SESSION 8B

WEED CONTROL IN OIL PRODUCING AND PROTEIN CROPS

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POSTERS 8B-1 to 8B-8

USE OF DPX-A7881 FOR WEED CONTROL IN SPRING OILSEED RAPE IN CANADA

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ABSTRACT

There are over 13 million hectares of oilseed rape grown worldwide and of these, approximately 2.5 million hectares are grown in the three Prairie Provinces of Canada (Alberta, Saskatchewan, and Manitoba). Here *Sinapis arvensis* and *Thlaspi arvense* are major weed problems causing loss of crop yield and quality. DPX-A7881 at low dose rates as a post-emergence treatment is effective against these two species and other broadleaf weeds and is selective in the spring sown oilseed rape "double zero" cultivars commonly grown in Canada. Replanting trials have so far shown a good safety margin for other crops grown in typical rotation. The favourable toxicology, low dose rates, good crop tolerance and unique spectrum of activity make DPX-A7881 a promising tool for oilseed rape growers in Canada.

INTRODUCTION

Approximately twenty percent of the world supply of oilseed rape is grown in the Prairie Provinces of Canada, with the majority of the Canadian crop devoted to "double zero" varieties specifically developed to yield low levels of erucic acid (less than 5%) and glucosinolates (less than 30 micromoles per gram of oil free meal). (Canola Council of Canada. 1984) These varieties are commonly referred to as canola in Canada.

On the prairies, oilseed rape is spring sown and grown in rotation with cereal crops. Wild mustard (*Sinapis arvensis*) and stinkweed (*Thlaspi arvense*), are common weeds on the prairies. Their presence in the rape crop causes yield loss from competition. Ten *S. arvensis* plants per square metre can cause up to twenty percent yield reduction (Canola Council of Canada). The contamination of the weed seeds in the harvested seed also results in an undesirable loss of quality of the rapeseed oil and meal. This causes a significant earnings loss to the grower.

Oilseed rape is graded as one, two, three, or "sample reject" dependent on its degree of soundness and contamination levels in delivered seed. A twelve percent reduction of crop worth occurs if the delivered seed is downgraded from "one" to "two", another twenty-two percent reduction occurs from a downgrading of "two" to "three" and if the delivered seed is downgraded to "sample reject" there is another reduction of nineteen percent. This is a total loss of fifty-seven percent downgrading from a number "one" to "sample reject". Contamination of only five percent of *S. arvensis* seed in the delivered seed, results in the load being graded as "sample reject". This level would correspond to a weed infestation of about twenty plants per square metre (Canola Council of Canada, 1984).

Dockage for T. arvense and other weed seed contamination that can be removed from the delivered seed is based on the percentage contaminant in the sample. For example, if five percent "foreign" material is cleaned from the seed, then dockage would result in five percent reduction in the price for the delivered seed.

Some canola growers in Canada have turned to new triazine herbicide tolerant varieties such as Tribute or Triton, allowing the application of triazine herbicides in crop for control of these weed problems. However, these cultivars are lower yielding and late maturing, so there is a risk of crop loss due to early frosts. The oil content of these varieties is lower than average and may have a slight green tinge, making these varieties undesirable to the Canadian oilseed crushers.

In 1982, Du Pont scientists discovered 2-[[[[4-ethoxy-6-(methylamino)-1,3,5-triazin-2yl]-amino]carbonyl]amino]sulfonyl]benzoate, methyl ester, DPX-A7881, a member of the sulfonylurea class of herbicides, showing postemergence herbicidal activity on S. arvensis and T. arvense as well as selectivity in canola. (Hutchison et al., 1987) This research report summarizes the field evaluation of DPX-A7881 as a postemergence weed control herbicide in spring sown oilseed rape in Canada from 1984 to 1987.

MATERIALS AND METHODS

In the years 1984 through to 1986, randomized block design small plot efficacy trials, were established in the spring oilseed rape growing regions of the Prairie Provinces at 84 sites, where infestations of either T. arvense or S. arvensis were problems in production. DPX-A7881 was applied at dose rates of 5.0 to 124.0 grams active ingredient per hectare, plus surfactant at 0.2% v/v of total spray volume, using a four nozzle hand-held CO_2 sprayer equipped with Tee Jet 8002 nozzles delivering 110 litres per hectare spray volume at a pressure of 207.0 kPa. Applications were made from the pre-emergent stage of the canola to early bolting and with weed stages pre-emergent to early bolting. Weed control was assessed by a visual scoring of biomass reduction versus untreated plots on a scale of 0 to 100 percent.

Trials were also established at 21 sites in the years from 1984 to 1986 to determine whether DPX-A7881 would carry over into the next growing season. The agronomic practice in the Prairie Provinces is to apply postemergence broadleaf herbicides in late May to early June to crops, with the next crop not planted on that ground until the following April or May; an eleven month interval between application and recropping. DPX-A7881 was applied with truck mounted sprayers at rates of 30 and 60 g a.i/ha plus surfactant at 0.2% v/v in volumes of 110 l/ha of water at 207 kPa. Plot size was 14m x 45m. These plots were applied to the typical soils of the spring oilseed rape growing areas of the Prairie Provinces, those being black and dark brown soils (Agriculture Canada, 1977).

The following spring these sites were seeded with various crop species typical of the test area along with species known to be sensitive to DPX-A7881 and other sulfonylurea herbicides. The crops were sown perpendicular to the direction the treatments were applied the previous year. Effects on crop growth were assessed as a visual scoring of biomass reduction versus untreated plots on a scale of 0 to 100 percent.

Small plot randomized block tolerance tests were also carried out in 1986 at 18 sites using the most commonly grown cultivars of Canola. DPX-A7881 was applied at 5.0 to 30 g a.i./ha post-emergence.

RESULTS

Efficacy

Results of the efficacy trials were combined to give the mean percentage weed control and are shown in Table 1.

TABLE 1

The mean percentage of broad-leaved weed control given by DPX-A7881 applied postemergence at dose rates between 5.0 and 22.5 g a.i./ha (1984-1986)

Weed	Leaf Stage	% Weed Control (mean)			
		Dose DPX-A7881 (g a.i./ha)			
		5.0	10.0	15.0	22.5
Thlaspi arvense	0-4	42 (7)	78 (9)	87(12)	91(13)
Thlaspi arvense	6	42 (4)	26 (3)	53 (5)	68 (4)
Sinapis arvensis	c-b	49(14)	71(18)	82(27)	90(17)
Galeopsis tetrahit	2-6			88 (4)	97 (3)
Polygonum scabrum	2-6	54 (2)	58 (3)	64(10)	82 (4)

Key: ( )= number of trials
c-b = cotyledon to bolting

DPX-A7881 has shown good control of *S. arvensis* at rates between 10.0 to 15.0 ga.i./ha. There is no evidence that weed staging has an effect on the control. *T. arvense* is more difficult to control in the field. This weed germinates throughout the early spring, thus application to a uniform weed staging is difficult. Our trials show earlier applications to be better than applications at the sixth leaf stage or later. Our observations in the field have shown that some *T. arvense* plants are not killed but are stunted and would generally be shorter than the average harvest cutting height for canola. The seed in this case would not be a contaminant in the harvested canola seed, and the plants left not competitive to the crop.

DPX-A7881 is also showing activity on other broadleaf weeds found in canola, such as *Galeopsis tetrahit* and *Polygonum scabrum*. Activity of DPX-A7881 was also reported for *Amaranthus retroflexus*, *Stellaria media* and *Polygonum persicaria*.

Recropping

The effect of applications of DPX-A7881 on crops sown 11 months after application is shown in Table 2.

TABLE 2

The number of trials where crops have shown more than 10 percent injury when sown 11 months after application at dose rates of 30 to 32 g a.i./ha or 45 to 64 g a.i./ha in trials established in 1984 to 1986

Crop Planted	Number of trials with greater than 10% injury — Dose DPX-A7881 (g a.i./ha) 30.0-32.0	45.0-64.0
Spring wheat	0 (15)	0 (17)
Durum wheat	0 (6)	0 (5)
Barley	0 (31)	1 (36)
Oats	0 (12)	0 (13)
Canola	1 (14)	1 (22)
Flax	0 (14)	0 (17)
Lentils	0 (14)	1 (15)
Alfalfa	0 (9)	2 (15)
Red clover	0 (4)	0 (4)
Peas	0 (9)	0 (9)
Mustard		0 (5)
Timothy	0 (3)	0 (3)

Key: ( ) = number of trials

Analysis of recropping trials in Western Canada is very difficult when faced with droughts, weed pressure and variable residual herbicides being used in cereal productions. Canola was injured at one site at both 30.0 and 60.0 ga.i./ha in 1987, while other more sensitive species were not affected. The parameters have not been assessed at this time as to the reason for this. However, canola is rarely grown two years in succession. Barley showed damage one year later at one site at the 64.0 gram rate. The damage was assessed at 20% as compared to the check. Lentils and alfalfa showed injury at one site at the 60.0 gram rate. The injury assessed was 35% for lentils and 20% for alfalfa.

The conclusions from these findings are dependent on the rate that the grower would apply for weed control and if there are distinguishable factors leading to any injury noted in the trials. If the final rates growers will use is approximately 20.0 g a.i./ha, then from these results, it would seem we have an approximate 3 times safety range to these sensitive crops grown 11 months after application of DPX-A7881.

Cultivar Tolerance

In the cultivar tolerance trials, DPX-A7881 applied post-emergence at rates of 10.0 to 30.0ga.i./ha caused no visual damage to canola cultivars, Tobin, Westar, Global, Altex, Regent or Triton. Efficacy trials reported no visual damage to the list above plus, Pivot and Tribute. The cultivar tolerance of Westar and Tobin, the two major cultivars, are shown in Table 3.

TABLE 3

Yield increase from applications of DPX-A7881 in spring oilseed rape vs the untreated plots.

Variety	Number Trials	Percentage increase for the 20.0-30.0 (g a.i./ha) dose rates
Tobin	16	5.2
Westar	13	8.1

No reports of visual crop injury have been reported for rates up to 124.0 ga.i./ha applied postemergence to spring oilseed rape in Canada. In the 16 tolerance-to-yield trials established, there were no reports of visual crop injury from postemergence application of 20 to 30ga.i./ha to the canola varieties grown. Across all varieties and rates from 10 to 30 grams the average yield increase over the untreated check was 6.6 percent. For rates of 20-30 g a.i./ha across all varieties tested the average increase was 8.1%. Westar showed an increase of 8.1% from applications of between 20-30ga.i./ha and Tobin 5.2%.

DPX-A7881 does not show any tolerance problems for the varieties of canola tested.

DISCUSSION

DPX-A7881 has shown excellent selectivity when applied spring emergence to canola cultivars. When 20ga.i./ha is used as the effective dose for weed control, _T. arvense_ (up to the four leaf stage), _S. arvensis_ and other broad leaved weed species, are controlled and/or suppressed in crop. At this use rate there is approximately 3 times safety factor to any residual chemical in the soil 11 months after application.

At present the only means available to the grower in controlling _S. arvensis_ or _T. arvense_ is to use cultural methods, grow lower yielding poorer quality triazine resistant cultivars and apply a triazine herbicide, or as a last resort, to take the land out of oilseed rape production. The last option is increasing in areas where these weeds are prevalent, although oilseed rape is an excellent cash crop for the farmer. DPX-A7881 is a new herbicide tool which may allow the oilseed rape producer to grow a cleaner crop free of contamination from _S. arvensis_, _T. arvense_ and other weeds achieving higher yields of high quality oil and meal products.

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EFFECT OF HERBICIDES ON WEED CONTROL AND CROP YIELD IN WINTER OILSEED RAPE IN SOUTH-EAST SCOTLAND

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ABSTRACT

Trials in south-east Scotland with a wide range of herbicides from 1984-7 confirm that in the absence of high levels of volunteer cereals, significant yield benefits are seldom seen. A trial in 1986 examined the use of metazachlor at a range of rates and timings at a site with a very high broad-leaved weed population (249/m^2; 78.2% ground cover). There were improvements in yield, but there was no correlation with the level of weed control. The results confirm the lack of sensitivity of oilseed rape yield to high levels of many weed species, and suggest scope for reduced herbicide costs, but more information is required as to the effect of weeds on other aspects of crop production and seed quality.

INTRODUCTION

Winter oilseed rape has become an important feature of Scottish arable farming since 1982. However, in common with other subsidised arable crops, the profitability of the crop is being seriously affected by reduction in financial support, and other market trends, (Gardner, 1984). In such circumstances there is increased interest in the cost effectiveness of inputs to the crop.

This paper examines the effectiveness of herbicide inputs, which can often exceed 20% of variable costs of growing winter oilseed rape (Scottish Agricultural Colleges, 1986).

The Agricultural Development and Advisory Service (ADAS) in England and Wales carried out eleven yielded trials in harvest years 1979-81 to assess the efficacy of weed control of a range of herbicides (Ward, 1982). A yield increase was found in only four of these trials, and there appeared to be no consistent pattern of response. In trials undertaken in harvest year 1982 (ADAS, 1983), significant improvements in yield were found at four out of seven sites, characterised by high levels of volunteer cereals, *Alopecurus myosuroides* or *Galium aparine*. Yield increases were again small at five sites harvested in 1983 (Orson, 1984), and, at a further nine sites harvested in 1984, a significant yield increase was found only at five sites. (Ward & Turner, 1985). Once again high levels of volunteer cereals characterised the improved yield sites. Where the oilseed rape was well established and populations of grass and broad-leaved weeds were low, yields were not significantly improved by the use of herbicides. This has been found by other workers(Lutman, 1984). In some cases yield reductions were noted. The competitive effect of volunteer cereals has been documented, and the ability of volunteer cereals, particularly in late sown or poorly established crops, to reduce yields has been frequently reported (Orson, 1984; Roebuck, 1984; Lutman & Dixon, 1985). The competitive effect of high levels of volunteer barley levels has been noted in Scottish trials (Davies & Wilson, 1987), but many Scottish farmers plough prior to drilling oilseed rape, which can reduce the problem. Many Scottish crops are apparently more seriously infested with broad-leaved weed species, notably *Stellaria media*, *Veronica* spp., *Lamium* spp., *Matricaria* spp., *Capsella bursa-pastoris*, and *Myosotis arvensis*, and *Poa annua*.

Results mentioned previously would indicate that yield responses to the control of these species would be small.

This paper reports the results of tests between 1984-7 on a range of herbicide products on broad-leaved weeds and low levels of volunteer cereals in south-east Scotland, and of a trial in 1986 in which metazachlor was used at a range of rates to modify weed levels, in order to determine the effect on yield.

MATERIALS AND METHODS

Treatments were applied to 2m x 20m plots by Van der Weij knapsack sprayer calibrated to deliver 200 l/ha volume through Teejet 8003 nozzles at 210 KPa pressure in all trials. Pre-sowing treatments were incorporated by a shallow harrow on the drill. Treatments were randomized within three replicate blocks in each trial. Weed assessments were made by visual estimation of ground cover on a percentage basis, and weed numbers assessed in untreated plots by counts with 5 x $0.5m^2$ quadrats. Plots were harvested by Claas Compact combine harvester, and yield calculated for grain at 9% moisture content.

