil from Anstey Hall was used for the pot work.

Spraying (Table 1) was carried out with a modified Van der Weij knapsack plot sprayer fitted with Lurmark F01, F02 or F03-80 nozzles at 2.5 bar for a total volume equivalent to 100 l/ha and 2.1 bar for a total volume equivalent to 200 or 300 l/ha as required. Plots were sprayed at right angles to the drilled rows in field trials. All pre-emergence applications were at a total volume equivalent to 200 l/ha. Treatments were a single application of the lowest recommended dose.

*Present address: Protectacrop (Cambs.) Ltd., Saxon Way, Melbourn, Royston, Herts, SG8 6DN

TABLE 1. Site and spray details.

	Anstey Hall Trial 1	Anstey Hall Trial 3	Terrington EHF Trial 2
Drilled	13.5.88	10.7.88	16.6.88
Pre-emergence spray	13.5.88	-	18.6.88
Post-emergence spray			-
cotyledon	25.5.88	-	
2 true leaf	3.6.88	-	
6 true leaf	22.6.88	2.8.88	

Evaluation of pre- and post-emergence herbicides (trials 1 and 2)

Trials 1 and 2 investigated pre-emergence herbicide control of Ariana at 2 depths of drilling, 'shallow' (0-12.5 mm) and 'deep' (50 mm) using a Wintersteiger Oyjord plot drill. Post-emergence control was additionally investigated in trial 1 using Ariana drilled to 25 mm. A standard seed rate of 6 kg/ha was used. The Cambridge roll, after drilling in trial 2, was omitted in trial 1 due to fear of rain and consequent soil capping.

Split plot design of the pre-emergence trials facilitated 5 replicates of the main blocking factor (depth of drilling) with full randomisation of the pre-emergence treatments and 2 untreated control plots within each block. In trial 1, the soil was irrigated with 10 mm of water 3 and 7 days after spraying and the soil surface remained moist thereafter. Each plot was 3 x 3 m, the central 1.86 m drilled. Trial 2 was not irrigated, with rain falling 9 days after pre-emergence herbicide application and the surface remaining moist thereafter. Plots at trial 2 were 3 x 6 m each containing 2 central 1.86 m drilled strips separated by a single wheeling. This method avoided wheelings within drilled rows.

Trial 1 (post-emergence treatments) consisted of 4 replicates as a randomised block design and was irrigated along with trial 1 (pre-emergence treatments).

The number of plants in each systematically placed 0.1 m^2 quadrat were recorded, 10 quadrats per plot at Anstey and 12 at Terrington to give at least 100 plants per control plot. In addition, vigour of the survivors was assessed using a score where 9 = complete kill and 0 = completely healthy.

Varietal response to herbicide at six leaf stage (trial 3)

A factorial design of 6 replicates assessed varietal response to herbicides including the effect of the addition of mineral oil. Each plot contained 2 rows each of hand sown Ariana, Bienvenu, Cobra and Libravo in randomly placed pairs, rows 25 cm apart. Vigour was assessed as % green leaf ground cover and dry weights were taken 2 weeks from spraying when maximum differences were apparent.

Depth of emergence investigation (trial 4)

Twenty seeds of each of Ariana, Bienvenu, Cobra and Libravo were sown on 28 June 1988 at 4 depths (12.5 mm, 50 mm, 75 mm and 100 mm), with one depth and variety per 15 cm diameter pot, with 4 replicates per treatment. All pots were gradually wetted to field capacity to 100 mm depth after sowing and watered daily. Some settling of the soil was noted. This was less than 10 mm over 2 weeks. Temperatures were an average maximum 19.3^{o}C and minimum 11.5^{o}C for the duration of emergence. Plant emergence was recorded over 19 days by which time maximum germination had occurred. Fresh and dry weights were taken of above ground plant material. Additional pots were included at 12.5 mm and 75 mm depths and treated with pendimethalin on 29 June 1988 at 2.0 kg a.i./ha. The number and percentage of survivors up to 4 leaf were recorded.

Time of spring emergence and flowering and seed set (trial 5)

Two metre rows of Ariana and Bienvenu were sown fortnightly from mid-March (18 March, 28 March, 11 April, 29 April) at 10-15 mm depth at Reading University. Plants were thinned to an even stand. Observations on flowering and plant morphology were made on 12 July and 12 August. Those plants setting seed were recorded.

RESULTS

Analysis of variance indicated that in trial 2, there was a significant trend ($p = 0.01$) for greater numbers of survivors of herbicide treatments from the deeper drilling. However in trial 1, depth of emergence was not as important as herbicide treatment (Table 2).

In trials 1 and 2 there was no significant difference in overall rape vigour between depths. Herbicides producing moderate mortality of plants tended to cause a greater plant growth check than those producing little or no mortality.

Some of the cotyledon and two leaf treatments of trial 1 (Table 3) recorded more plants with time suggesting that later emerged plants were not controlled. Plant vigour scores declined with time after treatment at cotyledon and two leaf stages with phenmedipham and also to a lesser extent, metamitron + oil. This represented an initial plant scorch followed by recovery with production of new leaves. Resultant plants were smaller than those of the control. Those post-emergence applications producing the greatest plant mortality also produced severe vigour checks. In some other cases, moderate to severe plant check counteracted a poor plant mortality.

In trial 3, application at six leaves to four varieties of winter oilseed rape produced no varietal vigour differences nor was there a varietal dry weight response to herbicide treatment. Dry weights from all treatments were significantly ($p = 0.01$) lower than untreated. Percentage green leaf ground cover scores (Table 4) produced highly significant differences between treatments and of all treatments compared with the control.

TABLE 2. Percentage mortality of oilseed rape from 'shallow' (0 mm) and 'deep' (50 mm) drilling 6 weeks after pre-emergence application (trials 1 and 2).

Herbicide	Rate kg a.i./ha	Percentage mortality: Trial 1 Anstey 0 mm	Trial 1 Anstey 50 mm	Trial 2 Terrington 0 mm	Trial 2 Terrington 50 mm
chloridazon	1.505	8.4	42.4	30.1	14.0
metamitron	2.1	24.2	6.9	43.4	12.8
linuron	0.55	44.2	23.5	83.1	86.0
simazine	0.85	9.5	11.8	79.5	62.8
pendimethalin	1.32	56.8	43.1	72.3	50.0
pendimethalin	2.0	86.3	88.2	95.2	81.4
trietazine/simazine	1.104	34.7	3.9	42.2	31.4
terbutryn/terbuthylazine	1.15	29.5	36.3	96.4	90.7
terbutryn	0.805	9.5	10.8	34.9	19.8
metribuzin	0.525	98.9	97.0	100	95.3
aziprotryne*	2.0	35.8	0	-	-
lenacil	0.96	42.1	45.1	100	97.7
SED between treatments (df)		± 12.89 (106)		± 8.71 (98)	
SED comparison in one depth (df)		± 12.49 (106)		± 8.59 (98)	

* treatment not applied at Terrington

In trial 4, 75 mm was found to be the maximum depth from which plants likely to be competitive would emerge. Maximum emergence from 12.5 mm occurred seven days before maximum emergence from 50 mm to 75 mm for all varieties except Cobra. 92% of the seed at 100 mm had not emerged but 70 to 100% at this depth had germinated. There were no clear varietal differences in response to pendimethalin treatment nor any significant response in terms of plant survival with the depths of drilling tested (12.5 mm and 75 mm).

Results from trial 5 are given in Table 5.

DISCUSSION

Pot work, using a single batch of seed, suggested that the double lows Cobra and Libravo were most vigorous and a potentially greater problem in a volunteer situation. Good emergence of all varieties down to 75 mm presents a problem for post-emergence herbicide timing due to staggered emergence.

There was a higher level of control and consistent trend (significant overall) to better control of shallow drilled plants with pre-emergence herbicides at Terrington (trial 2) where the seed bed was finer and firmer. The soil surface at Anstey (trial 1) remained looser with small

TABLE 3. Percentage mortality of oilseed rape (and plant vigour scores) after post-emergence applications at Anstey Hall (trial 1)

Herbicide (Timing)≠	Rate kg a.i./ha	Total volume l/ha	13 June		3 July	12 July
bentazone (b)	1.44	300	(7.75)	88.4	(6.50)	58.6
bentazone (c)	1.44	300	-	-	(4.75)	6.4
bentazone (b)	0.72	300	(7.25)	76.4	(5.75)	53.4
metamitron + oil* (a)	1.19	100	(6.00)	33.7	(1.75)	21.1
metamitron + oil* (b)	1.19	100	(4.50)	11.2	(0.50)	14.9
phenmedipham (a)	0.399	100	(4.75)	15.4	(0.75)	15.9
phenmedipham (b)	0.399	100	(3.50)	11.1	(1.00)	8.0
phenmedipham (c)	0.399	100	-	-	(0.50)	17.9
metribuzin (a)	0.7	200	(8.89)	98.6	(8.94)	99.0
metribuzin (b)	0.7	200	(9.00)	100.0	(9.00)	100.0
cyanazine + MCPB/MCPA(c)	1.0+0.5	300	-	-	(4.00)	1.9
bentazone/MCPB + cyanazine (c)	1.6+0.2	300	-	-	(5.75)	31.1
SED between treatments ±			(0.30)	9.43	(0.54)	6.75
df			(27)	27	(39)	39

* Actipron (mineral oil) was used at 1.7 litres/ha
≠ a = fully expanded cotyledons, b = 2 true leaves, c = 6 true leaves

TABLE 4. Effect of herbicide treatment at six leaf on dry weight (g/plant) and % green leaf ground cover of mean of all varieties. Anstey Hall (trial 3)

Herbicide	Rate kg a.i./ha	% ground cover	Dry weight g/plant
cyanazine + MCPB/MCPA	1.0 + 0.5	56.6	1.43
bentazone/MCPB + cyanazine	1.6 + 0.2	3.4	1.08
bentazone	1.44	40.0	1.26
bentazone + oil*	1.44 + oil	3.4	1.08
Untreated Control		80.0	2.43
SED ± (df)		± 5.8 (26)	± 0.149 (26)

* Actipron (mineral oil) was used at 2 l/ha

clods. This may have contributed to an overall poorer control and inconsistent effect of depth of drilling on herbicide efficacy at the Anstey site. Seed bed quality appeared to be more important for the

TABLE 5. Observations of rape morphology and flowering following spring sowings (trial 5)

Date of Sowing	Assessment Date							
	12 July				12 August			
	Ariana		Bienvenu		Ariana		Bienvenu	
	GS*	Fl'ring	GS*	Fl'ring	GS*	Pod Set	GS*	Pod Set
18/3/88	4	Yes	4.2	Yes	6.2	Yes (irregular)	6.5	Yes (irregular)
28/3/88	3.3	Flr bud	4.0	Flr bud	4.2	Yes (poor)	6.1	Yes (poor)
11/4/88	2.0	No	2.5	No	3.7	Green bud (poor)	4.1	Early flower
29/4/88	2.0	No	2.0	No	2.5	No	3.7	Flr bud

* Sylvester-Bradley et al (1984)

efficacy of simazine, terbutryn/terbuthylazine and lenacil which only performed well at the Terrington site.

Effective control of oilseed rape to two leaf and possibly beyond this stage appears to be available in potatoes with metribuzin. Terbutryn/terbuthylazine can provide fairly effective control pre-emergence in peas and field beans, provided that soil conditions are ideal for good activity. Pendimethlin offers more reliable control of oilseed rape in peas. In sugar beet, pre-emergence application of lenacil offers very good control, provided that seedbed conditions are suitable for herbicide activity and crop safety. Post-emergence control in beans and sugar beet is more difficult to achieve. Cyanazine + bentazone/MCPA is of value in peas and bentazone + oil in potatoes.

Mendham (1975) noted that winter oilseed rape cultivars sown in May may not flower until the next year having an unfulfilled requirement of 40 to 60 days below 15°C. In trial 5 inflorescence initiation in Bienvenu, a single low appeared to be triggered by higher temperatures than in Ariana. Plants of Ariana and Bienvenu emerging up to mid-April 1988 were able to set seed in the autumn 1988.

REFERENCES

Baker, E.A. (1980) Effect of cuticular components on foliar penetration. Pesticide Science, II, 367-370.

Hodgson, A.S. (1978) Rapeseed adaptation in Northern New South Wales. In: Phenological responses to vernalisation, temperature and photo period by annual and biennial cultivars of Brassica campestris L; Brassica napus L and wheat cv Timgalen. Australian Journal of Agricultural Research, 29, 693-710.

Mendham, N.J. (1975) Inflorescence initiation and yield development in oilseed rape (Brassica napus L). PhD Thesis, Nottingham University.

Sylvester-Bradley, R.; Makepeace, R.J.; Broad, H. (1984) A code for stages of development in oilseed rape. Aspects of Applied Biology, 6, 399-419.

THE USE OF MINERAL ADJUVANT OIL WITH POST-EMERGENCE APPLICATIONS OF METAMITRON PLUS PHENMEDIPHAM FOR WEED CONTROL IN SUGAR BEET

M.J. MAY

The Norfolk Agricultural Station, Morley, Wymondham, Norfolk, NR18 9DB

M.J. ARMSTRONG

British Sugar plc., Holmewood Hall Field Station, Holme, Peterborough, Cambs., PE7 3PG

D. BUCKLEY

ADAS, Woodthorne, Wolverhampton, WV6 8TQ

ABSTRACT

The addition of mineral adjuvant oil to herbicides for broad-leaved weed control in sugar beet is often assumed to improve their activity. Twenty trials were carried out, ten in 1987 and ten in 1988, to compare the activity of a tank mix of metamitron + phenmedipham at 875 + 194 g a.i./ha, when 0, 0.5, 1.0 or 2.0 l/ha of a mineral adjuvant oil was added. Over all the trials the major weeds were Polygonum aviculare, (11 trials), Viola arvensis (10 trials) and Bilderdykia convolvulus (9 trials). However, in only one, three and three of these trials respectively was there a significant improvement in control of these weeds by the addition of oil. Eight other weed species were recorded in sufficient numbers on 19 sites to analyse statistically but, at only four sites did the addition of oil improve weed control.

The addition of oil did not consistently improve the activity of the metamitron + phenmedipham mixture. Improved weed control did not coincide with dry conditions or relate to weed species.

INTRODUCTION

Phenmedipham was introduced in 1967 and metamitron in 1975 (Worthing, 1987) and each are widely used in sugar beet (Anon., 1989). However it is only since the early 1980s that their use as tank mixes has become widespread. In 1988 over 66% of the UK sugar beet area was sprayed post-emergence with a mixture of these herbicides (Anon., 1989). In 1985 some mineral oil manufacturers and some beet growers were claiming that the addition of mineral adjuvant oil improved the weed control achieved by a tank mix of metamitron + phenmedipham at 875 + 194 g a.i./ha. The amount of mineral oil used and the susceptibility of weed species to the mixture appeared, from the claims, to vary greatly. The trials series reported here set out to examine the effect on the various weeds of different rates of mineral oil added to the mixture.

MATERIALS AND METHODS

Ten trials were carried out each year in 1987 and 1988 and were situated throughout the sugar beet growing area.

TABLE 1. Trials details.

Site no.	Location	Soil type	Drilling date	Treatment dates I	II	III	IV
	1987						
1.	Colney, Norfolk	LS	7.4	24.4	15.5	5.6	-
2.	Allscot, Shrops.	LS	14.4	28.4	8.5	-	-
3.	Glinton, Cambs.	SCL	17.4	1.6	18.6	-	-
4.	Duxford, Cambs.	SL	18.4	8.5	5.6	-	-
5.	Morley, Norfolk	SL	18.4	15.5	13.6	22.6	-
6.	Banham, Norfolk	SCL	18.4	6.5	26.5	-	-
7.	Long Marston, Yorks.	FSL	24.4	27.5	5.6	-	-
8.	Terrington, Norfolk	ZyCL	24.4	25.5	5.6	-	-
9.	Albrighton, Shrops.	SL	25.4	10.5	18.5	-	-
10.	Mepal, Cambs.	PtyL	5.5	27.5	10.6	31.6	-
	1988						
1.	Mepal, Cambs.	PtyL	29.3	22.4	29.4	11.5	25.5
2.	Glinton, Cambs.	SCL	30.3	25.4	5.5	-	-
3.	Allscott, Shrops.	LS	1.4	22.4	6.5	-	-
4.	Telford, Shrops.	LS	1.4	6.5	21.5	-	-
5.	Colney, Norfolk	LS	2.4	28.4	13.5	-	-
6.	Morley, Norfolk	SL	4.4	5.5	21.5	-	-
7.	Fakenham, Norfolk	LS	7.4	26.4	5.5	-	-
8.	Harton, York	SL	11.4	6.5	16.5	-	-
9.	Cantley, Norfolk	SL	13.4	13.5	23.5	-	-
10.	Terrington, Norfolk	ZyCL	22.4	20.5	1.6	7.6	-

All trials except sites 4 and 7 in 1987 and site 1 in 1988 used a randomised block design replicated six times; site 4 in 1987 used four replications and site 7 in 1987 and site 1 in 1988 used five. Plot sizes ranged from 29.2 to 48 m^2. All were sprayed using the low volume, low dose technique (Smith, 1983) in a spray volume of 80 l/ha through flat fan 01 80^o or 110^o nozzles at 2 bar pressure. All trials, except site 3 in 1987, which used a tractor mounted sprayer, were sprayed with gas powered knapsack sprayers. The same formulations were used throughout: metamitron 'Goltix WG', phenmedipham 'Betanal E', mineral oil 'Cropspray 11E'.

The treatments applied are given in the results tables. The addition of the extra 34 g a.i/ha phenmedipham in treatment 5 was included in 1988 as a possible alternative to, but at the same commercial cost as, the mineral oil applied at 1.0 l/ha.

The first sprays were applied to weeds at the cotyledon to first true leaf stage. However applications were delayed at some sites; site 3 in 1987 was sprayed at the 4 to 6 leaf stage, sites 4 and 7 in 1987 were sprayed at the 2 to 4 leaf stage. In 1987 all of the sites were subject to moist growing conditions but, in 1988, sites 3, 4 and 8 received less rainfall and were drier than the others.

