SESSION 7B

WEED CONTROL IN VEGETABLES AND FRUIT

SESSION
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POSTERS   7B-1 to 7B-9

PROBLEMS OF HERBICIDE USE ON FIELD GROWN VEGETABLES UNDER LOW LEVEL PLASTICS

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ABSTRACT

There were about 6000 ha of low level plastics used with outdoor vegetables in 1986/87. This area is large enough to make a significant impact on the market with several crops and influence the economic viability of many growers. The techniques of mulching and film covering have limiting factors, one of the most important being weed control. What is advantageous for a crop is often even better for the weeds. The paper sets out to summarise experimental results to date, to define the problems and suggests guidelines for overcoming some of them. Many problems occur because of the lack of experimental data, due in part to the rapid uptake of the techniques of using low level plastics, which has overtaken experimental studies.

INTRODUCTION

Investigations into mulching and film covers (or crop covers) were commenced by ADAS in 1978. It was not until 1982 that the vegetable industry began to recognise the potential of the techniques and uptake since then has been rapid. The objectives ten years ago were primarily to give a longer cropping season on early frost free sites and better continuity. However more recently other benefits such as improved quality and yield, pest control, better overwintering, improved seedling emergence and a shorter growing season have seen the use of plastics taken up in many growing areas and earliness is not always the main objective. Over the seasons many types of cover and mulch have been trialled but the industry until recently has mainly used clear polythene that may or may not be perforated with slits or holes or is sometimes photodegradable. Nonwoven covers have become more prominent over the past three seasons and now account for about 15% of the area.

Crops

The main crops covered with clear polythene are early potatoes and carrots (approx. 1000 ha of each). Clear polythene mulch (much of it photodegradable) on sweet corn accounts for 350 ha - 400 ha: the use of covers on outdoor lettuce has risen to a similar area with nonwoven materials accounting for 50% of covered lettuce. Other crops with signifi-cant areas are courgettes, runner beans, calabrese, celery, and cabbage. Some twelve other, more minor crops are also grown using the techniques ranging from outdoor tomatoes, early swedes, radish and herbs. Covering of outdoor seed beds to improve germination and emergence is also becoming more widespread.

Herbicide use

There has never been any approval or recommendations for the use of any herbicides on any crop when using low level plastics. Even though the soil and crop is covered, often for several months, the industry has regarded the practice of using mulches and covers as part of the outdoor field vegetable situation. This has inevitably led to problems ranging from herbicides having no effect, to affecting the crop and not the

weeds. At other times weed control has been enhanced by the use of covers. In many crops the lack of suitable herbicides for whatever reason remains one of the most serious limiting factors in the use of mulches and covers.

ADAS trials

Weed control has been a particular limiting factor in the crops of lettuce, courgettes and runner beans under mulches and covers. There have also been problems of weed in carrots under covers. Over the past three seasons trials on selected crops have been conducted by Experimental Horticultural Stations at Rosewarne, Arthur Rickwood and Efford. In the last year trials have commenced at Luddington on weed control in early summer cauliflower and leeks.

1. Weed control in lettuce under nonwoven film cover. Efford 1986.
The variety Saladin was sown on 28 February into 43 mm peat blocks. The dazomet treatment was applied on 6 March, the trial being planted on 14 April. The post planting herbicides were applied before the cover was laid on 16 April. Cover removal was on 1 June. (See Table 1).

2. Weed control in courgettes. Efford and Rosewarne 1986
Light inhibiting mulches have been compared with herbicides both at Efford and Rosewarne. Similar core treatments and planting techniques were used at both sites. After planting and herbicide application covers were laid the same day because of the danger of frost. (See Table 2).

The trials at Efford EHS also indicated that low rates of dazomet have potential in giving good weed control in lettuce as well as courgettes. Crop was transplanted on 28 April. Dazomet was applied on 11 March at 19 g/m². (See Table 3).

3. Runner beans. Efford 1986
Trials at Efford on runner beans have also compared mulches and herbicides. The variety Enorma was sown in mid-April. Trifluralin was incorporated and the light inhibiting mulch laid prior to sowing, the seed being sown through. Other treatments include pre emergence herbicides applied on the 18 April and clear mulches for warming the soil laid the following day. (See Table 4).

4. Overwintering carrots under film covers. Arthur Rickwood 1985/86
The variety Tancar was drilled on 12 October. The film cover of clear polythene (200 holes/m²) was laid the same day. The cover was removed on 23 April. The harvest date was 31 May. (See Table 5).

Treatments: 1. Predrilling (incorporated into seed bed)
    a. Nil
    b. trifluralin at 0.76 kg/ha   as Treflan at 1.5 l/ha.
    c. trifluralin at 1.1 kg/ha a.i. (2.3 l/ha.c.p.)
    d. trifluralin at 2.2 kg/ha a.i. (4.6 l/ha.c.p.).

       2.   Post drilling (before covering) applied as log-dose strips in 300 l/ha water.
    a. 0.131 to 2.0 kg/ha a.i. linuron as 0.875 to 14 l/ha Linuron 15 (15% e.c.)
    b. 0.137 to 2.0 kg/ha a.i. chlorbromuron as 0.275 to 4.4 kg/ha Maloran (50% wp).
    c. 0.187 to 3.0 kg/ha a.i. fluorochloridone as 0.75 to 12 l/ha Racer (25% e.c.).

The log-dose strips were divided into sectors as follows.

Herbicide	Log dose			
	High	High/Medium	Medium/Low	Low
linuron l/ha	14 to 7	7 to 3.5	3.5 to 1.75	1.75 to 0.875
chlorbromuron kg/ha	4.4 to 2.2	2.2 to 1.1	1.1 to 0.55	0.55 to 0.275
fluorochloridone l/ha	12 to 6	6 to 3	3 to 1.5	1.5 to 0.75

RESULTS

TABLE 1

Iceberg lettuce under nonwoven cover (Growtect)

	Weed assessment	Marketable heads	
	Cover (%)	Cl.I & II (%)	Mean wt(g)
Bare soil			
propyzamide (as Kerb 50W) at 2.8 kg/ha	5.5	63	592
propachlor (as Ramrod flowable) at 4 l/ha	17.5	51	574
propyzamide at 1.4 kg/ha plus propachlor at 4 l/ha	5.8	51	580
dazomet (as Basamid) at 19g/m²	5.8	56	653
control no herbicide	23.7	59	552
SED±			
Nonwoven cover			
propyzamide at 2.8 kg/ha	11.7	75	486
propachlor at 4 l/ha	33.8	68	470
propyzamide at 1.4 kg/ha plus propachlor at 4 l/ha	9.2	72	491
dazomet at 19 g/m²	6.2	93	546
control no herbicide	47.5	59	473
SED ±			20.0

The nonwoven cover advanced the crop by 14 days. Bare soil records were therefore taken 14 days later than the nonwoven material. The weed cover was greater under the crop cover from all treatments. This difference was least apparent on the dazomet plots. Propachlor on its own did not give good weed control, especially under cover. The percentage marketable was greater from the cover compared to bare soil but head weight was less. Dazomet gave a significant increase in head weight

from both bare soil and covered plants. Other differences were generally small but the control and propachlor alone gave the smallest heads reflecting the extent of weed competition. Weather conditions were moist and showery when the post planting herbicides were applied giving them every chance to work properly and propyzamide gave a good result.

TABLE 2

Results at Efford and Rosewarne 1986. Early Courgettes

	Weed Assessment 0-9 (0 = no weed)			Marketable yield (t/ha)		
	Black Mulch	Enide + Dacthal*	Control	Black Mulch	Enide + Dacthal*	Control
Efford	1	3	7	22	5	14
Rosewarne	0	3	5	22	20	12

All treatments were covered with perforated polythene 200 x 10mm holes/m²
*diphenamid (as Enide 50W) at 9 kg/ha plus chlorthal-dimethyl (as Dacthal) at 9 kg/ha.

Much of the data between the two stations is remarkably similar, the exception is the yield from the diphenamid plus chlorthal-dimethyl treatment. At Efford considerable damage was caused. The explanation for this is not clear and further studies are required to find out under what circumstances damage occurs.

TABLE 3

Early Courgettes. Weed Control. Efford 1986

	Growth Assessment 2 June (1 = poor 5 = good)	Weed Assessment 28 June (1 = no weed 9 = >60% cover)	Early Yield to 5 July (t/ha) Marketable
no herbicide bare soil	1.0	8	0.46
no herbicide clear mulch	4.0	7	4.25
dazomet with clear mulch	4.8	2	7.76
SED ±	–	–	0.461

Clear mulch without weed control gave a considerably better early yield than bare soil, and the plants in the early stages were able to outgrow the weeds. However the areas treated with dazomet gave the best growth, successful weed control and a high early yield.

TABLE 4

Runner Bean Trial. Efford 1986

Treatments as rates of commercial products	Weed assessment	Vigour (5 = good)	Marketable Yield (t/ha)
	Cover (%)		
Bare soil			
pre emergence			
diphenamid at 12 kg/ha plus chlorthal-dimethyl at 12 kg/ha	3	3.0	21
pendimethalin at 6 l/ha	8	2.3	18
pre sowing			
trifluralin at 1.7 l/ha	19	2.0	18
black polythene alone	3	3.8	26
no herbicide - control	73	1.3	10
Under clear polythene mulch			
pre emergence			
diphenamid at 12 kg/ha plus chlorthal-dimethyl at 12 kg/ha	14	5.0	28
pendimethalin at 6 l/ha	14	2.5	23
pre sowing			
trifluralin at 1.7 l/ha	48	4.0	25
no herbicide - control	90	2.7	22
SED ±		-	-

Weed control from the herbicides was not so effective under clear mulches.

However the high rate of diphenamid + chlorthal-dimethyl was impressive (but expensive), showing no phytotoxicity and giving the best yield. The black polythene also gave a good result. Although giving good weed control pendimethalin reduced crop vigour and yield; in the early stages leaves showed some puckering. Trifluralin on its own did not give a good enough control.

TABLE 5

Overwintering carrots under film cover. Arthur Rickwood EHS 1985/86
Crop yield (t/ha including fanged) on 31 May

trifluralin (l/ha)	Post drilling	high	high/medium	medium/low	low	mean
SED			(±0.91)			(±0.578)
nil	linuron	5.2	6.3	4.3	3.3	4.8
1.6		7.7	5.5	6.6	4.5	6.1
2.3		5.7	6.1	6.7	4.5	5.8
4.6		4.8	4.1	5.1	5.3	4.8
Mean (±0.43)		5.9	5.5	5.7	4.4	
nil	chlorbromuron	4.9	3.8	3.7	3.2	3.9
1.6		6.2	7.9	6.8	5.5	6.6
2.3		7.4	5.7	5.3	4.7	5.8
4.6		4.5	3.2	3.7	5.0	4.1
Mean (±0.43)		5.8	5.2	4.9	4.6	
nil	fluorochloridone	4.9	6.5	5.6	5.4	5.6
1.6		3.9	5.5	4.6	4.9	4.7
2.3		6.7	7.4	6.0	6.1	6.6
4.6		5.2	5.3	6.1	6.1	5.7
Mean (±0.43)		5.2	6.2	5.6	5.7	

SE per plot (24 df) = ±0.72 t/ha or 13.4% of GM

Yields tended to increase with the improved weed control at the
high dose rates.   The highest rate of fluorochloridone was the only
treatment to give any indication of yield reduction due to herbicidal
effects on the crop.   Trifluralin at 1.6 or 2.3 kg/ha in combination
with medium to high rates of linuron, chlorbromuron and fluorochloridone
give the best regimes for adequate weed control without severely reducing
crop vigour and leading to the highest yields.

DISCUSSION

All the trials at the three Experimental Horticultural Stations
have shown that weed control can be successful when using low level
plastics.   When considering the results the soil types should be taken
into account and that in the main there has only been one full year
of trials.   The first indications are that 1987 results will show a
similar pattern.

Environment under mulches and covers

Before many of the problems of herbide use can be tackled
a proper understanding of the environment under mulches and covers
is required.   To be able to monitor this is a problem in itself and
it is only recently with modern data logging equipment that it has
been possible to begin to ascertain the microclimate that is created.   It
is not until the industry appreciates the effect covering has, will

the full benefits of using low level plastics be realised.

Because of the rise in soil temperature under cover some weeds germinate quicker and earlier in the season eg <u>Solanum nigrum</u> <u>L.</u>, this could mean that they will escape normal timings of herbicide application, especially post emergence/planting treatments. By the time removal takes place they may be too big for control by herbicides. There are certain other species that grow particularly well under mulches or covers eg. <u>Trifolium</u> sps.