1984-1987 Harvest Years Trials

A range of herbicide treatments were tested at four yielded sites in harvest seasons 1984, 1986 and 1987. Details of rates are given in Table 1; the materials tested alone or in mixture, were: benazolin/clopyralid, 'Benazalox', 35%WP; carbetamide, 'Carbetamex', 70%; carbetamide/dimefuron, 'Pradone Plus', 70% WP; cyanazine, 'Fortrol', 50% SC; metazachlor, 'Butisan S', 50% SC; propyzamide, 'Kerb 50 W', 50% WP; propyzamide/clopyralid, 'Matrikerb', 47.3% WP; TCA, 'NaTa'. 95% WP; tebutam, 'Comodor', 72% EC; trifluralin, 'Treflan', 48% EC; trifluralin/napropamide, 'Devrinol T', 24% EC.

The following winter oilseed rape varieties were sown at the sites:

(i) St Andrews, Fife; cv Bienvenu sown 22 August 1983
(ii) Cupar, Fife; cv Rafal sown 7 September 1985
(iii) Cupar, Fife; cv Rafal sown 27 August 1986
(iv) Chirnside, Border; cv Mikado sown 30 August 1986

1986 Metazachlor Trial

Metazachlor was applied at 500, 750 and 1250 g a.i./ha pre-emergence and post-emergence (growth stages given) (3-4 leaf crop stage) to winter oilseed rape cv Rafal at Cupar, Fife, sown 7 September 1985. The following weed species were treated pre-emergence and post-emergence: *Stellaria media* 4 leaf-stage (4 cm across); *Veronica arvensis* 2 leaf-stage; *Urtica urens* 2-4 leaf-stage; *Lamium purpureum* 2 leaf-stage; Volunteer barley 2 leaf-stage.

RESULTS

1984-1987 Harvest years trials

The volunteer barley and broad-leaf weed control at the four sites is given in Table 1, plus weed populations in the untreated plots. Only at site (ii) were weed populations high and consisted mainly of *Stellaria media*. Volunteer barley levels were moderately high at site (i), but insufficient to have a marked influence on yield (Table 2). Significant yield increases were noted at site (i) from two of the nine treatments, but these were not clearly associated with particular levels of weed control. At sites (iii) and (iv) only one treatment out of twenty-two gave a significant yield improvement to lower levels of weeds, but at site (ii) no significant yield response was found from control of weeds reaching 65% ground cover in the spring. Varying the rates of metazachlor and benazolin/clopyralid mixtures at sites (iii) and (iv) had a small effect on weed control (Table 1), but no effect on crop yield.

1986 Metazachlor Trial

There was a clear weed control response to the rate and timing of metazachlor treatment in this trial (Table 3). However, yield responses did not correspond with the variation in weed control (Table 3), although all treatments gave improvements at this weedy site.

TABLE 3

Effect of metazachlor rate and treatment timing on weed control in, and yield at 9% moisture of, a winter oilseed rape; harvest year 1986.

Timing and Treatment	Rate (g a.i./ha)	% ground cover Vol. barley	*S. media*	*V. arvensis*	*L. purpureum*	Total weed cover	Yield t/ha
Pre-emergence							
metazachlor	500	1.2	6.3	0	1.3	8.8	4.1
metazachlor	750	0.7	2.9	0	0.2	3.8	4.0
metazachlor	1250	0.6	0.3	0	0.1	1.0	4.0
Post-emergence							
metazachlor	500	1.6	26.7	0	3.5	31.8	4.0
metazachlor	750	1.6	9.3	0	3.2	14.8	4.0
metazachlor	1250	1.5	3.0	0	1.7	6.2	4.1
Untreated		2.3	63.7	6.2	6.0	78.2	3.8
Weed population/m² Untreated		(13)	(153)	(43)	(40)	(249)	
SED		0.5	4.4	1.0	1.4		0.16

DISCUSSION

The results from the 1984-1987 harvest years trials series reflect reports from earlier ADAS trials (Ward, 1982; Ward & Turner, 1984) that yield responses to herbicide use in winter oilseed rape are small where volunteer cereals and certain other weeds are not a problem. Even control of a 65.8% ground cover of weeds dominated by a high population of *S. media*, at one site, failed to give a significant yield increase, although yields improved a little. However, the yield improvements would barely cover the cost of the treatments tested.

A significant improvement in yield was found in the metazachlor trial in harvest year 1986, where the weed population reached 249/m² or 78.2% ground cover, again dominated by *S. media*. However, it made little difference what rate of metazachlor was used, and at what timing, as a reduction of weed cover to 1% ground cover by a 1250 g a.i./ha pre-emergence treatment gave no better yield response than a reduction to 31.8% ground cover of weeds by 500 g a.i./ha post-emergence treatment. At much lower weed populations, varying metazachlor and benazolin/clopyralid mixtures slightly affected weed control, but had no effect on yield differences at sites (iii) and (iv).

TABLE 1

Effect of herbicide treatment on weed control in winter oilseed rape; trials in harvest years 1984,6 and 7

Timing and Treatment	Rate (g a.i./ha)	Weed % ground cover Site: (i) Volunteer Cereal	(i) Broad-leaf weeds	(ii) Volunteer barley	(ii) Broad-leaf weeds	(iii) Broad-leaf weeds	(iv) Broad-leaf weeds
<u>Pre-sowing</u>							
TCA+trifl	1045+1104	2.5	2.0	0.9	12.0	-	-
trifl/napropamide	1680	3.0	2.5	0.6	4.3	-	-
<u>Pre-emergence</u>							
TCA+tebutam	1045+3600	0.2	6.5	-	-	-	-
tebutam	3600	-	-	0.0	10.8	-	-
metazachlor	750	-	-	-	-	0.6	3.6
metazachlor	1250	6.0	2.0	-	-	-	-
<u>Pre-/post-emergence Seq.</u>							
metaz then benaz/clopyr	500 t 175	-	-	-	-	3.6	1.7
<u>Post-emergence</u>							
metazachlor	1250	2.2	1.9	-	-	4.6	2.5
metaz+benaz/clopyr	375+175	-	-	-	-	0.2	5.9
metaz+benaz/clo	500+175	-	-	-	-	1.2	5.8
metaz+benaz/clopyr	500+263	-	-	-	-	0.2	2.3
metaz+benaz/clopyr	500+350	-	-	1.3	1.6	1.5	3.5
metaz+benaz/clo	1000+175	-	-	-	-	0.2	2.0
benaz/clopyr	350	17.7	7.4	-	-	-	-
benaz/clopyr/propyz	350+700	2.7	2.9	0.3	4.5	-	-
benaz/clopyr/carbet	350+2100	-	-	0.9	9.5	-	-
carbet/dimef	2100	-	-	0.7	13.4	3.0	5.5
cyanazine	500	-	-	-	-	1.1	2.6
cyanazine+propyz	500+700	1.0	0.5	-	-	-	-
propyzamide	700	-	-	0.0	22.4	6.5	6.1
propyz/clopyr	771	2.3	1.8	-	-	-	-
untreated		16.5	11.1	1.0	64.8	10.2	16.8
(Weed populations/m² untreated)		(82)	(54.5)	(20)	(256)	(106)	(60)

Key: trifl = trifluralin; benaz = benazolin; clopyr = clopyralid; propyz = propyzamide; carbet = carbetamide

TABLE 2
Effect of herbicide treatment on winter oilseed rape yield at 9% moisture content; trials in harvest years 1984,6 and 7

Timing Treatment	Rate (g a.i./ha)	Oilseed rape yield t/ha Site:(i)	(ii)	(iii)	(iv)
Pre-sowing					
TCA/trifl	1045+1104	2.7	3.9	-	-
trifl+napropamide	1680	2.0	4.1	-	-
Pre-emergence					
TCA/tebutam	1045+3600	3.2	-	-	-
tebutam	3600	-	4.1	-	-
metazachlor	750	-	-	4.8	4.8
metazachlor	1250	3.4	-	-	-
Pre/Post-em seq.					
metaz then benaz+clopyr	500 t 175	-	-	4.6	4.5
Post-emergence					
metazachlor	1250	2.9	-	4.4	4.6
metaz/benaz+clopyr	375+175	-	-	4.5	4.7
metaz/benaz+clopyr	500+175	-	-	4.7	4.5
metaz/benaz+clopyr	500+263	-	-	4.6	4.7
metaz/benaz+clopyr	500+350	-	4.0	4.6	4.5
metaz/benaz+clopyr	1000+175	-	-	4.6	4.7
benaz+clopyr	350	3.1	-	-	-
benaz+clopyr/propyz	350+700	2.8	4.1	-	-
benaz+clopyr/carbet	350+2100	-	4.0	-	-
Carbet+dimef	2100	-	4.0	4.6	4.6
cyanazine	500	-	-	4.9	4.6
cyanazine/propyz	500+700	3.1	-	-	-
propyzamide	700	-	3.9	4.8	4.8
propyz+clopyr	771	2.8	-	-	-
Untreated		2.8	3.8	4.6	4.8
SED		0.16	0.21	0.14	0.12

Key: trifl=trifluralin; metaz=metazachlor; benaz=benazolox; clopyr=clopyralid; propyz=propyzamide; carbet=carbetamide

These results confirm the lack of sensitivity of winter oilseed rape to high populations of many common weed species. Results from other sources mentioned earlier do show that certain weeds, such as volunteer cereals, A. myosuroides and G. aparine, are much more likely to cause significant yield depressions, but these weeds are not found at significant levels in all oilseed rape crops. There is apparently scope in many situations for reduced, or possibly less expensive, herbicide use in winter oilseed rape.

However, there is little experimental data and the effect of leaving such weeds on the costs and practical aspects of harvesting, and on factors such as disease levels in crops, seed quality, or weed levels in future crops in the rotation is uncertain. The need for such information is clear as farmers look to methods of reducing input costs.

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EVALUATION OF SULFONYL-UREA HERBICIDES FOR USE IN FLAX AND LINSEED IN SOUTH-EAST SCOTLAND

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ABSTRACT

There is a lack of suitable herbicide recommendations for use in flax and linseed. Trials in south-east Scotland in 1985 indicated that sulfonyl-urea herbicides have some potential for use in these crops. Further trials undertaken in 1986 showed that metsulfuron-methyl/thiameturon-methyl was more likely to cause early stunting of linseed and flax than metsulfuron-methyl alone. Treatments applied when the crop was 30 mm high were more likely to delay crop maturation than treatments when the crop was 150 mm high. However, later treatments did not generally give as good a yield of flax straw or linseed in comparison with earlier treatments. There is little evidence of a rate response in crop yields. Earlier treatments also gave better weed control. It is suggested that the sulfonyl-urea herbicides warrant further evaluation for use in these crops.

INTRODUCTION

The possible renaissance of the flax (*Linum usitatissimum*) growing industry in Scotland, and the lack of suitable herbicide recommendations stimulated research into herbicide use in this crop in south-east Scotland (Davies & Richards, 1984). There has also been an interest in growing the closely related linseed as an oilseed break crop in the same area.

This paper describes trials undertaken at Bush, Midlothian, and Eastfield, Angus in flax in 1985, and in flax and linseed in 1986 at Bush to examine the potential of sulfonyl-urea based cereal herbicides, manufactured by Du Pont (UK) Limited, for weed control in these two crops. Comparison is made with two commonly used herbicide treatments. Results for metsulfuron-methyl/chlorsulfuron ('Finesse', 20% w.g.) are not included in the paper, as it is unlikely to be recommended for spring use, but they are available elsewhere (Davies, 1986; 1987).

MATERIALS AND METHODS

Treatments (see Tables for rates) were applied to flax cv Regina at Bush and cv Herra at Eastfield, and to linseed cv Antares at Bush, by Van der Weij pressurised knapsack sprayer calibrated to deliver 200 l/ha volume through Teejet 8003 nozzles at 210 kPa. Plots were 2 m x 6m and randomised within three replicate blocks.

1985 Trials

Metsulfuron-methyl ('Ally', 20% w.d.g.) treatments were applied at normal and twice normal rates recommended when the crop was 30 mm high at Bush on 30 May, and at normal, half and twice normal rate when the crop was 150 mm high on 16 June at Eastfield. Metsulfuron-methyl/thiameturon-methyl (DPX R9490, 75% w.d.g.) was also applied at 45 g a.i./ha at Eastfield. A standard pre-emergence tank-mix of 840 g a.i./ha trifluralin ('Treflan', 48% wt/vol EC) + 750 g a.i./ha linuron ('Liquid Linuron', 13.3% wt/vol EC), was used for comparison at Bush, applied pre-emergence on 26 March.

1986 Trials

Treatments at normal and three times normal rates for use in cereals were applied on 29 May (PT1) and 26 June (PT2), equivalent to 30 mm and 150 mm crop height of flax and linseed. Comparison was made between metsulfuron-methyl and metsulfuron-methyl/thiameturon-methyl ('Harmony M', 75% w.d.g.). Further comparison was made with two tank-mix treatments currently used in these crops, trifluralin + linuron, applied pre-emergence on 25 April, and 290 g a.i./ha clopyralid/bromoxynil ('Vulcan', 29% wt/vol EC) + 960 g a.i./ha bentazone ('Basagran', 48% wt/vol a.c.) applied at PT1 and 2.

The flax crops were desiccated with glyphosate ('Roundup'; 48% wt/vol aq.c.) on 1 August 1985 at Bush and 9 August at Eastfield, and flax and linseed in 1986 were desiccated with diquat ('Reglone'; 20% wt/vol a.c.) on 18 September. Flax was pulled from 4 x 0.5 m row lengths on 20 August 1985 and 3 November 1986, and dried for 24 hours at 100°C to assess straw dry weight. Linseed was pulled from 4 x 0.5 m row lengths on 31 October 1986 and seed pod production and seed number/10 pods were assessed. The number of seed pods/m^2 shed onto ground was assessed by 4 x 0.25 m^2 quadrat counts. Linseed yield was calculated from total seed pod production/m^2, including harvested yield plus shedding, assessments and mean number of seeds/pods.

RESULTS

Crop tolerance, 1985 trials

There was no significant difference in straw length between treatments at harvest at Bush (Table 1). There was some indication of dry straw yield reduction from 12 g a.i./ha metsulfuron-methyl at Bush but this was not statistically significant. Crop height was not evaluated because of lodging at Eastfield, but the sulfonyl-urea treatments all improved dry straw yield over the untreated at this weedy site (Table 1).

Crop tolerance, 1986 trial

There were no significant early effects on the crop by any treatment. Crop height was assessed on 17 July (Table 2). Metsulfuron-methyl/thiameturon-methyl at 169 g a.i./ha at both timings significantly stunted linseed, and at the later timing (PT2), stunted flax.

Crop maturation or senescense was assessed on 27 August (Table 2). Metsulfuron-methyl at 18 g a.i./ha at PT1, with thiameturon-methyl at both rates at either timing, and clopyralid/ioxynil + bentazone applied at PT1 all significantly delayed maturation of linseed. Metsulfuron-methyl at 18 g a.i./ha, and, in particular, metsulfuron-methyl/thiameturon-methyl at both rates, when applied at PT1, delayed maturation of flax; PT2 treatments did not delay maturation.

TABLE 1

Effect of herbicide treatment on flax straw length at harvest and dry straw yield; 1985; Bush cv Regina, Eastfield cv Herra).

Treatment	Rate (g a.i./ha)	Bush		Eastfield
		Straw length (mm)	Dry straw yield (t/ha)	Dry straw yield (t/ha)
trifluralin + linuron	840 + 705	724	5.6	-
metsulfuron-methyl	3	-	-	8.1
metsulfuron-methyl	6	719	6.2	6.3
metsulfuron-methyl	12	678	5.1	7.7
metsulfuron-methyl /thiameturon-methyl	45	-	-	6.7
Untreated		686	6.5	5.1
SED		26.2	0.91	0.70

No treatment significantly reduced flax straw length compared with the untreated control (Table 2). Straw length, however, was reduced by most of the later treatments (PT2) compared with the PT1 treatments. The PT2 treatments also tended to reduce dry straw yield, with metsulfuron-methyl/thiameturon-methyl and clopyralid/ioxynil + bentazone reducing yield significantly. The only treatment to give a significant yield improvement was 6 g a.i./ha metsulfuron-methyl applied at PT1.