Assessments on weeds and crop were by counts and vigour scores. Counts were on a whole plot or by random quadrats, depending upon the number of plants present.

RESULTS

Due to lack of space only end of season weed numbers are presented. Comments are only made where weeds were present in sufficient quantity to be statistically analysed.

TABLE 2. Polygonum aviculare plant counts per m².

Year / Site / Treatment	1987 / 1		1988 / 8	1987/8 / all	
1. metamitron + phenmedipham	6	(2.55)	152.5	23.4	(3.62)
2. + 0.5 l/ha oil	3	(1.88)	70.8	14.4	(3.17)
3. + 1.0 l/ha oil	4	(2.27)	85.8	15.9	(3.22)
4. + 2.0 l/ha oil	1	(1.51)	58.5	11.3	(2.90)
5. + 34 g a.i./ha phenmedipham	-	-	103.3	-	-
S.E.		($\pm$0.233)	$\pm$24.88		($\pm$0.379)

Figures in brackets transformed to $\sqrt{x+1}$.
Treatment 1 = 875 + 194 g a.i./ha.

In 1987 at site 1 the addition of 0.5 or 2.0 l/ha oil improved control of P. aviculare compared to the treatment without oil (Table 2). At site 8 in 1988, there appeared to be large differences between treatments with and without oil, but there was no significant difference between them. On the following sites no significant difference between treatments was recorded on P. aviculare:- sites 4, 6 and 7 in 1987 and sites 1, 3, 4, 5, 6 and 7 in 1988, but there was a trend at site 4 in 1987 and sites 1 and 4 in 1988 for better control where oil was included. Similarly, when data from all sites was analysed together, there appeared to be better control where oil was included, but this was not significant.

At sites 5 and 10 the addition of oil improved control of Viola arvensis, (Table 3) but there was no difference between rates of oil. In 1987 at sites 2 and 3 there were more V. arvensis present on treatment 4 (2.0 l/ha oil) compared to the other three treatments, whilst at site 6 only the top two rates of oil (1.0 and 2.0 l/ha) appeared to improve control, but these differences were not statistically significant. In 1988 at site 5, treatments 2 and 5 inclusive resulted in significantly fewer weeds than treatment 1. There was no significant difference between treatments when all sites were analysed together.

At sites 5 and 10 in 1987 and site 1 in 1988 (Table 3) there were fewer Bilderdykia convolvulus where oil or extra phenmedipham was used compared to treatment 1. In 1988 at site 3, treatments 3 to 5 had low numbers of this weed compared to treatments 1 and 2 but the difference was not significant. The weed was also present at sites 6 and 8 in 1987 and sites 5, 7 and 9 in 1988, but there was no significant difference between treatments on these individual sites or when all trials were analysed together.

TABLE 3. V. arvensis and B. convolvulus plant counts per m^2.

Species	V. arvensis			B. convolvulus		
Year	1987	1988	1988	1987	1987	1988
Site	5	10	5	5	10	1
Treatment						
1. metamitron + phenmedipham	3.4	21	8 (2.83)	2.8	11	8
2. + 0.5 l/ha oil	1.5	6	3 (1.68)	1.7	6	3
3. + 1.0 l/ha oil	0.9	6	1 (1.25)	1.7	5	2
4. + 2.0 l/ha oil	0.7	2	3 (1.88)	1.2	3	3
5. + 34 g a.i./ha phenmedipham	-	-	3 (1.86)	-	-	3
S.E.	±0.58	±3.8	(±0.372)	±0.36	±4.0	±2.7

Figures in brackets transformed to $\sqrt{x+1}$.
Treatment 1 = 875 + 194 g a.i./ha.

TABLE 4. Galium aparine (G. apar), Polygonum persicaria (P. pers), P. lapathifolium (P.lap), Stellaria media and total weeds count per m^2.

Species	G. apar	P. pers + P. lap		S. media	Total weeds
Year	1987	1987	1988	1988	1987/8
Site	10	10	1	4	all
Treatment					
1. metamitron + phenmedipham	6.0	9.0	14.0	14.7	29 (4.79)
2. + 0.5 l/ha oil	2.3	4.0	22.6	6.0	22 (4.28)
3. + 1.0 l/ha oil	1.3	1.3	28.0	3.5	24 (4.36)
4. + 2.0 l/ha oil	2.3	5.3	31.3	1.7	22 (4.17)
5. + 34 g a.i./ha phenmedipham	-	-	31.3	14.5	- -
S.E.	±1.53	±3.08	±7.95	±3.51	(±0.244)

Figures in brackets transformed to $\sqrt{x+1}$.
Treatment 1 = 875 + 194 g a.i./ha.

G. aparine was only present on two sites, at site 10 in 1987 where the inclusion of oil improved control (but with no significant difference between rates of oil) and site 10 in 1988 where there was no significant difference between any treatment (Table 4).

A mixed population of P. persicaria and P. lapathifolium was present on both peaty loam sites (site 10 in 1987 and site 1 in 1988) (Table 4). In 1987 there was a trend for better weed control where oil was used, but in 1988 control from the low dose mixture without oil was significantly better than all the other treatments except 0.5 l/ha oil (treatment 2).

At site 4 in 1988 (Table 4) the three oil treatments gave better control of S. media than the no oil treatment or that containing extra phenmedipham. S. media occurred on three other sites, sites 3 and 7 in 1987 and site 6 in 1988, but no significant differences between treatments were recorded.

Only three sites had Poa annua present (sites 7 and 9 in 1987 and site 5 in 1988), but there was no significant difference between treatments at any site. Veronica hederifolia only occurred in sufficient numbers at three sites, (site 9 in 1987 and sites 6 and 10 in 1988), but there was no significant difference between treatments at any site. Chamomilla suaveolens was present on two sites (sites 4 and 5 in 1988), but no significant difference was recorded between treatments. Similarly, there was no significant difference between treatments on Chenopodium album; this weed occurred on three sites, 4 and 7 in 1987 and site 6 in 1988.

TABLE 5. Summary of weed occurrences and control.

Weed species	Number of trials in which		
	Weed occurred	Weed control significantly improved by addition of at least one rate of oil	No significant difference between treatments
P. aviculare	11	1	10
V. arvensis	10	3	7
F. convolvulus	9	3	6
S. media	4	1	3
C. album	3	0	3
P. annua	3	0	3
V. hederifolia	3	0	3
G. aparine	2	1	1
P. lapathifolium + P. persicaria	2	2	0
C. suaveolens	2	0	2
Total	49	11	38

When each of these weeds (G. aparine, P. persicaria + P. lapathifolium, S. media, P. annua, V. hederifolia and C. suaveolens) were analysed as totals for the sites at which they occured, there was no significant difference between them. However, for (G. aparine, S. media, V. hederifolia and C. suaveolens) there was a trend for improved weed control where oil was added. When all weeds at all sites were analysed together, treatments with oil were significantly better than treatments without, but there was no significant difference between rates of oil.

The data presented in table 5 indicate that in only 22% of individual cases was there a significant improvement in weed control by the addition of oil.

Crop effects

There was a strange effect in 1987, at sites 1 (after two sprays only) and 8 when the treatment with 1.0 l/ha of oil was significantly safer to the crop than all the other three treatments. No other significant effects were measured on crop vigour and there were no significant effects on crop population or, where measured, crop yield.

CONCLUSIONS

The trials showed a relatively low proportion (22%) of cases where the addition of a mineral adjuvant oil to a tank mix of metamitron + phenmedipham at 875 + 194 g a.i./ha improved weed control. The cases of improved control did not appear to be directly related to drier conditions during the season or to large growth stages of the weeds at the first spray timing.

There was no hard evidence of any particular weed being more susceptible than other species. However when all weeds at all the sites were analysed together, there appeared to be some benefit in the use of oil.

The trials series failed to pin-point any situations where the use of oil could be guaranteed to improve the activity of the metamitron + phenmedipham mixture used. Although the addition of oil did not consistently improve the weed control activity of the mixture, the increases that did occur were possibly large enough to justify the small cost (£1 to £2 per ha) for the addition of 0.5 or 1.0 l/ha of oil to the herbicide mixture.

ACKNOWLEDGEMENTS

The authors thank their colleagues for help with the work, Mr. J. Prince for help with the analysis of the data, the companies for supplying the chemicals and the growers who allowed the trials on their fields.

REFERENCES

Anon. (1989) Results of 1988 beet survey. British Sugar plc. Peterborough.

Smith, J. (1983) Review of the post-emergence, low volume, low dose application technique. Aspects of Applied Biology 2, 1983. Pests, diseases, weeds and weed beet in sugar beet, 189-196.

Worthing, C.R. (1987) The Pesticide Manual. In: The Pesticide Manual, C.R. Worthing and S. Barrie Walker (Eds), Thorton Heath: BCPC Publications, pp 8010 & 9500.

INVESTIGATIONS ON PROGRAMMES FOR WEED CONTROL IN FODDER BEET IN SOUTH-WEST SCOTLAND

G. P. WHYTOCK*, V. A. F. HEPPEL

The West of Scotland College, Auchincruive, Ayr, KA6 5HW

ABSTRACT

Previous trials on low dose-low volume post-emergence herbicides in fodder beet showed that the level of weed control achieved can be unreliable. Timing of the treatments was the major difficulty, and so further trials in 1987 and 1988 investigated programmes based on a pre-emergence herbicide followed by low dose-low volume post-emergence sprays. The results demonstrated that good weed control could be reliably achieved with such a programmed approach. Despite the high cost of the programmes, an economic assessment of margin over cost showed that because of the large yield responses to weed control achieved, the use of herbicide programmes was always highly cost-effective.

INTRODUCTION

Weed control is an important aspect of growing fodder beet (*Beta vulgaris*) successfully; the crop is very sensitive to weed competition and gives large yield responses to weed control (Cromack, 1984). Although a range of sugar beet herbicides have label recommendations for use in fodder beet (SAC, 1987), many of the soil-acting residuals are not suitable for the light soils of medium - high (6 - 12%) organic matter in south-west Scotland, and, as a result, weed control can be difficult.

Repeat low dose-low volume (LDLV) herbicide programmes are widely used in sugar beet where they give good weed control on very high organic matter fen soils and improved timeliness of spraying on mineral soils (Madge, 1982; May, 1982). Trials in south-west England have also given good results in fodder beet (ADAS, 1983) and these programmes appeared to have potential for use in south-west Scotland.

Accordingly, trials were set up in 1985 to investigate this. Although post-emergence LDLV programmes proved to be cost-effective, weed control was sometimes disappointing due to bad weather delaying spraying (Whytock and Heppel, 1987). It was felt that including an initial pre-emergence herbicide might improve control by delaying the first flush of weeds, giving greater flexibility with the timing of the crucial first post-emergence spray. In this paper we report the results of trials carried out in 1987 and 1988 on the use of programmes based on pre-emergence metamitron and post-emergence LDLV sprays in fodder beet.

*Present address: The North of Scotland College of Agriculture, 581 King Street, Aberdeen, AB9 1UD

MATERIALS AND METHODS

The trials were carried out at Crichton Royal Farm, Dumfries on a freely drained sandy loam with 7 - 8% organic matter content (loss on ignition). Fodder beet, cv. Kyros was sown on 29 April 1987 and 25 April 1988. Plot size was 4 drills 50 cm apart and 10 m long. Herbicides were applied by a small plot sprayer fitted with Teejet nozzles. Pre-emergence treatments were applied through 8003 tips in 200 l/ha at 2 bars pressure and post-emergence applications were made with 80015 tips in 100 l/ha at 3 bars pressure. Details of application rates are given in the tables. All pre-emergence treatments were applied on 30 April 1987 and 25 April 1988. Post-emergence applications were made on 18 and 25 May in 1987 and on 10, 16 and 24 May in 1988, following pre-emergence metamitron at reduced rate. Two inter-row cultivations were simulated with a hand tool, 14 days apart. Treatments were replicated four times in a randomised block design. Visual scores of crop damage and weed ground cover were made at regular intervals throughout the season and weeds were counted in untreated plots. Roots were harvested by hand on 2 - 4 November 1987 and 2 November 1988.

RESULTS

In 1987, metamitron applied pre-emergence at the full rate was not sufficient to keep the crop clean (Table 1); this treatment reduced numbers of Chenopodium album by 64% but Stellaria media and Fumaria officinalis by only 20% compared to untreated (data not presented).

After pre-emergence metamitron at reduced rate, the first post-emergence spray was applied on 18 May when weeds were at the cotyledon stage (single spray) and the second a week later (two-spray programme). Phenmedipham + ethofumesate caused some visible crop damage, expressed as a check to growth and necrosis of leaf margins (Table 1), but other treatments were relatively safe to the crop.

Single post-emergence sprays of metamitron or phenmedipham significantly reduced weed ground cover compared to pre-emergence treatment alone but were particularly weak on F. officinalis and overall weed control was not satisfactory. This weakness was partly overcome by the tank-mixes of phenmedipham + metamitron or ethofumesate which gave better results from a single spray. All two-spray programmes gave a high standard of weed control, particularly of C. album.

Root d.m. yield reflected the weediness of the crop (Table 1) and was almost negligible from the untreated control. Consequently, yield responses to herbicide were very large, and even pre-emergence metamitron alone significantly ($P < 0.05$) improved yield over untreated. A single post-emergence spray following pre-emergence metamitron more than doubled root yield compared with pre-emergence treatment alone and in all cases (except metamitron + phenmedipham), a two-spray post-emergence programme gave a further significant increase in yield. The similarity of yields from the two-spray programmes to that from handweeded plots suggests that any damage to the crop from herbicides had been of a transient nature.

In 1988 post-emergence sprays were applied as required when weeds were at the cotyledon stage, following a reduced rate of pre-emergence metamitron. Weed emergence began early and was very protracted, consequently three post-emergence sprays were necessary to control newly emerging weeds and those surviving previous treatments.

All herbicides caused some visible early crop damage in the form of a check to growth and necrosis of leaf margins (Table 2), particularly the phenmedipham + tri-allate tank-mixes. The tank-mix of metamitron + phenmedipham gave outstanding weed control and the other programmes were mostly satisfactory, except for inter-row cultivation where C. album grew vigorously in the rows later in the season.

As in the previous year, root d.m. yields were linked to weed ground cover (Table 2). Similarly, yield responses to weed control were very large and post-emergence programmes of metamitron alone and in tank-mix with phenmedipham were not significantly ($P < 0.05$) different from handweeded. However, programmes of phenmedipham alone and in tank-mix with tri-allate yielded significantly less than handweeded. Although weed control was poorer from these programmes because of incomplete control of F. officinalis, it appeared that the visible crop damage recorded early in the season had carried through to harvest.

ECONOMIC ASSESSMENT

On the basis of metabolisable energy content relative to barley at £96/t, fodder beet root d.m. is worth £103/t. The cost-effectiveness of the herbicide programmes is compared by margin over cost (Tables 1 & 2) i.e. the value of the yield response to weed control less the total treatment cost (herbicide + application + cultivation)

All treatments were highly cost-effective, particularly the LDLV post-emergence programmes preceded by pre-emergence metamitron. In 1987 (Table 1), two-spray post-emergence programmes were always more cost-effective than a single post-emergence spray and the value of the additional yield response was always much greater than the cost of the second spray. In 1988 (Table 2), despite the high cost of treatment, the metamitron + phenmedipham tank-mix gave the highest margin, reflecting excellent weed control and a very large yield response.

DISCUSSION

In both years, yield responses to weed control were very large and confirm results elsewhere (ADAS, 1983; Cromack, 1984). In the trials reviewed by Cromack (1984), pre-emergence herbicides contributed the greater part of the yield response and the additional benefit from the post-emergence herbicides was relatively small. However, the reverse was true in our trial in 1987 where by far the largest yield response came from the first post-emergence spray with a further significant yield improvement from a second spray. The pre-emergence herbicide reduced and slightly delayed weed emergence, especially C. album which made the correct timing of the first post-emergence herbicide much easier than in previous years (Whytock and Heppel, 1987). A second spray 7 days later gave a high standard of weed control from all programmes, highlighting the importance of timeliness stressed by Madge (1982) and May (1982), and suggesting that correct timing of application is far more important than relatively small differences between types of herbicide treatments. However, it was interesting to note that the tank-mix of metamitron + phenmedipham gave particularly good results in both years and was the only programme to control F. officinalis well in 1988.

The early crop damage noted with phenmedipham + ethofumesate in 1987 may have been due to early application and did not appear to reduce final yield. However, phenmedipham alone and phenmedipham + tri-allate tank-mixes yielded significantly less than the handweeded control in 1988, and although there may have been some competition from surviving F. officinalis, crop damage was recorded early in the season, suggesting that this was partly responsible for the reduction in yield from these treatments. Preston and Biscoe (1982) found that the tolerance of sugar beet to phenmedipham was influenced by temperature and radiation receipts around the time of application and that it was more damaging if applied at high temperatures on bright days. The first two sprays in the programme (10 and 16 May) were applied on bright sunny days with maximum temperatures of 19.1 C and 21.6 C respectively, which may offer some explanation for the lower yields from these treatments.

The trials demonstrated that a high standard of weed control in fodder beet can be reliably achieved with a programme based on pre-emergence and repeat LDLV post-emergence herbicides. Despite the high cost of such programmes, an economic assessment of margin over cost confirmed that weed control was always highly cost-effective in this crop.

ACKNOWLEDGEMENTS

We would like to thank the staff of the Crop Production Department at Auchincruive and Crichton Royal Farm for assistance with field work.

REFERENCES

ADAS (1983) Fodder beet herbicides: The value of residuals in a repeat low dose overall spray programme. ADAS Agriculture Service Research and Development Reports; Grassland, fodder conservation and forage crops 1983. MAFF Reference Book 227(83), 221-228.

Cromack, H.T.H. (1984) The economics of weed control in fodder root crops. Proceedings Crop Protection in Northern Britain, 1984, 202-209.

Madge, W.R. (1982) Repeat low volume overall spraying for weed control in sugar beet. Arthur Rickwood Experimental Husbandry Farm Annual Review, 1982, 23-28.