On bed systems when machine laying is used burying the edges of the plastics disturbs the soil and sometimes negates the herbicide application. If the plastic is to be in place for a long time applying a band of herbicide down the wheelings and over the edges may be appropriate.

Perforated clear polythene with 200 or 500 holes will always give uneven distribution of rain or irrigation. This can cause problems where herbicides are applied before covering especially if the cover was put on too soon. The chemical can also be prematurely leached if the water always runs to the same spot during a particularly wet spell.

Using clear polythene to advantage

The heat generated under solid clear polythene can be turned to advantage, especially during June and early July when used as a mulch. Crops with wide row spacings etc. sweet corn, runner beans, courgettes, normally have 650-750 mm between rows. The crop is best sown in small grooves, or shallow furrows to the sides of a domed shaped bed. Rainfall or irrigation is directed into these grooves leaving the space in between the row completely dry - especially the top 70-100 mm. The soil between the rows is either too dry for weed to germinate or if annual weed growth does occur a hot spell of weather in June will normally burn the weed off.

Effects of covering

Some of the important criteria have been identified by experience in conjunction with trials. After late March the soil surface becomes dry almost immediately after covering, especially in sunny conditions. Consequently any herbicide applied to the surface immediately prior to covering will also dry out and become inactive. Covering a few days later this can be turned to advantage.

Leaching is prevented under clear polythene or restricted under nonwoven materials. Studies made at Efford EHS and IHR Wellesbourne (H.A. Roberts and W. Bond) showed that herbicide residues were held for longer periods near the surface. The study at Efford EHS in 1985/86 was carried out using metribuzin (as Sencorex WG). 1.1 kg/ha was applied to a prepared seed bed in late October. Four days later seed beds were covered with solid clear polythene. Soil samples (0-50 mm) were analysed on the first week of February and on the sowing date in mid-March for test crops of lettuce, cabbage and onions. Although seedlings began to emerge in early April the phytotoxicity from the residues eventually killed the seedlings. The residues remaining in the surface in early February were equal to 0.2 kg/ha of metribuzin and only marginally lower at the sowing date. In an open ground situation the chemical would have dispersed by late January or earlier.

The ability of clear covers to prevent quick dispersal of the

herbicide has shown to be effective when applying propachlor plus chlorthal-dimethyl to overwintering seed beds for early drillings of onions. This gives a warm weedfree seed bed in February that requires no further cultivation before drilling.

Besides preventing downward movement of water, covers raise soil and air temperatures. Overwinter this may work in favour of the herbicide, but after late March the temperature can become too high. Volatile chemicals will disperse before they can work.

The enclosed environment created by crop covers makes crops soft and lush compared to outside conditions. Applying herbicides immediately after cover removal must therefore be treated with caution. Herbicide treatments that are normally safe on crops that have been grown in the open may cause damage to plants before they have had a chance to harden or renew their cuticular coating of wax after uncovering.

Other problems associated with plastics
Timing of herbicide application is a management problem. Residual pre emergence or pre drilling/planting herbicides can be applied before covers or mulches are laid. As described above to make the herbicide work satisfactorily the plastic should not be laid for 1-7 days after application to allow movement into the soil before the soil surface dries or the temperature is raised too much under the cover. The exact timing of laying the plastic after herbicide application depends on soil type, time of year and prevailing weather conditions.

Applying herbicides post emergence also requires considerable management skill. If the covers have to be removed for herbicide applica-tion the timing of removal must take into account the growth stage of the weeds and sufficient weaning of the crop to prevent damage. The length of time between removal and application will depend on weather conditions and chemical being used. If these guidelines are followed it could be argued that the recommendations for the use of herbicides are being followed.

Nonwoven materials offer the possibility of applying the herbicide through the cover. However in commercial practice this has not yet been achieved because of the quantity of water required to penetrate the cover, uneven distribution (even with nonwoven covers the spray run off will tend to run to the lowest point before going through the cover), and scorching the crop because of lack of waxing.

Criteria for successful use of herbicides under low level plastics

. Allow time between applying pre emergence residual herbicides and covering with plastics.
. Beware of using herbicides before covering in hot weather.
. If soil surface is dry after application apply 5-8 mm irrigation before covering.
. After removal allow crop to harden and form wax on the leaves before applying herbicides.
. Use the stale seed bed technique whenever possible for use with low level plastics.
. Remember that herbicides that have proved successful under covers take longer to disperse.

HERBICIDES ON NEWLY PLANTED ROOTSTOCKS AND BUDDED TREES

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ABSTRACT

Seven residual herbicide treatments were applied after planting
and heading back budded tree crops. The herbicides evaluated
were napropamide, napropamide + simazine, atrazine, diphenamid +
chlorthal-dimethyl, propyzamide + simazine, chlorthal-dimethyl +
metazachlor and oxadiazon. These were applied to a range of
genera: Fraxinus, Malus, Prunus, Sorbus and Tilia. A high level
of tree selectivity was recorded for all herbicides. Apart from
napropamide on S.aria 'Lutescens' no herbicide treatments gave
significantly smaller maiden trees than unsprayed controls. No
treatment gave complete weed control. The best overall
treatment was napropamide + simazine although oxadiazon gave
good control of most weeds except Chickweed.

INTRODUCTION

Effective chemical weed control in field grown nursery stock is not
easy to achieve. The aim is to apply a chemical or chemical combination
which selects against a broad range of weeds but does not adversely affect
a range of crop genera. The problem has been aggravated by the appearance
of weed species resistant to the triazine group of herbicides. (Moon
1984). The majority of tree producers have relied exclusively on simazine
for many years. Over the last five years triazine resistant groundsel
(Senecio vulgaris) has become widespread. It has been demonstrated that
simazine alone, at rates up to 1 kg/ha seldom damages Prunus 'Ukon'.
(Howard 1975). Other work on Acer platanoides 'Crimson King' Betula
pendula 'Dalecarlica', Robina pseudoacacia 'Frisia' and Tilia x euchlora
has indicated that simazine alone and in combination with pendimethalin
probably don't affect bud take but, in the case of Robina and Tilia
could affect the rootstock growth (Vasek 1985). Our experiment
investigates a range of herbicides as alternatives to simazine alone. The
trees trialled are all widely grown on nurseries in the U.K.

MATERIALS AND METHODS

Rootstocks of the following species were planted between 9 and 18
April 1985, Fraxinus excelsior, Malus MM106, Prunus 'Colt' Sorbus
intermedia and Tilia platyphyllos. These were budded during the following
August with F. excelsior 'Westhof Glory', M. 'Golden Hornet', P. Kanzan
S.aria 'Lutescens' and T. x euchlora rspectively. The chip budding
technique using degradable latex ties was employed. (Howard 1974)
(Skene 1983). All trees were headed back on 24 or 25 February 1986.

The herbicide treatments were napropamide at 4.05 kg/ha a.i. as
Banweed, napropamide at 3.5 kg/ha a.i. plus simazine at o.5kg/ha a.i. as
Banweed S, atrazine at 0.5kg/ha a.i. as Gesaprim, chlorthal-dimethyl at
7.5kg/ha a.i. as Dacthal diphenamid at 5kg/ha a.i. as Enide, simazine at
0.5kg/ha a.i. plus propyzamide at 0.5kg/ha a.i. as Kerb,
chlorthal-dimethyl at 7.5kg/ha a.i.plus metazachlor at 1.25kg/ha a.i. as
Butisan S, and oxadiazon at 1.0kg/ha a.i. applied as Ronstar liquid.

The trial was on a randomised block design replicated four times. Control plots were weeded by paraquat sprays, these being replicated eight times. The plot size was 1m x 3m, weed counts being done on the central 0.5 x 2m. There were 10 trees at 0.3m spacings per plot all of which were reduced. All end plants and out rows were guarded with trees of the same species. The field was a well drained snady loam of the Bishampton series with a mean PH of 7.2. Its nutrient status was an index of 1 of N, 4 of P, 3 of K and 4 of Mg using the standards described by the Ministry of Agriculture, Fisheries and Food (1985). The previous crop was a three year grass ley. A dressing of farm yard manure at 120 tonnes/ha was ploughed in during the autumn prior to planting.

The herbicides were applied by precision Knapsack sprayer using an Allman medium fan single nozzle, code 8002. This applied the treatments directly over the rootstocks. All treatments were applied in 1250 l/ha water.

Weeds were counted on 6 June, 30 July and 27 September in the rootstock year and 21 May, 26 June and 19 August in the maiden year. After counting, all plots, including the controls were sprayed with paraquat so that the possibility of recounting at the next assessment was eliminated.

Crop height from ground level was recorded at the end of the rootstock and maiden years. Stem diameter was recorded at the same time, 10cm from the ground for the rootstocks and half height for maiden trees.

RESULTS

Tree Growth
There were no visible differences in maiden tree growth on the different herbicide treatments. Signifcant sensitivity of rootstocks to herbicides, when compared with the untreated control, was only shown by F. excelsior on napropamide and simazine treated plots an the P. 'Colt' treated with oxadiazon. (Tables 1 + 2) Following application of oxadiazon on the P. 'Colt' there was a visible foliar scorch.

Bud take (Table 3) was not significantly affected by any treatment compared with the control. The F. 'Westhof Glory', M 'Profusion', P 'Kanzan' and T. x euchlora maidens did not show any significant treatments on height and diameter at half height compared with controls (Tables 4 + 5). However, the S.aria 'Lutescens' maidens on napropamide treatments were signficantly smaller than untreated controls (Tables 4 + 5).

TABLE 1

Mean rootstock height at 10cm (Nov 1985).

Treatment	g.a.i/ha	Mean rootstock height (cm)				
		A	B	C	D	E
Napropamide	4050	86.5	133.9	125.6	47.0	86.5
Napropamide	3500	76.3	132.1	122.3	57.8	75.8
and simazine	500					
Atrazine	500	94.0	132.8	124.2	49.2	94.0
Chlorthal-dimethyl	7500	87.7	129.0	125.1	55.4	87.7
and diphenamid	5000					
Simazine	500	84.8	131.6	121.3	49.8	84.3
and propyzamide	500					
Chlorthal-dimethyl	7500	92.9	132.2	124.2	50.5	92.1
and metazachlor	1250					
Oxadiazon	1000	92.9	124.6	105.6	49.0	92.7
Control	-	85.6	129.9	125.2	54.0	85.5
LSD.p=0.05		9.3	11.0	6.4	9.1	17.3

A F.excelsior
B MM106
C P.'Colt'
D S. intermedia
E T. platyphyllos

TABLE 2

Mean Rootstock height and diameter at 10cm (Nov 1985)

Treatment	g.a.i/ha	Mean Rootstock diameter (mm)				
		A	B	C	D	E
Napropamide	4050	12.97	13.52	19.50	9.68	9.84
Napropamide	3500	12.82	13.82	17.68	10.40	10.69
and simazine	500					
Atrazine	500	14.42	13.40	19.15	9.93	10.80
Chlorthal-dimethyl	7500	13.63	13.88	19.00	11.07	10.97
and diphenamid	5000					
Simazine	500	13.65	14.07	19.70	10.15	11.21
and propyzamide	500					
Chlorthal-dimethyl	7500	14.57	14.20	17.83	10.45	9.63
and metazachlor	1250					
Oxadiazon	1000	13.72	13.07	15.05	10.02	10.68
Control	-	13.70	13.90	19.46	11.21	10.64
LSD.p=0.5m		1.21	0.89	1.34	1.55	2.03

A F.excelsior   D S.aria 'Lutescens'
B MM106   E T x euchlora
C P.'Colt"

TABLE 3

% bud take

Treatment	g.a.i/ha	A	B	C	D	E
Napropamide	4050	97.3	95.0	92.5	77.5	80.6
Napropamide and simazine	3500 500	88.2	95.0	92.5	79.5	79.5
Atrazine	500	100.0	100.0	95.0	86.8	72.5
Chlorthal-dimethyl an diphenamid	7500 5000	92.5	97.5	90.0	66.7	84.6
Simazine and propyzamide	500 500	94.4	95.0	90.0	90.0	79.5
Chlorthal-dimethyl and metazachlor	7500 1250	97.1	100.0	95.0	80.0	73.7
Oxadiazon	1000	89.7	100.0	100.0	92.5	86.8
Control	-	94.8	96.3	92.5	85.0	76.6
LSD.p=0.5		11.1	7.2	8.7	26.8	14.1

A F.'Westhof Glory'
B M 'Profusion'
C P 'Kanzan'
D S.aria 'Lutescens'
E T x euchlora

TABLE 4

Mean maiden tree height (Nov 86)