Later treatments (PT2) tended to reduce the number of seed pods produced and the number of seeds per pod (Table 2). Metsulfuron-methyl /thiameturon-methyl applied at 169 g a.i./ha at PT2 significantly reduced the number of seeds per pod. This was reflected in grain yield. Grain yield was significantly higher following early post-emergence herbicide treatment (PT1), with the exception of the lowest rate of metsulfuron-methyl at PT1 and the pre-emergence treatment, which were less effective at controlling weeds. Late post-emergence treatments (PT2) did not increase grain yields significantly compared with the untreated control.

Weed control, 1985 and 1986 trials

Table 3 lists the predominant weed species found in the 1985 flax and 1986 linseed trials, and their ground cover in response to the herbicide treatments. A similar level and response in weed cover was evident in the adjoining 1986 flax trial.

The later post-emergence application (PT1) of the sulfonyl-urea herbicides did not give good control of the important weed *Polygonum aviculare*. In general, the earlier application of the sulfonyl-urea herbicides gave best control of weeds. The treatments currently used tank mixes of trifluralin + linuron, and clopyralid/ioxynil + bentazone, gave much poorer control of *Galeopsis tetrahit* and *P. aviculare* than the sulfonyl-ureas at PT1.

DISCUSSION

The results from the 1985 trials indicated that the sulfonyl-urea herbicides metsulfuron-methyl and metsulfuron-methyl/thiameturon-methyl showed promise as herbicides for use in flax, with little or no damage to the crop from use of twice the rate recommended for use in cereals, and with promising activity on weeds difficult to control in flax such as G. tetrahit and P. aviculare.

The trials in 1986 confirmed the earlier results of potential for use in flax, and also in the related crop, linseed. However, there is a stronger indication from these trials that earlier treatments at about 30 mm crop height, are safer to both crops than later treatments at about 150 mm crop height. There is no evidence of a yield response to a dose rate except from the highest rate tested (18 g a.i./ha) of metsulfuron-methyl applied to flax at 30 mm height and 169 g a.i./ha metsulfuron-methyl/thiameturon-methyl applied to linseed at 150 mm height although the yields were not significantly lower. Straw length and yield of flax and grain yield of linseed were improved by earlier removal of the weed competition by the sulfonyl-urea herbicides, as well as the standard clopyralid/ioxynil + bentazone mixture. Early check of the crops by, in particular, PT1 treatment with metsulfuron-methyl /thiameturon-methyl did not affect yields. Crop maturation in 1986, however, was generally delayed by the treatments and this may have been a factor towards the improved yield by prolonging the growing and seed filling period.

The sulfonyl-urea herbicides have a characteristic stunting effect on most broad-leaved species (Doig et al, 1983), which prevents competition with crops, or contamination of flax fibres with weed fibres or linseed with weed seed. The results show that early post-emergence treatments with sulfonyl-ureas were more effective on weed species present than the later treatments. They also gave better control of the important species present, P. aviculare and G. tetrahit, than the other treatments evaluated.

It is recommended that these sulfonyl-urea herbicides are evaluated further for use in these crops at early post-emergence growth stages, for both crop safety and weed control. The delay in crop maturation which may have improved yields, should also be evaluated further; in particular the effect on quality of flax fibre and linseed following crop desiccation where that is practised. Metsulfuron-methyl alone appeared more promising than metsulfuron-methyl/thiameturon-methyl because of the check by the latter combination on early crop growth, the increased delay in crop maturation, and the greater effect on yield when applied at later growth stages.

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TABLE 2
Effect of herbicide treatment on flax and linseed crop height and maturation, flax straw and linseed yield; Bush, 1986.

Timing and Treatment	Rate (g a.i./ha)	Crop height (mm) 17 July flax	Crop height (mm) 17 July linseed	Crop Maturation 27 August flax	Crop Maturation 27 August linseed	Flax Straw length (mm)	Flax Dry straw yield (t/ha)	Linseed Number seed pods/m²	Linseed Number seeds/pod	Linseed Grain yield (t/ha)
Pre-emergence										
trifl + linuron	840 + 705	750	653	7.2	4.3	603	3.98	4219	7.5	2.92
Early post-em (PT1)										
metsulf	6	731	593	7.0	7.2	614	4.45	4685	8.0	3.22
metsulf	18	687	580	6.3	4.5	569	3.83	5433	8.1	3.82
metsulf/thiamet	56.3	700	567	6.2	3.8	616	3.18	5528	8.1	3.88
metsulf/thiamet	169	663	533	4.5	2.8	612	4.00	5628	8.4	3.76
clo/brom + bent	290 + 960	723	583	7.3	4.5	614	3.63	5336	8.1	3.80
Late post-em (PT2)										
metsulf	6	707	583	7.5	7.7	578	2.63	3517	7.8	2.44
metsulf	18	670	580	7.3	7.2	583	2.80	4010	7.9	2.86
metsulf/thiamet	56.3	643	557	7.5	5.5	540	2.62	4483	6.7	2.45
metsulf/thiamet	169	680	530	6.8	3.8	566	3.67	4133	5.4	1.70
clo/brom + bent	290 + 960	637	563	7.2	7.3	540	2.48	4350	7.6	2.73
untreated		707	583	7.4	7.9	582	3.23	3686	7.7	2.44
SED		29.1	16.0	0.38	1.33	23.2	0.404	659.8	0.73	0.538

Key: trifl = trifluralin; metsulf = metsulfuron-methyl; thiamet = thiameturon-methyl; clo/brom = clopyralid/bromoxynil; bent = bentazone.

Crop maturation score: 0 = green (immature); 10 = brown (senesced)

TABLE 3
Effect of herbicides on control of main weeds; 1985[1] in flax at Bush[1] and Eastfield[1], and in 1986 in linseed at Bush[2]

Treatment and Timing	Rate (g a.i./ha)	Weed % ground cover G. tetrahit Bush[1]	 Eastfield[1]	 Bush[2]	 P. aviculare Bush[1]	 Bush[2]	 Viola arvensis Eastfield[1]	 Bush[2]
Pre-emergence								
trifl + linuron	840 + 705	7.2	-	4.2	6.7	6.7	-	0.0
Early post-em (PT1)								
metsulf	6	0.0	-	0.0	4.3	1.1	-	0.0
metsulf	12	0.0	-	0.0	-	-	-	0.0
metsulf	18	-	-	-	2.8	0.0	-	0.0
metsulf/thiamet	56.3	-	-	0.0	-	0.0	-	0.0
metsulf/thiamet	169	-	-	0.0	-	0.0	-	0.0
clo/brom + bent	290 + 960	-	-	2.0	-	1.0	-	1.7
Late post-em (PT2)								
metsulf	3	-	17.3	-	-	-	7.7	-
metsulf	6	-	12.0	4.7	-	4.3	-	0.7
metsulf	12	-	12.0	-	-	-	3.3	-
metsulf	18	-	-	2.7	-	4.3	-	0.7
metsulf/thiamet	45	-	7.7	-	-	-	4.0	-
metsulf/thiamet	56.3	-	-	3.3	-	6.3	-	1.7
metsulf/thiamet	169	-	-	3.7	-	5.0	-	1.0
clo/brom + bent	290 + 960	-	-	2.7	-	1.0	-	3.7
untreated		5.3	38.7	6.7	7.0	8.2	22.7	3.3
SED		2.52	4.73	1.84	3.74	1.77	5.32	0.78

Key: trifl = trifluralin; metsulf = metsulfuron-methyl; thiamet = thiameturon-methyl; clo/brom = clopyralid/bromoxynil; bent = bentazone.

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BROAD-LEAVED WEED CONTROL IN LINSEED

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ABSTRACT

The tolerance of linseed grown for oilseed to a wide range of pre-sowing incorporated, pre- and post-emergence herbicides was assessed in a series of trials in 1985 and 1986. Some of the pre-emergence materials were non-selective. The post-emergence herbicides were generally more consistent in achieving good weed control and the growth distortion effects caused by MCPA in tank mixtures did not result in reduced yields. Metsulfuron-methyl post-emergence appeared the most effective treatment and was safe to the linseed crop.

INTRODUCTION

Cereal surpluses within the EEC and price restraints have renewed the interest in arable break crops. The area of linseed (Linum usitatissimum) grown in the UK increased to an estimated 7 200 ha in 1986. Linseed is well suited to a cool humid climate but it is not competitive during early growth and therefore good weed control is essential during establishment and as an aid to harvesting (Davies and Richards, 1984, and Davies, 1985). Few herbicides are registered in the UK for use in linseed and most have limited selectivity and range of weeds controlled. There is therefore a need to continue assessing new materials for safety and efficacy in linseed and in 1984 a number were screened by International Seed Producers (ISP).

This research report describes five trials by the Agricultural Development and Advisory Service (ADAS) in South East, Eastern and Northern Regions in 1985 and 1986, and two observation tests by ISP in the same years. The trials series are continuing.

MATERIALS AND METHODS

The ADAS trials were laid out in randomised block design, with three or four replications each containing two to four untreated controls. The ISP trials were unreplicated, with two or four controls. Apart from herbicides the trials received normal farm treatment. All trials were drilled with the variety Antares with the exception of Lidgate at site 1, between 10-21 April. Chemicals were applied by plot sprayers in 200-225 l water/ha at 200-250 kPa through fan nozzles. Plot area was $24m^2$-$72m^2$. The sites and spray dates are shown in Table 1.

TABLE 1

Experimental sites, soil type, spray dates and crop height at post-emergence application

Site No.	Year	Location	Soil* type	Pre-emergence	Post-emergence	Crop height (cm)
ADAS						
1.	1985	Lincs	LS	18, 24/4	31/5	15
2.	1985	N.Yorks	SCL	23/4	2,9,16/6	10-15
3.	1986	Lincs	ZyCL	18/4	11/6	18
4.	1986	Hants	ZyCL	11/4	5/6	20-25
5.	1986	N.Yorks	SCL	6/5	24/6	15-23
ISP						
6.	1985	Herts	C	16/4	25/5	12-15
7.	1986	Suffolk	C	16/4	12/6	15

* ADAS soil texture classification 1985

In 1985 the following pre- and post-emergence materials were evaluated either alone or as tank mixes: trifluralin 48 g a.i./l EC; linuron 50% WP or 15 g a.i./l EC; trifluralin/linuron 240/120 g a.i./l EC; trifluralin/trietazine/linuron 208/54/46 g a.i./l EC; bifenox/linuron 343/142 g a.i./l SC; trietazine/simazine 402.5/57.5 g a.i,/l SC; linuron/lenacil 30%/32% WP; isoxaben 500 g a.i./l SC; metazachlor 500 g a.i./l SC; pendimethalin 330 g a.i./l EC; bentazone 480 g a.i./l a.c; clopyralid 100 or 200 g a.i./l SC; cyanazine/clopyralid 350/60 g a.i./l SC; clopyralid/bromoxynil 50/240 g a.i./l EC; MCPA 500 g a.i./l a.c; metsulfuron-methyl 20% w.d.g..

In 1986, the unsuitable products were withdrawn or the rate adjusted and other promising materials; bromoxynil/MCPA 200 g a.i./l SC; thiameturon-methyl/metsulfuron-methyl 75% w.d.g. included. The ISP observations included several more chemicals and details are not shown here.

Phytotoxicity was recorded as crop dry weight on 22 July at site 4, plant population on 22 May at site 2, or as comments on overall treatment effects. Site 5 was harvested and seed yields recorded. The degree of weed control was assessed by a range of techniques depending on the numbers present. Weeds were recorded as total weed dry weight on 22 July at site 4, percentage ground cover of main species at site 6 and at site 2 (on 23 July), number/m^2 of the main species on 3 July at site 1 or percentage occurrence using a 16 section quadrat of 0.25 m^2 area, on 14 August at site 5. Weed control was not assessed at site 7.

RESULTS

Crop Tolerance

Crop tolerance to pre-drilling incorporated and pre-emergence herbicides is shown in Table 2, and to post-emergence herbicides in Table 3. Site 3 was not assessed.

TABLE 2

Effect of pre-drilling incorporated and pre-emergence herbicides on crop vigour (score), dry weight (d.w. g/m^2), plant population ($plants/m^2$) and seed yield (t/ha @ 9% MC)

Chemical	Dose (kg a.i./ha) Site	$plants/m^2$ 2	score 6	score 4	d.w 4	yield 5	score 7
Pre-drilling incorporated							
trifl	1.08	367	9	-	-	-	-
trifl	0.84	-	-	6.7	541	1.77	-
trifl	0.54	342	-	-	-	-	-
Pre-emergence							
trifl	1.08	626	-	-	-	-	-
trifl	0.54	643	-	-	-	-	-
lin	1.0	600	-	7.5	655	1.76	-
lin	0.75	478	8	7.5	616	1.67	9
trifl + lin	0.54 + 0.75	660	-	-	-	-	-
trifl/lin	0.96/0.48	597	-	7.7	573	1.69	-
trifl/lin	0.72/0.36	586	-	-	-	-	-
trifl/triet/lin	1.04/0.27/0.23	460	-	-	-	-	-
bifen/lin	1.2/0.5	224	-	-	-	-	-
triet/sim	*(a)	481	-	-	-	-	-
lin/lenacil	*(b)	588	-	-	-	-	9
isox	0.1	564	-	-	-	-	-
isox	0.075	478	-	6.7	536	1.26	-
trifl + isox	0.84 + 0.075	-	-	6.0	482	1.56	-
metazachlor	1.0	589	-	5.0	583	1.74	8
pendimethalin	2.0	531	-	7.3	589	0.92	-
pendimethalin	1.3	-	-	7.7	622	1.49	-
Untreated		651	9	7.9	539	1.55	9
SED ± (Comparing treatment with untreated)		85.3	-	0.44	49.0	0.131	-
CV%		22.5	-	11.1	87.7	8.8	-

Key: Vigour score 9 = max vigour, 0 = complete kill

* range of rates according to soil texture (a) 0.72/0.1 - 1.01/0.14 (b) 0.42/0/45 - 0.48/0.52kg a.i./ha

trifl = trifluralin, lin = linuron, triet = trietazine, bifen = bifenox, isox = isoxaben, sim = simazine

The results of ADAS trials and ISP screening tests showed that some materials were non-selective in linseed. Formulations of trifluralin/ trietazine/linuron, bifenox/linuron and trietazine/simazine caused significant reductions in plant population in 1985 and were not included in 1986. Conversely, linseed appeared tolerant of chlorsulfuron/

metsulfuron-methyl but this was withdrawn from the trial series by the manufacturer and the results are not presented. In addition to the chemicals listed in the tables the ISP observation in 1985 showed metribuzin, propyzamide, carbetamide and dicamba to be particularly damaging.