May, M.J. (1982) Repeat low dose herbicide herbicide treatments for weed control in sugar beet. Proceedings 1982 British Crop Protection Conference - Weeds, 1, 79-84.

Preston, P.E. and Biscoe, P.V. (1982) Environmental factors influencing sugar beet tolerance to herbicides. Proceedings 1982 British Crop Protection Conference - Weeds, 1, 85-90.

Scottish Agricultural Colleges (1987) Weed control in fodder beet. Technical Note T18, 4 pp.

Whytock, G.P. and Heppel, V.A.F. (1987) Investigations on weed control in fodder beet on a soil of medium organic matter content in south-west Scotland. Proceedings Crop Protection in Northern Britain, 1987, 255-260.

TABLE 1 Crop damage scores, weed ground cover (%), root dry matter yields and margins over treatment costs, 1987

Treatment (kg a.i./ha)	Crop damage score, 0 = nil 10 = severe 13 June	+Weed ground cover (%) 8 July				Root d.m. yield (t/ha)	Treatment cost (£/ha)	Margin over cost (£/ha)
		C.a.	F.o.	S.m.	Total			
Metamitron (3.5) pre-em	0.0	29	18	9	56	4.83	88	298
Metamitron (3.5) pre-em then cultivation x 2	0.0	5	6	4	18	11.34	120	937
Post-em programmes*								
Metamitron (1.19) x 1^	0.9	4	12	6	22	12.36	89	1073
Metamitron (1.19) x 2^	1.1	0	1	1	2	16.88	124	1503
Phenmedipham (0.40) x 1	1.7	3	6	4	14	12.80	86	1122
Phenmedipham (0.40) x 2	1.1	0	0	1	1	15.86	117	1405
Metamitron (1.05) + phenmedipham (0.285) x 1	0.9	2	4	2	8	14.42	103	1271
Metamitron (1.05) + phenmedipham (0.285) x 2	1.3	0	0	1	1	16.50	152	1436
Phenmedipham (0.285) + ethofumestate (0.30) x 1	2.8	2	3	0	6	12.19	98	1046
Phenmedipham (0.285) + ethofumestate (0.30) x 2	5.3	0	1	0	1	15.47	142	1340
Hand weeded	0.2	-	-	-	-	16.53	-	-
Untreated	0.0	59	23	10	92	1.08	-	-
(Weed numbers per m^2)		(127)	(40)	(80)	(323)			
SED (DF = 33) ±	0.70	6.0	5.2	2.0	6.1	1.300	-	-

*All post-em programmes followed a pre-emergence spray of metamitron at 2.1 kg a.i./ha on 30 April
^Post-emergence metamitron was applied with added mineral oil at 1.7 l/ha product
+Key: C.a. = _Chenopodium album_, F.o. = _Fumaria officinalis_, S.m. = _Stellaria media_; other weeds included _Poa annua_, _Matricaria_ spp

TABLE 2 Crop damage scores, weed ground cover (%), root dry matter yields and margins over treatment costs, 1988

Treatment (kg a.i./ha)	Crop damage score, 0 = nil 10 = severe 31 May	+Weed ground cover (%) 15 June C.a.	F.o.	P.a.	Total	Root d.m. yield (t/ha)	Treatment cost (£/ha)	Margin over cost (£/ha)
Metamitron (3.5) pre-em then cultivation x 2	1.5	4	2	1	7	10.54	120	665
<u>Post-em programmes</u>*								
Metamitron (1.19) x 3^	2.5	0	2	0	2	16.90	159	1280
Phenmedipham (0.40) x 3	3.5	1	4	0	5	12.78	149	867
Metamitron (1.05) + phenmedipham (0.285) x 3~	4.0	0	0	0	0	17.41	190	1301
Phenmedipham (0.40) then a) Phenmedipham (0.285) + triallate (0.60) x 2	5.0	0	3	0	4	13.09	149	898
or b) Phenmedipham (0.40) + triallate (0.60) x 2	5.8	1	2	0	2	12.08	166	778
Hand weeded	0.0	-	-	-	-	17.68	-	-
Untreated	0.2	54	26	2	84	2.92	-	-
(Weed numbers per m^2)		(113)	(106)	(36)	(368)			
SED (DF = 21) ±	0.62	7.5	4.9	0.8	3.4	1.887	-	-

*All post-em programmes followed a pre-emergence spray of metamitron at 2.1 kg a.i./ha on 25 April
^Post-emergence metamitron was applied with added mineral oil at 1.7 l/ha product
~First spray = Metamintron (0.875) + phenmedipham (0.194); thereafter as shown
+Key: C.a. = <u>Chenopodium album</u>, F.o. = <u>Fumaria officinalis</u>, P.a. <u>Polygonum aviculare</u>; other weeds included <u>Poa annua</u>, <u>Stellaria media</u>, <u>Matricaria</u> spp

IMAZETHAPYR/PENDIMETHALIN: A NEW HERBICIDE MIXTURE FOR WEED CONTROL IN LEGUMES

C. M. KNOTT

Processors & Growers Research Organisation, Thornhaugh, Peterborough, Cambridgeshire PE8 6HJ

K. R. EKE

Cyanamid of Great Britain Ltd., Cyanamid House, Gosport, Hampshire PO13 OAS

ABSTRACT

Following initial development in soya beans, AC 263,499 imazethapyr, was assessed for use in UK legume crops. The weed spectrum activity of pendimethalin is complementary and thus imazethapyr/pendimethalin formulations were evaluated in extensive trials. At rates of 50/1000 g a.i./ha the mixture was active on a wide range of broad-leaved weeds, and controlled oilseed rape volunteers. Imazethapyr/pendimethalin has flexibility of both pre- and early post-emergence timing in peas and possibly beans *(Vicia faba)*.

INTRODUCTION

In recent years the area of peas and field beans *(Vicia faba)* grown for protein for animal feed in the EEC has increased, but UK growers have a limited choice of post-emergence treatments in peas, and only one, bentazone is available to bean growers. In legume crops there is also a need for a herbicide which offers flexibility of pre- or post-emergence timing. Herbicides are rarely introduced specifically for these 'minor' legumes but those developed for soya beans, a major market, may offer some potential, such as AC 263,499, imazethapyr, discovered by the American Cyanamid Company (Peoples *et al*., 1985).

Imazethapyr was screened in 1985 in the UK in peas for activity on weeds with promising results and was further evaluated in field trials in 1986 at a range of dose rates and application timings. Although most broad-leaved species were controlled, imazethapyr alone was inadequate for *Viola arvensis* and inconsistent post-emergence for *Poa annua*. Pendimethalin was chosen as a partner, since it is also selective in legumes and weed spectra activity is complementary. Extensive field trials evaluating imazethapyr and pendimethalin as tank-mixes in 1987, and as formulations in 1988 and 1989 in peas and field beans were carried out by Cyanamid of Great Britain Ltd and the Processors & Growers Research Organisation. This paper summarises some of this programme.

MATERIALS AND METHOD

Trials were carried out with tank-mixes of imazethapyr plus pendimethalin and later these were compared with various formulations of imazethapyr/pendimethalin as a soluble concentrate, with the finalised formulation in 1989 containing 16.7/330 g a.i./l. Treatments were compared with reference products pendimethalin 'Stomp'* or terbutryn/terbuthylazine pre-emergence and with cyanazine + MCPB/MCPA or bentazone/MCPB + cyanazine post-emergence.

Sixty-nine trials covering very light to heavy soil types were carried out from 1986 to 1989 in commercial crops of combining peas harvested dry, vining peas for quick-freezing or canning, and winter and spring sown field beans. The aim was to evaluate imazethapyr alone and in mixture with pendimethalin at different timings of application for crop tolerance and for weed control with natural weed populations.

The trials were of randomised block design with three or four replications and a plot size of $10m^2$ or $16m^2$. Treatments were applied with precision plot sprayers using 02F80 Lurmark fan nozzles delivering 220 l/ha spray volume at 280 kPa pressure. Broad-leaved and grass weed species were counted in random quadrats for $1m^2$ per plot, and the percentage weed control was calculated. Crop damage was assessed visually as percentage vigour reduction compared with untreated plots and other effects were also scored. Trials were harvested to determine yield using a plot combine for peas harvested dry; vining peas were cut by hand and threshed with a static plot pea viner. Moisture contents were recorded and combining pea yields were adjusted to 16% moisture content. Vining pea maturities were assessed with a Martin Pea Tenderometer.

RESULTS

Percentage control of weed species with pre- and post-emergence treatments is shown in Table 1. Pre-emergence treatment with imazethapyr at 50 g a.i./ha achieved effective control of the more common weeds of the pea crop, Stellaria media, Chenopodiaceae, Polygonum aviculare and Sinapis arvensis but was less reliable for some species. The addition of pendimethalin, as a tank-mix or formulation of imazethapyr/pendimethalin at a rate of 50/1000 g a.i./ha, improved efficacy on Viola arvensis, Veronica spp., Matricaria spp., Galium aparine, Bilderdykia convolvulus, Fumaria officinalis and Poa annua. This mixture was also very effective on Urtica urens, Lamium purpureum and on volunteer oilseed rape (Brassica napus). Control of Sonchus oleraceus was variable. Limited information (not tabulated) also showed some control of Chrysanthemum segetum and some suppression of Cirsium arvense and Rumex obtusifolius with imazethapyr. Results overall showed little difference in weed susceptibility to rates of 50/1000 or 67/1340 g a.i./ha of imazethapyr/pendimethalin when applied pre-emergence.

Post-emergence, imazethapyr/pendimethalin at 50/1000 g a.i./ha controlled a similar range of weed species to the pre-emergence treatment. It was particularly effective on B. napus, B. convolvulus, C. album, G. aparine, S. media, S. arvensis, U. urens, P. aviculare and L. purpureum. Control of Matricaria spp. and V. arvensis was variable where the weeds were large and a rate of 67/1340 g a.i./ha improved reliability. P. annua, particularly at advanced growth stages was not well controlled by either rate and S. oleraceus and C. bursa-pastoris may be moderately resistant.

*Registered trademark of the American Cyanamid Company.

Data for pre- or post-emergence control of grass weeds (other than *P. annua*) for the imazethapyr/pendimethalin mixture are limited. However, good activity on *Poa trivialis* and a useful suppression of volunteer cereals, *Lolium* spp., *Avena fatua*, *Alopecurus myosuroides* and even some foliar kill of *Elymus repens* was generally achieved.

TABLE 1. Percentage control of numbers of broad-leaved weed species and *Poa annua*, mean of trials 1986 -1989

Species		Percentage control of weed species (no. of trials)					
	Herbicide:	ima	ima/pen	ima/pen	ter/ter	ima/pen	ima/pen
	Rate g a.i./ha	50	50/1000	67/1340≁	N	50/1000	67/1340≁
	Timing:	pre-em	pre-em	pre-em	pre-em	post-em	post-em
Aethusa cynapium		85(3)	97(6)	98(4)	88(1)	90(6)	91(3)
Atriplex patula		58(2)	98(4)	97(1)	-	97(6)	77(2)
Bilderdykia convolvulus		68(4)	92(11)	97(7)	84(7)	97(9)	93(5)
Brassica napus		85(2)	91(5)	95(3)	39(2)	91(4)	100(2)
Capsella bursa-pastoris		-	90(3)	79(3)	-	41(2)	61(1)
Chenopodium album		85(5)	99(11)	100(7)	100(7)	99(8)	100(3)
Chenopodium ficifolium		97(3)	100(2)	100(1)	86(1)	-	-
Fumaria officinalis		38(2)	90(5)	98(2)	90(4)	93(5)	98(2)
Galeopsis tetrahit		58(3)	-	-	-	100(2)	100(1)
Galium aparine		67(1)	91(5)	84(4)	0(3)	95(5)	84(4)
Geranium dissectum		-	100(4)	-	-	88(4)	-
Lamium purpureum		87(3)	99(6)	100(2)	85(3)	100(4)	100(3)
Matricaria spp.		54(4)	97(13)	96(6)	99(12)	66(12)	83(5)
Myosotis arvensis		95(1)	94(3)	-	95(1)	65(1)	-
Poa annua		81(4)	95(14)	96(7)	98(9)	53(8)	58(3)
Polygonum aviculare		74(3)	86(12)	91(4)	87(6)	93(6)	92(5)
Sinapis arvensis		100(1)	90(8)	94(5)	77(4)	91(9)	89(5)
Solanum nigrum		93(1)	96(5)	93(3)	87(3)	100(3)	100(1)
Sonchus oleraceus		50(1)	52(1)	78(1)	48(1)	52(1)	67(1)
Stellaria media		86(6)	95(22)	96(11)	95(14)	97(23)	100(9)
Thlaspi arvense		98(1)	100(1)	100(1)	-	100(2)	100(1)
Urtica urens		82(1)	100(3)	100(3)	95(4)	99(5)	100(4)
Veronica persica		75(5)	85(2)	89(6)	82(8)	78(10)	64(5)
Viola arvensis		20(4)	96(13)	91(5)	96(9)	65(11)	94(4)

ima = imazethapyr; pen = pendimethalin;
ter/ter = terbutryn/terbuthylazine; N = normal rate for soil type
≁ some trials were with 67/1000 g a.i./ha

Results also showed that the mean percentage control of total numbers of broad-leaved weeds with imazethapyr/pendimethalin at 50/1000 g a.i./ha for sites of peas and field beans was similar to the pre-emergence reference material terbutryn/terbuthylazine and was similar to, or slightly better than, the post-emergence reference tank-mixes in peas (the latter data not presented). Considerably better control was achieved with imazethapyr/pendimethalin than with the only existing product for post-emergence use in spring field beans, bentazone, which was ineffective on *P. aviculare* and *Chenopodium* spp (data not presented).

Crop Tolerance

Crop effects were related to timing and dose rates of imazethapyr/pendimethalin and over the range of very light to medium/heavy soils there was no evidence to suggest that selectivity was influenced by soil type.

TABLE 2. Yields of peas as a percentage of untreated control; maturity TR readings (of vining peas). Combining peas 1988 (sites 1, 2 & 3), 1989 (sites 4 & 5) and for vining peas 1989 (sites 6, 7 & 8)

Material	Rate	Timing	Combining Peas Yield %					Vining Peas Yield %			TR reading		
		Site:	1	2	3	4	5	6	7≠	8	6	7	8
ima/pen	n	T1	113	106	96	115	99	101	119	98	102	106	94
ima/pen	2n	T1	110	103	105	100	108	103	112	101	102	108	93
ter/ter	N	T1	-	-	-	88	106	99	131	99	102	108	96
ima/pen	n	T2	97	121	116	91	106	100	123	100	96	105	96
ima/pen	2n	T2	104	94	96	103	98	96	71	97	99	97	93
ima/pen	n	T3	102	112	96	118	100	90	98	98	91	104	94
ima/pen	2n	T3	100	97	112	100	92	70	94	100	88	108	94
cy + T	N	T3	-	-	-	97	95	87	112	91	98	104	94
ima/pen	n	T4	-	106	105	109	90	62	80	29	90	96	98
ima/pen	2n	T4	-	70	80	88	89	34	48	6	79	94	-≁
cy + T	N	T4	-	-	-	109	93	98	115	81	99	107	94
untreated	-	-	100	100	100	100	100	100	100	100	101	110	95
Yield untreated t/ha			2.3	2.1	3.1	3.3	6.2	5.1	1.3	6.2			
Significance @ P = 0.05			NS	S	NS	NS	NS	S	S	S	S	S	S
LSD @ P = 0.05			-	18.6	-	-	-	13.5	32.2	9.3	7.7	6.1	3.1
CV %			13.2	9.9	8.6	18.6	10.6	10.8	22.4	7.7	5.6	4.1	2.3

ima/pen = imazethapyr/pendimethalin tank mix 1988; formulation 1989
n = 50/1000 g a.i./ha, 2n = 100/2000 g a.i./ha.
ter/ter = terbutryn/terbuthylazine N = normal recommended rate
cy + T = cyanazine+MCPB/MCPA tank-mix N = normal recommended rates
T1 = pre-emergence
T2 = peas just emerging
T3 = peas 2 to 4 node stage (timing not recommended for cy + T)
T4 = from 4 node stage
≁ too immature for TR reading; ≠ weedy site (others low weed populations)

Combining peas

Imazethapyr alone, and imazethapyr/pendimethalin at rates up to 100/2000 g a.i./ha had a wide margin of crop safety when applied pre-emergence of combining peas. Applications of the mixture just prior to emergence or when a few plumules had just emerged occasionally caused slight stunting and leaf crinkling but these effects, probably due to pendimethalin, were soon outgrown. Post-emergence applications of doses up to 67/1340 g a.i./ha were tolerated up to 3 or 4 node growth stage even when pea leaf wax cover was poor, as shown by crystal violet wax tests.

Yield data for five sites is shown in Table 2. Significant yield loss was seen at one site from application later than the 4 node stage.

Vining peas (8 trials, 1988 - 1989)

Imazethapyr/pendimethalin applied pre-emergence at rates up to 100/2000 g a.i./ha caused negligible crop effects. Post-emergence applications were generally tolerated at timings up to the 3 node stage for doses up to 50/1000 g a.i./ha although transient chlorosis, followed by slight stunting and delays in flowering were observed. At this rate the effects were acceptable to a farmer. Post-emergence treatments from the 4 node stage caused severe vigour reduction which was reflected in yield loss, and maturity (Table 2).

Field beans (spring sown) (6 trials 1989)

Spring sown beans showed good tolerance when imazethapyr/pendimethalin was applied pre-emergence at 38/750, 50/1000, 67/1340 g a.i./ha, and at twice these dose rates (data not presented). The crop appeared tolerant at the 1 node stage to post-emergence application of imazethapyr alone up to 134 g a.i./ha, but persistent damage was recorded at two sites for the imazethapyr/ pendimethalin co-formulation. The trials were not yielded.

Varietal tolerance

Variety screens in peas and beans carried out at the Processors & Growers Research Organisation showed that tolerance to imazethapyr/ pendimethalin appears to be related to timing of application rather than variety. In general however, combining pea varieties were more tolerant than vining pea varieties.