Treatment	g.a.i/ha	A	B	C	D	E
Napropamide	4050	109.1	118.2	151.5	129.1	105.7
Napropamide and simazine	3500 500	113.1	114.0	157.1	158.4	104.2
Atrazine	500	113.3	113.3	157.9	142.9	106.1
Chlorthal-dimethyl and diphenamid	7500 5000	109.6	116.8	153.0	154.1	106.2
Simazine and propyzamide	500 500	113.3	117.7	159.9	147.0	107.4
Chlorthal-dimethyl and metazachlor	7500 1250	114.4	119.4	160.6	150.6	97.5
Oxadiazon	1000	114.1	113.8	162.9	142.4	101.5
Control	-	108.2	116.4	150.0	152.4	104.8
LSD.p=0.5m		9.2	7.3	24.7	18.2	12.4

A F. 'Westhof Glory'   D S.aria 'Lutescens'
B M. 'Profusion'   E T x euchlora
C P. 'Kanzan'

TABLE 5

Mean diameter at half height (Nov 86)

Treatment	g.a.i/ha	A	B	C	D	E
Napropamide	4050	14.35	9.05	9.07	11.95	7.81
Napropamide	3500	13.93	9.03	9.57	12.55	7.53
and simazine	500					
Atrazine	500	14.57	8.70	9.45	12.20	7.59
Chlorthal-dimethyl	7500	14.05	9.03	9.13	13.15	8.02
and diphenamid	5000					
Simazine	500	14.05	9.05	9.75	12.70	7.80
and propyzamide	500					
Chlorthal-dimethyl	7500	14.85	9.28	9.68	12.78	7.09
and metazachlor	1250					
Oxadiazon	1000	13.98	8.73	9.85	12.45	7.67
Control	-	13.20	8.95	8.97	12.93	7.69
LSD.p=0.5		1.40	0.47	1.27	0.84	1.21

A F. 'Westhof Gory'   D S.aria 'Lutescens'
B M 'Profusion'   E T x euchlora
C P 'Kanzan'

TABLE 6

Weed population expressed as percentage of control. (Combined total of all plots at all counts)

Treatment	g.a.i/ha	1	2	3	4	5	6	7	8	9
Napropamide	4050	9.7	15.2	220.6	58.8	69.1	47.8	35.5	78.9	78.9
Napropamide	3500	7.1	12.7	19.8	42.8	10.1	22.1	22.7	32.9	31.9
and Simazine	500									
Atrazine	500	25.8	28.5	36.0	43.0	10.3	42.5	15.5	72.3	19.2
Chlorthal-dimethyl	7500	13.6	67.6	166.4	83.3	84.1	146.9	18.2	114.5	44.1
and diphenamid	5000									
Simazine	500	23.6	48.6	79.4	43.4	24.5	46.0	20.0	63.2	41.4
and propyzamide	500									
Chlorthal-dimethyl	7500	25.8	39.3	126.9	67.3	45.8	31.0	20.0	78.9	24.0
and metazachlor	1250									
Oxadiazon	1000	20.5	202.3	196.4	77.1	15.6	33.6	42.7	27.6	50.1
Control	-	100	100	100	100	100	100	100	100	100

1 Poa annua   9 Lamium purpureum
2 Stellaria media
3 Capsella bursa-pastoris
4 Senecio vulgaris
5 Polygonum aviculare
6 Matricaria matricarioides
7 Veronica officinalis
8 Vicia sativa

Weed Control

There were large differences in weed number from plot to plot within treatments. All treatments controlled P. annua quite well but overall napropamide and simazine was the best. (Table 6) With the exception of oxadiazon all treatments offered fair control of S. media, napropamide and napropamide and simazine being most effective. Oxadiazon, napropamide and chlorthal-dimethyl and diphenamid were weak on C. bursa-pastoris, the best control of this weed being from napropamide plus simazine and atrazine. Control of S. vulgaris was not good on any treatment but. until the final assessment, had been good on napropamide and simazine treated plots. P. aviculare was not effectively controlled by any treatment in the first year although in the second year napropamide and simazine were most effective. M. matricarioides was not an abundant weed on any plot. Reasonable control of V. officinalis was offered by all treatments compared with untreated plots. L. purpureum was not controlled very effectively by any treatment, the napropamide being particularly weak. The best treatment on this weed was atrazine.

DISCUSSION

Herbicide treatments were applied 2-3 weeks after planting. The most rapid leafing P. 'Colt' and S. intermedia were damaged by the contact activity of oxadiazon. No othher species suffered apparant damage. The growth of the P. 'Colt' was reduced on oxadiazon treated plots in the rootstock year. Although S. intermedia also suffered visical damage the plants were not significantly maller than the control at the end of the rootstock year. The damage to the P. 'Colt' rootstocks by the oxadiazon did not affect bud take or subsequent maiden growth. This contact activity would be useful for taking out emerging weed seedlings but could have been very damaging to a less robust crop than P. 'Colt'. The only significant maiden tree growth reduction was from napropamide on S.aria 'Lutescens'. Although growth in the rootstock year was the lowest of all treatments this was not significant compared with the control. By the end of maiden year napropamide treated trees were significantly smaller than control ones. Whilst this would appear to be a strong treatment effect further investigations would be required for confirmation, especially as no such effect is shown by the mixture of napropamide and simazine.

None of the treatments gave anywhere near total weed control and because plot to plot populations were very variable meaningful analysis could not be done. Napropamide gave a good spectrum of control except for C.bursa-pastoris, where it was consistantly the least effective chemical treatment. In combination with simazine its control of C.bursa-pastoris is much improved. Atrazine gave good control of a wide range of weeds. Triazine resistant S.vulgaris was new to Luddington in 1985 and for the duration of this trial atrazine offered reasonable control. Chlorthal-dimethyl and diphenamid and chlorthal-dimethyl and metazachlor did not give as good overall weed control as napropamide plus simazine and atrazine. Both were very weak on S. vulgaris and the chlorthal-dimethyl and diphenamid in particular was letting a very wide spectrum of weed through by the end of the maiden year. Simazine and propyzamide gave a good spectrum of control and retained its comparative effectiveness against S. vulgaris, an indication that triazine resistance is not prevalant on this site.

The main weakness of oxadiazon is its failure to control <u>S.media</u>.
Numbers were frequently higher than on control plots, a result probably
explained by the oxadiazon excluding competition from other weeds on
treated plots.

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WEED CONTROL IN CARROTS AND RELATED CROPS WITH SOME NEWER HERBICIDES

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ABSTRACT

In field trials on a sandy loam soil R-40244 (3-chloro-4-chloromethyl-1-(α,α,α-trifluoro-m-tolyl)-2-pyrrolidone) applied pre-emergence at 0.5 and 1.0 kg a.i./ha gave complete weed control but caused transient bleaching of carrot, parsley and parsnip foliage. Plots treated with SMY 1500 (4-amino-6-(1,1-dimethylethyl)-3-(ethylthio)-1,2,4-triazin-5(4H)-one) were almost weed free but at 0.5 and 1.0 kg a.i./ha parsley and parsnip were damaged. Carrots were more tolerant but there was some loss of stand with 2.0 kg a.i./ha. Pendimethalin and aclonifen were selective in all three crops except under certain weather conditions. Weed control was variable depending on the species present and was improved by the addition of linuron. Diflufenican at a low dose was tolerated by carrots but weed control was again variable except when applied in a mixture with linuron.

INTRODUCTION

In field evaluation trials on a range of vegetables at Wellesbourne, several herbicides have shown selectivity in umbelliferous crops. These chemicals include pendimethalin (Roberts & Bond 1974), R-40244 (3-chloro-4-chloromethyl-1-(α,α,α-trifluoro-m-tolyl)-2- pyrrolidone) (Roberts et al. 1980), aclonifen (Roberts & Bond 1984), diflufenican (Roberts & Bond 1986) and SMY 1500 (4-amino-6-(1,1-dimethylethyl)-3-(ethylthio)-1,2,4-triazin-5(4H)-one) (Bond & Burch 1987). The present report summarises the results from field trials made in the period 1983-86.

EXPERIMENTAL METHOD AND RESULTS

The experiments were of randomised block design with three replicates, and were carried out on a sandy loam soil with 2% o.m. Plot size was 4.5 m2, with four crop rows 30 cm apart of which the centre two were harvested. The pre-emergence treatments were applied in a volume of 1100 l/ha and linuron (Linuron 50WP) at 0.55 kg a.i./ha was included for comparison as appropriate. Weed kill was assessed by counting survivors and by visual scoring of overall weed control on a scale of 0 (no effect) to 10 (complete kill). After assessment, plots were weeded to prevent competition and allow direct effects on yield to be determined. Crop injury was scored on the same 0-10 scale and crop number and weight were recorded at harvest. The yields are presented as percentages of the values for hand-weeded controls. The crop cultivars used were carrot cv. Chantenay red-cored Royal Chantenay, parsley cv. Bravour and parsnip cv. Offenham.

Carrots

In 1983 aclonifen and R-40244 were included in two carrot trials. After the first was drilled and sprayed on 7 April, there was rain almost every day totalling 60 mm in the following three weeks. Weed density was 187/m2 and the main species were Matricaria perforata, Chamomilla recutita, Poa annua, Polygonum aviculare, Bilderdykia convolvulus, Viola arvensis, Senecio vulgaris, Fumaria officinalis and Veronica persica. R-40244 at 0.5

and 1.0 kg a.i./ha gave complete kill of all the weeds present. The only survivors with aclonifen were P. aviculare and Aethusa cynapium. Under the cold, wet conditions prevailing R-40244 caused bleaching of the crop leaves and with 1.0 kg a.i./ha a few seedlings died. The remaining crop recovered and yields were similar to those of the controls (Table 1). Initially, there were no obvious effects with aclonifen but following the continued wet weather the carrots became stunted. However, once the weather improved the crop recovered and final yields were not significantly affected.

A second trial was drilled and sprayed on 14 April. Rainfall in the first three weeks was 82 mm. The seedbed was rougher than in the earlier trial and weed density higher at 277 weeds/m2 with P. aviculare the commonest weed. Again, R-40244 plots were completely weed free. On plots treated with aclonifen P. aviculare was the main survivor with some S. vulgaris and A. cynapium. R-40244 caused initial bleaching of the crop and with 1.0 kg a.i./ha there was a reduction in root numbers at harvest. There was little injury with aclonifen in this trial and no effect on yield (Table 1).

TABLE 1

Response of carrots and weeds to pre-emergence applications of R-40244 and aclonifen, 1983.

| Treatments kg a.i./ha | | Trial 1 | | | | Trial 2 | | | |
		Weeds % kill	Crop score	Crop % no.	Crop % wt	Weeds % kill	Crop score	Crop % no.	Crop % wt
R-40244	0.5	100	0.7	98	105	100	1.7	97	98
R-40244	1.0	100	2.7	87	96	100	5.3	86	100
aclonifen	1.2	96	1.3	97	100	89	0	93	106
aclonifen	1.8	97	2.3	98	92	71	0	93	97
aclonifen	2.4	99	2.3	99	97	100	0.7	97	98
L.S.D. (5%) for comparison with control				20	14			14	4

In 1985, two tests were made to examine the effects of pendimethalin and diflufenican, either alone or in combination with linuron. The first was drilled and sprayed on 2 April during a cold wet spell, with 35 mm rain in the following three weeks. Weed control was assessed on 23 May and weeds counted on 25 May. There were 218 weeds/m2 with P. aviculare, S. vulgaris, P. annua, C. suaveolens, Thlaspi arvense and Stellaria media the main weeds. The standard linuron treatment gave good weed control but results with pendimethalin were poor because of the prevalence of S. vulgaris. Addition of linuron improved control appreciably, killing most S. vulgaris, although some T. arvense and Veronica hederifolia survived the combined treatment. Weed control with diflufenican was good at 50 g a.i./ha, P. aviculare and P. annua being the main survivors. The lower rate of diflufenican gave only moderate control but was improved by the addition of linuron. During the early stages of this trial the soil was cold and wet so that crop emergence and growth were slow. Linuron caused a significant reduction in root numbers (Table 2) but pendimethalin, whether alone or in combination with a low rate of linuron, had no adverse effect on number or weight of roots. Diflufenican caused little visible injury but with 50g a.i./ha there was a

reduction in root weight and, when combined with linuron, both root number and weight were adversely affected.

TABLE 2

Response of carrots and weeds to pre-emergence applications of diflufenican and pendimethalin, alone and in combination with linuron, 1985.