TABLE 3

Effect of post-emergence herbicides on crop vigour (score), dry weight (d.w. g/m), plant population (plants/m) and seed yield (t/ha @ 9% MC)

Chemical	Dose (kg a.i./ha) Site	plants 2	score 6	score 4	d.w 4	yield 5	score 7
Post-emergence							
bent	1.44	515	8	7.7	634	1.36	7
bent	0.96	-	-	7.5	637	1.50	-
bent + clop/brom	0.96 + 0.29	504	8	7.0	629	1.44	7
bent + clop/brom	0.72 + 0.29	-	8	6.7	635	1.45	8
clop	0.10	-	7	7.5	533	1.54	8
clop/brom	0.41	-	7	6.7	585	1.48	7
clop/brom	0.29	495	7	6.7	616	1.54	7
clop/brom + MCPA	0.29 + 0.5	575	-	5.5	641	1.72	-
cyan/clop + MCPA	0.8 + 0.5	547	-	-	-	-	-
cyan/clop + MCPA	0.6 + 0.5	-	-	5.3	604	1.64	5
brom/MCPA	0.56	539	-	5.3	581	1.57	9
metsul	0.006	539	-	7.3	610	1.52	8
metsul + brom	0.003 + 0.25	-	-	4.0	550	1.45	-
thiamet/metsul	0.015	-	-	4.0	572	1.61	-
thiamet/metsul	0.0075	-	-	5.0	590	1.55	-
Untreated		651	8	7.9	539	1.55	9
SED ± (Comparing treatment with untreated)		85.3	-	0.44	49.0	0.131	-
CV%		22.5	-	11.1	87.7	8.8	-

Key: Vigour score 9 = max vigour, 0 = complete kill
bent = bentazone, clop = clopyralid, brom = bromoxynil, cyan = cyanazine, metsul = metsulfuron-methyl, thiamet = thiameturon-methyl

Pre-emergence application of pendimethalin at rates of 2.0 and 1.3 kg a.i./ha caused severe damage and crop death at site 5 resulting in significantly reduced seed yields. Crop tolerance to isoxaben was low, applications of 0.075 kg a.i./ha significantly reduced seed yield at site 5 and at site 2 caused significant crop thinning at 0.075 kg a.i./ha but not at 0.1 kg a.i./ha, at site 4 a rate 0.075 kg a.i./ha reduced crop vigour on 23 June although not crop dry weight on 22 July 1986. Metazachlor at a rate of 1.0 kg a.i./ha reduced crop vigour but not crop dry weight at site 4 and slightly reduced crop vigour on site 7, both in 1986. Trifluralin incorporated by rotavator reduced the plant population by 45% in 1985 at site 2 however at site 5 (1986) trifluralin had no effect on seed yield.

Deleterious effects on soil structure by rotary incorporation may have been responsible for crop effects at site 2. Pre-emergence applications of trifluralin in 1985 on sites 1 and 2 did not appear to be damaging except for temporary chlorosis and at site 4 in 1986 caused visible crop damage but this was not reflected in a reduction of crop dry weight. Linuron reduced plant population only at the 0.75 kg a.i./ha rate at site 2 and at site 1 reduced crop height by 5 cm at 1.0 kg a.i./ha and caused temporary chlorosis at 0.75 kg a.i./ha.

Of the post-emergence applications, the tank mix of cyanazine/ clopyralid with MCPA reduced crop vigour two to four weeks after treatment at sites 4 and 7 but damage was not reflected in reduced crop dry weight at site 4 eight weeks after treatment. The tank mix of MCPA with clopyralid/bromoxynil also caused visible damage at site 4, however this treatment was the only one to produce a significant yield increase over the untreated control at site 5, the one site harvested. Clopyralid alone at a rate of 1.0 kg a.i./ha reduced crop vigour at site 6 and 7 but had no adverse effect on dry weight or seed yield at sites 4 and 5. Clopyralid/ bromoxynil at rates of 1.0 and 1.4 kg a.i./ha reduced crop vigour, at all recorded sites (4, 6 and 7) but this was not reflected in reduced dry weight or seed yield. Bromoxynil/MCPA at a rate of 0.56 kg a.i./ha also reduced crop vigour but not dry weight or seed yield. Bentazone was relatively safe to linseed although delays in flowering and reduced crop height were noted at site 5. No significant phytotoxic effects were recorded from the tank mixes of bentazone with clopyralid/bromoxynil. Metsulfuron-methyl showed good crop safety on all sites but the tank mixture with bromoxynil severely affected crop vigour at site 4. Thiameturon-methyl/metsulfuron methyl also reduced crop vigour on the same site.

Weed Control

Weed assessments are shown in Tables 4 and 5. Site 7 had insufficent weeds to record treatment effects. Weed species varied between sites and years and results are not meaned over trials.

The dominant species at site 4 were *Veronica persica*, *Papaver rhoeas* and *Matricaria* spp. At site 3 there was a poor plant stand of linseed of 180 plants/m . Here, on untreated plots there was a very dense weed population 200 - 300 plants/m predominantly *Polygonum aviculare* which was 22 cm tall when the post-emergence treatments were applied but on 9 July *Stellaria media* accounted for 90% ground cover. None of the pre-emergence treatments were effective in controlling the spectrum of broad-leaved species present. The most effective post-emergence treatments were those containing metsulfuron-methyl. A mixture of bentazone + clopyralid/ bromoxynil applied to the crop adjacent to the trial area ten days before the trial treatments, when the weeds were at a less advanced growth stage, achieved a higher degree of weed control.

Of the pre-emergence treatments at the other sites, trifluralin gave good control of *Galeopsis tetrahit* and *Polygonum* spp. particularly when incorporated. Linuron reduced weed dry weight at site 4 but gave poor control of *G. tetrahit*, *Veronica* spp., *Polygonum* spp. and *Viola arvensis*; the rate of 1.0 kg a.i./ha was not consistently better than 0.75 kg

TABLE 4

Weed control as % untreated from pre-drilling incorporated and pre-emergence herbicides assessed as total weed dry weight d.w. g/m^2 (site 4), % cover (sites 2 and 6), weeds/m^2 (site 1) and % occurrence (site 5)

Chemical	Dose (kg a.i./ha) Site	4	*S. arvensis*	*G. tetrahit*	*V. hederifolia*	*V. persica*	*P. annua*	*Trifolium spp.*	*P. aviculare*	*P. persicaria*	*L. purpureum*	*S. arvensis*	*S. media*	*P. lapathifolium*
			% Weed Control											
	Site	4	2		1			5			7			
Pre-drilling incorporated														
trifl	1.08	-	32	85	-	-	-	-	-	-	90	0	95	95
trifl	0.84	72	-	-	-	-	-	19	100	82	-	-	-	-
trifl	0.54	-	0	65	-	-	-	-	-	-	-	-	-	-
Pre-emergence														
trifl	1.08	-	55	0	29	0	35	-	-	-	-	-	-	-
trifl	0.54	-	0	7	53	0	35	-	-	-	-	-	-	-
lin	1.0	93	100	0	59	0	55	99	0	64	-	-	-	-
lin	0.75	94	80	0	0	42	40	95	0	38	90	80	90	95
trifl + lin	0.54 + 0.75	-	100	0	47	0	50	-	-	-	-	-	-	-
trifl/lin	0.96/0.48	85	55	0	69	0	35	50	0	48	-	-	-	-
trifl/lin	0.72/0.36	-	24	0	59	0	35	-	-	-	-	-	-	-
trifl/triet/lin	1.04/0.27/0.23	-	15	0	35	25	75	-	-	-	-	-	-	-
bifen/lin	1.2/0.5	-	0	0	88	67	40	-	-	-	-	-	-	-
triet/sim	* (a)	-	44	0	41	0	50	-	-	-	-	-	-	-
lin/lenacil	* (b)	-	82	7	12	0	75	-	-	-	-	-	-	-
isox	0.1	-	0	0	76	8	0	-	-	-	-	-	-	-
isox	0.075	42	43	0	53	0	0	77	13	0	-	-	-	-
trifl + isox	0.84 + 0.075	89	-	-	-	-	-	69	20	0	-	-	-	-
metazachlor	1.0	91	0	65	94	0	95	76	0	92	-	-	-	-
pendimethalin	2.0	87	0	92	94	94	75	0	100	78	-	-	-	-
pendimethalin	1.0	-	-	-	-	-	-	0	100	86	-	-	-	-
Untreated d.w. g/m^2		84	-	-	-	-	-	-	-	-	-	-	-	-
plants/m^2		-	17.2	27.2	17	12	20	-	-	-	7.6	5.0	10.0	7.0
% occurence		-	-	-	-	-	-	30	17	10	-	-	-	-
SED $\pm$ (Comparing treatment with untreated)		-	39.9	47.9	-	-	-	20.4	32.8	28.8	-	-	-	-

Key: weed score 9 = max population, 0 = freedom from weeds

trifl = trifluralin, lin = linuron, triet = trietazine, isox = isoxaben, sim = simazine, bifen = bifenox

* range of rates according to soil texture (a) 0.72/0.1 - 1.01/0.14 (b) 0.42/0.45 - 0.48/0.52kg a.i./ha

TABLE 5

Weed control as % untreated from post-emergence herbicides assessed as total weed dry weight d.w. g/m^2 (site 4), % cover (sites 2 and 6), weeds/m^2 (site 1) and % occurrence (site 5)

Chemical	Dose (kg a.i./ha)	Site 4	S. arvensis (2)	G. tetrahit (2)	V. hederifolia (1)	V. persica (1)	P. annua (1)	Trifolium spp. (5)	P. aviculare (5)	P. persicaria (5)	L. purpureum (6)	S. arvensis (6)	S. media (6)	P. lapathifolium (6)
Post-emergence														
bent	1.44	95	100	0	23	0	0	16	0	58	85	95	95	95
bent	0.96	99	-	-	-	-	-	24	26	92	-	-	-	-
bent + clop/brom	0.96 + 0.29	100	100	0	41	0	0	69	42	94	90	95	95	95
bent + clop/brom	0.72 + 0.29	-	-	-	-	-	-	95	65	100	90	95	90	95
clopyralid	0.10	27	-	-	-	-	-	45	0	54	50	30	40	50
clop/brom	0.41	98	-	-	-	-	-	59	68	82	85	95	80	90
clop/brom	0.29	90	100	41	47	0	0	50	52	53	80	90	70	90
clop/brom + MCPA	0.29 + 0.5	100	100	67	23	0	0	80	72	74	-	-	-	-
cyan/clop + MCPA	0.8 + 0.5	-	100	94	12	25	25	-	-	-	-	-	-	-
cyan/clop + MCPA	0.6 + 0.5	92	-	-	-	-	-	20	20	17	-	-	-	-
brom/MCPA	0.56	89	100	26	-	-	-	60	68	60	-	-	-	-
metsul	0.006	100	100	100	76	8	44	100	0	94	-	-	-	-
metsul + brom	0.003 + 0.25	100	-	-	-	-	-	94	74	94	-	-	-	-
thiamet/metsul	0.015	100	-	-	-	-	-	99	77	100	-	-	-	-
thiamet/metsul	0.0075	-	-	-	-	-	-	100	40	98	-	-	-	-
Untreated weed d.w. g/m^2		84	-	-	-	-	-	-	-	-	-	-	-	-
plants/m^2		-	17.2	27.2	17	12	20	-	-	-	7.6	5.0	10.0	7.0
% occurence		-	-	-	-	-	-	30	17	10	-	-	-	-
SED ± (Comparing treatment with untreated)		-	39.9	47.9	-	-	-	20.4	32.8	28.8	-	-	-	-

bent = bentazone, clop = clopyralid, brom = bromoxynil, cyan = cyanazine, metsul = metsulfuron-methyl, thiamet = thiameturon-methyl.

a.i./ha. Isoxaben gave poor weed control when seedbeds were dry. Metazachlor and pendimethalin both reduced weed dry weight at site 5 but neither chemical controlled Sinapis arvensis, and metazachlor also failed to control V. persica and P. aviculare whilst pendimethalin did not control Trifolium spp..

The post-emergence treatments gave more reliable weed control. Bentazone at a rate of 0.96 kg a.i./ha gave good control of S. arvensis, Bilderdykia convolvulus, P. rhoeas and V. arvensis; control was not improved at the 1.44 kg a.i./ha rate. The addition of clopyralid/bromoxynil produced small but insignificant improvements in weed control. Metsulfuron-methyl did not control V. persica at site 1 or P. aviculare at site 6 but provided moderate control of Veronica hederifolia and good control of S. arvensis, G. tetrahit, Trifolium spp, Polygonum persicaria, S. media, V. arvensis, and P. rhoeas. The addition of bromoxynil improved the control of P. aviculare.

DISCUSSION

Few products have a UK label recommendation for use in linseed. MCPA, although approved, can cause considerable crop epinasty and has a limited weed spectrum. Trifluralin and linuron pre-emergence and bentazone, post-emergence also have UK label recommendations. There is a narrow safety margin for these materials with damage occuring under some circumstances and weed control is often inadequate in non-competitive crops. Bentazone tank mixed with clopyralid/bromoxynil and clopyralid/bromoxynil + MCPA gave good weed control in the trials and the growth distortion effect caused by MCPA did not result in reduced yield.

None of the herbicides gave complete control of all weed species occurring on the trial sites. Chlorsulfuron/metsulfuron-methyl gave good control but is unlikely to be recommended for spring use. Of the other materials tolerated by linseed, metsulfuron-methyl applied post-emergence gave the most consistent control. The addition of bromoxynil as a tank mix increased the weed spectrum but reduced crop tolerance. These findings are supported by results from Scotland (Davies, 1985) and from Northern Ireland (Courtney, 1986).

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SELECTIVITY AND EFFICACY OF HERBICIDES IN SPRING SOWN LUPINS

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ABSTRACT

Lupins are poor competitors with weeds and good weed control is essential to achieve high yields. Pre-sowing and incorporated, pre- and post-emergence herbicides were evaluated in an extensive series of experiments in France, for selectivity and efficacy in spring sown lupins (*Lupinus albus*). The results showed many pre-emergence herbicides for broad-leaved weeds were selective in lupins including isoxaben, aclonifen and low rates of flurochloridone and some were more effective than methabenzthiazuron, the standard. However, most post-emergence treatments were phytotoxic to lupins with the exception of metamitron and carbetamide/dimefuron. All the post-emergence graminicides tested had a wide margin of safety in the crop.

INTRODUCTION

Good weed control is essential in order to achieve high yields in spring sown lupins since they appear very sensitive to weed competition during the early stages of growth. There is a wide choice of suitable pre-emergence herbicides for broad-leaved weeds in lupins, but no means of control post-emergence. This research report presents the results of field trials carried out in France during the period 1983 - 1985 to evaluate new and established herbicides and their tank mixes for broad-leaved and grass weed control and selectivity in spring sown lupins (*Lupinus albus*). Although pre-sowing and pre-emergence herbicides were also tested, a safe post-emergence treatment was particularly sought.

MATERIALS AND METHODS

During the years 1983, 84, 85 and 86, field observation trials were carried out in lupins by the Institut Technique des Cereales et des Fourrages (ITCF), the Federation Nationale des Agriculteurs Multiplicateurs de Semences (FNAMS) and by the Crop Protection Service (SPV) at 23 sites in East Central, Western and Western Central France.

Crop tolerance and efficacy in spring sown lupins were evaluated for a total of 82 herbicide treatments of formulated products, alone or as tank mixes. The herbicide active ingredients, formulations, dose rates and timings of application are shown in Tables 1, 2 and 3. The herbicides were applied at normal and twice normal rates recommended for other crops either pre-sowing and soil incorporated, pre-emergence, early post-emergence when the lupins were at the one to three leaf stage of development, or later post-emergence at the four to six leaf stage. Applications were made using Ourtal plot sprayers at volumes of 400 l/ha and pressures of about 210 kPa. Treatments were sprayed across the direction of drilling and there was an untreated control plot between every pair of treated plots. Different lupin cultivars Lublanc, Kalina and Lucky were grown at the various sites. Crop tolerance to herbicide treatments was assessed by scoring visible damage effects. Efficacy on broad-leaved and grass weeds was also assessed by visual estimates and comparison with untreated plots, and scores were recorded for weed control overall and for predominant species.