Safety in following crops

The effects from soil residues in succeeding crops of winter wheat and winter barley sown following treatment in the same year to a spring legume crop with imazethapyr/pendimethalin has been monitored. No carry over effects were observed 12 - 16 weeks after application. Similar assessments including double rates are being undertaken in oilseed rape and sugar beet, which are both sensitive to imazethapyr (Peoples *et al*., 1985).

Residues and taints

Samples of peas and beans treated with imazethapyr/pendimethalin were analysed for residues and none were found using a method with sensitivity of 0.05 ppm. Tests carried out so far by Campden Food & Drink Research Association have shown that peas and broad beans grown for quick-freezing and canning treated with imazethapyr were free from taints or off-flavours. Taints tests with the formulation are in progress.

DISCUSSION

Pre- and post-emergence applications of imazethapyr/pendimethalin at a rate of 50/1000 g a.i./ha gave excellent control of a very wide spectrum of annual broad-leaved species including *Polygonum* and *Chenopodium* spp. and volunteer oilseed rape (*B. napus*) which cause harvesting difficulties in combining peas. Good control of *G. aparine* and *B. napus* is achieved and this offers an improvement over most existing pre-emergence products. *S. nigrum* which can cause contaminant problems with berries in vining pea produce was also controlled. The mixture was less effective post-emergence on Matricaria spp. and also V. arvensis, P. annua and sometimes Veronica spp., particularly at more advanced growth stages, but the lower margin of crop safety at this stage may preclude the use of higher rates.

Selectivity of imazethapyr/pendimethalin was excellent in combining peas, vining peas and field beans when applied pre-emergence. Efficacy and selectivity of pre-emergence applications of imazethapyr/pendimethalin seemed unaffected by mineral soil type. Further work is needed for efficacy on organic soils, and for safety of vining peas on sands where no existing product has a UK label recommendation for use.

Timing trials showed that peas were more sensitive to later applications. For combining peas imazethapyr/pendimethalin can safely be applied prior to emergence, and early post-emergence up to the 4 node growth stage, without suffering unacceptable levels of damage or yield loss. Flexibility of pre- or post-emergence timing is an asset particularly where spraying has to be delayed if the soil becomes too wet for sprayers to travel. Safety does not appear to be dependent on pea leaf wax cover, which is often poor at early stages, and at the early post-emergence timing weeds are usually smaller and more susceptible. The early timing for imazethapyr/pendimethalin offers an advantage over standard contact-acting post-emergence tank-mixes which cannot safely be used before leaf wax is adequate or before the 3 or, in one case, 4 node stage.

The trials series showed that vining peas were more sensitive to post-emergence applications than combining peas. Treatments which cause maturity delay are unacceptable since harvesting schedules and factory intake are likely to be disrupted. Timings just prior to emergence and perhaps before the 3 node stage may be possible but further work is required for the latter.

It is concluded that the promising new herbicide mixture imazethapyr/pendimethalin has great potential for UK pea and bean crops, offering advantages of greater flexibility in peas with timings pre-emergence, just emerging and early post-emergence, and controlling a weed spectrum which includes G. aparine and B. napus. For safe use it will be essential that the farmer has a clear understanding both of stages of development of peas (Knott, 1987) and the consequences of spraying too late.

ACKNOWLEDGEMENTS

Acknowledgements are due to colleagues of Cyanamid of Great Britain and Processors & Growers Research Organisation for assistance with trials.

REFERENCES

Knott, C. M. (1987) A key for stages of development of the pea (Pisum sativum). Annals of Applied Biology (1987), 111, 233-244.

Peoples, T. R.; Wang, T.; Fine, R. R.; Orwick, P. L.; Graham, S. E.; Kirkland, K. (1985) AC 263,499: A new broad-spectrum herbicide for use in soybeans and other legumes. 1985 British Crop Protection Conference - Weeds, 1, 99-106.

EVALUATION OF PRE- AND POST-EMERGENCE HERBICIDES FOR BROAD-LEAVED WEED CONTROL IN COMBINING PEAS

N J GILTRAP, J F ROEBUCK

Agricultural Development and Advisory Service, (ADAS), Block B, Government Buildings, Brooklands Avenue, Cambridge, CB2 2DR, UK.

ABSTRACT

A wide range of pre- and post-emergence herbicides was compared to assess their efficacy on broad-leaved weed control and the effect on the yield of combining peas. The trial was undertaken over 4 seasons (1984-87) at Bridgets Experimental Husbandry Farm in Hampshire on a silty loam over chalk. The efficacy of pre-emergence herbicides varied between years due to variable soil conditions. Post-emergence treatments gave similar levels of weed control and were slightly more consistent between seasons but responses in yield tended to be lower. Some treatments reduced crop vigour and yield.

INTRODUCTION

Peas are not able to compete strongly with weeds and consequently infestations can cause yield depressions in addition to impeding combine-harvesting and drying. The entire pea crop receives one or more herbicide applications (King, 1976). Pre-emergence residual herbicides are used to control broad-leaved weeds on an estimated 70% of the UK pea crop (Knott, 1986). Their main advantages over post-emergence treatments are that they prevent early weed competition and have a wide spectrum of activity including species less well controlled post-emergence. They are however expensive (£14-40/ha) and in a dry spring may be ineffective such that a post-emergence spray is also required. The objective of this work was to compare the relative efficacy of a range of pre- and post-emergence herbicides on a silty loam soil, overlying chalk, representative of many pea growing areas in Central and Southern England, in an attempt to identify the most cost-effective strategies for broad-leaved weed control.

MATERIALS AND METHODS

A single trial was undertaken over a 4 year period at Bridgets Experimental Husbandry Farm on a silty loam over chalk (Andover series). The site details are given in Table 1. The experiment was of randomised block design with 3 replicates. Plot size was 3 x 24-30 m. A range of treatments (Tables 2-5) were applied with a Van der Weij plot sprayer, delivering 225 l/ha through Tee Jet 11002 nozzles at 250 kPa pressure. The crystal (methyl) violet test was undertaken to ensure pea leaf wax was adequate prior to application of post-emergence treatments.

Broad-leaved weed control was assessed by quadrat counts of 4 x 0.25 m^2 quadrat per plot of each species present or by visual assessment of the density of ground cover (0-9). Crop tolerance was assessed by scoring crop vigour (0-9).

TABLE 1. Site details

Year	1984	1985	1986	1987
Cultivar	Progreta	Progreta	Progreta	Bohatyr
Date Sown	13 March	8 March	26 March	13 April
Weed assessment	6 June	29 July	23 June	3 July
Spray timing				
pre-emergence	14 March	11 March	26 March	14 March
post-emergence	14 May	23 May	5 June	18 May
crop growth stage	4 leaves	4 leaves	enclosed bud	3-4 leaves

RESULTS

1984 Trial

The main broad-leaved weeds present in April were *Stellaria media*, *Veronica persica*, *Viola arvensis*, *Aethusa cynapium* and *Anagallis arvensis*. *Sinapis arvensis* and *Sonchus oleraceus* germinated later in small numbers. The pre-emergence herbicides generally gave poorer weed control than the post-emergence treatments (Table 2) due to dry seed-bed conditions post-drilling (total rainfall in April was 1.4 mm). The activity of cyanazine applied pre-emergence was particularly reduced. Bentazone + MCPB and cyanazine + MCPA/MCPB gave very good control post-emergence but the former reduced crop vigour. Bentazone + MCPB also controlled *V. persica* which is normally not susceptible to this mixture. The trial was not taken to yield.

1985 Trial

S. media and *Fallopia convolvulus* were the main weeds present together with low numbers of *V. arvensis*, *Papaver rhoeas*, *V. persica* and *Chenopodium album*. Soil conditions were suitable for pre-emergence herbicides (43.1 mm rainfall in April) and terbutryn + terbuthylazine, trietazine + simazine and pendimethalin all gave high levels of control through to harvest (Table 3). Cyanazine + MCPB/MCPA was the most effective post-emergence treatment. There were no visible effects of treatments on crop vigour. All herbicide treatments reduced weed growth at harvest and all except bentazone + MCPB significantly (p 0.05) outyielded the untreated. Yields were poor due to a wet harvest and extensive crop lodging.

1986 Trial

The pre-emergence treatments were applied to a fine, moist seedbed (63.4 mm rainfall in April) and all gave good weed control with terbutryn + terbuthylazine, trietazine + simazine and pendimethalin (2.0 kg a.i./ha) being particularly effective (Table 4). The post-emergence treatments were delayed by wet weather until 5 June and the enclosed flower buds were just detectable. Despite the weeds being relatively large by this stage (*S. media*, 6-10 leaves; *F. convolvulus*, 4 leaves; *Polygonum persicaria*, 4-6 leaves; *C. album*, 5-7 leaves; *V. persica*, 6-8 leaves) cyanazine + MCPA/MCPB gave similar high levels of control. Weed competition did not influence yield, but bentazone + MCPB which was applied beyond its latest recommended crop growth stage reduced crop vigour and yield.

TABLE 2. Weed control as % of untreated and crop vigour (1984)

	Product	kg a.i./ha	S. media	V. persica	V. arvensis	S. arvensis	All weeds	Crop vigour
pre-emergence								
1	terbutryn + terbuthylazine	0.42 0.98	52	85	44	100	60	8.0
2	trietazine + simazine	1.21 0.17	31	55	67	44	52	7.7
3	pendimethalin	1.33	39	40	37	67	40	7.7
4	pendimethalin	2.0	26	61	63	33	33	7.3
5	aziprotryne	2.0	5	40	100	33	24	7.7
6	cyanazine	1.75	0	0	67	0	4	8.0
post-emergence								
11	cyanazine + MCPB/MCPA	1.0 0.6	91	90	97	100	88	7.3
12	bentazone + MCPB	1.44 1.50	87	85	92	100	88	5.7
13	dinoseb amine	2.04	83	81	89	100	67	7.0
14	Untreated (number/m^2)		(24)	(12)	(16)	(5)	(155)	7.0

1987 Trial

The seedbed tilth was reasonable but a little compacted just below drilling depth. The main weeds present on 18 May, when the post-emergence treatments were applied were C. album (cotyledon to 8 leaves), Atriplex patula (2 leaves) and S. media (2-6 leaves). Other weeds present were V. arvensis, Matricaria perforata, Mercurialis annua, Lamium purpureum, F. convolvulus and Brassica napus but in low numbers and too erratic in distribution for accurate assessments. The levels of weed control by the pre-emergence treatments were generally poor (Table 5) and this could not be attributed to lack of soil moisture since rainfall in March was 62.1 mm with 16 rain days and in April 63.4 mm with 19 rain days. Pendimethalin (1.33

kg a.i./ha) gave the highest level of weed control and the addition of cyanazine did not significantly improve its overall performance although control of C. album was slightly better. The high rate of pendimethalin (2.0 kg a.i./ha) reduced crop vigour initially, probably due to inadequate drilling depth, and this allowed some recovery of surviving weeds. Control with post-emergence treatments was also poor and cyanazine + MCPB/MCPA reduced both crop vigour and yield. Only the terbutryn + terbuthylazine and pendimethalin (1.33 kg a.i./ha) treatments significantly outyielded the untreated.

TABLE 3. Weed control as % of untreated, crop vigour and yield (1985)

Product		kg a.i./ha	S. media	F. convolvulus	All weeds	% ground Cover weeds at harvest	Crop vigour	Yield (t/ha) S.E.D.± 0.15 d.f.20
pre-emergence								
1	terbutryn + terbuthylazine	0.42 0.98	98	64	81	2	7.3	1.96
2	trietazine + simazine	1.21 0.17	98	96	97	8	7.3	2.21
3	pendimethalin	1.33	98	93	91	3	6.7	2.31
4	pendimethalin	2.0	100	100	92	0	6.7	2.17
5	aziprotryne	2.0	51	67	50	30	6.7	1.68
6	cyanazine	1.75	77	67	63	18	7.7	2.11
post-emergence								
11	cyanazine + MCPB/MCPA	1.0 0.6	98	100	97	10	7.0	1.96
12	bentazone + MCPB	1.44 1.50	75	83	78	33	7.0	1.61
13	dinoseb amine	2.04	70	76	74	25	7.3	1.81
14	Untreated (number/m^2)		(13)	(8)	(25)	68	7.0	1.32

DISCUSSION

In this 4 year investigation, the efficacy of the pre-emergence herbicides varied between years due to variable soil conditions. The post-emergence treatments gave similar levels of weed control and were slightly more consistent between seasons, but responses in yield tended to be lower. Over the 3 years trials (1985-87), the most effective pre-emergence treatments terbutryn plus terbuthylazine, trietazine plus simazine and pendimethalin all significantly (P 0.05) outyielded the post-emergence treament cyanazine + MCPB/MCPA. Cyanazine + MCPB/MCPA and bentazone + MCPB both reduced crop vigour and yield in one trial; the latter did so when the spray was applied beyond its latest recommended growth stage.

TABLE 4. Weed control as % of untreated, crop vigour and yield (1986)

Product		kg a.i./ha	*S. media*	*F. convolvulus*	All weeds	Crop vigour	Yield (t/ha) S.E.D.± 0.25 d.f.20
pre-emergence							
1	terbutryn + terbuthylazine	0.42 0.98	90	100	92	8.3	4.31
2	trietazine + simazine	1.21 0.17	90	100	87	8.7	4.11
3	pendimethalin	1.33	100	77	73	8.7	4.22
4	pendimethalin	2.0	90	100	93	8.7	4.20
7	pendimethalin + cyanazine	1.33 0.75	100	100	84	8.0	4.22
8	pendimethalin + cyanazine	0.83 0.75	67	77	71	8.7	4.44
9	pendimethalin + isoxaben	1.33 0.05	90	100	84	8.7	4.55
10	terbutryn + prometryne	1.06 0.53	57	33	61	7.7	4.35
post-emergence							
11	cyanazine + MCPB/MCPA	1.0 0.6	100	100	95	9.0	4.12
12	bentazone + MCPB	1.44 1.50	100	100	61	5.3	3.51
14	Untreated (Number/m^2)		(3.0)	(3.0)	(25.0)	9.0	4.30

TABLE 5. Weed control as % of untreated, crop vigour and yield (1987)

Product		kg a.i./ha	*S. media*	*C. album*	*A. patula*	All weeds	Crop vigour	Yield (t/ha) (S.E.D. ± 0.17) d.f.20
pre-emergence								
1	terbutryn + terbuthylazine	0.42 0.98	44	25	72	38	8.0	3.42
2	trietazine + simazine	1.21 0.17	48	16	49	39	6.0	3.22
3	pendimethalin	1.33	64	71	54	71	8.0	3.42
4	pendimethalin	2.0	26	29	43	38	6.3	3.14
7	pendimethalin + cyanazine	1.33 0.75	68	44	80	61	8.3	3.34
8	pendimethalin + cyanazine	0.83 0.75	31	40	82	39	6.3	3.34
9	pendimethalin + isoxaben	1.33 0.05	35	54	43	57	7.0	3.34
10	terbutryn + prometryne	1.06 0.53	39	3	54	26	7.3	3.05
post-emergence								
11	cyanazine + MCPB/MCPA	1.0 0.6	57	44	44	44	5.3	3.02
12	bentazone + MCPB + cyanazine	0.8 0.8 0.2	70	16	44	44	5.7	2.63
14	Untreated (number/m^2)		(7.7)	(8.0)	(6.5)	(53)	6.3	3.04

REFERENCES

Knott, C.M. (1986) Weed control in peas - current practices and future prospects Aspects of Applied Biology, 12, 159-170.

King, J.M. (1976) Field experiments for the control of wild oats (*Avena fatua*) in peas with granular tri-allate. British Crop Protection Monograph Number 18, 73-9.

WEED CONTROL IN POTATOES AND LEGUME CROPS WITH A TRIETAZINE/TERBUTRYN COFORMULATION

E.S. BARDSLEY, B.L. REA, G.J. FIELDER

Schering Agriculture Limited, Nottingham Road, Stapleford, Nottingham, NG9 8AJ.

ABSTRACT

A 50% a.i. suspension concentrate coformulation containing 250 g/l trietazine and 250 g/l terbutryn was evaluated in 93 trials throughout the United Kingdom from 1987 to 1989 for the pre-emergence control of a wide range of broad-leaved weeds in peas, field beans (Vicia faba) and potatoes.

Weed control and crop safety over a range of soil types was excellent, comparing favourably with currently available commercial products.

The data presented demonstrate its safe and effective use on vining, combining and forage peas up to 5% emergence; potatoes (early, second early and maincrop) up to 10% emergence, and spring sown field beans pre-emergence only. It can be used on soils ranging from very light to heavy and on organic soils, the dose varying according to type. The product was granted Ministry Approval and launched in spring 1989.

INTRODUCTION

Effective weed control is essential in potatoes and legume crops to maximise yield and allow speedy, efficient harvesting. High infestations of weeds such as Bilderdykia (Fallopia) convolvulus, Polygonum aviculare and Stellaria media can considerably reduce yield and interfere with harvesting.

Potatoes are particularly sensitive to weed competition especially during the period from emergence until the crop canopy closes. Many of the pea varieties currently grown in the UK are the less competitive semi-leafless type, which require a very high standard of weed control. In vining peas it is also important to prevent contamination, at harvest, of the sample by weed fruits and seedheads of species such as Papaver rhoeas, and Matricaria spp which can reduce the value of the crop and even lead to its rejection if heavily contaminated.

This paper describes the efficacy, in comparison with standard herbicides, of a new trietazine/terbutryn coformulation which has been successfully developed for use in potatoes and legume crops.

MATERIALS AND METHODS

Trietazine/terbutryn was evaluated throughout the UK during 1987-89 in 93 efficacy trials over a range of soil types.

The herbicides used were:-

Experimental coformulation
trietazine + terbutryn 250 g + 250 g/l S.C. 'Senate'*

Standard products
trietazine + simazine 402.5 g + 57.5 g/l S.C. (legume crops only)
trietazine + linuron 240 g + 240 g/kg WP (potatoes only)
terbutryn + terbuthylazine 350 g + 150 g/l S.C.