Trial 1

Treatments kg a.i./ha	Weeds		Crop	Yield, % of control	
	% kill	score	score	number	weight
pendimethalin 0.67	58	7.3	0	107	98
pendimethalin 1.33	65	7.7	0	108	106
pend. 0.67 + linuron 0.25	91	8.7	0	94	104
pend. 1.33 + linuron 0.25	91	9.0	0	90	94
diflufenican 0.025	71	7.7	0	98	100
diflufenican 0.050	88	9.0	0.7	97	86
difl. 0.025 + linuron 0.25	89	9.2	0	95	92
difl. 0.050 + linuron 0.25	95	9.2	0.7	77	87
linuron 0.55	88	8.7	0.7	82	89
L.S.D. (5%) for comparison with control				17	13

Trial 2

Treatments kg a.i./ha	Weeds		Crop	Yield, % of control	
	% kill	score	score	number	weight
pendimethalin 0.67	90	8.7	1.7	92	98
pendimethalin 1.33	86	9.2	3.0	69	94
pend. 0.67 + linuron 0.25	97	9.0	2.3	74	97
pend. 1.33 + linuron 0.25	96	9.7	3.0	70	93
diflufenican 0.025	52	6.3	0	93	101
diflufenican 0.050	77	7.3	0	101	98
difl. 0.025 + linuron 0.25	99	9.5	0	106	101
difl. 0.050 + linuron 0.25	96	9.7	0.7	99	104
linuron 0.55	90	9.3	0	96	102
L.S.D. (5%) for comparison with control				20	19

Drilling and spraying of the second test on 17 June was followed by a very wet period with rain every day in the first week, totalling 49 mm. Weeds were counted on 17 July and control assessed visually on 18 July when crop injury scores were recorded The carrots were harvested on 12 September. Weed emergence was low, mainly S. media with a few seedlings of other species. Pendimethalin alone controlled all weeds except S. vulgaris, with the addition of linuron however, only isolated plants of this species survived. Diflufenican was only effective when combined with linuron. There were no visible effects on the crop from linuron in this trial but all plots treated with pendimethalin suffered some stunting and with three of

the four treatments crop stand was reduced (Table 2). Diflufenican did not affect root number or total weight.

In two trials made in 1986, pendimethalin alone and in combination with linuron was examined; treatments with SMY 1500 at three rates were also included. The first test was drilled on 28 April and pre-emergence treatments applied the same day. Rainfall in the following three weeks totalled 47 mm. Weed counts were made on 12 June and plots handweeded. Crop injury was assessed on 27 June. The carrots were harvested on 9 September and the number and total weight of roots from each plot recorded. The weed population on the controls was 35/m2. The main species present were V. persica, Capsella bursa-pastoris, P. annua, S. media, F. officinalis and T. arvense. Additional species were present in low numbers. SMY 1500 controlled all the weeds apart from an occasional S. vulgaris. Pendimethalin alone killed all S.media, P. annua, and V. persica. Fumaria

TABLE 3

Response of carrots and weeds to pre-emergence applications of SMY 1500 and pendimethalin, 1986.

| | | Trial 1 | | | |
| | | Weeds | Crop | Yield, % of control | |
Treatments	kg a.i./ha	% kill	score	number	weight
SMY 1500	0.5	99	0.3	107	102
SMY 1500	1.0	99	2.0	98	103
SMY 1500	2.0	100	5.7	67	95
pendimethalin	0.67	93	0	106	96
pendimethalin	1.33	97	0	102	100
pend. 0.67 + linuron 0.25		97	0	95	98
pend. 1.33 + linuron 0.25		99	0	101	101
linuron	0.55	93	1.0	89	99
L.S.D. (5%) for comparison with control				13	8

| | | Trial 2 | | | |
| | | Weeds | Crop | Yield, % of control | |
Treatments	kg a.i./ha	% kill	score	number	weight
SMY 1500	0.5	90	0.3	93	108
SMY 1500	1.0	99	0.3	99	109
SMY 1500	2.0	87	3.3	87	102
pendimethalin	0.67	94	0	109	108
pendimethalin	1.33	96	0.7	101	108
pend. 0.67 + linuron 0.25		95	0	107	105
pend. 1.33 + linuron 0.25		97	0.3	105	107
linuron	0.55	52	0	108	106
L.S.D. (5%) for comparison with control				15	8

officinalis and S. vulgaris were the main survivors at the 1.33 kg a.i./ha
rate, with 0.67 kg a.i./ha occasional T. arvense, C. bursa-pastoris and
mayweeds also remained. The addition of linuron reduced the number of
surviving weeds. The standard treatment of linuron alone, left mainly V.
persica and F. officinalis. The highest rate of SMY 1500 caused severe crop
injury, plant stand was reduced but survivors recovered and growth of these
widely spaced roots compensated for the missing plants and yield per plot
was not reduced (Table 3). There was some transient damage with lower rates
of SMY 1500. Pendimethalin alone or in the mixture did not check the early
growth of the crop or affect the number and weight of carrots at harvest.

The second trial was drilled and sprayed on 19 May. Rainfall in the
following three weeks totalled 23 mm. Weed numbers were recorded and crop
injury assessed on 7 July. Weed numbers were low, only 12/m2 on the
controls with V. persica accounting for more than half of these. Other
species present included S. media, P. annua and Solanum nigrum. A few S.
nigrum and V. persica seedlings survived on plots treated with the lowest
rate of SMY 1500 but at higher rates, plots were again virtually weed free.
All the pendimethalin treatments killed V. persica. With 1.33 kg a.i. plus
linuron F. officinalis was the only survivor, while pendimethalin alone at
this rate failed to control the occasional P. annua seedlings. A few
survivors of several species remained on plots treated with 0.67 kg
pendimethalin alone or in the mixture. Linuron alone did not kill V.
persica which accounted for the poor weed control on these plots. No
treatment adversely affected crop weight at harvest (Table 3).

Parsley
In 1983, aclonifen and R-40244 treatments were included in two parsley
trials. In the first experiment, drilled and sprayed on April 7, there were
314 weeds/m2 on the controls prior to weeding. Rainfall in the first three
weeks totalled 60 mm. R-40244 at 0.5 and 1.0 kg a.i./ha gave complete weed
control. All rates of aclonifen gave excellent weed kill though some P.
aviculare survived at 1.2 and 1.8 kg a.i./ha. There was complete control of
M. perforata, C. recutita, P. annua and Urtica urens. R-40244, especially
at 1.0 kg a.i./ha, caused bleaching of the parsley leaves and this persisted
until the weather became warmer. After that, the crop recovered and at
harvest there was no adverse effect of R-40244 or aclonifen on final yield
(Table 4). Plant numbers were not recorded.

In the second experiment prepared on 14 April, the seedbed was rough
and weed density was 228 weeds/m2. Rainfall in the first three weeks
totalled 82 mm. The R-40244 treatments gave complete weed kill. In this
trial P. aviculare, the main weed present, was only controlled by aclonifen
at 3.6 kg a.i./ha. A few A. cynapium and S. vulgaris also remained. There
was however complete kill of Chenopodium album, Atriplex patula, Viola
arvensis, B. convolvulus and Sonchus asper. There was again some initial
injury with R-40244 and a slight check with the two higher rates of
aclonifen but neither chemical affected final yields (Table 4). Weeding of
plots was delayed by the wet weather and there was some competition from P.
aviculare where only 1.2 kg a.i. of aclonifen had been applied.

In 1986, a single parsley trial was drilled on 28 April and
pre-emergence treatments of SMY 1500 and of pendimethalin plus linuron
applied on 30 April. Rainfall in the following three weeks totalled 47 mm.
Weed counts were made on 9 June and crop injury and overall weed control
assessed on 27 June. At harvest on 27 July the number and total fresh
weight of plants were recorded. Weed number on the controls was 33

weeds/m2. The main species were P. annua, C. bursa-pastoris, V. persica, T. arvense, S. media, F. officinalis, M. perforata and C. suaveolens. SMY 1500 at 1 and 2 kg a.i./ha killed all weeds apart from an occasional plant of S. vulgaris. With 0.5 kg a few F. officinalis and T. arvense also survived. Plots treated with 1.33 kg a.i./ha pendimethalin plus linuron were virtually weed free. The main survivor with the lower rate of pendimethalin was F. officinalis. Linuron alone left mainly V. persica and F. officinalis. Crop injury was severe with SMY 1500; all three rates reduced plant stand (Table 5). Only with 0.5 kg a.i./ha was total weight unaffected at harvest. No other treatments affected crop growth or yield.

TABLE 4

Response of parsley and weeds to pre-emergence applications of aclonifen and R-40244, 1983.

		Trial 1			Trial 2		
Treatments kg a.i./ha		Weeds % kill	Crop score	Yield as % of control	Weeds % kill	Crop score	Yield as % of control
R-40244	0.5	100	0.7	119	100	2.7	100
R-40244	1.0	100	2.3	105	100	3.7	106
aclonifen	1.2	98	0.7	98	57	0	86
aclonifen	1.8	98	0.3	108	81	0.3	95
aclonifen	2.4	100	0.3	110	65	1.0	97
aclonifen	3.6	100	0.7	110	88	0.7	100
L.S.D. (5%) for comparison with control				19			11

TABLE 5

Response of parsley and weeds to pre-emergence applications of SMY 1500 and of pendimethalin plus linuron, 1986.

Treatments kg a.i./ha		Weeds % kill	Weed score	Crop score	Yield, % of control	
					number	weight
SMY 1500	0.5	98	8.3	6.3	65	92
SMY 1500	1.0	99	9.5	9.3	4	15
SMY 1500	2.0	99	9.7	9.7	1	1
pend. 0.67 + linuron 0.25		94	9.0	0	100	98
pend. 1.33 + linuron 0.25		99	9.3	0.3	99	102
linuron	0.55	87	6.3	0	99	92
L.S.D. (5%) for comparison with control					14	13

Parsnip
    In 1983, aclonifen and R-40244 treatments were included in two parsnip experiments drilled on 7 and 14 April. Rainfall was the same as that

recorded in the parsley trials. The parsnips were thinned to 10 cm apart in the row once the seedlings had established. In the first trial, weed density was 303 weeds/m2 and R-40244 gave complete weed kill. Overall weed control with aclonifen was also good, P. aviculare being the main survivor together with A. cynapium. There was complete kill of M. perforata, C. recutita, V. arvensis, B. convolvulus, and Urtica urens. The characteristic R-40244 bleaching that occurred in the other crops was seen in parsnip and there was also a crop check with aclonifen treatments. The parsnips recovered and there was no effect on root weights at harvest (Table 6).

TABLE 6

Response of parsnip and weeds to pre-emergence applications of aclonifen and R-40244, 1983.

Treatments kg a.i./ha		Trial 1			Trial 2		
		Weeds % kill	Crop score	Yield as % of control	Weeds % kill	Crop score	Yield as % of control
R-40244	0.5	100	1.7	96	100	3.3	92
R-40244	1.0	100	2.3	93	100	4.0	96
aclonifen	1.2	96	0.3	101	78	0.3	99
aclonifen	1.8	94	0.3	92	81	0.3	99
aclonifen	2.4	97	0.3	95	83	0	103
aclonifen	3.6	99	1.0	93	97	1.7	99
L.S.D. (5%) for comparison with control				9			9

TABLE 7

Response of parsnip and weeds to pre-emergence applications of SMY 1500 and of pendimethalin plus linuron, 1986.

Treatments kg a.i./ha	Weeds % kill	Weed score	Crop score	Yield, % of control	
				number	weight
SMY 1500	0.5	99	9.7	3.0	81	95
SMY 1500	1.0	99	9.7	7.0	52	79
SMY 1500	2.0	100	10.0	8.8	10	30
pend. 0.67 + linuron 0.25	98	9.2	0	93	103
pend. 1.33 + linuron 0.25	97	9.2	0	101	94
linuron 0.55	68	5.0	0.6	110	87
L.S.D. (5%) for comparison with control				25	22

The second trial, made on a rougher seedbed, had a weed density of 191 weeds/m2 and once again R-40244 gave complete weed control. The main weed was P. aviculare which remained on all aclonifen treated plots, although survivors were small and less competitive at higher rates. Some S.

arvensis also survived at rates below 2.4 kg a.i./ha. Species killed included V. arvensis, M. perforata, S. asper and P. annua. In addition to the injury seen previously, there was some yellowing of the crop at an early stage where aclonifen at 3.6 kg a.i./ha had been applied. Yield of roots at harvest on 20 September did not differ from those of the controls (Table 6).

In 1986, pre-emergence treatments of pendimethalin plus linuron and of SMY 1500 at three rates were included in a parsnip trial drilled on 28 April. The dates of spraying and assessments were the same as for the 1986 parsley trial. Plant numbers and total weight of roots, for each plot, were recorded at harvest on 4 September. The weed population was 35 seedling/m2 and the main species present were the same as those in the parsley trial. Weed control was virtually complete with all rates of SMY 1500, although a few S. vulgaris survived with 0.5 kg a.i./ha. Plots treated with the mixture of pendimethalin and linuron were almost weed free. A few F. officinalis and P. annua remained with both rates of pendimethalin. Linuron alone, left more of these species together with large numbers of V. persica. Parsnip was less susceptible than parsley to SMY 1500 but a reduction in stand which increased with higher rates of chemical was reflected in the weights at harvest. There was no effect on yield from the other treatments, but poor crop establishment made the results very variable (Table 7).