RESULTS

Results for crop selectivity and efficacy of herbicides in spring sown lupins are presented in Table 1 (pre-sowing incorporated and pre-emergence treatments), Table 2 (early post-emergence) and Table 3 (post-emergence treatments) and show the mean for crop and weed scores for all sites over the four years tests. The cultivars of spring sown lupins, Lublanc, Kalina and Lucky showed a similar response to herbicide treatment and therefore the cultivar used is not specified in the tables of results.

The following herbicide treatments caused an unacceptable level of crop damage and were non-selective in lupins:-

Pre-emergence applications of metazachlor, mixtures containing chlorsulfuron or imazamethabenz such as methbenzthiazuron/chlorsulfuron or pendimethalin/imazamethabenz. Post-emergence applications of dinoseb-acetate, bentazone, bentazone plus dinoseb-acetate as a tank mix, bromoxynil, 2,4-DB, MCPB, MCPA, 2,4-DB/dinoseb, mecoprop/bifenox, mecoprop/bifenox plus clopyralid as a tank mix, pyridate alone or in tank mix with MCPB or with 2,4-DB or simazine, fluroxypyr, metsulfuron-methyl and pendimethalin/imazamethabenz. MCPB or pyridate were also phytotoxic when applied to lupins at the latest post-emergence stage.

The following were selective in the crop and appeared promising:-

Herbicides applied pre-sowing and soil incorporated (Table 1)

Benfluralin was very selective in lupins in 12 experiments and at 1260 g a.i./ha achieved good control of *Polygonum* spp., *Chenopodium* spp. and *Alopecurus myosuroides*. EPTC was selective but only effective on grass weeds present. Flurochloridone was only selective at the normal rate of 500 g a.i./ha, but gave excellent control of *Polygonum aviculare*, *Bilderdykia convolvulus*, *Chenopodium album* and *Cruciferae*.

Herbicides applied pre-emergence (Table 1)

The standard herbicide recommended for broad-leaved weeds in lupins in France, methabenzthiazuron at a dose rate of 2800 g a.i./ha was very safe to the crop, but controlled a limited weed spectrum. Efficacy was better for many weeds including *Polygonum* spp., *C. album*, *Stellaria media* and *Viola arvensis* with the formulated product mixtures neburon/terbutryn, trifluralin/linuron, trifluralin/neburon/linuron and chlomethoxynil/neburon which all showed good selectivity. The latter controlled *A. myosuroides* and to some extent, *Galium aparine*. Butralin alone, and in formulated mixtures butralin/linuron, butralin/monolinuron, pendimethalin alone, pendimethalin/linuron and neburon/pendimethalin were all very selective, and efficacy on several weed species was superior to methabenzthiazuron. Chlorotoluron/trifluralin also appeared selective. However, efficacy was poor for metamitron alone, and with the exception of *Matricaria* spp. for neburon/isoproturon/bifenox.

Among the newer herbicides, isoxaben appeared very safe to lupins but gave poor weed control at some sites even at 150 g a.i./ha where soil conditions were dry, and control was more reliable with mixtures with linuron or chlorotoluron. Although there was some crop damage for aclonifen, it performed well in 18 experiments achieving acceptable control of several species including *G. aparine* and *A. myosuroides*. At low rates of 500 or 750 g a.i./ha, flurochloridone proved selective and controlled a wide range of weeds including *A. myosuroides*, *Polygonum* spp., *Matricaria* spp., *C. album*, *S. media*, *Cruciferae* and some control of *G. aparine*. The safety margin was reduced for a formulation of neburon/flurochloridone.

The results of a limited number of evaluations, not presented in the tables indicated that metamitron + simazine tank mix, simazine, carbetamide/dimefuron, chloridazon and propachlor may be selective in lupins. Lenacil appeared safe at 400 g a.i./ha but weed control was only just acceptable.

Herbicides applied post-emergence (Tables 2 and 3)

Some of the foliar applied materials for broad-leaved weed control were extremely damaging and few showed acceptable selectivity in lupins in the series of experiments.

Only metamitron and carbetamide/dimefuron appeared safe to the crop. In one years test methabenzthiazuron, chloridazon, propachlor, propyzamide, lenacil and phenmedipham plus oil were selective, but further work is needed for confirmation. Weed control with the latter was less effective than with other materials.

Herbicides for broad-leaved weeds were still damaging to the crop when applied at a later timing with the exception of carbetamide/dimefuron which was tolerated at high rates 3500/1750 g a.i./ha but control was reduced when *P. aviculare*, *B. convolvulus*, *Cruciferae* and *C. album* were at a more advanced stage.

The graminicides fluazifop-P-butyl plus Agral wetter and quizalofop-ethyl, haloxyfop-ethoxyethyl, sethoxydim, alloxydim-sodium all with oil additives, and diclofop-methyl were highly selective in lupins.

DISCUSSION

In the series of experiments in which 82 herbicides were evaluated, results indicate that there is no available means of control for perennial broad-leaved species such as *Cirsium arvense*, *Convolvulus arvensis* or *Sonchus* spp. since herbicides such as MCPB and MCPA are non-selective in lupins. Annual species such as *Galium aparine* can also be a problem in lupins and while aclonifen (which performs well on a dry seedbed), chlomethoxynil/neburon, flurochloridone, pendimethalin and isoxaben (which performs well on a dry seedbed) achieve some control pre-emergence they are not always reliable, and bentazone and pyridate post-emergence are too phytotoxic to the crop.

Since all the post-emergence graminicides evaluated were well tolerated by lupins, and *Poa annua* can be controlled pre-emergence, the grass weed problem appears to be solved.

Some pre-emergence herbicides and mixtures were selective and more effective than the standard, methabenzthiazuron, and in addition several new pre-emergence materials appeared promising such as isoxaben and low rates of flurochloridone either alone or in tank mixes. These treatments will be evaluated further.

Most post-emergence treatments caused considerable damage to lupins, with the exception of metamitron and carbetamide/dimefuron, but for good results these must be applied early when weeds are small. A safe post-emergence treatment for lupins is essential to control weeds which are late germinating, weed species resistant to pre-emergence herbicides, or for situations where dry seedbeds reduce residual herbicide activity.

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TABLE 1
The selectivity and efficacy of herbicides applied pre-sowing and soil incorporated, or pre-emergence in spring sown lupins; mean scores for all sites for years 1983 - 1986.

*Score 0 = no effect on crop or weed, 3 = acceptable damage on crop or efficacy on weed, 10 = total kill of crop or weed

Herbicide (formulation)	Rate (g a.i./ha)	Crop Score*	Weed Score*										Number of trials ITCF FNAMS & SPV
			A. myosuroides	P. aviculare	B. convolvulus	Veronica spp.	S. media	Cruciferae	C. album	V. arvensis	Matricaria spp.	G. aparine	
Pre-sowing													
benfluralin	1080	0		3	0				4	0	0	3	4
(180g/l EC)	1260	0	8	9	6	9			9	1	0	0	12
EPTC	2880	0	8		1						0		6
(360g/l CS)	5760	2	9		2						2		6
flurochloridone	500	1		10	9			8	10				4
(250g/l EC)	1000	3		10	10			9	10				4
	1500	5		10	10			9	10				4
Pre-emergence													
methabenzthiazuron	2800	0		6	4	6	5	7	3	6	8		7
(70% WP)	5600	1		7	6								4
neburon/terbutryn	1200/ 800	0		6		6	7	8	9	8			2
(300/200g/l EC)	1500/1000	0		9	9	6	7	6	9	6	8	0	8
	2100/1400	0		9			9	9	9	9	9		1
	3000/2000	0		10	10			9	10	9	9	0	6
trifluralin/linuron	960/ 480	1		7	6	6	7	7	8	5	6		15
(240/120g/l EC)	1200/ 600	0			6	7	7	6	9	2	3		2
	1920/ 960	1		9	9			10	8	9	9		10
trifluralin/neburon/ linuron	750/ 750/ 360	0			5			9					4
(125/125/60g/l EC)	1500/1500/ 720	2		7	7			10					4
chlomethoxynil/neburon	2000/1080	0	7	8	7	10	9	7	8	8	8	4	23
(25/24.7% WP)	4000/3960	1	8	9	9	10	9	9	9	8	10	4	20
butralin/linuron (240/60g/l EC)	1920/ 480	0		6		7	9	7	9	9			2
butralin/monolinuron (240/60g/l EC)	1440/ 360	0		6		7	8	7	9	7			2
butralin (480g/l EC)	3360	0		7		8	6	6	8	6	0		5
pendimethalin	980	0		10	9			4	8				4
(330g/l EC)	1980	2		10	10			5	9				4
pendimethalin/linuron (20/50% WP)	800/800	0			5	7	7	6	6	0	5		2

TABLE 1 (continued)

Herbicide (formulation)	Rate (g a.i./ha)	Crop Score*	Weed Score*										Number of trials ITCF FNAMS & SPV
Pre-emergence (continued)													
neburon/pendimethalin (46/10% WP)	1840/ 400	0		8	8	8	7	8	4	5	5		4
	2300/ 500	0	1			9			9				2
	4600/1000	0	4			8			9				2
chlorotoluron/trifluralin (400/140g/l SC)	2000/ 700	1		10	9			9	9	8			6
	4000/1400	2		10	10			9	9	9			6
metamitron (70% WG)	2800	1	8	5	3		3	6	2	2	5		6
	5600	2	9		6					5			4
neburon/isoproturon/ bifenox (200/133/133g/l SC)	800/ 532/ 532	1		5	6			7	7		10		8
	1600/1064/1064	2		7	8			9	8		10		9
isoxaben (125g/l SC)	62.5	1		7	5			9	8	10		2	5
	75	0			2					1		0	7
	125	1		8	7			9	8	10		4	5
	150	0			3					2		0	7
isoxaben+linuron (125g/l SC)+(50% WP)	62.5+1500	1		8	9			10	8	9		3	6
	125+1000	1		9	9			10	8	9		5	6
chlorotoluron/isoxaben (60/19g/l SC)	2404/ 76	1		9	9			9	9	9			6
	4808/ 152	2		10	10			9	10	10			6
aclonifen (540g/l EC)	2430	2	4	6	6		10	9	7	6	8	4	18
	4860	3	8	7	7		10	9	8	7	9	5	18
flurochloridone (250g/l EC)	500	2	9	9	7		7	9	8	8	9	3	15
	750	0		9	7		9	9	9	3	8		3
	1000	4	9	9	8		10	10	8	6	9	5	15
neburon/flurochloridone (40/5% SP)	1200/ 150	1			9			6		0	3		1
	2000/ 250	1		9	9		9	9	9	4	8	4	6
	2400/ 300	2	6		7						10		5
	4000/ 500	2		10	10			9	9				4
	4800/ 600	4	8		10						10		5
pendimethalin/ imazamethabenz (200/125g/l EC)	1000/ 625	7		10	10			9	8				4
	2000/1250	8		10	10			9	9				4
methabenzthiazuron/ chlorsulfuron (70/0.5% WP)	2800/ 20	7	8	10	10	10			10				8
	5600/ 40	9	9	10	10				10				6
metazachlor (500g/l SC)	1000	4			6	3	6	5	9	7			3

TABLE 2
The selectivity and efficacy of herbicides applied early post-emergence at 1 - 3 leaf stage of spring sown lupins; mean scores for all sites for years 1983 - 1986.

*Score 0 = no effect on crop or weed, 3 = acceptable damage on crop or efficacy on weed, 10 = total kill of crop or weed

Herbicide (formulation)	Rate (g a.i./ha)	Crop Score*	Weed Score*: P. aviculare	B. convolvulus	Veronica spp.	S. media	Cruciferae	C. album	V. arvensis	Matricaria spp.	G. aparine	Number of trials ITCF, FNAMS & SPV
Early post-emergence												
Carbetamide/dimefuron	875/437.5	0	4									1
(50/25% WP)	1875/937.5	0	5	6	7	8	6	6	7	8	2	19
	3500/1750	1	6	7			4	6	10	10	3	16
metamitron	2800	1	8	3		5	7	9	7	8	4	11
(70% WP)	5600	2		2			6	10	6		6	8
methabenzthiazuron (70% WP)	2800	0		8			9		8	8		1
chloridazon	1075	0		6			0		0	5		1
(430g/l SC)	2150	0	9	6			8	9	7	8		1
propachlor (50% WP)	1920	0		6			5		0	9		1
propyzamide (50% WP)	1500	0		9			8		8	7		1
lenacil (80% WP)	1200	0	6	4			9	9	9	9		1
phenmedipham+oil (16.7% EC)	1002+1000	0		7			6		0	5		1
dinoseb-acetate	1569	2	2	4	0		7	4				5
(523g/l EC)	2092	2	4	3			8	4	2	10		12
	3138	4	8	4	5		9	9				5
bromoxynil	500	3		6						10		5
(250g/l EC)	1000	5		7						10		5
2,4-DB	1800	4	0	2			3	6				6
(300g/l a.c.)	3600	6	1	3			5	7				6
MCPB	1600	4	3	1			9	2		8	0	9
(400g/l a.c.)	3200	6	4	0			10	3				4
MCPA	400	4		0						5	0	5
(400g/l a.c.)	800	7		0						6	0	6
2,4-DB/dinoseb	1500/ 900	5	2	3			7	6				5
(250/150g/l a.c.)	3000/1800	6	5	4			9	7				5

TABLE 2 (continued)

Herbicide (formulation)	Rate (g a.i./ha)	Crop Score*	Weed Score*: *P. aviculare*	*B. convolvulus*	*Veronica* spp.	*S. media*	Cruciferae	*C. album*	*V. arvensis*	*Matricaria* spp.	*G. aparine*	Number of ITCF, FNAMS & SPV
Early post-emergence (continued)												
mecoprop/bifenox (162.5/187.5g/l SC)	925/ 375	5		4						4		5
	1850/ 750	7		7						7		5
mecoprop/bifenox+ clopyralid (462.5/187.5g/l SC)+ (100g/l a.c.)	925/ 375 + 15	7		5						7		5
	1850/ 750 + 30	9		8						9		5
pyridate (45% WP)	900	2	3	4			6	8				6
	1800	4	4	6			8	9				6
pyridate+simazine (45% WP)+(50% WP)	450+ 500	2	2	3			5	5				6
pyridate+2,4-DB (45% WP)+(300g/l a.c.)	450+1800	5	8	6			10	5				4
	450+3600	7	8	7			10	6				4
pyridate+MCPB (45% WP)+(400g/l a.c.)	450+1600	6	7	6			7	7				6
	450+2400	8	8	7			7	8				6
bentazone (480g/l a.c.)	1200	5	4	6			7	5		10	1	9
	2400	8	6	6			8	7		10	2	9
bentazone+dinoseb-acetate (480g/l a.c.)+(523g/l EC)	960+1307.5	8	6	9			9	9			3	3
fluroxpyr (200g/l EC)	60	5	7	5			10	4				4
	150	9	8	6			10	5				4
metsulfuron-methyl (20% WG)	20	8		6				7				1
	40	8		6				7				1
	80	8		8				8				1
pendimethalin/imazamethabenz (200/125g/l EC)	1000/ 625	9	2	2			9	5				4
	2000/1250	9	3	4			10	6				4

TABLE 3
The selectivity and efficacy of herbicides applied post-emergence at 4 - 6 leaf stage of spring sown lupins; mean scores for all sites for years 1983 - 1986.