TABLE 1. Normal dose rates (g/ha) of products used by crop and soil type

	Soil type				
	Very light	Light	Medium	Heavy	Organic
Peas and spring field beans					
trietazine/terbutryn	500/500	750/750	1000/1000	1000/1000	1000/1000
trietazine/simazine	725/104	966/138	1208/ 173	1208/ 173	1208/ 173*
terbutryn/terbuthylazine	560/240	805/345	980/ 420	1190/ 510	1190/ 510*
Potatoes (first earlies)					
trietazine/terbutryn	750/750	------------ All Soils ------→			
trietazine/linuron	720/720	-----------------------------→			
terbutryn/terbuthylazine	805/345	-----------------------------→			
Potatoes (second earlies and maincrop)					
trietazine/terbutryn	750/750	1000/1000	1000/1000	1250/1250	1250/1250
trietazine/linuron	840/840	840/ 840	1128/1128	1128/1128	1128/1128*
terbutryn/terbuthylazine	980/420	980/ 420	1190/ 510	1190/ 510	1190/ 510

* outside manufacturer's recommendation.

The herbicides were applied at normal (N) dose according to soil type (MAFF, 1985) for weed control (Table 1) and at double (2N) doses for crop safety. Applications, in comparison with appropriate standards, were made pre-emergence over a range of timings for all crops and up to 5% emergence in peas and up to 10% emergence in potatoes. Treatments were applied by pressurised knapsack sprayer fitted with TeeJet flat fan nozzles delivering 200-220 l/ha at 210-280 kPa. Plot sizes of 7-10 m x 2 m were used. Treatments were randomised and replicated three times. Crop effects (scorch, chlorosis and crop vigour) and weed control were assessed visually on a percentage scale where 0 = no effect and 100 = complete kill or weed control.

* Registered Trade Mark of Schering Agriculture.

Varietal Tolerance Trials

During 1987-89 the Processors & Growers Research Organisation (PGRO) carried out tolerance trials with trietazine/terbutryn on commercial spring sown field beans, vining, combining and forage pea varieties.

RESULTS

Efficacy

Legume crops (Table 2)

Trietazine/terbutryn gave excellent control of broad-leaved weeds and annual meadow-grass (Poa annua) in 38 trials over three seasons embracing a wide range of soil types. Weed control in peas was equally effective whether applied pre-emergence or at 5% crop emergence. On organic soils, application at 5% crop emergence to emerged weeds often resulted in improved efficacy compared with pre-emergence applications. Applied pre-emergence in spring sown field beans, results compared very favourably with the standard products.

TABLE 2. Mean % overall broad-leaved weed control in peas and spring sown field beans 1987-89.

	Soil Type			
Treatments (N dose)	Very light	Light	Medium	Organic
Peas				
trietazine/terbutryn	98	98	98	85
trietazine/simazine	98	97	95	77*
terbutryn/terbuthylazine	98	99	96	82*
number of trials	5	12	11	5
Spring field beans				
		Light	Medium	
trietazine/terbutryn		98	95	
trietazine/simazine		95	92	
terbutryn/terbuthylazine		99	96	
number of trials		3	3	

*outside manufacturer's recommendation.

Broad-leaved weeds controlled included B. convolvulus, Matricaria spp, S. media, P. aviculare, Veronica spp, Chenopodium spp, Viola arvensis, P. rhoeas, and Sinapis arvensis.

Potatoes (Table 3)

The experimental coformulation was highly effective against a wide range of broad-leaved weeds and *P. annua*. Efficacy was very good irrespective of timing of application. On organic soils when applications were made at around 10% crop emergence to emerged weeds trietazine/terbutryn had excellent activity, and was usually superior to pre-emergence applications.

TABLE 3. Mean % overall broad-leaved weed control in potatoes 1987-89

Crop:	First earlies	Second earlies and maincrop				
Soil type:	All soils	Very light	Light	Medium	Heavy	Organic
Treatments (N dose)						
trietazine/terbutryn	94	99	99	98	100	91
trietazine/linuron	93	99	99	97	99	
terbutryn/terbuthylazine	93	98	97	98	99	87
number of trials	11	3	8	9	2	6

In addition to the broad-leaved weeds listed under Table 2, *Atriplex patula*, *Lamium purpureum*, *Polygonum lapathifolium*, *Polygonum persicaria*, *Urtica urens*, *Myosotis arvensis* and *Senecio vulgaris* were well-controlled.

A range of broad-leaved weeds occurring in the trials (Table 4) were well-controlled by trietazine/terbutryn in all crops. In peas, efficacy with the new coformulation was often superior to trietazine/simazine. In 1987, trietazine/terbutryn had good activity against volunteer oilseed rape (*Brassica napus*), but in subsequent seasons control was rather variable.

TABLE 4. Mean % control of broad-leaved weeds and *Poa annua* in potatoes and legumes 1987-89 (all soils)

Weeds	trietazine/ terbutryn	trietazine/ simazine	trietazine/ linuron	terbutryn/ terbuthylazine
	Treatments (N dose)			
Atriplex patula	93(5)	72(2)	93(3)	94(5)
Bilderdykia convolvulus	94(21)	90(7)	95(10)	93(21)
Brassica napus	86(7)	-	92(5)	92(5)
Chenopodium album	98(23)	97(9)	98(14)	97(21)
Lamium purpureum	99(9)	86(3)	98(5)	98(9)
Matricaria spp	99(20)	99(8)	99(9)	99(20)
Papaver rhoeas	99(3)	98(3)	-	100(3)
Poa annua	97(19)	99(9)	97(9)	94(18)
Polygonum aviculare	97(19)	93(7)	95(11)	96(19)
Polygonum persicaria	93(7)	96(2)	92(3)	91(5)
Stellaria media	99(28)	95(12)	94(13)	98(28)
Veronica hederifolia	96(7)	95(1)	96(5)	98(7)
Veronica persica	98(17)	98(7)	96(10)	99(15)
Viola arvensis	95(19)	91(11)	96(7)	95(18)

( ) = number of trials.

Crop safety (Table 5)

Applied pre-emergence on a range of soil types at N and 2N doses trietazine/terbutryn was well-tolerated by all crops tested under normal growing conditions. When applied up to 5% crop emergence in vining and combining peas and up to 10% emergence in first early, second early and maincrop potatoes crop safety compared very favourably with existing standard products. Crops recovered well from occasional symptoms of scorch, chlorosis and reduced vigour.

Varietal testing over several seasons at PGRO (personal communication) has confirmed the excellent selectivity of trietazine/terbutryn in vining, combining and forage peas, and spring sown field beans.

TABLE 5. Mean % crop effect in peas, field beans and potatoes, 1987-89.

Application timing:		Pre-emergence			At emergence*	
		peas	field beans	potatoes	peas	potatoes
Treatment	Dose					
trietazine/ terbutryn	N	1.4(0-5)	3.0(0-7)	1.7(0-15)	2.3(0-14)	3.7(0-13)
	2N	2.4(0-10)	4.2(0-10)	2.0(0-10)	4.9(0-27)	3.8(0-20)
trietazine/ simazine	N	1.6(0-9)	2.2(0-6)		1.3(0-7)	
	2N	3.1(0-16)	3.3(0-7)		4.3(0-35)	
trietazine/ linuron	N			1.3(0-10)		1.4(0-10)
	2N			2.2(0-15)		3.0(0-25)
trietazine/ terbuthylazine	N	1.9(0-11)	3.2(0-7)	1.5(0-7)		3.3(0-22)
	2N	1.8(0-7)	5.0(3-7)	2.4(0-15)		6.4(0-25)
number of trials		16	7	35	12	27

* up to 5% emergence in peas and up to 10% emergence in potatoes.( ) = range.

DISCUSSION

In 93 trials over three seasons (1987-89) the trietazine/terbutryn coformulation gave excellent control of more than 30 species of broad-leaved weeds and showed excellent crop safety. Unlike many other products currently available, it may be used on organic soils, although when organic matter content is high persistence may be reduced. It also has valuable contact activity against emerged weeds especially at the cotyledon stage but weeds at a larger growth stage are also well controlled.

There are no varietal restrictions and trietazine/terbutryn can be used in vining, combining and forage peas up to 5% emergence, potatoes up to 10% emergence and spring sown field beans pre-emergence only. It can be used on soils from very light to heavy and organic, the dose varying according to soil type.

Taint tests have shown no taint or off-flavour and the product can be used on crops destined for freezing, canning and processing.

ACKNOWLEDGEMENTS

We wish to thank colleagues who helped with trials, farmers who provided the sites and PGRO who carried out additional trials.

REFERENCES

Ministry of Agriculture Fisheries and Food (1985) Soil Texture (85) System and Pesticide Use.

TOLERANCE OF SEED POTATO TO TWO NEW RESIDUAL HERBICIDE MIXTURES

H.M. LAWSON, J.S. WISEMAN, G. McN. WRIGHT

Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA

ABSTRACT

Mixtures of terbutryn and prometryn (E149) or fomesafen (FP282) were evaluated for crop safety against the standard terbutryn + terbuthylazine and untreated controls in weed-free crops of potato cv. Maris Piper grown for seed. Crop reaction to overdosing and mis-timing of E149 and terbutryn + terbuthylazine was similar, suggesting that growth stage recommendations for the latter (up to 10% crop emergence) might safely be applied to E149. FP282 applied pre-emergence was no less safe than terbutryn + terbuthylazine, but when applied during crop emergence it desiccated all emerged foliage and in one experiment reduced yield, even at the recommended rate. This herbicide mixture should probably be limited to application strictly pre-emergence.

INTRODUCTION

Potato crops grown for seed are particularly vulnerable to injury by herbicides because of their short growing season, their inspection for certification and the risk of effects on the subsequent growth of daughter tubers. It is therefore important that any possible adverse effects caused by overdosing, mis-timing etc should be identified and quantified prior to marketing a herbicide for this specialist crop. The evaluation technique used has been described elsewhere (Lawson & Wiseman, 1986). This paper reports experiments with two new formulated herbicide mixtures - terbutryn + prometryn (E149) and terbutryn + fomesafen (FP282) - which were compared against the established standard mixture terbutryn + terbuthylazine ('Opogard').

MATERIALS AND METHODS

Two experiments were carried out on sandy clay loam soils (6-8% o.m. by loss on ignition) at Invergowrie in crops of cv. Maris Piper. Plots consisted of two rows each of 28 plants, plus shared guard rows. Tubers (45-55 mm diameter) were planted at 30 cm spacing in rows 75 cm apart. Treatments were arranged in randomised blocks and replicated three times. Four untreated plots were included in each replicate.

The herbicides were applied by Oxford Precision Sprayer in a water volume of 530 l/ha either just prior to emergence or 3-4 days after first emergence of potato shoots. Rates of application were as follows:

Herbicide mixture	Code (in tables)	Dose kg a.i./ha Single	Dose kg a.i./ha Treble
Terbutryn + terbuthylazine	T+T	1.2+0.5	3.6+1.5
Terbutryn + prometryn	E149	1.2+0.6	3.6+1.8
Terbutryn + fomesafen	FP282	1.0+0.2	3.0+0.6

Potato haulm was removed when the majority of tubers were of seed size (35-55 mm diameter). Tubers were harvested and graded and samples were assessed for internal vascular browning, skin set, disease incidence and dry matter content. Seed size tubers were stored in trays until mid February in the dark at 2°C and then submitted to a chitting regime of 12 h light and 12 h dark, both at 15°C until late April. Records were taken of sprout numbers and growth on 20 tubers/plot.

Routine applications of insecticides and fungicides were made to the field crops as and when necessary for protection against aphids and potato blight. The crops were not irrigated. A contact herbicide was applied overall well before crop emergence to control seedling weeds. Any weeds surviving this and/or experimental treatments were removed by hand. Dates of relevant operations were as follows:

	Expt I 1986-87	Expt II 1987-88
Tubers planted	2 May	20 April
Treatments applied		
a) just pre-emergence	30 May	15 May
b) during emergence	3 June	20 May
% plants with emerged shoots	23	60
Tubers harvested	2-9 October	7 October
Chitting started	23 February	19 February

RESULTS

In both experiments all spray treatments were applied to moist seedbeds in warm, calm weather. Shoot emergence was more uniform in 1987 than in 1986, hence the much higher percentage emergence recorded at the second treatment date (60% as compared with 23%). In 1986 a substantial soil moisture deficit built up over the summer months, whereas in 1987 this period was marked by well above average rainfall. In both years, pre-emergence application of all three herbicides at the single dose had no adverse effect on shoot emergence or appearance or on foliage development. Treble rates caused some leaf chlorosis in shoots emerging shortly after treatment. This was soon outgrown, with no evidence of translocation into new foliage. No pre-emergence treatment significantly reduced tuber numbers or yield in either year in comparison with records for untreated plots (Tables 1 and 2).

All treatments applied during crop emergence adversely affected above-ground shoots and those which emerged shortly after application. Terbutryn + terbuthylazine and E149 caused leaf chlorosis, severe at the treble rates, while both rates of FP282 desiccated all emerged foliage and caused chlorosis of shoots emerging over the next few days. There was no evidence of translocation into new foliage with any treatment. Delays in crop canopy development were more severe in 1987 because of the much higher proportion of emerged shoots at the time of application (Tables 1 and 2), but at harvest the only late-application treatments showing significant reductions in tuber yield and/or numbers in comparison with untreated controls were the treble rates of terbutryn + terbuthylazine and of FP282 (in both years) and the single rate of FP282 in 1987.

Records on skin set and percentage dry matter of harvested tubers showed

TABLE 1. Experiment I 1986. Field and harvest records

Herbicide treatment and dose		% ground cover by crop foliage 20 June	Fresh wt tubers t/ha Seed (35-55 mm)	Fresh wt tubers t/ha Total	Number tubers /plot	% dry matter tubers
Untreated		27	34.7	53.5	1177	20.5
S.E. mean ±		0.8	0.62	0.74	18.3	0.17
Pre-emergence						
T+T	single	29	35.7	52.0	1178	20.3
	treble	26	34.3	52.4	1136	20.1
E149	single	26	33.9	51.3	1178	20.9
	treble	28	35.5	51.9	1184	20.7
FP282	single	27	33.5	50.9	1159	20.6
	treble	26	34.0	50.5	1102	20.9
23% emergence						
T+T	single	26	32.7	50.4	1129	20.5
	treble	26	33.3	49.7*	1152	19.8
E149	single	26	34.7	51.5	1205	21.3*
	treble	27	34.6	50.3	1126	20.2
FP282	single	26	34.1	51.9	1134	20.1
	treble	23*	33.4	49.8*	1117	20.5
S.E. mean ±		1.5	1.24	1.49	36.6	0.34

* Significantly different from Untreated at the 5% level

no indication of adverse effects of any of the three herbicide mixtures, while the incidence of internal vascular browning or tuber diseases was negligible in both years. Chitting records (Table 3) suggested no carry-over effects of herbicide treatments into daughter tubers, with the possible exception of FP282 applied late at the treble rate in 1987.

DISCUSSION

Terbutryn + terbuthylazine has been widely used in the United Kingdom as a soil-applied potato herbicide for many years and its interaction with seasonal weather and crop growth patterns is a useful barometer against which to assess the relative crop phytotoxicity of new herbicides (Lawson & Wiseman 1985, 1986, 1987). Label recommendations limit application to treatment at up to no more than 10% emergence and the relatively small phytotoxic effects caused by gross overdosing and mis-timing in these experiments demonstrate both its wide margin of safety and the absence in 1986 and 1987 of the type of adverse environmental conditions before and after application which can occasionally exacerbate phytotoxicity (Lawson & Wiseman, 1985).

TABLE 2. Experiment II 1987. Field and harvest records

Herbicide treatment and dose		% ground cover by crop foliage 9 June	Fresh wt tubers t/ha Seed (35-55 mm)	Fresh wt tubers t/ha Total	Number tubers /plot	% dry matter tubers
Untreated		33	45.8	67.4	1125	22.2
S.E. mean ±		1.1	0.90	1.15	22.4	0.16
Pre-emergence						
T+T	single	30	45.3	67.4	1157	22.1
	treble	32	43.4	66.4	1054	22.0
E149	single	31	44.7	68.1	1129	22.7
	treble	28	44.9	64.9	1055	22.5
FP282	single	34	44.7	65.9	1111	22.6
	treble	31	45.3	64.3	1076	22.1
60% emergence						
T+T	single	29	46.4	65.3	1124	21.8
	treble	24***	38.7***	58.7**	958**	22.2
E149	single	25**	44.7	64.7	1068	21.8
	treble	23***	43.0	62.6	1028	21.8
FP282	single	14***	42.8	60.3**	995*	21.6
	treble	13***	38.2***	60.4**	940***	21.9
S.E. mean ±		2.2	1.80	2.30	44.8	0.31

*, **, *** Significantly different from Untreated at the 5%, 1% or 0.1% level

Crop reaction to the various doses and timings of application of E149 and terbutryn + terbuthylazine was very similar. Foliar symptoms were restricted to chlorosis of shoots and early leaves, were not translocated up the developing haulm and would not have caused problems during inspection for seed certification. There was no evidence of residual carry-over into daughter tubers. Overall E149, if applied at the suggested rate before 10% emergence, would appear to be marginally safer to the seed potato crop than terbutryn + terbuthylazine. This conclusion may need to be verified over a wider range of cultivars. E149, ('Peaweed'), had its official Approval for use in peas and beans in the United Kingdom extended to include ware potato crops in 1989.

FP282 is also being developed initially for use in legume crops (Knott, 1987; Lake et al., 1987), where, with pre-emergence treatments, cultivars appear to be less sensitive to injury than with terbutryn + terbuthylazine. The contact effect of the fomesafen constituent of the mixture rules out its use in these crops during emergence. In potato, pre-emergence application was no less safe to the crop than with terbutryn + terbuthylazine, but constraints on application during emergence also appear necessary in this crop because of the desiccation of all emerged foliage. This effect, together with some chlorosis caused by the terbutryn component, made emerged

TABLE 3. Experiments I and II. Chitting records/20 tubers.