DISCUSSION

All the herbicides tested, including linuron, caused occasional crop damage under the cold, wet conditions that prevailed during the early stages of some trials. R-40244 was exceptional in giving complete weed control in all three crops at a dose which caused only transient injury. At 1.0 kg a.i./ha damage was more severe especially when growing conditions were poor. SMY 1500 also controlled most of the weeds but at rates which caused unacceptable damage to parsley and parsnip. There was some loss of stand in carrot with 2 kg a.i./ha. Weed control with the other three herbicides was variable depending on the species present but the addition of linuron gave consistently better results. Diflufenican at 50 g a.i./ha was damaging in carrot but the lower dose gave poor weed control. When cold, wet weather followed aclonifen application early crop growth was checked but plants recovered as conditions improved. The damage that occured with pendimethalin in carrots developed after exceptionally heavy rainfall. This could have resulted from uptake of the chemical by the crop at the soil surface.

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THE EFFECT OF FOLIAR AND SOIL-ACTIVE HERBICIDES ON BLACKCURRANTS

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ABSTRACT

Napropamide (4 and 8 kg/ha) and pendimethalin (2 and 4 kg/ha applied in
mixture with simazine (1 kg/ha) to newly-planted and established black-
currants in February caused no adverse effects on growth or fruit
yield. Soil residues 9 months after the last of three annual applic-
ations were 10% of the annual dose or less. Oxadiazon and oxyfluorfen
applied post-planting in February caused severe stunting and necrosis
of emerging shoots but damage was subsequently outgrown. At doses
required for control of simazine-resistant weeds, applications in
February to 1 and 2 year old bushes caused some damage to basal shoots
in spring but had no effect on fruit yield or overall shoot growth.
Pyridate (1.5 and 3 kg/ha) + simazine (1 kg/ha) applied in December or
February had no adverse effect on growth or fruit yield.

Clopyralid (0.2 kg a.e/ha) applied overall at different dates during
the growing season caused most damage from spraying in April during
flowering or in late September before leaf fall. Fruit yield was
reduced and new shoot growth distorted. Subsequent growth was normal
and fruit yield the following year unaffected. Results suggested there
should be little risk of serious damage from directed sprays for
creeping thistle (Cirsium arvense) control.

INTRODUCTION

Weed control in non-cultivated blackcurrants in the U.K. has been
largely based on annual applications of simazine. Repeated use of this
herbicide has however led to an increase in resistant annual weeds and the
spread of perennial weeds. Other herbicides such as dichlobenil, diuron,
MCPB and propyzamide have given improved control (Fryer & Makepeace 1978)
but there has been a need for alternative effective and economic treatments.
Following screening of 30 herbicides for tolerance to blackcurrants in pot
tests (Clay 1985) promising herbicides were applied to field-grown
blackcurrants as single or repeated annual treatments to assess tolerance.
The results of this work are reported.

MATERIALS AND METHODS

Six experiments were carried out at the Weed Research Organisation at
Begbroke Hill, Oxford on a sandy loam soil of the Sutton/Badsey series,
overlying calcareous gravel to a depth of 0.5 - 0.75 m (o.m. 2 - 3%, pH 6.5
- 7.0). Blackcurrants, cv. Baldwin, were planted in late winter as cuttings
or as 1 year old bushes, cut-down immediately after planting. Spacing
between plants was 0.6 m and between rows 2.5 m. Herbicides were applied to
4.2 m long plots at a 1 m spray swath using a pressurized knapsack sprayer
fitted with a boom with 3, 6502 Spraying System Tee jets, giving 330 l/ha
spray volume at 200 kPa pressure. Herbicides and formulations used are
shown in the tables (all doses are expressed as kg a.i./ha). Experiments
were laid out as randomised blocks with two control treatments, with three

blocks in Expts. 1, 2 and 4, four in Expts. 3 and 5 and six in Expt. 6.
Fertilizer was applied each spring and a standard pesticide programme
followed. Weeds developing on plots were killed as seedlings by paraquat
applied in alleys and hand pulling in rows.

Assessments were made on the central five bushes on each plot row.
Herbicide damage was scored using a 0-9 scale where 0=plant dead, 5=50%
growth inhibition, 9=plant healthy. A single pick of all fruit was made in
July. Growth was recorded in winter by measuring the length of the previous
year's extension growth on shoots >5cm long. Basal shoot length was
recorded separately. In Expt. 2, soil samples were taken in November 1985
from napropamide and pendimethalin treatments for herbicide residue
measurement. Ten 2.5 cm diameter samples were taken per plot to 10 cm
depth, from positions 20 cm either side of the row centre. Soil was sieved
through a 3 mm mesh, mixed and deep frozen. Analysis was by gas
chromatography for pendimethalin (lowest detectable dose, 0.01 mg/kg dry
soil) and hplc for napropamide (lowest detectable dose, 0.04 mg/kg) (Byast
et al. 1977).

RESULTS

Expt 1. Oxadiazon and oxyfluorfen at both doses applied to newly
planted bushes caused severe damage to new growth during April and May.
Developing shoots were stunted and leaves chlorotic, distorted and often
severely necrotic (Table 1). Plants grew out of the damage during the
summer, and the height of leading shoots was only slightly less than the
control in July for oxadiazon treatments though 20-40% less with
oxyfluorfen. Subsequent growth of oxadiazon treated bushes was normal and
although bush size was smaller in 1982 at the higher dose, fruit yield and
final growth were similar to the control. With oxyfluorfen treatments
bushes were smaller than the control treatment and fruit yield reduced by
14-24%. Pendimethalin at the higher dose caused slight stunting of shoots
with the post planting application but subsequent growth was similar to the
control treatment and growth and fruit yield unaffected following
reapplication of the treatments in 1983. Propyzamide at the higher dose
caused slight shoot stunting but this was outgrown and subsequent growth and
yield were similar to the control treatment.

Expt 2. Napropamide applied each spring at 4 or 8 kg/ha had no adverse
effect on growth or fruit yield (Table 2). Soil residues 9 months after the
final application were 1.20 and 2.38 kg/ha respectively. Oxadiazon applied
post-planting caused severe damage to emerging shoots in spring but this was
outgrown during the summer and only the higher dose resulted in smaller bush
size in winter and reduced fruit yield the following summer. When the doses
were reapplied in February 1985 only the higher doses caused damage to basal
shoots (stunting and leaf necrosis) and 13% fruit yield reduction.
Oxyfluorfen applied post-planting caused severe damage to emerging shoots
but this was outgrown and only the higher dose led to fruit yield reduction
(27%) the following year. When the treatments were reapplied in 1985 only
the higher dose caused damage - stunting and necrosis of basal shoots and
13% fruit yield reduction. Pendimethalin, 2 and 4 kg/ha, applied
post-planting and in two subsequent years had no adverse effect on growth or
yield. Soil residues measured 9 months after the final application were
0.38 and 0.98 kg/ha respectively.

Expt 3. Napropamide and pendimethalin applied in February to
established bushes had no adverse effect on growth or fruit yield compared

TABLE 1

The effect of herbicides applied before bud burst on 19 Feb. 1982 and 21 Feb. 1983 on the growth and fruit yield of blackcurrants[a] (Experiment 1)

Herbicide[b]	Formulation % ai and product name	Dose (kg ai/ha)	1982				1983		
			Vigour score[d] 5 Apr.	2 Jul.	Shoot height[e] 2 Jul.	Shoot length[e] 15 Nov.	Vigour score[d] 6 May	Fruit yield[e] Jul.	Shoot length[e] Dec.
Oxadiazon[c]	e.c., 20	2.0	4.7	7.0	92	92	8.7	100	100
"	(Ronstar)	4.0	4.3	6.0	92	85	7.0	101	110
Oxyfluorfen[c]	e.c., 24	1.5	4.0	5.0	80	95	7.0	86	93
"	(Goal)	3.0	3.7	3.3	60	80	5.7	76	79
Pendimethalin	e.c., 33	2.0	7.3	8.7	103	93	9.0	105	102
"	(Stomp)	4.0	6.3	8.3	98	99	8.3	109	99
Propyzamide[c]	w.p., 50	0.9	7.3	8.0	102	88	8.7	87	102
"	(Kerb 50 W)	1.8	6.7	7.0	98	89	7.7	96	101
Simazine	s.c., 50	1.0	7.5	8.5	100	100	8.8	100	100
Actual value					50.4 cm	287 cm/bush		0.48 kg/bush	1085 cm/bush
S.E.±			0.48	0.38	3.3	7.5	0.37	9.3	15.1

[a] planted as 1 year old bushes, Feb. 82   [b] Treatments applied as a tank mix with simazine 1kg/ha
[c] Simazine only applied 21 Feb. 83   [d] Vigour score, 0-9 scale   [e] % simazine-treated standard

TABLE 2

The effect of herbicides applied in Feb. 1983, 1984 and 1985 on the growth and fruit yield of blackcurrants[a]
(Experiment 2)

		Results as % simazine treated standard							
		1983			1984		1985		
Herbicide[b]	Dose (kg ai/ha)	Vigour		Total shoot length 29 Nov.	Fruit yield July	Total shoot length 3 Dec.	Vigour 3 May	Fruit yield Jul.	Total shoot length Dec.
		6 May	13 Jul.						
Napropamide[c]	4.0	98	98	100	102	98	100	100	96
"	8.0	102	107	109	121	107	100	103	97
Oxadiazon	2.0	34	71	97	81	94	81	98	116
"	4.0	26	53	74	58	73	81	87	117
Oxyfluorfen	0.25	45	76	90	107	85	92	97	108
"	0.75	23	53	85	73	65	77	87	113
Pendimethalin	2.0	98	102	103	116	105	100	104	107
"	4.0	98	107	107	99	110	100	103	104
Simazine	1.0	100	100	100	100	100	100	100	100
Actual value		8.8[d]	7.5[d]	309 cm/ bush	0.57 kg/ bush	2373 cm/ bush	8.7[d]	2.64 kg/ bush	2632 cm/ bush
SE+		2.7	3.2	5.1	7.6	5.2	4.6	4.3	7.2

[a] Planted as 1 year old bushes, Feb. 82
[b] Treatments applied as a tank mix with simazine 1 kg/ha; oxadiazon and oxyfluorfen not applied 1984
[c] Napropamide as 45% a.i., s.c. (Devrinol)   [d] 0-9 scale

TABLE 3

The effect of herbicides applied in February 1983 to established blackcurrants planted as cuttings Feb. 1981[a] (Experiment 3)

Herbicide[b]	Dose (kg/ha)	Vigour[c] score 6 May	Fruit yield[d] 13 Jul.	Total shoot length[d] Dec. 83	No. basal shoots[d] Dec. 83
Napropamide	4.0	8.7	102	110	78
"	8.0	9.0	99	87	114
Oxadiazon	2.0	7.0	92	80	16
Oxyfluorfen	0.25	7.0	99	99	106
"	0.75	6.0	93	97	57
Pendimethalin	2.0	9.0	116	91	78
"	4.0	8.7	99	112	82
Simazine	1.0	8.9	100	100	100
Actual value			0.56 kg/bush	637 cm/bush	6.1 per plant
S.E.±			0.13	9.5	6.8	19.1

[a] Planted into polythene, removed Feb. 1983 before spraying
[b] Treatments applied as a tank mixture with simazine 1kg/ha
[c] Vigour score 0-9, [d] % simazine-treated standard

TABLE 4

The effect of oxyfluorfen and pyridate on dormant 1 year-old blackcurrants[a] (Experiment 4)

Herbicide	Dose (kg/ha)	Application date	Vigour score[c] 6 May	Fruit yield[d] 20 Jul.	Shoot length[d] 21 Nov.
Oxyfluorfen[b]	0.75	1 Dec. 82	7.0	90	82
"	1.5	1 Dec. 82	6.0	79	85
"	0.75	21 Feb. 83	6.0	89	109
"	1.5	21 Feb. 83	5.3	76	95
Pyridate[be]	1.5	1 Dec. 82	9.0	86	92
"	3.0	1 Dec. 82	9.0	90	102
"	1.5	21 Feb. 83	8.7	87	87
"	3.0	21 Feb. 83	8.7	87	97
Simazine	1.0	21 Feb. 83	8.5	100	100
Actual value				0.49 kg/bush	1131 cm/bush
SE±			0.25	7.8	8.2