*Score 0 = no effect on crop or weed, 3 = acceptable damage to crop or efficacy on weed, 10 = total kill of crop or weed

Herbicide (formulation)	Rate (g a.i./ha) (l oil)	Crop Score*	Weed Score*								Number of ITCF, FNAMS & SPV
Post-emergence											
fluazifop-P-butyl+Agral≠	187.5	0	10	7	10	0					12
(250g/l EC)	375	0	10	8		0					12
quizalofop-ethyl+oil∤	125+1l	0	10	7	10	0					10
(100g/l EC)	250+2l	0	10	7	10	0					10
haloxyfop-ethoxyethyl+oil∤	125+0.5l	0	10	9							8
(125g/l EC)	250+1l	1	10	10							8
sethoxydim+oil∤	480+1l	0	10	6							7
(122g/l EC)	960+2l	0	10	8							7
alloxydim-sodium+oil∤ (75% SP)	1125+1l	0									2
diclofop-methyl (360g/l EC)	900	0									2
carbetamide/dimefuron	875/437.5	0					4				1
(50/25% WP)	1750/ 875	0					4	5	2	4	2
	3500/1750	0					6	8	4	5	2
MCPB (400g/l a.c.)	1600	5							5		2
pyridate (45% WP)	900	6							4		2

≠ Agral wetter added as 0.1% of spray volume
∤ mineral oil additive

ANNUAL AND PERENNIAL GRASS WEED CONTROL IN OILSEED RAPE, PEAS AND LUPINS WITH POST-EMERGENCE GRAMINICIDES

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ABSTRACT

In the years 1984-1987, field experiments were carried out in Poland to assess the control of grass weeds in winter oilseed rape, peas and lupins (*Lupinus albus*, *luteus* and *angustifolius*), using post-emergence graminicides. Autumn applications controlled volunteer cereals and *Apera spica-venti* in winter oilseed rape. Effective control of *Avena fatua* and *Echinochloa crus-galli* in peas, and of *Elymus repens* and *Agrostis tenuis* in lupins resulted in significant increases in seed yield.

INTRODUCTION

Prolonged use of herbicides to control dicotyledonous weeds as well as lack of crop rotations has caused an increase in the occurrence of monocotyledonous weeds. High populations of grasses such as *Apera spica-venti*, *Avena fatua*, *Echinochloa crus-galli* and *Elymus repens* are frequently encountered in broad-leaved crops in Poland (Adamczewski, 1985). About 70% of winter oilseed rape crops are grown after cereals, therefore volunteer cereals constitute a major problem, and although rape herbicides such as metazachlor, tebutam or dimetachlor may give some control, post-emergence sprays are often necessary. *A. fatua* affects pea crops in many regions of Poland and incidence of *E. crus-galli* is increasing. Lupins are frequently grown after a fallow where *E. repens* occurs and *Agrostis tenuis* sometimes causes a problem.

In recent years new post-emergence graminicides have been introduced, which successfully control many species of monocotyledonous weeds and are selective in many broad-leaved crops. Graminicides have now been developed for oilseed rape and peas, but there has been less work in lupins although the area of lupins in Poland is increasing. Experiments in Poland evaluating control of dicotyledonous weeds (Adamczewski & Paszkiewicz, 1986) did not include grass weed control in lupins.

The purpose of the experiments carried out in Poland over the period 1984-1987 was to evaluate the efficacy of several graminicides in winter oilseed rape, peas, and in white (*Lupinus albus*), yellow (*Lupinus luteus*) and blue (*Lupinus angustifolius*) lupins.

MATERIALS AND METHODS

Experiments in winter oilseed rape from 1984-1986 and in peas from 1985-1987 were performed at the Experimental Department in Winnogora on a sandy clay soil with 1.6-1.8% humus content, while experiments in lupins in 1985 and 1986 were at the Experimental Department in Wiatrowo on a sandy soil containing 1% humus. All the experiments were carried out in a randomised block design with four replications. Plot area was $30m^2$ for oilseed rape and $20m^2$ for peas and lupins. Winter rape was sown in the latter part of August, and peas and lupins were sown at the beginning of April. The crops were harvested with a Hege combine harvester.

The herbicides were all applied by an air-pressurised back-pack sprayer using System 8002 Tee-Jet nozzles delivering a volume of 250 l/ha at pressure of 210 kPa. Graminicides fluazifop-P-butyl (as the commercial product containing adjuvants), haloxyfop-ethoxyethyl, sethoxydim and quizalofop-ethyl were evaluated in all crops and in addition cycloxydim, fenoxaprop-ethyl and diclofop-methyl were tested in peas.

The chemical metazachlor at a rate of 1.25 kg a.i./ha was applied pre-emergence in winter oilseed rape to control dicotyledonous weeds on all plots except on untreated controls, whereas graminicides for controlling volunteer cereals and A. spica-venti were applied to the foliage in autumn at the 4-6 leaf stage of oilseed rape and when grass weeds were at 3 - 5 leaf stage. In peas a tank mix of bentazone at 1.25 kg a.i./ha was used with all graminicide treatments to control both di- and monocotyledonous weeds, and applied when peas were at growth stage when plants were 10-12 cm high. Here A. fatua was at the 3 - 5 leaf stage but E. crus-galli was at the 1 - 3 leaf stage. In lupins, cyanazine at 1.0 kg a.i./ha was pre-emergence to control dicotyledonous weeds, and graminicides were applied when E. repens and A. tenuis were at the 5-6 leaf stage, and lupins at the 4 - 5 leaf stage of development.

Weed control was assessed for winter oilseed rape in the spring, and about 3 weeks after treatments were applied for peas and lupins, by counts of the number of weeds in 4 x 0.25m² quadrats per plot.

RESULTS

Winter oilseed rape

Data for efficacy and selectivity of herbicide treatments in oilseed rape are presented in Table 1.

TABLE 1

Influence of herbicides on weed control and on the yield and thousand seed weight of winter oilseed rape, 1984-1986

Herbicide	Rate (kg a.i./ha)	% control (numbers)			Yield≠ of seed (t/ha)	Weight of 1000 seeds (g)
		Volunteer cereals	A. spica-venti	Total BLW[x]		
fluazifop-P-butyl*	0.125	92	94	90	3.54 c	5.35
haloxyfop-ethoxyethyl*	0.125	92	92	89	3.53 c	5.32
sethoxydim*	0.200	77	83	88	3.31 bc	5.23
quizalofop-ethyl*	0.107	91	93	89	3.54 c	5.34
metazachlor	1.250	47	14	86	3.13 b	5.02
unsprayed controls (weed density /m²)	-	(57)	(31)	(65)	2.49 a	4.79

* Sequential treatment, pre-emergence broad-leaved weed control metazachlor @ 1.25kg a.i./ha

[x] dominant broad-leaved weeds (BLW): Stellaria media, Viola arvensis, Matricaria spp., Lamium purpureum, Capsella bursa-pastoris

≠ values with no letters in common are significantly different at the 95% confidence limit

The most effective graminicides in controlling volunteer cereals and A. spica-venti were fluazifop-P-butyl, haloxyfop-ethoxyethyl and quizalofop-ethyl. The rates of sethoxydim used appeared insufficient to give effective control of these grass weeds. Good control of dicotyledonous weeds was achieved with metazachlor which also gave a low level of grass weed control.

Graminicides used in the experiment were selective in winter oilseed rape. Yield of rape seed was a reflection of the level of weed control obtained and was therefore significantly higher for graminicide treatments than from metazachlor alone. Although yield of rape seed from sethoxydim treatment was lower, it did not differ statistically from the yield obtained after the application of the more effective treatments fluazifop-P-butyl, haloxyfop-ethoxyethyl and quizalofop-ethyl. Yield of the untreated control was 1.0 t/ha lower than that for the best herbicide combinations. The 1000 seed weights recorded were also dependent to a very large degree on efficacy of the treatments, particularly for dicotyledonous weed species.

Peas

Data for efficacy and selectivity of herbicide treatments in peas are presented in Table 2.

TABLE 2

Influence of herbicides on weed control and on the yield and thousand seed weight of peas, 1985-1987

Herbicide	Rate (kg a.i./ha)	% control (numbers)			Yield≠ of seed (t/ha)	Weight of 1000 seeds (g)
		A. fatua	E. crus-galli	Total BLW[x]		
fluazifop-P-butyl + bentazone	0.187+1.250	99	98	86	3.12 d	265
haloxyfop-ethoxyethyl + bentazone	0.187+1.250	98	98	88	3.10 d	264
sethoxydim + bentazone	0.400+1.250	94	94	76	2.89 cd	263
quizalofop-ethyl + bentazone	0.161+1.250	94	98	86	3.08 d	266
cycloxydim + bentazone	0.200+1.250	98	96	88	3.09 d	263
fenoxaprop-ethyl + bentazone	0.240+1.250	83	87	86	2.75 c	260
diclofop-methyl + bentazone	1.00+1.250	93	94	83	2.88 cd	263
bentazone	1.250	0	0	79	2.39 b	255
unsprayed controls (weed density /m²)	-	(70)	(21)	(145)	1.66 a	245

[x] dominant broad-leaved weeds (BLW): Chenopodium album, S. media, V. arvensis, Thlaspi arvense, Sinapis arvensis

≠ values with no letters in common are significantly different at the 95% confidence limit

TABLE 3

Influence of herbicides on weed control and on the yield of lupins 1985 and 1986

Herbicide	Rate (kg a.i./ha)	% control (numbers)						Yield of seed† (t/ha)		
		Elymus repens *Agrostis tenuis*			Total BLW[x]					
		White lupin	Yellow lupin	Blue lupin	White lupin	Yellow lupin	Blue lupin	White lupin	Yellow lupin	Blue lupin
fluazifop-P-butyl*	0.375	94	93	92	98	95	91	2.31 d	1.58 c	1.62 c
haloxyfop-etoxyethyl*	0.375	94	91	93	97	96	93	2.25 d	1.61 c	1.57 c
sethoxydim*	0.800	81	78	77	97	95	90	1.96 c	1.46 c	1.33 b
quizalofop-ethyl*	0.321	93	90	93	98	96	92	2.27 d	1.62 c	1.60 c
cyanazine	1.000	0	0	0	97	95	91	1.62 b	1.22 b	1.13 b
unsprayed controls (weed density/m²)	-	(45)	(56)	(64)	(70)	(92)	(98)	1.28 a	0.96 a	0.88 a

* sequential treatment, pre-emergence broad-leaved weed control with cyanazine 1.0 kg a.i./ha
x dominant broad-leaved weeds (BLW): *C. album*, *S. arvensis*, *S. media*, *Centaurea cyanus*
† values with no letters in common are significantly different at the 95% confidence limit

All treatments with graminicide tank mixes gave excellent control of heavy infestation of A. fatua and E. crus-galli, with the exception of the fenoxaprop-ethyl treatment which was the least effective at rate tested. Bentazone alone achieved good control of dicotyledonous weeds, and the addition of graminicides (with the exception of sethoxydim) as a tank-mix appeared to increase activity.

The graminicides used in tank mix with bentazone appeared to be selective to peas. Pea yields were related to the percentage weed control. All treatments yielded significantly higher than untreated plots. The highest yields were from the most effective tank mixes of bentazone plus fluazifop-P-butyl, haloxyfop-ethoxyethyl, cycloxydim and quizalofop-ethyl and yields from application of sethoxydim, diclofop-methyl and fenoxaprop-ethyl in tank mix were significantly lower than these. The 1000 seed weights followed a similar trend.

Lupins

Data for efficacy and selectivity of herbicide treatments in lupins are presented in Table 3.

E. repens the predominant grass weed, and A. tenuis occurred at the same sites and were assessed together in view of the difficulties in distinguishing these grasses from one another. The growth of these perennial grasses was similar in the three species of lupins, and the most effective treatments were with fluazifop-P-butyl, haloxyfop-ethoxyethyl and quizalofop-ethyl, with slightly inferior control from sethoxydim. The rate of sethoxydim used was insufficient for good perennial grass weed control in this crop. Destruction of dicotyledonous weeds with cyanazine was very effective.

Graminicides used in the experiment appeared to be selective in white, yellow and blue lupins. The degree of weed control achieved by the treatments was reflected in the yield of lupins. E. repens and A. tenuis appeared to be very competitive with the three lupin species and where these grasses were effectively controlled by graminicides, yield increases were much higher than where cyanazine alone controlled broad-leaved weeds.

DISCUSSION

The experiments demonstrated the effect of weed competition on crop yield. Under the climatic conditions of Poland early control of weeds, particularly volunteer cereals in winter oilseed rape is very important. The graminicides applied in the experiment eliminated competition from volunteer cereals and grasses at an early stage. In contrast, early weed control seems not to be necessary to maintain optimum yields in August sown oilseed rape (Lutman & Dixon, 1985) under climatic conditions in England.

In peas heavy infestation of A. fatua is very competitive and the experiments showed that effective control of A. fatua and E. crus-galli with all the graminicides tested was reflected in large yield increases, with the exception of fenoxaprop-ethyl at a rate of 0.24 kg a.i./ha which did not perform as well.

The area of lupins in Poland is increasing. Lupins are characterised by rather slow growth initially and the 'open' growth habit offers less competition than many crops. They are therefore subject to weed infestation and early weed control is essential. The experiments highlighted the competitive nature of perennial species such as *A. tenuis* with lupins and their removal with effective graminicides resulted in large increases in yield.

All graminicides tested were safe to oilseed rape and the three lupin species (*Lupinus albus*, *L. luteus* and *L. angustifolius*). Peas were even tolerant of a tank mix of graminicide plus bentazone and with the exception of sethoxydim, an increased activity on broad-leaved weeds suggested a possible synergistic effect. Sethoxydim was used at rates recommended on the product label but seemed too low, and at 0.2 kg a.i./ha in oilseed rape control of volunteer cereals was slightly inferior to other graminicides, and similarly 0.8 kg a.i./ha was inferior in control of perennial grasses in lupins. In the experiments the most effective control of annual and perennial grasses and volunteer cereals was achieved with fluazifop-P-butyl, haloxyfop-ethoxyethyl and quizalofop-ethyl, and cycloxydim, which was only used in the peas for annual grasses, also gave good control.

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TERBUTHYLAZINE PLUS ISOXABEN FOR WEED CONTROL IN PEAS

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ABSTRACT

The eliminiation of competitive and contaminant weeds in vining and dry harvest peas is essential in order to maximise yield and ensure high quality. Traditionally, a pre-emergence herbicide has been employed for weed control, however, wet weather may prevent application and dry soil conditions can reduce efficacy and thus necessitate the use of a post-emergence herbicide. This paper describes the efficacy and selectivity of a new product containing terbuthylazine/isoxaben 420/75 g a.i./ha with the flexibility for pre-emergence or early post-emergence application of both the crop and weeds.

INTRODUCTION

Over the years 1984-87 the United Kingdom hectareage of dry harvest peas has substantially increased from an estimated 30,000 to 95,000 ha. In the same period the vining pea hectareage has remained reasonably stable at an estimated 40,000 ha. The area of combining peas grown is likely to continue increasing, being one of the few crops where expansion of hectareage is expected. This is a direct result of several factors; the development of new pea varieties with increased yield potential and harvest ability, a strong demand for pea utilisation in animal feed (UK market estimated at 1.5 million tonnes), and the search by farmers for profitable alternative crops to cereals.