Herbicide treatment and dose		Expt I 1987 A 23 March	Expt I 1987 B 29 April	Expt II 1988 A 28 March	Expt II 1988 B 18 April
Untreated		15.7	30.3	18.6	32.9
S.E. mean ±		0.34	1.39	0.34	0.90
Pre-emergence					
T+T	single	15.7	29.9	18.5	30.9
	treble	16.3	24.6	19.0	30.9
E149	single	15.9	26.4	18.3	29.6
	treble	15.6	30.0	17.9	30.0
FP282	single	16.7	31.2	17.7	30.8
	treble	14.9	28.6	19.1	35.0
During emergence					
T+T	single	16.1	31.4	18.5	32.7
	treble	16.8	29.0	17.9	31.3
E149	single	15.3	25.8	17.6	31.8
	treble	16.4	27.8	18.0	29.2
FP282	single	15.2	28.0	17.9	29.6
	treble	15.1	28.0	17.2	28.5*
S.E. mean ±		0.69	2.78	0.68	1.80

A - Mean length (mm) largest sprout
B - Fresh wt sprouts (g)
* Significantly different from Untreated at the 5% level

plants looked badly damaged for 2-3 weeks, but new growth was unaffected and no symptoms were visible by the normal time of seed certification inspection. However, yield was adversely affected at both the single and treble rates in 1987, following treatment at 60% emergence. There was also some evidence of a possible carry-over effect of the late treble rate treatment on the chitting behaviour of daughter tubers. This point requires investigation if the possibility of treatment during crop emergence is to be evaluated further. FP282 currently has no commercial registration for any crop use in the United Kingdom.

As pre-emergence treatments, both E149 and FP282 appear to have safety margins more than adequate to permit their consideration for use in seed potato crops.

ACKNOWLEDGEMENTS

These experiments were carried out with financial support from Pan Britannica Industries Ltd and Farm Protection Ltd.

REFERENCES

Knott, C.M. (1987) Fomesafen/terbutryn - a pre-emergence herbicide for annual broad leaved weed control in legumes for processing. Proceedings 1987 British Crop Protection Conference - Weeds, 2, 649-656.

Lake, C.T,; Brennan, A.T.; Plowman, R.E. (1987) FP282 - A new pre-emergence herbicide for use in peas. Proceedings 1987 British Crop Protection Conference - Weeds, 1, 189-196.

Lawson, H.M.; Wiseman, J.S. (1985) Evaluation of new residual herbicides for use in seed potato crops. Proceedings 1985 British Crop Protection Conference - Weeds, 2, 805-810.

Lawson, H.M.; Wiseman, J.S. (1986) Potato herbicides - the evaluation of crop tolerance. Aspects of Applied Biology, 13, 239-243.

Lawson, H.M., Wiseman, J.S. (1987). Preliminary evaluation of the tolerance of seed potato to isoxaben. Proceedings Crop Protection in Northern Britain 1987. Association for Crop Protection in Northern Britain, 202-207.

DI-ISOPROPYL NAPHTHALENE - A NOVEL PLANT GROWTH REGULATOR

M. EVEREST-TODD, A.K. KARPINSKI

Willow House Research Centre, Ings Farm, Carr Road, North Kelsey, Lincolnshire, LN7 6LG

ABSTRACT

Di-isopropyl naphthalene (DIPN) is a plant growth regulator for use in potatoes to control dormancy. Extensive trials with potato growers have demonstrated the bipolar dose related activity of the chemical. Applications of DIPN at a rate of 100 mg of a.i./kg of potatoes have given effective control of sprouting in ware stores for 180 days comparing favourably with existing proprietary formulations of tecnazene.

Treatment of seed potatoes at the rate of 12.5 mg of a.i./kg has effected dormancy and apical dominance with an increase in sprout number.

Extension of studies to include maize has shown a beneficial effect on germination and early growth.

INTRODUCTION

The isolation and identification of alkyl naphthalenes from a wide range of plant species mainly in the form of di-methyl naphthalenes indicated that the naphthalene moiety previously only known to be present in the plant as naphthylacetic acid (NAA) fulfilled an unexplained function as a plant metabolite.

Burton and Meigh (1971) and Meigh et al.(1973) separated the 1, 4 and 2, 6 isomers of di-methyl naphthalene (DMN) from the volatiles produced by potatoes and their findings indicated a possible role for alkyl naphthalenes in the control of dormancy. Beveridge et al.(1978, 1981) demonstrated that effective control of dormancy and sprouting could be achieved with the application of DMN to potatoes.

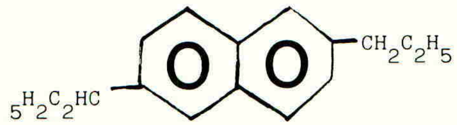
This concept was developed on a macro scale by Everest-Todd in 1980 (unpublished work), which confirmed DMN as being a highly effective chemical for sprout control in commercial ware stores. Difficulties with the synthesis of the active ingredient caused the abandonment of the project.

In 1985 Everest-Todd (unpublished work) demonstrated that di-isopropyl naphthalene (DIPN) exerted a similar effect to DMN on sprouting. Moreover the response was dose related. Treatment of potatoes with relatively higher doses of DIPN inhibited sprout growth whereas lower rate applications stimulated sprout growth resulting in an increase in stem and tuber number, tuber size and yield in the progeny.

The dual nature of its activity provides an insight into the chemical's mode of action. A tentative hypothesis suggests that DIPN is metabolised reversibly via the intermediate naphthoquinone to naphthylacetic acid.

CHEMICAL AND PHYSICAL PROPERTIES

Structural formula



Chemical name - di-isopropyl naphthalene (BSI)
bis-1-methyl ethyl naphthalene (IUPAC)

Molecular formula and weight - C_{16} H_{20}; 212

Form - colourless, odourless liquid
boiling range: 290-299°C
vapour pressure (20°C) 1.5 m. bar
solubility in water (25°C) 10^{-3} g/l

TOXICOLOGY

DIPN has been subjected to a wide range of toxicity tests using acute, subacute and chronic dosing regimes. In acute tests the compound has very low toxicity by both oral and dermal routes, is only slightly irritant to skin and eyes and does not cause skin sensitisation. The compound is not carcinogenic or teratogenic and is unlikely to produce any hazard to the environment.

Residue determinations of potatoes sampled 180 days following treatment at the higher dose rate of 100 mg a.i./kg returned low levels in the region of 1 ppm.

MATERIALS AND METHODS

Formulations

(1) 10% wt/wt DIPN granule
(2) 96% wt/vol DIPN emulsifiable concentrate.

Storage system

(i) 10 kg samples stored in wooden boxes in a frost free environment with a temperature range from 5° - 10°C.
(ii) Environmentally controlled 2,000 tonne capacity potato stores using 1 tonne storage boxes:-

1 store maintained at 8°C ± 1°C and
1 store maintained at 5°C ± 1°C.

Treatment and assessment techniques

Sprout inhibition trials

Spray treatments using two concentrations of the a.i. were applied in a standard volume of 50 ml for each 10 kg of potatoes on a roller conveyor utilising an ultra low volume rotary disc atomiser. The concentration employed was designed to give application rates of 50 mg/kg and 100 mg/kg. Four replicates of each dosage rate were made to the cultivar Cara 12 days after harvesting. The tubers were dry with some adhering soil at the time of treatment.

Granule applications were made at a standard rate of 1 kg 10% a.i. granule/tonne of potatoes to six 1 tonne boxes of the cultivar Estima and to four 1 tonne boxes of Maris Piper. Following treatment the Estima were stored at 5°C in an environmentally controlled store and the Maris Piper held at 8°C in a similar store. All of the granular applications were made to the top of the loaded container by hand taking care to spread the granules as evenly as possible.

The effect on sprouting was evaluated by counting the total number of sprouts falling within the categories 1 - 5 mm; 5 - 10 mm; 10 - 20 mm and those greater than 20 mm.

Sprout stimulation trials

10 kg batches of Cara were treated twelve days post harvest utilising the spraying techniques adopted in sprout inhibition trials.

Two dosage levels were employed i.e. 12.5 mg/kg and 25 mg/kg each being replicated 4 times.

Sprout stimulation was evaluated in the same way as sprout control.

Maize

Test solution: 1.0% wt/wt di-isopropyl naphthalene in ethyl alcohol. This test solution was then diluted with water to give 20 x 50 ml lots of the following concentrations:- 80 mg; 160 mg and 400 mg of DIPN/litre of solution. Similar dilution of pure ethanol in water was prepared for comparison.

Five gram samples of seed were introduced to 100 ml flasks containing the diluted test solution and allowed to stand for twenty four hours. At the end of 24 hours immersion 10 seeds per treatment were drained for 1 hour then planted out in trays of potting compost and covered with sand to a depth of 5 cm. The trays were maintained at 15°C under a 12 hour day length regime for fourteen days.

Assessments were made on the emergence and rate of growth by a daily count of the number of maize coleoptiles which had appeared through the growing medium and by recording plant height as an indicator of growth rate.

RESULTS

Sprout inhibition

Spray application

TABLE 1. Sprout control in tubers of the cultivar Cara following a spray application of DIPN.

Dose mg/kg	Total number of tubers	Number of sprouts in size category 1-5mm	5-10mm	10-20mm	>20mm	Total
120 DAT						
50	559	4	0	0	0	4
100	569	4	0	0	0	4
0	430	313	62	43	7	425
150 DAT						
50	559	1363	1	0	0	1364
100	569	781	3	0	0	784
0	430	186	77	81	154	498

Granule application

No sprouting had occurred in the treated tubers of cv. Estima after 150 days storage at 5°C, whereas in the untreated considerable sprouting had occurred (Table 2).

Similarly, no sprouting occurred in DIPN treated tubers of cv. Maris Piper after 150 days storage at 8°C, whereas some was recorded for tecnazene (Table 2).

TABLE 2. Sprout control in tubers following treatment with granular DIPN.

Treatment	mg/kg	Cultivar	Number of sprouts in size category 1-5mm	5-10mm	10-20mm	>20mm	Total
DIPN	100	Estima	1	0	0	0	1
Untreated	0	Estima	80	32	14	2	128
DIPN	100	Maris Piper	0	0	0	0	0
Tecnazene	100	Maris Piper	11	3	0	0	14

Average of 100 tubers per box.

Sprout stimulation

No increase in sprout number was recorded after 120 days storage at 5°C at either dosage level, after a further 30 days at 15°C there was a significant increase.

TABLE 3. Sprout assessment in tubers of the cultivar Cara following a spray application of DIPN.

Dose mg/kg	Total number of tubers	Number of sprouts in size category 1-5mm	5-10mm	10-20mm	>20mm	Total
120 DAT						
12.5	516	173	8	0	0	181
25.0	545	0	0	0	0	0
0	430	313	62	43	7	425
150 DAT						
12.5	516	2298	24	1	0	2323
25.0	545	1565	5	0	0	1570
0	430	186	77	81	154	498

Maize germination trial

TABLE 4. Effect of DIPN on germination and rate of emergence in maize.

DIPN concn mg/l		Total number emerged coleoptiles											
	Day	3	4	5	6	7	8	9	10	11	12	13	14
400			5	7	7	8	10						10
160				4	8	10	10						10
80				5	10	10	10						10
0					5	7	8	10					10

DISCUSSION

In the current climate of concern regarding food safety the use of chemicals in food production is constantly being reviewed. Potato storage is no exception and opinion within the potato industry suggests that current chemically managed storage regimes are likely to be threatened. Already growers supplying the high street multiple outlets have been instructed to comply with UN guidelines for maximum residue levels in their usage of tecnazene which effectively precludes its use on potatoes destined for this market.

The amount of interest generated by the current research topic is a measure of the anxiety the industry feels and the availability of DIPN as a sprout suppressant would provide a much needed alternative.

Its efficacy in store is remarkable with a single application of 100 ppm exercising control over sprouting for 180 days. Recent studies on sprout suppression have demonstrated that the naphthalene derivative appears at least equal to tecnazene. The absence of adverse effects on wound healing during the curing process add to its acceptability.

With its low toxicological profile and the very low levels of residue remaining on treated potatoes DIPN withstands the most critical of examinations.

The versatility of the molecule and in particular its ability to promote sprout growth at low dosage rates may have useful implications for the potato seed industry. The concept of dormancy release, reduction of apical dominance and subsequent regulation of growth, including an increase in the seed size tuber fraction in the progeny possesses immediate practical applications such as dormancy breaking of seed tubers for export or local use and incorporation into seed multiplication programmes.

Advantages to be gained by the ware grower treating his seed include uniform sprouting for maximum production, more uniform development and fewer late maturing plants.

Experimentation with other plant species has identified maize as showing a promising response to DIPN particularly at the germination and early growth stages. There may be some scope for use in species which are slow starters in the U.K. such as maize.

ACKNOWLEDGEMENTS

The authors thank B. Lundy, Esq., for providing facilities for trials on maize.

REFERENCES

Beveridge, J.L.; Daiziel, J.; and Duncan, H.J.; (1978) Evaluation of di-methyl naphthalene (DMN) as a sprout suppressant for seed potatoes. 7th Triennial Conference EAPR, 147-148.

Beveridge, J.L.; Daiziel, J.; and Duncan, H.J.; (1981a) The assessment of some volatile organic compounds as sprout suppressant for ware and seed potatoes. Potato Research, 24, 61-76.

Beveridge, J.L.; Daiziel, J.; and Duncan, H.J.; (1981d) Di-methyl naphthalene as a sprout suppressant for seed and ware potatoes. Potato Research, 24, 77.

Burton, W.G.; and Meigh, D.F.; (1971) The production of growth suppressing volatile substances by stored potato tubers. Potato Research, 14, 96-101.

Meigh, D.F.; Filmer, A.A.E.; and Self, R.; (1973) Growth inhibitory volatile aromatic compounds produced by Solarum Tuberosum tubers. Phytochem, 12, 987-993.

A DIMEFURON/BENAZOLIN MIXTURE FOR BROAD-LEAVED WEED CONTROL IN WINTER OILSEED RAPE

J.M. KING, M.T.F. TURNER

Rhône-Poulenc Agriculture, Fyfield Road, Ongar, Essex, CM5 OHW

ABSTRACT

Results are presented for the formulated herbicide mixture containing 375 g/kg dimefuron and 125 g/kg of benazolin (FR 1510) which was evaluated in an extensive series of experiments in winter oilseed rape over the seasons 1986/87, 1987/88 and 1988/89. FR 1510 was tested for efficacy at dose rates of 1.5 and 2.0 kg of product/ha at two post-emergence application timings, in comparison to a range of standard products. Dose rates of 2.0 and 4.0 kg/ha were tested in tolerance tests, while tank-mix and sequential application tests with fungicides, insecticides, micronutrients and herbicides were also carried out. In 1988/89 fourteen farmer 'user' trials were conducted using commercial equipment.

FR 1510 was shown to be a very safe and effective treatment giving excellent control at rates of 1.5 and 2.0 kg/ha of the important weed species found in winter oilseed rape.

Crop tolerance was excellent and FR 1510 was shown to be compatible with a number of fungicides, insecticides, micronutrients and herbicides, but sequential applications were necessary for certain graminicides.

INTRODUCTION

Dimefuron, generally in combination with carbetamide, has been used extensively throughout Europe for post-emergence weed control in oilseed rape (Chevrel et al., 1977; Pink, 1976; Proctor & Finch, 1978; Schiller, 1984; Soper, 1978; Rola & Franek, 1979). As a post-emergence treatment, dimefuron has both contact and residual root uptake activity on a wide range of annual broad-leaved weeds and annual meadow grasses. Benazolin, alone or in combination with clopyralid, has also been widely used in Europe as a post-emergence contact and translocated treatment for the control of broad-leaved weeds in winter oilseed rape (Proctor & Finch, 1976; Rea et al., 1976; Rola & Franek, 1979). The two actives complement one another for broad spectrum control in oilseed rape and following initial tests with tank mixtures a formulated mixture, coded FR 1510, was developed. The results of the experiments carried out with this formulation from 1986 to 1988 are reported in this paper.

METHOD AND MATERIALS

From autumn 1986 to autumn 1988 forty-two replicated experiments were carried out in commercial crops of winter oilseed rape for efficacy assessments. A further five specific tolerance experiments were carried out in 1987/88. The experiments were of randomised block layout with four replicates and the plots were 3 x 6m in size. The treatments were applied using a motor-driven small plot sprayer at a volume of approx. 200 l/ha using 'Lurmark' 02-F110 flat fan nozzles. The experiments were assessed at 14-21 and 28-35 days post-spraying for crop effects and bulk reduction and weed counts were carried out at the time of spraying and at maximum effect on 0.5m² quadrats. Three of the specific tolerance experiments were harvested for yield using a Claas 'Compact 25' combine.

In the autumn of 1988 fourteen large-scale 'farmer user' trials were carried out. The treatments were applied by the farmer to single unreplicated 1 ha plots using commercial sprayers. Assessments were carried out for crop effects and weed counts were carried out at maximum effect on 0.5m² quadrats. Untreated areas were left on all sites for comparison.

Herbicides included in the experiments were as follows:-

FR 1510 (WP) benazolin-ethyl 125 g/kg ester and dimefuron 375 g/kg proposed trade name 'Ranger'.
clopyralid 200 g/l 'Dow Shield'.
benazolin-ethyl ester 30% w/w and clopyralid 5% w/w 'Benazalox'.
propyzamide 50% 'Kerb'.
metazachlor 500 g/l 'Butisan S'.

RESULTS

Weed control

The results for treatments of FR 1510 at dose rates of 1.5 and 2.0 kg/ha of product, on twelve weed species are presented in Table 1 in comparison to three standard products. Data is only presented where the weed population was five plants/m² or above.