[a] Planted as 1 year old bushes Feb. 82 [b-d], as in Table 3
[e] 50% w.p. (Lentagran)

TABLE 5

The effect of overall sprays of clopyralid 0.2 kg a.e./ha[a] on 2-year-old blackcurrant bushes[b] (Experiment 5)

Application date (1981)	Vigour score 10 Jul. 81	Vigour score 17 Aug. 81	5 Apr. 82	Fruit yield July 81	Berry size	Shoot length Jan. 82	Fruit yield Aug. 82	Shoot length Nov. 82
				Results as % untreated				
21 Apr.	84	72	100	73	89	97	107	114
13 May	78	61	78	113	101	76	109	153
22 Jun.	88	78	78	127	99	106	106	93
17 Aug.	100	89	69	99	101	104	98	104
Untreated	100	100	100	100	100	100	100	100
Actual value	8.0[c]	9.0[c]	9.0[c]	0.99 kg/bush	63[d]	407 cm/bush	1.40 kg/bush	2029 cm/bush
SE+	2.1	3.5	1.4	7.9	5.8	6.6	5.0	13.3

[a] 100g a.e./l a.c.(Format) [b] planted as 1 year old bushes Feb. 79
[c] 0-9 scale [d] 200 berry wt(g)

TABLE 6

The effect of overall sprays of clopyralid 0.2 kg a.e./ha applied to blackcurrant bushes in the year of planting[a] (Experiment 6)

Application date (1983)	Leaf no. 1 Dec.	Shoot length Jan. 84	Vigour score (1984) 18 Apr.	24 May	26 Jun.	Fruit yield 30 Jul.84	Shoot length Feb.85
			Results as % untreated				
25 Jul.	184	96	85	111	100	124	98
18 Aug.	390	95	73	109	106	104	102
6 Sep.	515	101	67	96	98	119	100
29 Sep.	870	99	48	73	92	50	103
Untreated	100	100	100	100	100	100	100
Actual value	10.2[b]	300 cm/bush	8.0[c]	8.8	8.2	0.58 kg/bush	2049 cm/bush
SE+		3.7	2.1	2.9	3.1	6.8	5.5

[a] 1 year old bushes, planted Feb. 83, cut down and sprayed with simazine 1 kg/ha
[b] No. of leaves remaining/bush [c] Vigour score, 0-9 scale

with the simazine treated control (Table 3). Oxadiazon 2 kg/ha did not affect fruit yield but caused stunting, necrosis and death of basal shoots. Oxyfluorfen at 0.75 kg/ha caused similar effects but at 0.25 kg/ha there was no reduction in basal shoot numbers the winter after treatment.

Expt 4. Oxyfluorfen caused slightly more damage to basal shoot and leaf growth when applied in February compared with December but subsequent growth and fruit yield were similar (Table 4). Pyridate applied at both dates had no apparent adverse effect on growth or yield.

Expt 5. Clopyralid 0.2 kg a.e./ha applied over bushes on 21 April during flowering caused distortion of new leaves, slight epinasty,leaf cupping, and bending of shoot tips. These leaf symptoms were outgrown and shoot growth in that and the following year was unaffected (Table 5). Fruit yield was reduced by 27% in 1981 with a small reduction in fruit size but yield in 1982 was unaffected. Treatment on 13 May, when fruit was setting, resulted in distortion of leaves growing out in June and bending of shoot tips at the top of bushes; crop yield was not affected. Shoot growth recorded at the end of the year was reduced by 24% but yield and growth in 1982 were not reduced. Application of clopyralid on 22 June caused slight bending of shoot tips in July but no adverse effects on amount of growth or fruit yield in 1981 or 1982. Slight distortion was seen on the first leaves growing out in spring 1982. No adverse effects of the post-harvest application on 17 August were seen in the year of treatment but first leaves produced in 1982 showed formative effects (leaf cupping on upper shoots, vein clearing and increased marginal serration on basal shoots). These effects were outgrown; subsequent growth was unaffected and fruit yield 27% higher than the control.

Expt 6. When young bushes were treated with clopyralid, no effects were seen that year apart from delayed fall of dead leaves in autumn, the later the treatment the more leaves being retained into December (Table 6). All clopyralid treatments affected leaf growth the following spring, the 29 September applications to dormant bushes having severe effects. All developing shoots were stunted and leaves distorted initially as described above. Leaf growth from May became normal but effects remained obvious until June. Effects from the other application dates were less severe particularly that in July. Only the 29 September application had obvious effects on flowering, which was delayed and fruit set appeared less; fruit yield was 50% less than control. Fruit yield was not reduced by the other treatments and no treatment resulted in less shoot growth when recorded at the end of the year. In July 1985 fruit yield was recorded from the 29 September treatment when there was no significant difference from the untreated control (data not shown).

DISCUSSION

The tolerance of blackcurrants to dormant season sprays of napropamide and pendimethalin at recommended and double rates corresponds to results with other perennial crops (Clay 1984) and with earlier pot tests of pendimethalin on blackcurrants (Clay 1985). Both herbicides applied as a tank-mix with simazine in late winter gave a broad-spectrum pre-emergence weed control. The soil residues remaining 9 months after the last of three annual applications were 10% of the annual dose for napropamide and 6-8% for pendimethalin, comparable to amounts of simazine remaining after repeated applications on adjacent land (Clay 1978). There has been no evidence of damage to subsequent crops following widespread use of pendimethalin but

napropamide has caused damage to cereal crops following its use in Brassicae; avoidance of use the season before sowing sensitive crops would therefore be advisable.

Oxadiazon and oxyfluorfen applied to dormant plants caused severe damage to emerging shoots in newly-planted bushes and some damage to basal shoots in established bushes. Since these herbicides do not cause damage through root uptake (Clay 1980,1985) injury is probably caused by transfer of herbicide by splashing of treated soil onto young shoots and leaves near ground level (Clay 1982). At doses necessary for season long control of simazine-resistant weeds any adverse effects were short-term and growth and yield unaffected. Oxadiazon is recommended as a dormant-season treatment in established blackcurrants. Pyridate has caused damage applied to blackcurrants in summer (Clay 1985) but appeared safe in this work as a dormant season treatment. It has potential for post-emergence control of certain problem weeds such as cleavers (Galium aparine).

Clopyralid is widely-used as an overall treatment for the control of creeping thistle (C.arvense) in strawberries. Blackcurrants appeared less tolerant in pot tests (Clay 1985) although damage from applications to the bush base were outgrown. The field experiments showed that over-spraying bushes during April, May or September was most likely to cause leaf and shoot distortion and crop reduction. However, even with overall spraying bushes recovered suggesting that directed sprays, where much less herbicide reaches the bush, should be acceptable considering the alternative of leaving thistle uncontrolled. The effect of September spraying clearly persisted in the bush for a long time considering the effects on leaf fall and on spring flowering and fruit set seen in Expt 6. This contrasts with the apparent tolerance of September spraying of bushes with MCPB, the only phenoxy-alkanoic herbicide recommended in the crop (Fryer & Makepeace 1978).

ACKNOWLEDGEMENTS

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FOMESAFEN/TERBUTRYN - A PRE-EMERGENCE HERBICIDE FOR ANNUAL BROAD-LEAVED WEED CONTROL IN LEGUMES FOR PROCESSING

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ABSTRACT

A new pre-emergence herbicide mixture of fomesafen/terbutryn shows good selectivity in peas and beans (Vicia faba) for processing. Data assessed as crop damage during growth, and yield of produce in pea trials have demonstrated crop safety when fomesafen/terbutryn was applied pre-emergence of the crop, however, visible damage was caused when applied to emerged peas. Three years of experiments in the UK have shown activity against a wide spectrum of broad-leaved weeds.

INTRODUCTION

The EEC subsidy scheme for home grown protein has resulted in an expansion in the dry harvest pea and bean areas and also in increased development of herbicides. Some of these materials may also be useful in vining peas and broad beans (Vicia faba) for processing (quick-freezing and canning) but here cultivars are often more sensitive to herbicides and a high level of weed control is desirable as Matricaria or Solanum nigrum seedheads or berries cause contaminant problems in produce.

Fomesafen, a herbicide with residual and post-emergence activity was discovered at ICI's Plant Protection Division, England and the properties are described by Colby et al., 1982. Mixtures of fomesafen and terbutryn have since been evaluated and results for efficacy and crop safety in dry harvest peas are published elsewhere in the proceedings (Lake et al., 1987).

This research report summarises experiments in the UK from 1985 to 1987 with fomesafen and terbutryn mixtures in vining peas and broad beans for processing.

MATERIALS AND METHODS

The mixtures of fomesafen/terbutryn used were coded as follows: FP278 (a 50% SC formulation at 100/400g a.i./l), and from 1986, FP282 (a 48% SC at 80/400g a.i./l). Pre-emergence applications in vining peas at a range of dose rates on different soil types were evaluated for broad-leaved weed control and crop tolerance in 1985 (FP278) and 1986 (FP282) and compared with standard herbicides terbutryn/terbuthylazine as a 350/150g a.i./l SC, and trietazine/simazine as a 402.5/57.5 g a.i./l SC formulation. The work was extended in 1987 to look at crop safety and timing of application at 5-10%, and 50-70% crop emergence for FP282, compared with trietazine/simazine, the only pre-emergence residual herbicide with a UK label recommendation for safe application up to 5% pea emergence. In 1987 FP282 applied pre-emergence was also assessed for crop tolerance of broad bean Beryl, a sensitive cultivar, in comparison with terbutryn/terbuthylazine, trietazine/simazine and simazine also as a 500g a.i./l SC formulation. The site details are shown in Table 1.

At all sites seed was covered by 34 cm of settled soil, and seedbeds

were rolled except at sites 2, 6 and 8. Herbicides were applied pre-emergence of the crop at sites 1,2,3,4,5,6 and 9 at a stage when seed was swollen but no radicle was apparent with the exception of sites 2 and 9 where the seed was dry. At site 7 the first treatments were applied pre-emergence at dry seed stage, later timings were at 5-10% of the crop at emergence stage, and at 60-70% of the crop at emergence stage when some of the plumules had become green but no leaves were unfolded. At site 8 the first timing was pre-emergence when a radicle had formed but no plumule. Heavy rain followed by dry conditions caused soil to 'cap', resulting in delayed crop emergence. Later timings were at 5% of the crop at emergence stage, and 50% of the crop at emergence stage with a small proportion at 1st node stage.

TABLE 1

Site details

Site No./ Location	Soil type	Cultivar	Date sown	Herbicide applied DAS*
1985		Vining pea		
1. Thornhaugh	Sandy silt loam	Sprite	20/6	5
2. Grimston	Sandy loam	Sprite	3/4	1
3. Deeping	Silty clay loam	S.S. Freezer	30/4	10
1986				
4. Thornhaugh	Fine sandy loam	Scout	25/3	2
5. Holbeach	Fine sandy silt loam	Sprite	11/3	15
6. Deeping	Organic silty clay	Bikini	2/5	6
1987				
7. Thornhaugh	Sandy loam	D.S. Perfection	13/4	1,11,13
8. Holbeach	Fine sandy silt loam	Sprite	31/4	10,20,24
		Broad bean		
9. Thornhaugh	Sandy loam	Beryl	21/4	0

* DAS = Days after sowing

Data presented were obtained from replicated small plot experiments of randomised block design with three or four replicates. Plot size was 2 x 5m. All treatments were applied using a van der Weij plot sprayer with Birchmeier cone nozzles delivering 220 l/ha at a pressure of 210 kPa.

Broad-leaved weed control was assessed by quadrat counts of 3 x $0.33m^2$ quadrats per plot for each species present. After full emergence crop plant counts were carried out. Crop tolerance was assessed by scoring visible damage. Pea yields at the green quick-freezing or canning stage of maturity were determined by hand harvesting and vining with a plot viner. Maturity of the peas was tested with a Martin Pea Tenderometer. Samples of produce treated with the highest rates of FP282 were canned and quick-frozen and submitted to Campden Food Preservation Research Association for taint testing.

In cultivar susceptibility experiments FP282 was applied at 3.8 kg a.i./ha in 1986 and at 4.8 kg a.i./ha in 1987 to a range of commercially grown and new vining, edible-podded, picking and dry harvest pea cultivars,

and at 4.8 kg a.i./ha in 1987 to broad bean and spring sown field bean cultivars. The method used was that described by King, 1980. FP282 was applied pre-sowing and incorporated to induce root uptake and hence crop damage, and comparisons were made with standard varieties and with standard herbicides terbutryn/terbuthylazine in peas, and simazine in beans applied at four times normal rates for the soil type.