For successful establishment, peas require a friable, non-compacted seed bed and the absence of weed competition. After drilling, the window for application of a pre-emergence herbicide can range from greater than 21 to 7 days or less. Weather conditions may be unfavourable over this period for spray application and very few pea herbicides with soil residual properties are safe to apply both pre-emergence and post-crop emergence. SL 363 (terbuthylazine/isoxaben, 420/75 g a.i./ha) has been developed to fulfill the need for a herbicide with a flexible application timing of pre-emergence to early post-emergence of both crop and weeds with residual activity.

This paper summarises the results of 19 trials in commercial crops and three cultivar sensitivity trials carried out in the UK over the years 1985-87 to determine the efficacy and selectivity of this novel terbuthylazine/isoxaben mixture in peas.

MATERIALS AND METHODS

During the period 1985-87 15 efficacy trials located in areas of natural weed infestation were undertaken. The trials were of a randomized complete block design with three replicates and a plot size or 3 x 8 m. Treatments were made using a precision plot sprayer incorporating 6 Lurmark F11002 nozzles delivering 200 l/ha at 233 kPa. Treatment application was made at three distinct timings; pre-emergence, at emergence and early post-emergence of both the crop and weeds. Weed growth stage and population were recorded for species emerged at the second and third applications.

Weed populations were evaluated using quadrat counts 28-35 days after final treatment.

Selectivity was monitored in commercial crops of two vining and two dried pea varieties. Treatments were applied at twice normal rate (terbuthylazine/isoxaben, 840/150 g a.i./ha) at the timings as described above and yield data collected at the appropriate stage of maturity. Plot size was 3 x 12 m with four replicates in a randomized complete block design.

Taint and residue determinations are in progress.

Cultivar susceptibility was evaluated for terbuthylazine/isoxaben with some of the major vining and dry harvest pea cultivars. Terbuthylazine/isoxaben was applied at 420/75 and 840/150 g a.i./ha at the three timings and phytotoxicity assessed visually. The cultivars Vedette, Printana, Minerva and Rosakrone were included, as these are known to be sensitive to pre-emergence applications of some triazine herbicides (Gane et al.,1984).

Terbutryn /terbuthylazine formulated as a 350/150 g a.i./l SC was applied at the recommended rate according to soil type; 560/240 g a.i./ha to 1400/600 g a.i./ha over the range of soils coarse sandy loam to silty clay and peat. Terbuthylazine / isoxaben formulated as a 50% SC was applied at 420/75 g a.i./ha for weed control irrespective of soil type.

RESULTS

Efficacy (Table 1)

Twenty annual broad-leaved and one annual grass weed species were encountered in the efficacy trials. Terbuthylazine/isoxaben at 420/75 g a.i./ha applied over a wide range of soil types gave excellent control of 18 of these species when applied pre-emergence. There was particularly good control of the important Compositae and Scrophulariaceae species and of the Polygonaceae with the exception of *Polygonum aviculare*. *Galium aparine* and volunteer oilseed rape were not controlled although the only other cruciferous species, *Sinapis arvensis* was highly susceptible.

The weeds controlled by terbuthylazine/isoxaben applied at emergence or fully post-emergence were broadly similar to that from pre-emergence applications, with continued good control of the majority of species. For *Matricaria* spp. however, the degree of control declined from the 99% recorded for pre-emergence applications to 88% and 60% for the at emergence and early post-emergence applications respectively. *Polygonum aviculare* was susceptible to applications made at emergence but rapidly became tolerant to later applications. Volunteer oilseed rape which had not been controlled pre-emergence, was susceptible to at emergence or fully post-emergence applications independent of growth stage.

The only grass species encountered, *Poa annua* was susceptible to terbuthylazine/isoxaben at all application timings.

Varietal Reaction (Table 2)

Minerva and Rosakrone (forage peas) were sensitive to terbuthylazine/ isoxaben (420/75 and 840/150 g a.i./ha) applied pre-emergence and post-emergence. Printana and Vedette were also sensitive pre-emergence but this appeared to be soil type related with damage apparent only on a light soil type. All the other 17 cultivars (Table 2) were highly tolerant of double rates (840/150 g a.i./ha) terbuthylazine/isoxaben. All dry harvest and vining pea cultivars did not exhibit any cultivar response and were tolerant of terbuthylazine/isoxaben applied post-emergence irrespective of soil type.

TABLE 1

Weed control with terbuthylazine/isoxaben and terbutryn /terbuthylazine.

terbutryn (g a.i./ha)		560-1400*		
terbuthylazine (g a.i./ha)	420	240-600*	420	420
isoxaben (g a.i./ha)	75		75	75
Application time	pre-em	pre-em	at em	post-em
Weed Species	Mean % Control** (no. of sites)			
Aethusa cynapium	99 (4)	97 (4)	-	-
Anagallis arvensis	100 (1)	100 (1)	-	-
Chenopodium album	98 (1)	100 (1)	100 (1)	98 (1)
Galeopsis tetrahit	96 (2)	93 (2)	95 (1)	97 (1)
Galium aparine	18 (2)	0 (2)	0 (1)	16 (1)
Lamium purpureum	98 (2)	100 (2)	-	-
Matricaria spp.	99 (9)	100 (9)	88 (5)	60 (5)
Poa annua	93 (2)	96 (2)	96 (2)	91 (2)
Polygonum aviculare	85 (5)	97 (5)	91 (1)	0 (1)
Polygonum convolvulus	91 (7)	94 (7)	93 (2)	80 (2)
Polygonum lapathifolium	100 (2)	100 (2)	99 (2)	100 (2)
Polygonum persicaria	94 (2)	98 (2)	98 (2)	93 (2)
Senecio vulgaris	100 (2)	100 (2)	-	-
Sinapis arvensis	98 (6)	97 (6)	100 (2)	95 (2)
Sonchus arvensis	100 (2)	100 (2)	100 (1)	100 (1)
Stellaria media	98 (4)	98 (4)	90 (2)	100 (2)
Veronica arvensis	100 (1)	98 (1)	100 (1)	-
Veronica hederifolia	94 (2)	98 (2)	97 (1)	93 (1)
Veronica persica	97 (5)	98 (5)	100 (1)	100 (1)
Viola arvensis	99 (5)	98 (5)	100 (1)	100 (1)
Volunteer oilseed rape	41 (2)	33 (2)	100 (2)	100 (2)

* Rate of application dependant on soil type.
** Mean % control as reduction in the number of weeds relative to untreated

TABLE 2

Cultivars examined for herbicide varietal reaction.

Cultivars tested in 1986 and 1987	Cultivars tested in 1986 only	Cultivars tested in 1987 only
Bunting	Belinda	Consort
D.S.P.	Bikini	Countess
Markana	Danielle	
Printana	Filby	
Progreta	Finale	
Scout	Imposant	
Sprite	Maro	
Vedette	Minerva	
Waverex	Rosakrone	
	Sparkle	

Selectivity

Terbuthylazine/isoxaben had an excellent crop safety margin when applied pre-emergence, at emergence, or early post-emergence of the crop. With the exception of the sensitive varieties noted, damage was not seen pre-emergence from double rate applications, except at one site. In that particular case, damage was seen when heavy rainfall occurred after pre-emergence application and the soil became waterlogged. Treatments applied at emergence and early post-emergence caused slight leaf margin yellowing and subsequently leaf margin thickening. These symptoms were not significant as they were quickly outgrown and vigour was not impeded.

Yield Data (Table 3)

Four trials consisting of two vining pea and two dry harvest pea varieties were examined at weed free or low weed infestation sites for the effect of terbuthylazine/isoxaben on yield. No significant effect on yield was recorded for any of the double rate treatments (Table 3), at any time.

TABLE 3

Effect on mean grain yield (as % of untreated plot yields at low weed population sites, four sites).

terbutryn	(g a.i./ha)		1120-2800*			Untreated (t/ha)
terbuthylazine	(g a.i./ha)	840	480-1200*	840	840	
isoxaben	(g a.i./ha)	150		150	150	
Application time		pre-em	pre-em	at em	post-em	
Vining peas		91.4	103.1	99.8	102.7	5.1
Dry harvest peas		97.2	103.4	100.5	101.9	5.3
Significance @ P = 0.05		NSD	NSD	NSD	NSD	

* Rate of application dependent on soil type.

DISCUSSION

Terbuthylazine/isoxaben as a 50% SC formulation of 420/75 g a.i./l had a wide margin of crop safety, with the exception of the triazine sensitive cultivars; Minerva, Rosakrone, Printana and Vedette following a pre-emergence application. Significantly, there was no apparent cultivar response from at emergence or early post-emergence applications. In common with other herbicides, applications made under some weather conditions, in particular those which cause stress to the crop, are liable to result in crop damage. This was the case in one field trial where the waterlogged soil conditions following applications resulted in reduced emergence. Those plants which emerged normally showed hypocotyl thickening, indicating that the presence of surface water resulted in a concentration of herbicide at the hypocotyl/soil interface.

Terbuthylazine/isoxaben at 420/75 g a.i./ha gave effective control of P. annua when applied pre-emergence, at emergence or early post-emergence of the weeds. Although volunteer oilseed rape was highly susceptible to at emergence and post-emergence applications, it did show tolerance to pre-emergence applications. In view of the known sensitivity of oilseed rape to isoxaben (Huggenberger et al, 1982) the degree of tolerance noted here could be related to the variable depth of germination of the rapeseed. Soil cultivation practices following oilseed rape cultivation are liable to distribute seed through the soil profile to considerable depth. As isoxaben is relatively immobile in the soil, a proportion of deep germinating and emerging rapeseed plants are liable to escape the effects of a pre-emergence application. Applied post-emergence, however, the potency of isoxaben is unhindered resulting in the very high levels of control recorded.

The large number of species encountered in these trials demonstrates the wide weed control spectrum of terbuthylazine/isoxaben. The flexibility endowed by the choice of application timings is particularly significant in view of the changeable weather conditions often associated with the period of pea crop establishment.

In 1986 dinoseb-amine and dinoseb-acetate were withdrawn from commercial use in peas, pending review, thus severely curtailing the present post-emergence options available to the grower, here terbuthylazine/isoxaben may be a possible alternative. The post-emergence efficacy and safety of this combination also indicates a possible extension of use to very light soils or to soils with a high organic matter content where few herbicides are recommended for use.

Two years field testing with terbuthylazine/isoxaben have demonstrated a useful role for this herbicide in pea production. The flexibility and versatility of this combination offer significant advantages to pea growers, over many herbicides currently available.

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HERBICIDE RATES AND TIMING FOR BROAD-LEAVED WEED CONTROL IN SPRING FIELD BEANS GROWN ON ORGANIC SOILS

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ABSTRACT

Results from three years' trials with spring sown field beans (Vicia faba) on organic soils comparing propyzamide with the 'standard' herbicide simazine, each applied at one or two rates as full or split doses, showed broad-leaved weed control was no better with propyzamide. Yields were sometimes higher with propyzamide, but not sufficiently to justify the cost of the high rates necessary. Four other residual herbicides, compared with similar applications of simazine and with bentazone over a further two years, achieved less consistent weed control. Both trial series showed that split doses of simazine improved weed control where frequent rainfall occurred but tended to increase crop damage under these conditions. Rates of 3 kg a.i./ha were safer than 6 kg a.i./ha, especially when applied as split doses. Bentazone applied as two post-emergence sprays achieved the best weed control in one year and caused only transient crop damage in both years tested.

INTRODUCTION

Since 1984 the area of field beans (Vicia faba) grown in the UK has steadily increased (M.A.F.F., 1986), largely as a result of the expanding popularity of spring sown varieties. Unfortunately, advances in breeding spring field beans have not been matched by advances in broad-leaved weed control; more widespread use of glyphosate pre-harvest in cereal crops and developments with specific graminicides have reduced the severity of grass weed problems, but some broad-leaved weeds such as Polygonum spp. and Galium aparine remain a problem (Lawson & Wiseman, 1978, Hebblethwaite et al, 1983).

Trials by Glasgow et al (1976) showed that yields of spring beans were almost halved in the absence of any weed control, yet considerable reductions in yield can also result from herbicide damage. Since their introduction in the 1950's, simazine pre-emergence and dinoseb acetate post-emergence have until recently accounted for nearly all commercial herbicide usage in the U.K., yet both have phytotoxic effects on the crop and can reduce yields as a result (Roebuck, 1970, Lawson & Wiseman, 1978). Since the use of dinoseb products was suspended, growers have no fully approved herbicides for post-emergence use in spring field beans and have to rely on pre-emergence applied residual materials for chemical weed control.

In practice the use of pre-emergence chemicals can sometimes cause severe problems. Firstly, the phytotoxic effect of simazine increases with shallower drilling depth (Holloway, 1974) and with heavy rainfall, and the commercial recommendation for at least 75mm of soil cover is often difficult to achieve. Alternative residual materials such as trietazine/simazine and terbutryn/terbuthylazine do not require such deep drilling and are safer to the crop (Fryer & Makepeace, 1978). Secondly, wet soils and poor weather conditions frequently prevent the application of pre-emergence chemicals within their permitted timings, and conversely, dry soil conditions may severely limit the activity of residual materials. In addition, soil types impose further restrictions on the use of these chemicals in that crop damage due to leaching readily occurs on very light soils, and at the other extreme, poor activity results on soils with high levels of organic matter.

The difficulty of controlling weeds with residual chemicals on organic soils led to the initiation of the series of trials reported here. However, the more recent results on sequential treatments applied both pre- and post-emergence are relevant to all soils where, for the reasons already mentioned, levels of weed control or crop damage may be unacceptable.

MATERIALS AND METHODS

Two different trials series were conducted over a five year period comparing a range of herbicides for spring sown field beans grown on organic soils. Trials were sited on soils of 15% organic matter (o.m.) in 1983, 23 to 30% o.m. in 1984, 1986 and 1987 and 14% o.m. in 1985. The crops were drilled in 18 or 25cm rows, except in 1987 when 12cm rows were used, at a seed rate of approximately 200 kg/ha. In all years, a drilling depth of at least 75mm was achieved. In the first two years, all treatments were applied in 480 l/ha water; in subsequent years, pre-emergence treatments were applied in 500 or 600 l/ha and post-emergence treatments in 250 l/ha. An Oxford Precision Sprayer fitted with TeeJet 8002 fan nozzles was used, operating at 2 bar pressure. Plot sizes were 3 x 15m in the first two years, with 2.6 x 13m harvested, and 4 x 22.5m in subsequent years with 2.8 x 20m harvested.

The first trial series from 1983 to 1985 inclusive tested the activity of simazine (50% a.i., SC) and propyzamide (50% a.i., WP) on organic soils. In 1983, a total of 6.0 kg a.i./ha simazine or 4.5 kg a.i./ha propyzamide were applied to cv Blaze sown on 9 March either as one full dose 5 days after sowing (DAS), or as two (5 and 27 DAS), three (5, 27 and 48 DAS), four (5, 15, 27 and 37 DAS) or six (5, 15, 27, 37, 48 and 57 DAS) split doses. Initial crop emergence was noted on the third spray date, and full emergence had occurred when the fourth spray was applied.

In 1984, a total of 6.0 or 3.0 kg a.i./ha simazine or 4.5 or 2.25 kg a.i./ha propyzamide were applied to cv Blaze sown on 16 February, either as one full dose 8 DAS, three split doses 8, 31 and 53 DAS, or six split doses 8, 18, 31, 39, 53 and 62 DAS. Crop emergence was first observed at the time of the fourth spray.

In 1985, the same total rates of chemicals as used in 1984 were applied either as one full dose on the day after sowing or as three split doses 1, 21 and 44 days after sowing cv Nabor on 5 March. The crop was fully emerged by the time of the final spray.