FR 1510 at both rates and timings gave excellent control of *Capsella bursa-pastoris*, *Fumaria officinalis*, *Lamium amplexicaule*, *L. purpureum*, *Papaver rhoeas*, *Stellaria media*, and *Veronica persica*. At the early timing when the weeds were generally small, both rates of FR 1510 gave good control of *Galium aparine*. Control of *Matricaria* spp. was better at the earlier timing at rates of 1.5 kg/ha or above, while the addition of clopyralid improved control. FR 1510 gave moderate levels of control of *Myosotis arvensis* and *Viola arvensis*, but in general the control was superior to the standard products. On *Poa annua* results were inconsistent with better control from the later timing on more advanced weeds.

TABLE 1. Replicated trials 1986-88 - mean control of weed species.

Treatment	Dose kg/l/ha product	≠ Timing	Percentage control weed species (see key)											
			CBP	FO	GA	LA	LP	MAT	MA	PR	SM	VP	VA	PA
FR 1510	1.50	2	99	97	91	89	99	86	61	100	95	93	58	8
" "	2.00	2	99	-	96	-	99	80	73	-	99	95	43	46
FR 1510 + clopyralid	1.50 + 0.5	2	78	94	-	100	99	99	32	100	93	92	62	34
FR 1510	1.50	3	84	100	-	100	92	70	50	96	88	93	57	74
" "	2.00	3	97	100	-	100	97	79	46	100	94	93	84	80
FR 1510 + clopyralid	2.00 + 0.5	3	80	100	-	100	100	98	39	96	89	93	70	73
Benazolin/clopyralid	1.25	3	53	100	100	27	28	91	19	82	79	4	45	0
Propyzamide	1.00	3	11	94	-	1	27	2	23	89	82	43	42	84
Metazachlor	2.50	2	56	-	51	-	35	71	9	-	37	54	12	64
Metazachlor "	1.50 1.00	1 } 2 }	-	100	-	98	90	100	-	96	100	100	50	100
Number of sites			1	1	1	1	7	8	2	1	14	7	10	4
Weed Nos./m² (range)			33	7	7	13	6-27	5-198	9-11	6	8-45	9-32	6-130	17-85

KEY : Weed species:- CBP - *Capsella bursa-pastoris*, FO - *Fumaria officinalis*, GA - *Galium aparine*, LA - *Lamium amplexicaule*, LP - *Lamium purpureum*, MAT - *Matricaria* spp., MA - *Myosotis arvensis*, PR - *Papaver rhoeas*, SM - *Stellaria media*, VP - *Veronica persica*, VA - *Viola arvensis*, PA - *Poa annua*

Timing ≠
1. Pre-emergence.
2. After 3 expanded leaf stage of crop and when weeds approx. 2.5 - 10cm in size.
3. Approximately 28 days after timing 2, weeds up to 15cm size.

The results from the large-scale 'user' trials are presented in Table 2. The results confirm the data from the small plot replicated trials with FR 1510 at dose rates of 1.5 and 2.0 kg/ha giving excellent control of C. bursa-pastoris, F. officinalis, L. amplexicaule, L. purpureum, P. rhoeas, S. media, V. hederifolia and V. persica. FR 1510 was less effective on M. arvensis and V. arvensis while the rate of 2.0 kg/ha was necessary to give acceptable control of A. arvensis, Matricaria spp. and P. annua. FR 1510 proved to be more effective than the standard benazolin/ clopyralid on A. arvensis, Lamium spp., P. rhoeas, S. media and Veronica spp.

TABLE 2. Large-scale 'user' trials 1988 - mean % control of weed species

Species	≠ Timing	Dose kg/ha Product FR 1510 1.5	Dose kg/ha Product FR 1510 2.0	Benazolin/ clopyralid 1.0 - 1.25	Number of Sites	Untreated weeds/ m^2
Aphanes arvensis	3	50	93	22	1	519
Capsella bursa-pastoris	3	97	100	100	1	6
Fumaria officinalis	3	94	100	96	2	7-17
Lamium amplexicaule	3	100	100	0	1	13
Lamium purpureum	3	100	100	0	1	107
Matricaria spp.	3	58	84	73	2	6-74
Myosotis arvensis	3	58	53	50	2	12-83
Papaver rhoeas	3	86	88	31	3	6-13
Poa annua	3	64	90	16	4	7-213
Stellaria media	3	96	97	73	9	5-118
Veronica hederifolia	3	97	97	75	2	8-12
Veronica persica	3	94	95	53	6	6-36
Viola arvensis	3	42	47	56	6	10-42

Key: ≠ Timing 3 - after 3 expanded leaf stage of crop, weeds up to 15cm in size.

Crop tolerance

Experiments with FR 1510 have been carried out on twenty-seven crops of the cultivar Bienvenu, four crops each of Ariana and Rafal, three crops of Mikado, thirteen crops of Libravo and ten crops of Cobra. Crop tolerance in all cultivars has been excellent with no adverse effects being recorded in 1986/87 or in 1987/88. In the autumn of 1988 at three sites where the crop was growing rapidly and night frosts followed the applications, slight marginal leaf chlorosis (max. 7.3% leaf area affected) was recorded between 14 and 23 days following treatment with FR 1510 at 1.5 kg/ha. The effects were transitory and no bulk reduction was observed.

Three of the tolerance experiments laid down in autumn 1987 were harvested for yield. The results are shown in Table 3.

TABLE 3. Crop tolerance yield data - harvest 1988.

Treatment	Dose kg/ha product	Timing //	Site/	Yield (8% m/c) % of untreated E1	E2	E5
FR 1510	2.0	2		109	114	147***
" "	4.0	2		104	97	145***
" "	2.0	3		101	109	141***
" "	4.0	3		100	120	148***
Untreated control		-		100	100	100
(Yield T/ha)				(3.8)	(2.3)	(2.0)
Significance (%)				NS	NS	0.1
Co-efficient of Variation (%)				13.25	14.02	11.97
L.S.D. (0.1%)				-	-	1.67

KEY: / Sites E1, E2 and E5 cv. Bienvenu
// Crop timing: 1. Four-six expanded leaves (crop).
2. Nine-thirteen expanded leaves (crop).

At sites E1 and E2 there were no significant yield differences from the untreated control plots with either normal or twice normal dose rates of FR 1510 at either crop growth stage timing. At site E5 a heavy infestation of V. persica developed in the late-drilled and rather thin crop and by March had produced 100% ground cover. At harvest all treatments significantly outyielded the untreated control plots.

Tank-mixes and sequences

A series of compatibility and sequence experiments were carried out in the 1987/88 and 1988/89 seasons to investigate tank-mixes with insecticides, fungicides, micronutrients and herbicides. The data is not presented, but the experiments showed that FR 1510 could be safely mixed with a wide range of insecticides, fungicides and micronutrients. Tank-mixes with graminicides caused unacceptable damage and in certain instances reduced control of grass weeds. For these products a minimum of fourteen days must elapse between their application and the application of FR 1510.

DISCUSSION

Previous experience with dimefuron and benazolin has shown them to be safe and effective herbicides in oilseed rape. The results of the work with the mixture confirmed the value of combining the two actives. Control of even established S. media was outstanding while control of other important weeds such as Lamium spp., P. rhoeas and Veronica spp. was excellent. Control of Matricaria spp. was dependent on weed size and dose rate. An early treatment of 2.0 kg/ha applied when the weed was relatively small (approx. 2.5 cm) gave 80-85% control. In light infestations this could be acceptable but where heavy infestations occur a tank-mix with clopyralid would be required.

The effect on weeds was often slow to show and full effects from applications made in October or November were not usually seen until the early spring.

Crop tolerance to FR 1510 was good and there appeared to be no varietal susceptibility to the six cultivars tested. The only crop effects recorded at three sites followed a period of rapid growth and night frosts occurred soon after application. The effects seen were slight and transitory and did not affect later growth. Applications were not made until the crop had 3-4 expanded leaves as previous work with dimefuron has indicated that the crop can be more sensitive at earlier growth stages.

FR 1510 cannot be tank-mixed with specific graminicides and for the control of volunteer cereals and broad-leaved weeds a programme will be necessary, the application of FR 1510 following the graminicide by at least 14 days. Such a programme will be capable of controlling all the important weed problems generally encountered in oilseed rape.

ACKNOWLEDGMENTS

The authors wish to thank their colleagues at Rhône-Poulenc who have been involved in the work and Schering Agriculture for their help and assistance with the project.

REFERENCES

Chevrel, J.; Rognon, J.; Gatineau, F. (1977) L'association dimefuron plus carbetamide pour le desherbage complet du colza d'hiver. Compte Rendu des journees d'etudes sur les herbicides, 9e Conference du Columa, 1, 136-146.

Pink, R.B.; (1976) Weed control and yield response in winter rape with carbetamide and dimefuron. British Crop Protection Conference - Weeds, 2, 541-548.

Proctor, J.; Finch, R.J. (1976) Chemical weed control in winter oilseed rape, 1974 and 1976 harvest years. British Crop Protection Conference - Weeds, 2, 509-516.

Proctor, J.; Finch, R.J. (1978) Chemical weed control in winter oilseed rape, 1977 and 1978 harvest years. British Crop Protection Conference - Weeds, 2, 527-534.

Rea, B.L,; Palmer, R.A.; De St.Blanquat, A. (1976) Weed control in rapeseed with benazolin ester/3,6 dichloropicolinic acid mixtures, British Crop Protection Conference - Weeds, 2, 517-525.

Rola, J,; Franek, M. (1979) Evaluation of new herbicides and their method of use for controlling weeds in winter rape. Zeszyty Problemowe Postepow Nauk Rolniczch, 229, 51-58.

Schiller, R. (1984) Pradone Kombi zur gezielten Unkrautbekampfung in Raps im. Zeitschrift fur Pflanzenkrankheiten und Pflanzenschutz, 10, 377-383.

Soper, D. (1978) Herbicidal control of volunteer cereals in winter oilseed rape over four seasons. British Crop Protection Conference - Weeds, 2, 415-422.

WEED CONTROL IN OILSEED RAPE WITH A BENAZOLIN/CLOPYRALID/DIMEFURON COFORMULATION

A.J. MAYES, J. MARSHALL, R.I. HARRIS

Schering Agriculture Limited, Nottingham Road, Stapleford, Nottingham NG9 8AJ.

ABSTRACT

Three seasons' extensive field trials in the United Kingdom from 1986 to 1989 evaluated the post-emergence performance of a 42.5% a.i. wettable powder coformulation of benazolin, clopyralid and dimefuron, 150 + 25 + 250 g/kg against broad-leaved weeds in winter oilseed rape.

Excellent control of a wide range of species was achieved at product doses in the range 1.5 to 2.0 kg/ha depending on weed size, including Stellaria media, mayweeds (Matricaria spp, Anthemis spp, and Chamomilla spp), Veronica spp, Lamium spp, Galium aparine, Fumaria officinale and Papaver rhoeas. Useful control of Viola arvensis, Capsella bursa-pastoris, Myosotis arvensis and Poa annua was also obtained.

Crop safety was excellent over a range of growth stages from the third true leaf exposed (GS 1,03), to flower buds present but enclosed by leaves (GS 3,1).

Consideration of results over three very different seasons suggest that this coformulation of benazolin/clopyralid/dimefuron, which has been submitted for Approval, will set a new standard of post-emergence broad-leaved weed control in winter oilseed rape.

INTRODUCTION

In many years autumn sown oilseed rape offers little competition to developing weeds until active crop growth resumes in the spring. Depending on seasonal conditions, weeds continue to emerge over the winter months and can become strongly competitive. Pre-emergence herbicide treatments often lack persistence and premature post-emergence application will not always control later germinating weeds. Suitable spraying conditions are less frequent during the shorter days of October to March and therefore products which are flexible in their period of use offer a considerable advantage.

Benazolin coformulated with clopyralid has performed well in this respect since its introduction in the mid-seventies (Rea et al, 1976), particularly against Stellaria media and mayweeds. Recently other weeds have become increasingly important highlighting the need for a broader spectrum, flexible timing product.

In 1986 the opportunity arose to evaluate a mixture of benazolin/clopyralid with dimefuron, a contact and residual herbicide with complementary activity. Following preliminary tank-mix work a coformulation of benazolin/clopyralid/dimefuron was prepared for field testing.

Results are presented of extensive field trials conducted in the past three climatically diverse seasons against a wide range of annual broad-leaved weeds and Poa annua.

MATERIALS AND METHODS

A WP formulation of benazolin ester + clopyralid + dimefuron (150 + 25 + 250 g/kg) was tested at 1.5, 2.0 kg/ha and at double doses against the principal broad-leaved weeds of winter oilseed rape. Efficacy in the major commercial cultivars was evaluated in 44 geographically widespread trials with high weed populations. In addition a further six trials with little or no weed, were treated with the experimental coformulation at 2.0 and 4.0 kg/ha at different stages of crop development and taken to yield as an added test of crop safety.

Standard products were benazolin/clopyralid 300 + 50 g/kg WP applied at 1.0 and 1.25 kg/ha and at double doses in efficacy and weed free yield trials, benazolin/clopyralid tank mixed with metazachlor 500 g/l S.C. at 0.75 kg/ha + 1.5 l/ha and metazachlor alone at 2.5 l/ha in efficacy trials.

Three application timings were compared in efficacy trials at crop growth stages defined by Sylvester-Bradley and Makepeace, 1984.

Stage I - 2 to 6 true leaves exposed (1,02 to 1,06), from September to October when weeds were at the cotyledon stage to 10 cm high or across.

Stage II - 3 to 10 true leaves exposed (1,03 to 1,10), from November to December when weeds were from 5 cm to 40 cm high or across.

Stage III - One internode detectable to flower buds visible from above (2,01 to 3,03), from January to March when weeds were from 10 to 60 cm high or across.

Similar application timings were compared in the weed free yield trials.

Plot size was 8-10 m x 2-3 m with three replicates in efficacy trials and 20 x 3 m with six replicates for yield determination. Treatments were applied by pressurised knapsack sprayer equipped with TeeJet 8001 or 11002 nozzles in 200 l/ha of water at 210 to 280 kPa.

Crop safety and weed control were assessed visually on a percentage scale. Yield trials were harvested by Claas combine adapted for small plot work and grain yields statistically analysed employing Duncan's Multiple Range Test.

RESULTS

Weed control

Irrespective of season or stage of application, the experimental coformulation performed very well in comparison with the standards (Table 1). Excellent overall broad-leaved weed control was achieved at 1.5 kg/ha following stage I applications against small weeds. Later in the season similarly consistent control was achieved at stage II with the 2.0 kg/ha rate. Even large overwintering weeds treated at stage III responded very

TABLE 1. Mean percentage weed control: three seasons trials: 1986-1989 April assessment. ( ) = number of trials

Treatment:	benazolin/clopyralid/dimefuron				benazolin/clopyralid		
Stage:	I	II		III	I	II	III
Dose (kg or l/ha)	1.5	1.5	2.0	2.0	1.25	1.25	1.25
Overall broad-leaved weeds	90 (27)	83 (28)	87 (36)	76 (16)	71 (21)	63 (28)	61 (16)
Stellaria media	100 (17)	96 (21)	98 (21)	86 (9)	99 (9)	91 (21)	68 (7)
*Mayweeds	99 (6)	91 (7)	97 (7)	90 (3)	91 (3)	88 (6)	75 (3)
Veronica spp	86 (18)	89 (19)	90 (18)	71 (7)	26 (12)	29 (19)	21 (10)
Lamium spp	94 (6)	88 (9)	96 (9)	86 (4)	51 (5)	49 (9)	48 (3)
Galium aparine	88 (3)	92 (3)	96 (3)	95 (3)	77 (3)	77 (3)	52 (3)
Viola arvensis	76 (15)	64 (16)	77 (16)	49 (4)	43 (8)	40 (16)	14 (14)
Papaver rhoeas	95 (8)	84 (5)	85 (4)	40 (3)	68 (8)	71 (5)	19 (2)
Capsella bursa-pastoris	81 (4)	64 (4)	83 (5)	80 (1)	10 (1)	62 (5)	73 (1)
Myosotis arvensis	70 (3)	58 (4)	67 (4)	60 (2)	77 (2)	49 (4)	43 (2)
Fumaria officinalis	99 (3)	100 (3)	96 (3)	100 (1)	100 (1)	93 (3)	83 (1)
Aphanes arvensis	97 (3)	60 (3)	74 (3)	100 (3)	83 (3)	27 (3)	85 (2)
Poa annua	63 (6)	31 (6)	47 (6)		2 (6)	26 (6)	

* Mayweeds = Matricaria spp, Anthemis spp and Chamomilla spp.

well to the experimental coformulation up to the time formal assessments were discontinued in early to mid April. Further detailed evaluation was impractical because of the increasingly dense crop cover but it was clear that strong competition was effectively completing the task of weed control.

Not surprisingly S. media, mayweeds (Matricaria spp, Anthemis spp and Chamomilla spp), and Fumaria officinalis, susceptible to the benazolin/clopyralid standard, were well controlled by the experimental coformulation (Tables 1 and 2). In addition very good control of Veronica spp, Lamium spp, Galium aparine, Papaver rhoeas, Aphanes arvensis, Spergula arvensis and Amsinckia lycopsoides was also obtained.

TABLE 2. Mean percentage weed control stage I application: two seasons trials 1987-89. ( ) = number of trials

Treatment:	benazolin/ clopyralid/ dimefuron	benazolin/ clopyralid	benazolin/ clopyralid+ metazachlor	metazachlor
Dose (kg or l/ha)	1.5	1.0	0.75 + 1.5	2.5
Overall broad-leaved weeds	91 (16)	65 (16)	78 (16)	71 (16)
Stellaria media	99 (14)	96 (14)	99 (14)	67 (12)
Mayweeds	99 (4)	85 (4)	93 (4)	61 (4)
Veronica spp	89 (13)	15 (13)	65 (13)	66 (13)
Lamium spp	98 (6)	39 (6)	57 (6)	44 (4)
Galium aparine	96 (3)	58 (3)	84 (2)	47 (3)
Viola arvensis	72 (12)	30 (12)	44 (12)	31 (12)
Papaver rhoeas	94 (3)	73 (3)	79 (3)	45 (3)
Aphanes arvensis	97 (2)	66 (3)	88 (3)	84 (3)
Capsella bursa-pastoris	81 (4)	34 (4)	64 (4)	52 (4)
Fumaria officinale	99 (3)	98 (3)	78 (3)	100 (3)
Myosotis arvensis	52 (7)	38 (7)	33 (7)	25 (7)
Spergula arvensis	100 (1)	83 (1)	83 (1)	67 (1)
Amsinkia lycopsoides	100 (1)	100 (1)	82 (1)	100 (1)
Poa annua	50 (8)	2 (8)	58 (8)	72 (8)

Useful control of *Viola arvensis*, *Capsella bursa-pastoris* and *Myosotis arvensis* was obtained at all stages. Control of these weeds at least equalled that of metazachlor based treatments applied early post-emergence as recommended. *P. annua* was well suppressed.