RESULTS

Crop tolerance of vining peas

Results for pre-emergence application of fomesafen/terbutryn formulations and standard herbicides are presented for crop effects, yield and maturity in Table 2 (1985) and Table 3 (1986). Counts of pea plant populations showed that herbicide treatments applied pre-emergence did not reduce plant stand compared with the untreated at any site. There were no visible crop effects from fomesafen/terbutryn at sites 2 and 3 and damage was negligible at site 1 where temporary chlorosis and stunting of peas was observed on plots treated with FP278 at 1.25 kg a.i./ha. There were no statistically significant differences in yield between treated and untreated peas at any site, possibly because weed populations were low except at site 5 and here vigorous pea growth suppressed the weeds. Effects of herbicide treatment and weed control on pea maturity were non-significant, or at sites 1 and 5 were negligible in practical terms.

Results for crop effects and yield and maturity data for timing of application trials in 1987 are presented in Table 4. As in previous experiments FP282 applied pre-emergence showed a wide margin of crop safety even at 2.4 kg a.i./ha. However FP282 caused damage to the emerged and emerging crop in the form of necrosis on leaf margins, and crinkling and distortion of the leaves and these effects were attributable to the fomesafen component of the compound rather than the terbutryn which causes chlorosis in peas. Although damage was at an acceptable level for FP282 applied when 5-10% of the crop was at emergence stage, peas treated at this stage by the standard trietazine/simazine showed few effects. Effects were more severe and damage unacceptable from FP282 at 1.2 and 2.4 kg a.i./ha at the latest timing, with stunting and some plant death at site 8 as indicated by statistically significant reduction in plant population compared with untreated plots. The twice normal rate of trietazine/simazine applied when 50% or more of the crop emerged also caused severe visible damage. However, the visible effects were not reflected in pea yields or maturity and there were no significant differences between treated and untreated plots.

Crop tolerance of broad beans

There were few visible damage effects from pre-emergence applications of FP282 or standard herbicides in broad bean cultivar Beryl which is often sensitive to simazine, possibly because there was little herbicide leaching during the dry weather conditions which followed application. There were no reductions in plant stand from FP282 which appeared very safe to broad beans, while simazine at 1.7 kg a.i./ha gave a slight but significant reduction compared with untreated plots.

Broad-leaved weed control in vining peas

Results for efficacy of broad-leaved weed control overall and weed counts for individual species are presented for the pre-emergence herbicide experiments in Table 2 (1985) and Table 3 (1986). Data is not shown for site 6 where conditions were dry and only a few potato seedlings emerged

which were not controlled by any treatment. With the exception of site 5, weed populations were low, but included the main species usually found in pea crops.

In the 1985 experiments control of Bilderdykia convolvulus, Polygonum aviculare, Veronica persica and Chenopodium album was poor or variable for FP278 at the lower rates and was inferior to standard herbicides terbutryn/ terbuthylazine and trietazine/simazine at sites 1 and 2. At site 3, where Stellaria media was the predominant species, FP278 at 1.00 kg a.i./ha and below was ineffective and here trietazine/simazine also gave an unacceptable level of weed control. FP278 at rates of 1.25 kg a.i./ha on light, and 2.00 kg a.i./ha on medium soil appeared to give an acceptable level of weed control but no better than the standard terbutryn/ terbuthylazine. FP278 appeared effective against Solanum nigrum, Matricaria spp., Viola arvensis and Fumaria officinalis which occurred at low populations.

In the 1986 experiment a revised formulation, FP282, a 48% SC with fomesafen/terbutryn 80/400 g a.i./l was used. At site 5 all treatments gave good control of high populations of Urtica urens, Polygonum persicaria, B. convolvulus , Matricaria spp. and V. persica, but at site 6 FP282 at 0.72 kg a.i./ha was inadequate for control of P. aviculare. While FP282 at 0.96 kg a.i./ha and above gave acceptable weed control, no treatment performed better than terbutryn/terbuthylazine at normal rate.

In the 1987 timing experiment (Table 4), 1.2 and 2.4 kg a.i./ha of FP282 at all timings performed better in control of early germinating S. nigrum, the predominant species at site 7, and on B. convolvulus at site 8, than the normal and twice normal rates of trietazine/simazine. Both materials gave some control of weed beet (Beta vulgaris). FP282 had some contact action on emerged weeds at the later timings and achieved better weed control than pre-emergence applications.

Broad-leaved weed control in broad beans
FP282 at 1.2 kg a.i./ha performed better overall than normal rates of the cheapest pre-emergence herbicide simazine, was comparable to trietazine/simazine, but not as effective as terbutryn/terbuthylazine. Control of B. convolvulus was poor particularly for simazine applications. FP282 was less effective than other treatments on S. media.

Cultivar susceptibility
Results for susceptibility tests in 1986 and 1987 indicated that most cultivars of vining, edible-podded and dry harvest peas were classified as tolerant or highly tolerant to FP282. Exceptions were Vedette and Printana dry harvest peas, Petila, a small-seeded vining pea, and Minerva, a forage type used for pigeon feed, which were all slightly sensitive, but a further years testing is required before a final classification is made. Cultivars appeared less sensitive to FP282 than to terbutryn/ terbuthylazine. In 1987, the first year of tests, all broad beans and spring sown field bean cultivars tested appeared tolerant or highly tolerant to FP282 including Beryl, Rowena and Minica normally sensitive to simazine. The only symptoms of damage in these crops from 4.8 kg a.i./ha rates of FP282 was slight leaf chlorosis.

DISCUSSION
In three years experiments in vining peas and one year in broad beans,

excellent selectivity was shown for pre-emergence applications of fomesafen/terbutryn mixtures including fomesafen/terbutryn 80/400 g a.i./ha as the 48% SC formulation FP282, now developed in some countries. Many cultivars of vining, edible-podded, picking and dry harvest peas, field beans and broad beans appear tolerant to FP282 at high rates of 4.8 kg a.i./ha and none tested so far appeared sufficiently sensitive to warrant exclusion from treatment.

In timing experiments in vining peas the safety margin was reduced where FP282 was applied when 5-10% of the crop was at emergence stage, and visible damage was unacceptable when 50-70% of the crop was at emergence stage. This damage was not reflected in yields, however. Fomesafen and terbutryn both have contact action and thus the FP282 mixture does not appear to have the same flexibility of timing as trietazine/simazine which has a UK label recommendation for application up to 5% pea crop emergence.

The results indicated a need for a minimum dose of FP282 of 1.2 kg a.i./ha (fomesafen/terbutryn 200/1000 g a.i./ha) on a light soil and 1.44 kg a.i./ha (fomesafen/terbutryn 240/1200 g a.i./ha) on a medium soil to give acceptable weed control and higher doses may be necessary to consistently achieve a similar level of control to terbutryn/terbuthylazine. FP282 controlled a wide spectrum of weeds commonly found in pea crops such as C. album, U. urens, P. persicaria, P. aviculare, V. persica, P. annua, B. convolvulus and including weeds which can cause crop rejection of vining peas because of contamination of produce, Matricaria spp. (with flower heads) and S. nigrum (with poisonous berries).

No taints have been found so far in canned and quick-frozen samples of produce treated with FP282 in tests by Campden Food Preservation Research Association. Further data is required before taint clearance can be given.

FP282 is thus a promising new herbicide with a wide margin of crop safety when applied pre-emergence in peas and beans.

ACKNOWLEDGEMENTS

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TABLE 2

Weed assessments, population counts for main weed species and total including other species, crop assessments yield and maturity data for pre-emergence applications in vining peas at sites 1, 2 and 3 in 1985

Material‡	Rate kg a.i./ha (a)	(b)	Weed Score site: 1	2	3	Weed Counts/m² — 1 (16/5) P. aviculare	B. convolvulus	C. album	V. persica	Total	2 (23/5) V. persica	B. convolvulus	P. aviculare	Total	3 (14/6) S. media	V. persica	C. album	Total	Crop Score** 1 (18/4)	Yield shelled peas % untreated 1 (12/7)	2 (16/7)	3 (30/7)	Maturity Tenderometer Reading 1 (12/7)	2 (16/7)	3 (30/7)
			date: 7/7	9/7	30/7																				
terb/terb	1.15	1.40	9	10	8	2	3	0	0	5	0	3	0	3	15	1	0	21	10	98	88	106	92	111	97
terb/terb	2.30	2.80	10	10	9	0	1	0	0	1	0	0	0	0	2	1	0	5	8.2	91	80	105	92	113	97
triet/sim	1.20	1.20	8	10	5	3	3	0	0	6	0	5	1	11	24	6	2	45	10	110	93	105	92	110	96
FP 278	0.50	0.62	4	5	4	12	2	0	0	14	12	8	1	25	42	4	3	60	9.5	94	98	105	93	113	97
FP 278	0.62	0.75	5	6	5	7	4	0	1	11	6	4	1	13	42	4	1	57	9.0	108	86	105	91	113	97
FP 278	0.72	1.00	6	8	6	6	2	0	2	10	5	3	1	10	36	3	2	47	8.5	89	98	104	95	113	97
FP 278	1.25	2.00	7	9	8	6	1	0	0	7	1	1	0	2	16	1	1	20	7.7	98	96	106	95	113	94
untreated	–	–	0	0	0	23	4	7	9	46	35	10	5	69	42	4	3	69	10	100	100	100			
Yield of untreated (tonnes/ha)																				4.5	6.3	4.3			
Significance @ P = 0.05																			NSD	NSD	NSD	NSD	SD	NSD	NSD
LSD @ P = 0.05																			–	–	–	–	2.7	–	–
S.E. as % general mean																			10.0	20.4	4.6		1.7	3.0	1.8

‡ FP 278=fomesafen/terbutryn (100/400)g a.i./l as a % SC formulation; terb/terb=terbutryn/terbuthylazine; triet/sim = trietazine/simazine.

* Dose rates (a) were based on light soils at sites 1 and 2, rate (b) on medium soil at site 3

Key: Crop Score 10 = no visible damage, 7 = acceptable damage, 0 = crop killed
Weed Score 10 = complete control, 7 = acceptable control, 0 = no control

**Crop Scores 10 for all treatments and untreated assessed on 10/5 at site 2 and on 2/6 at site 3

TABLE 3

Weed assessments, population counts for main weed species and total including other species, crop assessments, yield and maturity data for pre-emergence applications in vining peas at sites 4, 5 and 6 in 1986

Material✚	Rate* kg a.i./ha (c)	(d)	Weed Score site: 4 / 29/6	Weed Score site: 5 / 30/6	P.aviculare (4, 23/5)	P. annua	Matricaria spp.	Total	U. urens (5, 22/5)	P. persicaria	B. convolvulus	Matricaria spp.	V. persica	Total	Crop Score 4 / 2/5	Crop Score 5 / 7/5	Crop Score 6 / 30/5	Yield 4 / 8/7	Yield 5 / 11/7	Yield 6 / 23/7	Maturity 4 / 8/7	Maturity 5 / 11/7	Maturity 6 / 23/7
terb/terb	1.15	1.40	10	10	0	0	0	1	0	0	0	0	0	1	9.5	9.5	10	98	104	110	97	96	92
terb/terb	2.30	2.80	10	10	0	0	0	0	0	0	0	0	0	1	8.5	9.1	10	101	111	104	97	96	89
FP 282	0.72	0.96	4.0	8.5	7	2	1	12	0	0	0	0	0	2	10	9.5	10	100	103	108	98	96	94
FP 282	0.96	1.20	8.0	9.5	1	0	0	1	0	0	0	0	0	1	9.8	9.5	10	111	97	99	98	96	90
FP 282	1.20	1.44	8.5	9.8	1	0	0	1	0	0	0	0	0	1	9.8	9.5	10	103	107	109	98	96	90
FP 282	1.92	2.40	9.0	10	0	0	0	1	0	0	0	0	0	1	9.8	9.0	10	102	104	101	98	99	90
untreated	-	-	0	0	28	9	3	44	123	34	39	31	34	334	10	10	10	100	100	100	96	95	92

Yield of untreated (tonnes/ha) — 4.0 7.8 5.1

Significance @ P = 0.05
LSD @ P = 0.05 — NSD NSD NSD   NSD SD NSD
S.E. as % general mean

			Yield 4	Yield 5	Yield 6	Mat 4	Mat 5	Mat 6
Significance @ P = 0.05			NSD	NSD	NSD	NSD	SD	NSD
LSD @ P = 0.05			-	-	-	-	3.0	-
S.E. as % general mean			7.8	9.4	8.9	2.3	2.1	3.4

✚ FP 282=fomesafen/terbutryn 80/400g a.i./l as a 48% SC formulation;
  terb/terb=terbutryn/terbuthylazine

* Dose rates (c) were used on light soils at site 4 and (d) at sites 5 and 6

Key: Crops Score: 10 = no visible damage, 7 = acceptable damage, 0 = crop killed
      Weed Score: 10 = complete control, 7 = acceptable control, 0 = no control

CROP TOLERANCE TO TRIFLURALIN AND ISOXABEN, APPLIED ALONE OR IN MIXTURE WITH NAPROPAMIDE, AS LATE WINTER HERBICIDE TREATMENTS IN ESTABLISHED STRAWBERRY AND RASPBERRY

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ABSTRACT

Trifluralin and isoxaben were evaluated alone and in mixture with napropamide as potential surface-applied winter herbicide treatments in established strawberry and raspberry. At rates of 2 kg a.i./ha and above trifluralin adversely affected growth and yield of strawberry and delayed cane and sucker emergence in raspberry. Isoxaben had no phytotoxic effects on either crop at up to 0.8 kg a.i./ha. The addition of napropamide at up to 4 kg a.i./ha had no influence on the reaction of the crops to either trifluralin or isoxaben. Isoxaben alone or in mixture with napropamide is recommended for further development for use in these two crops.