In 1986, the first year of the second trial series, the same rates of simazine were tested, but applied as one full dose 5 days after sowing or as three split doses 5, 25 and 52 days after sowing. These treatments were compared with a late pre-emergence application of terbutryn/ terbuthylazine (50% a.i., SC), a sequence of metazachlor (500g a.i./l, SC) late pre-emergence followed by cyanazine (50% a.i. SC) post-emergence and with split post-emergence doses of bentazone (48% a.i., a.c.) applied when the crop was at the 2 leaf stage and again when it was 10-15cm high. Rates and timings are shown in Table 3. The crop of cv Alfred high. Rates are shown in Table 3. The crop, cv. Alfred, drilled on 12 March was partially emerged at the time of the second simazine application.

In the 1987 trial, the rates of simazine were reduced by half so that they more closely resembled the maximum recommended rates on product labels. The timings, at 13 or 13, 33 and 62 days after sowing, were similar to those used in previous years. The terbutryn/terbuthylazine and bentazone treatments were retained and were compared with cyanazine post-drilling, chlorpropham/fenuron (200/50g a.i./l, SC) late pre-emergence, a tank mix of simazine plus paraquat (18% a.i., a.c.) late pre-emergence and a sequence of simazine post-drilling followed by bentazone applied as previously described. Rates and timings are shown with the results in Table 4. The crop treated was cv Troy sown on 11 March.

Throughout both trial series treatment efficacy was assessed by scoring weed vigour and estimating weed ground cover. In three of the trials populations of individual weed species were counted using five 0.1m² quadrats per plot. In the final year weeds visible above the crop were assessed. Crop tolerance to treatments was assessed by scoring crop vigour, counting plant populations and in some years by measuring crop height. All trials were combine harvested and grain yields recorded.

RESULTS

In the presence of more than adequate rainfall and soil moisture on all application dates in 1983, good residual herbicide activity resulted in a high level of weed control, and no visible differences in efficacy of treatments were observed. The results in Table 1 show that although propyzamide reduced crop vigour initially, particularly when applied in only one, two or three doses, simazine ultimately caused the greatest reduction in crop height and yield ($P<0.001$).

TABLE 1

Crop vigour, height and grain yield (t/ha @ 85% DM) 1983

Herbicide	Rate (kg a.i./ha)	x number sprays	Crop vigour score* 11 May	Crop height (cm) 26 Aug	Yield (t/ha)
simazine	6.0	x 1	10.0	92	2.83
simazine	3.0	x 2	10.0	73	2.55
simazine	2.0	x 3	8.0	58	2.41
simazine	1.5	x 4	10.0	80	2.55
simazine	1.0	x 6	8.7	53	2.41
propyzamide	4.5	x 1	5.3	100	3.45
propyzamide	2.25	x 2	6.0	103	3.17
propyzamide	1.5	x 3	7.3	103	3.17
propyzamide	1.125	x 4	8.7	103	3.38
propyzamide	0.75	x 6	8.7	87	3.45
Mean			8.3	85	2.94
SED (comparing treatments)			±0.81	±6.6	±0.278

SE per plot (18 df) = ±0.341 t/ha or 11.6% of GM
*Score (linear scale): 0 = killed, 10 = no visible treatment effect

In 1984, soil moisture was low directly after drilling and again throughout April and the first half of May. As a result, weed control was less effective than in 1983 but crop damage was not as severe. Weed populations (predominantly Bilderdykia convolvulus, Polygonum persicaria and Polygonum lapathifolium, Polygonum aviculare and Galeopsis speciosa) were lower than normal for this soil type, and were controlled equally well whether or not the herbicides were applied in one dose or as split doses (Table 2). Weed populations were lower where the high rate of propyzamide was applied, but were similar for all other treatments. There were no measurable treatment effects on the numbers of individual weed species. Plant populations were not affected by treatment, although there was an indication as in 1983 that propyzamide was causing a slight reduction in early crop vigour. This effect did not persist, and yields, although variable, were similar for all treatments.

TABLE 2

Crop vigour and yield, 1984 and 1985, weed populations 1984 and weed vigour and percentage ground cover 1985.

Herbicide	Rate (kg a.i./ha)	x	number sprays	Weeds (no/m²) 24 May 1984	Weed vigour score# 22 May 1985	Weed cover (%) 22 May 1985	Crop vigour score# 24 May 1984	Crop vigour score# 22 May 1985	Yield (t/ha @ 85% DM) 1984	Yield (t/ha @ 85% DM) 1985
simazine	6.0	x	1	40	4.5	25	6.3	5.5	4.29	2.88
simazine	2.0	x	3	41	4.0	20	5.4	5.0	4.65	2.37
simazine	1.0	x	6	39	*	*	5.7	*	4.44	*
simazine	3.0	x	1	40	5.8	34	6.4	6.3	4.49	3.59
simazine	1.0	x	3	44	6.3	26	6.3	6.5	4.42	3.59
simazine	0.5	x	6	50	*	*	6.1	*	4.27	*
propyzamide	4.5	x	1	32	5.3	24	4.5	6.8	4.60	3.26
propyzamide	1.5	x	3	29	3.3	15	5.1	6.5	4.63	3.16
propyzamide	0.75	x	6	34	*	*	5.4	*	4.62	*
propyzamide	2.25	x	1	41	5.5	32	5.2	6.5	4.52	3.32
propyzamide	0.75	x	3	45	6.0	25	5.3	7.0	4.26	3.84
propyzamide	0.375	x	6	42	*	*	5.3	*	4.12	*
Mean				40	5.1	25	5.6	6.3	4.44	3.25
SED (comparing treatments)				±8.2	±0.68	±6.4	±0.36	±0.52	±0.22	±0.28

SE per plot:- 1984 (33 df) = 0.315 t/ha or 7.1% GM.
1985 (21 df) = ±0.403 t/ha or 12.4% of GM.

#Crop and weed vigour score (linear scale): 0 = killed
9 = no visible treatment effect

*Treatments omitted in 1985.

The spring of 1985 was again wet with regular rainfall throughout March, April and May. All treatments had low infestations of weeds by harvest, although some marked differences in weed levels were noted in May (Table 2). Weed cover and weed vigour were lowest where the higher rates of both herbicides were applied as split doses. In contrast to the two previous years, early crop vigour was not visibly affected by propyzamide but was slightly reduced by simazine applied at the 6 kg a.i./ha rate, regardless of timing. This effect persisted and resulted in lower yields, especially following split dose applications (P<0.01).

In 1986, between 4 and 11mm of rain fell after every residual herbicide treatment and good herbicide activity resulted. Table 3 shows that the overall level of weed control achieved for all simazine treatments was good, whether applied as full or split doses of either rate. The terbutryn/terbuthylazine and metazachlor treatments were delayed until 'late' pre-emergence, actually 16 days before the crop emerged, in an attempt to prolong their residual effect until after emergence. This was not successful for terbutryn/terbuthylazine, and a high population of weeds resulted, which only failed to develop further due to vigorous crop growth. Following the sequence of metazachlor and cyanazine, the resultant lack of crop vigour failed to smother a relatively low initial weed population, which ultimately developed to unacceptable levels. Bentazone applied as two post-emergence doses 13 days apart did not control some of the larger weeds, but the high population of weeds recorded in June did not subsequently develop due to strong crop competition. Principal weed species recorded were Veronica persica, P. aviculare, G. aparine, Stellaria media and B. convolvulus. Although differences were not significant, simazine appeared more effective on P. aviculare and S. media, whereas G. aparine was best controlled by bentazone or metazachlor followed by cyanazine.

TABLE 3

Weed populations and percentage ground cover, and crop height and yield (t/ha @ 85% DM), 1986

Herbicide	Rate (kg a.i./ha)	Timing	Weeds (no/m²) 6 Jun	Weed cover (%) 8 Jul	Crop height (cm) 17 Jun	Crop height (cm) 12 Aug	Yield (t/ha)
simazine	6.0	post-drill	22	3	74	106	4.33
simazine	3.0	post-drill	31	13	76	106	4.14
simazine	2.0	post-drill					
"	2.0	" +3 wks	16	8	54	88	3.73
"	2.0	" +6 wks					
simazine	1.0	post-drill					
"	1.0	" +3 wks	27	8	71	100	4.55
"	1.0	" +6 wks					
terbutryn/ terbuthylazine	1.4/ 0.6	late pre-em	57	12	78	109	4.51
metazachlor	0.75	late pre-em	23	30	46	82	3.68
cyanazine	0.25	post-em					
bentazone	0.72	crop @ 2 leaves	47	13	78	111	4.79
"	0.72	crop @ 10-15 cm					
Mean			34	15	67	99	4.20
SED (comparing treatments)			±11.6	±5.6	±2.5	±2.3	±0.286

SE per plot (21 df) = ±0.405 t/ha or 9.6% of GM.

Simazine applied as one post-drilling spray did not adversely affect the crop whereas both split dose treatments caused some reduction in height and vigour. This effect was greater where three 2 kg a.i./ha doses were applied, and a considerably lower yield resulted ($P<0.05$). Crop growth was vigorous throughout where terbutryn/terbuthylazine was used, and following bentazone, which caused only transient crop scorch. In contrast, the crop emerged with severely blackened leaves and leaf margins following pre-emergence metazachlor, and cyanazine applied post-emergence appeared to cause prolonged crop stunting and a poor yield resulted.

TABLE 4

Populations of individual weed species and of total weeds, weed vigour, percentage ground cover and percentage visible above the crop, 1987

Herbicide	Rate (kg a.i./ha)	Timing	B. convolvulus (no/m² 3 June)	Polygonum spp.* (no/m² 3 June)	Total weeds (no/m² 3 June)	Weed vigour# (score 25 June)	Weed ground cover (% 25 June)	Weed cover above crop (% 27 July)
simazine	3.0	post-drill	44	35	303	7.7	90	48
simazine	1.5	post-drill	57	46	315	8.7	82	53
simazine	1.0	post-drill						
"	1.0	" +3 wks	62	18	253	8.3	69	26
"	1.0	" +6 wks						
simazine	0.5	post-drill						
"	0.5	" +3 wks	65	41	349	8.3	93	48
"	0.5	" +6 wks						
terbutryn/ terbuthylazine	1.4/ 0.6	late pre-em	33	30	235	9.0	92	83
cyanazine	3.0	post-drill	48	37	279	7.7	70	41
chlorpropham/ fenuron	1.2/ 0.3	late pre-em	49	37	307	8.3	93	65
simazine + paraquat	1.15+ 0.8	late pre-em	46	30	309	8.3	97	65
bentazone	0.72	crop @ 2 leaves	11	1	132	6.0	53	2
"	0.72	crop @ 10-15 cm						
simazine	1.15	post-drill						
bentazone	0.72	crop @ 2 leaves	11	1	131	5.7	68	0
"	0.72	crop @ 10-15 cm						
Mean			43	28	261	7.8	81	43
SED (comparing treatments)			±16.9	±13.0	±80.4	±0.68	±14.4	±15.0

*Polygonum spp. includes P. lapathifolium and P. persicaria.
#Weed vigour score (linear scale): 0 = killed
9 = no visible treatment effect.

Although wet conditions persisted after drilling in 1987, the soil dried out considerably after the late pre-emergence treatments and the second split dose of simazine were applied, though it became wetter throughout most of May. Partly as a result of these dry conditions and a slightly more organic site, weed control was generally very poor. The predominant weed species were B. convolvulus, Viola arvensis and Polygonum spp. Where control was poor, P. lapathifolium, P. persicaria and to a lesser extent B. convolvulus and G. speciosa had emerged above the crop canopy by mid-July. Only populations of B. convolvulus and P. lapathifolium/persicaria varied according to treatment (Table 4). Of the simazine treatments, only the 3 x 1.0 kg a.i./ha dose appeared to slightly reduce the levels of weed infestation which were otherwise unacceptably high. The addition of paraquat to simazine did not improve control. No other pre-emergence treatments achieved a useful level of control, although terbutryn/ terbuthylazine may have reduced initial weed populations. Only where bentazone was applied were weed populations, predominately of P. aviculare, significantly lower than for most of the other treatments, and the weed vigour 37 days after spraying was the lowest recorded. Weed ground cover on the bentazone treatments tended to decrease due to crop competition after the June assessment, and only on these treatments did the crop remain clearly visible by late July. Preceding bentazone with simazine at 1.15 kg a.i./ha gave no advantage.

No treatment effects on crop vigour were observed. Low levels of leaf scorch developed following the early spray of bentazone (applied in sunny conditions with a temperature of 20°C) which did not appear to affect the subsequent vigour of the crop.

DISCUSSION

On organic soils, applying a given rate of soil-acting herbicide as split doses has been shown to build up residual activity to a greater level than the same rate applied as one dose (May, 1983). However, this effect was not consistently observed in these trials for either simazine or propyzamide, and a significant improvement in weed control was recorded only in 1985. These results suggest there is no strong case for splitting the full rate into more than three repeat doses.

The effect on crop safety of splitting the simazine dose was variable, but both crop damage and yield reductions tended to be greater in seasons with regular and above average rainfall. Rates in excess of 3 kg a.i./ha appeared to greatly increase the risk of damage especially when applied as split doses. No foliar crop damage was observed following peri- and post-emergence applications of simazine in the split dose treatments tested, and the best combination of weed control and crop yield on this soil type seems most likely to result from three doses of 1.0 kg a.i./ha simazine applied at 3-4 week intervals.

Propyzamide did not generally achieve higher levels of weed control than simazine. Crop yields tended to be higher following its use, even where early vigour was reduced, but the yield advantage did not appear consistent enough to warrant the extremely high cost of propyzamide (equivalent to 0.6-1.2 t/ha extra yield at current prices) at the rates necessary to achieve satisfactory weed control on this soil type.

Residual activity of the alternative soil-acting herbicides tested was no more reliable than that of simazine, even when delayed until late pre-emergence. Although terbutryn has useful contact activity, the residual activity of terbutryn/terbuthylazine was insufficient on the organic soils for control of Polygonum spp. and B. convolvulus, even at the high rate tested. Cyanazine proved safe to the crop when applied before emergence, but was too phytotoxic post-emergence and did not control weeds very well on either occasion. Weed control was very poor with chlorpropham/fenuron, as it was with the 'label' rates of simazine tested in 1987.

In 1987, two split dose post-emergence applications of bentazone applied to weeds at the two to four leaf stage only, achieved a valuable reduction in weed competition from most species except for P. aviculare, though it was no better than any other treatment in 1986. In both years the crop rapidly grew away from the transient crop scorch caused by this chemical. On a field scale at Arthur Rickwood Experimental Husbandry Farm, the use of simazine post-drilling followed by two post-emergence applications of bentazone over the past two years has achieved reliable weed control. Bentazone could therefore prove useful in the UK in the absence of a post-emergence herbicide recommendation for spring sown field beans following the suspension of dinoseb products.

Observations made throughout these trials series confirmed the importance of crop competition in suppressing weed growth, provided that a sufficiently high seed rate and narrow row spacing was used. As long as some degree of initial weed control was achieved by herbicides, without reducing crop vigour, the crop usually outgrew and smothered most weeds successfully. Where early weed control was poor, or a check in the growth of the crop was caused by herbicides, vigorous growth of weeds such as G. aparine, B. convolvulus, P. lapathifolium, P. persicaria, G. speciosa, and to a lesser extent, P. aviculare, rapidly overwhelmed the crop, causing severe harvesting difficulties and yield losses.

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