Crop safety

There were no visible adverse crop effects or yield loss due to any treatment throughout the three seasons' work. This is exemplified by yield data from the 1987-8 trials, (Table 3).

TABLE 3. Weed free yields 1987-8 as percentage of untreated, ( ) = crop stage

Treatment kg/ha		trial 1	trial 2	trial 3
		(1,07-1,08)	(1,04-1,05)	(1,08-1,09)
benazolin/clopyralid/dimefuron	2.0	96	103	97
benazolin/clopyralid/dimefuron	4.0	100	106	98
benazolin/clopyralid	1.25	104	105	96
benazolin/clopyralid	2.5	96	101	97
		(1,10-1,12)	(1,12-1,14)	(3,1-3,3)
benazolin/clopyralid/dimefuron	2.0	106	103	97
benazolin/clopyralid/dimefuron	4.0	103	98	99
benazolin/clopyralid	1.25	103	102	96
benazolin/clopyralid	2.5	96	102	100
untreated (t/ha)		3.6	3.4	3.2

No significant differences p = 0.05.

DISCUSSION

Three seasons' trials with the benazolin/clopyralid/dimefuron coformulation have demonstrated reliable and effective control of the major broad-leaved weeds of winter oilseed rape. The high standard of control achieved against S. media and mayweeds with benazolin/clopyralid was maintained together with good control of a wide range of other important species. Spray timing flexibility of the experimental product was excellent with a window of safe application from the third true leaf exposed (stage 1,03), to the flower buds present but enclosed by leaves (stage 3,1).

This new coformulation, which has been submitted for Approval under the trade name 'Scorpio', constitutes a considerable advance in post-emergence broad-leaved weed control in winter oilseed rape. Recommendations for its use at doses of 1.5 and 2.0 kg/ha according to weed stage have been submitted for registration and marketing will follow receipt of approval.

ACKNOWLEDGEMENTS

We thank all our colleagues who have participated in the development of the new coformulation and collaborating farmers who have provided the trial sites. We also thank Rhone-Poulenc Agriculture for their co-operation.

REFERENCES

Rea, B.L.; Palmer, R.A.; de St Blanquat, A. (1976) Weed control in rapeseed with benazolin ester/3,6 dichloropicolinic acid mixtures. Proceedings of the 1976 British Crop Protection Conference-Weeds, 2, 517-524.

Sylvester-Bradley, R.; Makepeace, R.J.; (1984) A code for stages of development in oilseed rape (Brassica napus L.). Aspects of Applied Biology, 6, Agronomy, physiology, plant breeding and crop protection of oilseed rape, 399-419.

THE CONTROL OF BROAD-LEAVED WEEDS IN SUNFLOWERS IN ENGLAND

F.L. DIXON, P.J.W. LUTMAN, T.M.WEST

Department of Agricultural Sciences, University of Bristol, A.F.R.C., Institute of Arable Crops Research, Long Ashton Research Station, Long Ashton, Bristol, Avon, BS18 9AF

ABSTRACT

The activity of several pre- and post-emergence herbicides on sunflowers and broad-leaved weeds was studied in two outdoor pot and three field experiments. The pot experiments identified four post-emergence herbicides, propyzamide, carbetamide, metamitron and phenmedipham that appeared safe to use on sunflowers, but their performance in a subsequent field experiment was not acceptable. Metamitron and phenmedipham caused too much crop damage and propyzamide and carbetamide failed to control the weeds. In two field experiments pre-planting soil-incorporation of trifluralin, and pre-emergence sprays of linuron, oxadiazon, terbutryn and pendimethalin all achieved good weed control with little or no crop damage.

INTRODUCTION

The new very early maturing cultivars of sunflower (*Helianthus annuus*) may be suitable for cultivation in southern England. Because sunflowers have not been grown in the U.K. before, there is a lack of information on appropriate agronomy (Osborne, 1988), including weed control. The control of grass weeds should not be a problem, as there are several effective graminicides available for use in other broad-leaf crops (Knott, 1985). Although there are recommendations for the control of dicotyledonous weeds in the U.S.A. and Europe, especially France (Regnault, 1986), most of these are for pre-emergence treatments only. There is a need to validate the safety of these pre-emergence herbicides under U.K. conditions. The possibility of controlling broad-leaved weeds with post-emergence treatments also deserves study. Three field and two pot experiments were done in order to reveal the tolerance of sunflowers to pre- and/or post-emergence herbicide treatments, and the degree of weed control obtained in the field.

MATERIALS AND METHODS

Pot experiments

Plants were grown in a sandy clay loam soil, one sunflower plant (cv. Frankasol) in each 10 cm diameter 'Long Tom' plastic pot. Following germination in the glasshouse the plants were placed outdoors on a 'pot standing' area with additional irrigation as required. Both experiments were of a randomized block design with four replicates. Herbicide treatments were applied when the plants had two pairs of leaves fully expanded and the third pair developing, using a laboratory track sprayer fitted with a flat fan nozzle ('Teejet' 80015), at a pressure of 210 kPa and delivering 350 l/ha. Each herbicide was applied at five doses and the ranges are given in Table 1. Visual assessments of damage were conducted 10 and 34 days after application, heights were also recorded at the later assessment. Plants were harvested and both fresh and dry weights were recorded.

Field experiments

All three field experiments were carried out at Long Ashton Research Station, with the cultivar Frankasol, and were of a randomized block design with three replicates. The plots were 2 x 6m in Experiments 3 and 5, and 4 x 18m in Experiment 4. All the experiments were drilled using a Stanhay precision drill set to sow 10 seeds/m^2. Approximately 65 kg/ha P and K were applied to the seedbed prior to ploughing, followed by 40 kg/ha N and 25 kg/ha K (80 kg/ha K on Experiment 5), before the crop emerged. Pests and diseases were treated when required.

The herbicide treatments on Experiments 3 and 4 (Table 2) were applied pre-crop emergence with the exception of trifluralin which was applied pre-planting and incorporated, and bentazone on Experiment 3 which was sprayed when the sunflowers had 3 pairs of leaves. The treatments on Experiment 5 (Table 3) were all applied when the sunflowers had 5 to 6 pairs of leaves. The treatments were applied with an Oxford Precision Sprayer fitted with four (eight on Experiment 4) 'Spraying systems' 8002 'Teejet' nozzles, delivering 250 l/ha at a pressure of 207 kPa. The herbicides and doses used are presented in Tables 2 and 3.

Herbicide effects were assessed in Experiments 3 and 4 by recording the final sunflower population (10 m lengths of row were counted per plot), heights (10 plants were measured per plot), and overall weed control. Heights were measured in early July on Experiment 3 before the plants had reached their maximum, but in Experiment 4 the measurements were taken at the end of July when the plants were nearly at full height. On Experiment 4 crop yields, calculated as clean seed at 8% moisture, were also measured using a Claas Compact combine. Crop damage symptoms, heights and weed control were also recorded in Experiment 5 (Table 3). The major weed species present on all three experiments were Chamomilla spp. (mayweed), Capsella bursa-pastoris, Stellaria media, Veronica persica, Polygonum persicaria and Chenopodium album.

RESULTS

Pot experiments

Experiment 1

Most of the herbicides caused appreciable damage to the sunflowers at the lowest doses tested (Table 1), some were so damaging that it was not possible to plot a valid dose-response curve. The developmental product (BAS 518) was damaging at the higher doses, but not at the lowest. Carbetamide and propyzamide had no adverse effects, even at 6 and 4 kg/ha a.i., respectively.

Experiment 2

The activity of aclonifen, pyridate and methazole appeared to be greater in Experiment 2 than Experiment 1, and all three herbicides resulted in severe damage at the lowest dose. Clopyralid also caused damage at the lowest dose tested. All doses of carbetamide, propyzamide and phenmedipham had no adverse effects on the sunflowers. Metamitron had no effect at the lower doses, but produced a 10% reduction in plant fresh weights at 2.36 kg/ha a.i.

TABLE 1. Effect of 15 herbicides on fresh weights of sunflowers in 2 pot experiments.

Herbicide	% a.i. and Formulation	Dose Range (kg/ha a.i.)	Transformed Log Dose⁺	S.E.$	Detransformed Dose⁺
Experiment 1					
BAS 518	50 WP	0.25 - 4.0	0.391	0.084	2.46
Aclonifen	60 SC	0.3 - 4.8	-0.602	0.387	0.25
DPX L5300	75 WG	0.0025 - 0.04		Too damaging	
Pyridate	45 WP	0.125 - 2.0	-0.684	0.237	0.208
Methazole	75 WP	0.125 - 2.0	-0.292	0.153	0.511
Ethofumesate	20 EC	0.25 - 4.0	-0.709	0.123	0.196
Linuron	45 SC	0.25 - 4.0		Too damaging	
Carbetamide	70 WP	0.375 - 6.0		No effect	
Desmetryn	25 WP	0.125 - 2.0	-0.923	0.157	0.120
Pentanochlor	40 EC	0.5 - 8.0	-0.202	0.084	0.628
Propyzamide	40 SC	0.25 - 4.0		No effect	
Experiment 2					
Aclonifen	60 SC	1.2 - 6.0	-1.044	0.808	0.090
Pyridate	45 WP	0.2 - 1.0		Too damaging	
Methazole	75 WP	0.2 - 1.0	-1.650	0.598	0.022
Carbetamide	70 WP	0.5 - 8.0		No effect	
Propyzamide	40 SC	0.25 - 4.0		No effect	
Clopyralid	20 SL	0.025 - 0.4	-1.578	0.137	0.026
Phenmedipham	11.4 EC	0.4 - 2.0		No effect	
Metamitron	70 WG	0.25 - 4.0	0.373	0.094	2.36

⁺ = Doses (kg/ha a.i.) causing 10% weight reductions (ED 10 values)
$ = Standard Errors based on 38 degrees of freedom in Experiment 1 and 34 in Experiment 2.

Field experiments

Experiment 3

Applications of high rates of trifluralin and trifluralin plus linuron slightly decreased plant populations, but the other pre-emergence treatments had no effect. There were no detectable effects on sunflower heights from any of the pre-emergence herbicides, nor were any foliar symptoms noticed. Weed control was variable from the recommended rates of the pre-emergence applications (Table 2). Trifluralin plus linuron, ethofumesate and pendimethalin gave the best results, achieving over 85% control. Post-emergence treatments of bentazone damaged the sunflowers, resulting in extreme leaf scorch, yellowing and some stunting, weed control was also poor.

TABLE 2. Weed control from 7 herbicides and their effects on the growth and yield of sunflowers in 2 field experiments.

Herbicide	% a.i. & Formulation	Dose kg/ha a.i.	Experiment 3 Plants $/m^2$	Experiment 3 Height cm 1.7.87	Experiment 3 Weed +% gc	Experiment 4 Plants $/m^2$	Experiment 4 Height cm 20.7.87	Experiment 4 Yield t/ha	Experiment 4 Weed +% gc
Trifluralin	48 EC	1.2	16.3	70.7	27		153	1.98	8
		* 2.4	15.8	69.0	25		157	2.21	3
		3.6					158	2.03	3
		4.8	15.5	62.7	8	12.0	148	2.03	2
Linuron	45 SC	0.25	17.7	70.0	28				
		* 0.5	18.2	70.1	38		162	1.99	12
		0.75	17.9	65.8	15				
		1.0	16.3	66.1	8		162	1.92	5
		1.5	18.1	66.8	13		158	2.31	4
		2.0	18.0	66.9	2	13.1	155	2.51	2
Pendimeth-alin	33 EC	1.0	16.6	68.8	17		155	2.38	5
		* 2.0	15.9	69.5	7		159	1.96	4
		3.0					156	1.99	2
		4.0	17.0	70.7	3	14.5	161	1.76	0
Terbutryn	50 SC	0.75	16.5	67.8	30		160	2.08	8
		* 1.5	16.6	70.6	43		161	1.82	4
		2.25					156	2.32	4
		3.0	16.5	72.0	7	13.2	155	2.26	3
Ethofumesate	20 EC	1.0	18.4	74.0	7				
		* 2.0	16.8	70.0	7				
		4.0	17.5	70.1	3				
Oxadiazon	25 EC	0.75	15.9	71.8	60				
		* 1.5	15.0	69.3	18				
		3.0	16.9	71.6	57				
Trifluralin + Linuron	48 EC 45 SC	1.2+0.5	18.5	69.2	3				
		1.2+1.0	16.9	72.1	0				
		1.2+2.0	15.3	65.0	0				
Bentazone	48 SL	* 1.44	15.2	32.4	30				
		2.88	15.6	24.0	65				
		5.76	16.8	0.0	78				
UNTREATED CONTROL			16.8	72.6	57	13.3	153	1.90	22
S.E.D.			1.276	4.14		1.14	4.23	0.194	
D.F.			62	59		173	35	33	

* = Normal recommended field rate for other crops
+ = % ground cover

Experiment 4

None of the treatments affected either the population or the height of the sunflowers, nor were there any symptoms of damage. There was no detectable effect on yields from trifluralin, linuron and terbutryn, but the highest dose of pendimethalin appeared to cause a small reduction, when compared with that from the lowest dose (Table 2). Weed control was acceptable from all the treatments, reducing weed ground cover to less than 12% in August. However, susceptibility of weed species to the herbicides varied. For example, trifluralin and pendimethalin were particularly effective on V. persica and C. album, but had very little effect on the Chamomilla spp. present, whilst linuron controlled the Chamomilla spp., but left the V. persica virtually unaffected.

Experiment 5

Propyzamide and carbetamide caused no adverse effects on the sunflowers, either visually or on their heights, except for the higher rate of carbetamide which caused a few scorch spots on the leaves. Both metamitron and phenmedipham caused considerable damage, the leaves were scorched and some plants were stunted. This damage was reflected in the heights measured in July which were significantly reduced by the two highest doses of phenmedipham (Table 3). Weed control by all treatments was generally poor on this experiment.

TABLE 3. Weed control from 4 post-emergence herbicides and their effects on the growth of sunflowers in the third field experiment.

Herbicide	% a.i.	Dose kg/ha a.i.	28.6.88 Crop Symptoms	20.7.88 Heights (cm)	18.7.88 % Weed cover
Propyzamide	50 WP	0.7		152	58
		* 1.4		152	63
		2.1		154	58
		2.8		155	58
Carbetamide	70 WP	1.05		156	62
		* 2.1		156	53
		4.2		148	48
		6.3		149	60
Metamitron	70 WG	2.0	2	148	57
		* 3.5	3	139	42
		5.0	3	144	55
		6.5	3	142	45
Phenmedipham	11.4 EC	0.25	3	151	62
		* 0.5	4	145	47
		1.0	4	131	43
		2.0	4S	127	62
UNTREATED CONTROL				148	57
S.E.D.				4.27	10.42
D.F.				35	34

* = Normal recommended field rate for other crops.
1 - 4 = Score for scorch:- 1 = A few scorch spots on leaves, 4 = Severe leaf scorch and yellowing. S = Plants stunted

DISCUSSION

The two pot experiments demonstrated that the majority of post-emergence herbicides that could have potential for weed control in sunflowers were not adequately selective. However metamitron, phenmedipham, carbetamide and propyzamide appeared to be selective and so were investigated in more detail in the field (Experiment 5). Unfortunately, metamitron and phenmedipham were too damaging at doses that might be expected to give good weed control. In this experiment the herbicide treatments were applied when the weeds were large and in consequence control was poor, even from the high doses of the two herbicides. The other two herbicides, propyzamide and carbetamide did not cause any damage to the sunflowers, but they also failed to control the weeds. This may have been due to the large size of the weeds and to the intrinsic resistance of the species present, but may also have been attributable to the warm dry weather at application. Both herbicides are used primarily as autumn/winter treatments (e.g. winter rape) and as they are mainly soil-acting they require moist soil for optimum activity. Thus, the warm dry soil conditions at application, and the large size of the weeds would have minimised the activity of both herbicides. It must be concluded from this work that it is not yet possible to control broad-leaved weed species with post-emergence herbicides in sunflowers.

Because of the lack of post-emergence treatments, pre-emergence products must be relied upon for the control of broad-leaved weeds. The two field experiments demonstrated that a range of herbicides could be safely and effectively used in sunflowers grown in the south of England. Although linuron appeared safe in these two experiments, a previous experiment conducted in a wet spring indicated that some crop damage could occur (Dixon & Lutman, unpublished). Regnault (1986) has also found linuron could cause crop damage in wet conditions. Terbutryn, trifluralin, ethofumesate and oxadiazon appeared safe and achieved good levels of weed control in both experiments. There is some evidence from Experiment 4 that high rates of pendimethalin might cause some slight damage to the sunflowers. Previous work (Dixon & Lutman, unpublished) also suggested that this herbicide could cause some crop damage, but this needs further confirmation.

ACKNOWLEDGEMENTS

We would like to thank the Experimental Husbandry Section and the Glasshouse staff for all their help, and Charles Marshall for the statistical analysis of the data.

REFERENCES

Knott, C.M. (1985) Grass-weed control for broad-leaved crops - the options. Proceedings 1985 British Crop Protection Conference - Weeds, **2**, 429-440.

Osborne, R. (1988) Sunflower: a new crop in British agriculture. Proceedings of the 12th International Sunflower Conference, 331-335.

Regnault, Y. (1986) Progres recents dans le desherbage du tournesol. Annales 13th Conference du COLUMA, **III**, 31-40.