INTRODUCTION

Soft fruit growers are becoming increasingly interested in extending the 'spraying window' for residual soil-applied herbicides to include application during the winter months. To be effective, herbicides applied at this time should be a) not readily leached by winter rains and b) sufficiently persistent to control spring-germinating weeds. Two candidate herbicides with these characteristics, trifluralin and isoxaben, were evaluated for crop tolerance in raspberry and strawberry.

Napropamide has already been shown to be a safe and effective herbicide for winter application in various soft fruit crops, but fails to control several important species (particularly brassica weeds) and may be too persistent in the soil, at the rate recommended, for use in the final years of a crop to be followed by cereals (Clay, 1984; Lawson & Wiseman, 1987; Mathews & Wright, 1984). In an attempt to broaden the spectrum of weeds controlled and to reduce the risk of residues of high rates of napropamide in the soil affecting the growth of subsequent crops, mixtures of this herbicide and other residual herbicides are being assessed. Crop tolerance to mixtures with trifluralin and isoxaben was examined in the current series of experiments.

MATERIALS AND METHODS

Four experiments were carried out at Invergowrie on a sandy loam soil with an organic matter content of 6-8% (as determined by loss on ignition). In the two strawberry experiments, plots consisted of single matted rows of cv Cambridge Favourite, 45 cm wide by 6.75 m long, with 45 cm alleys between rows. In the two raspberry experiments, plots comprised single stooled rows of cv Glen Prosen, each 9 m long and with 2 m alleys between rows. Both plantations were established in spring 1983. Plots were arranged in randomised blocks with four replications. All except the 1986 raspberry experiment had two untreated plots in each block.

Herbicide treatments were applied using an Oxford Precision Sprayer, with fan jets delivering a spray volume of 780 l/treated ha. In 1985 treatments were applied on 5 February (strawberry) and 28 February

(raspberry), while in 1986 the relevant dates were 7 March (strawberry) and 13 March (raspberry). Herbicides were applied to a 45 cm band centred on the strawberry row and 50 cm bands on either side of each raspberry row; the herbicides were not incorporated into the soil. No other residual herbicides were applied in any of the experiments. Weeds were removed by hand-weeding and shallow hand-hoeing along the rows and by shielded spray treatment with paraquat in the alleyways.

Trifluralin (as Treflan), isoxaben (as Flexidor - both Elanco Products Ltd) and napropamide (as Devrinol - Stauffer Chemicals Ltd) were applied at the rates and in the combinations shown in Tables 1 and 3.

RESULTS

In 1985, treatments were applied in mild weather, after a relatively mild winter. Treatments made in 1986 were delayed, due to hard frost and lying snow during the greater part of February. No new growth was evident in any experiment at the time of treatment.

1985 experiments

Treatment with trifluralin at 2 kg a.i./ha and above delayed, malformed and reduced foliage development and killed a proportion of crowns in strawberry plots in spring (Table 1). This resulted in reductions in truss numbers and hence in yield of fruit. At 4 and 8 kg a.i./ha, berry size was also reduced. Continuing adverse effects of higher application rates were recorded in truss counts taken in May 1986. In raspberry, trifluralin at 2 kg a.i./ha and above delayed and stunted emergence of suckers in the alleys and between the stools (Table 2). Young stool canes were less sensitive than suckers at all but the 8 kg a.i./ha rate. There was no evidence of any translocation into fruiting canes or of long-term suppression of vegetative cane growth.

In both experiments the addition of napropamide to trifluralin had no extra effect on crop growth or yield, regardless of rate of application. Any crop injury reflected the rate of application of trifluralin included in the mixture.

1986 experiments

Treatment with isoxaben, whether applied alone or in mixture with napropamide, caused no adverse effects on any aspect of vegetative development or fruit production in either crop within the eight-fold dose range tested (Tables 3 and 4).

DISCUSSION

These experiments confirmed the wide margin of safety to napropamide of both strawberry and raspberry reported earlier by Lawson & Wiseman (1987).

Trifluralin has a similar weed control spectrum, is less persistent in the soil (Walker et al, 1985) and is considerably cheaper in comparison with equivalent rates of napropamide. It is also already recommended as a pre-plant incorporated herbicide treatment for use in maiden strawberry and raspberry plantations in the United Kingdom. There would therefore have been several advantages to be gained if trifluralin could have been substituted for, alternated with, or mixed with napropamide for use in established crops. Mixtures are currently used in several brassica crops in the United Kingdom (Walker et al, 1985). However, the greater

phytotoxicity of trifluralin to both crops and especially to strawberry, when applied as a surface treatment, makes these options much less attractive. While the early effects on cane and sucker emergence in raspberry caused no reduction in total cane production in this experiment, the possibility of such a reaction would need to be examined in detail over a range of seasons and cultivars, before any recommendations could be formulated.

Isoxaben, by contrast, showed no evidence of phytoxicity to either crop at more than three times the rate of 250 g a.i./ha likely to be recommended for use in fruit (Elanco Products Ltd - personal communication). It controls a wide range of broad-leaved weeds, but is ineffective on several grass species (Drinkall & Ryan, 1984). It is relatively persistent and brassica crops are those most susceptible to residues of isoxaben in the soil (Huggenberger & Ryan, 1985). While isoxaben should readily find a place as a fruit herbicide in its own right, the complementary nature of the weed control ranges of isoxaben and napropamide and the absence of phytotoxic reaction by the crops to tank-mixtures suggest that combinations might achieve a very wide spectrum of weed control at rates of the two constituents below those which would pose problems for succeeding crops.

ACKNOWLEDGEMENTS

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Table 1

1985 Strawberry Expt. – Crop records

Treatment	kg a.i./ha	Ground≠ cover	Truss no. /plot	Fruit yield t/ha	Berry no./ truss	Overall mean wt g/berry	Mean harvest date∅	1986 truss no. /plot
Untreated		57	316	20.8	3.62	11.1	12.1	599
S.E. mean +		3.1	8.1	0.58	0.149	0.17	0.39	21.2
Trifluralin	1	54	319	20.7	3.75	10.6	11.5	634
	2	46	283*	18.7*	3.78	10.7	11.8	607
	4	33***	249***	16.9***	4.10	9.9***	11.2	556
	8	20***	207***	13.9***	3.98	10.1**	11.6	520*
Trifluralin + napropamide	0.5+0.5	66	339	21.5	3.54	10.9	12.2	589
	1 + 1	60	338	20.5	3.48	10.6	12.1	650
	2 + 2	44*	298	19.6	3.73	10.7	11.9	610
	4 + 4	29***	240***	16.4***	3.96	10.3*	12.0	558
S.E. mean +		4.4	11.5	0.82	0.210	0.24	0.55	30.0
Sig. of effect								
T linear		+++	+++	+++	NS	+	NS	++
T+N linear		+++	+++	+++	NS	NS	NS	NS
T+N (at equivalent rates)	NS	NS	NS	NS	NS	NS	NS	NS

*, **, *** – Significantly different from untreated at the 5%, 1% or 0.1% level.

+, ++, +++ – Effect significant at the 5%, 1% or 0.1% level.

NS – not significant.

≠ – % ground cover by new leaves mid-May.

∅ – days after 9 July.

Table 2

1985 Raspberry Expt. - Crop records

Treatment	kg a.i./ha	Vigour Score (10-0) 30 April Stool canes	Suckers	Fruit yield t/ha	Yield g/metre of cane	Mean wt(g) /100 berries	Cane production /plot Total no.	Mean ht(cm)
Untreated		10.0	10.0	9.20	46.4	318	186	143
Trifluralin	1	8.9	8.2	8.94	39.4	317	188	137
	2	10.0	7.6*	9.35	44.0	303	180	137
	4	7.6	5.9***	8.76	41.4	324	187	140
	8	4.1**	4.6***	10.07	43.2	334	188	143
Trifluralin +	0.5+0.5	9.4	9.4	9.29	40.1	325	192	142
napropamide	1 + 1	8.4	8.6	9.48	44.8	309	182	135
	2 + 2	8.6	5.5***	9.77	45.2	324	177	135
	4 + 4	6.8	5.1***	9.95	43.1	328	176	139
S.E. mean +		1.30	0.75	0.501	2.85	11.1	9.5	3.6
Sig. of effect								
T linear		++	+++	NS	NS	NS	NS	NS
T+N linear		NS	+++	NS	NS	NS	NS	NS
T+N (at equivalent rates)		NS	NS	NS	NS	NS	NS	NS

Key - see Table 1.

Table 3

1986 Strawberry Expt. - Crop records

Treatment	kg a.i./ha	Ground# cover	Truss no. /plot	Fruit yield t/ha	Berry no./ truss	Overall mean wt g/berry	Mean harvest date∅	1987 truss no. /plot
Untreated		68	600	21.3	2.46	9.0	10.4	283
S.E. mean ±		2.3	26.7	1.01	0.150	0.21	0.27	13.1
Isoxaben	0.1	71	631	22.2	2.45	8.8	10.1	282
	0.2	74	631	22.5	2.51	8.7	10.0	288
	0.4	72	616	25.7	2.86	8.9	10.5	272
	0.8	71	610	22.5	2.45	9.2	10.2	256
Isoxaben +	0.05+0.5	68	562	22.5	2.76	8.8	10.2	269
napropamide	0.1 +1	78	616	24.6	2.70	9.3	11.3	302
	0.2 +2	70	537	20.9	2.75	8.5	10.0	237
	0.4 +4	76	611	25.1	2.87	9.0	10.1	278
S.E. mean ±		3.3	37.7	1.43	0.212	0.30	0.38	18.5
Sig. of effect								
I linear		NS	NS	NS	NS	NS	NS	NS
I+N linear		NS	NS	NS	NS	NS	NS	NS
I+N (at equivalent rates)		NS	NS	NS	NS	NS	NS	NS

Key - see Table 1.

Table 4

1986 Raspberry Expt. - Crop records

Treatment	kg a.i./ha	Young canes 8 July No/ stool	Young canes 8 July Mean ht(cm)	Fruit yield t/ha	Yield g/metre of cane	Mean wt(g) 100 berries	Cane production /plot Total no.	Cane production /plot Mean ht(cm)
Untreated		16.1	82.9	8.47	158	372	182	121
S.E. mean ±		1.14	2.54	0.291	4.9	5.9	7.3	2.1
Isoxaben	0.1	14.6	81.0	8.28	158	355	160	118
	0.2	13.9	83.0	8.50	165	385	174	120
	0.4	15.9	80.0	8.51	167	365	169	121
	0.8	16.8	84.0	7.98	150	376	181	121
Isoxaben +	0.05+0.5	14.9	85.8	9.01	173	376	177	120
napropamide	0.1 +1	16.6	85.5	8.01	158	382	180	124
	0.2 +2	15.0	84.0	7.87	143	366	186	118
	0.4 +4	14.9	88.3	8.57	160	377	174	123
S.E. mean ±		1.61	3.59	0.412	6.9	8.3	10.3	3.0
Sig. of effect								
I linear		NS	NS	NS	NS	NS	NS	NS
I+N linear		NS	NS	NS	NS	NS	NS	NS
I+N (at equivalent rates)		NS	NS	NS	NS	NS	NS	NS

Key - see Table 1.

THE USE OF IMAZAQUIN IN THE MANAGMENT OF PLUM ORCHARDS

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ABSTRACT

Spring treatment with imazaquin alone 0.15 and
0.30 kga.i./ha and in mixture with pendimethalin
0.15 + 1.32 kg a.i./ha were carried out in field
trials in new plum orchards. The influence of
these herbicides on growth and on the contents of
leaf pigments were assessed together with weed
control.

INTRODUCTION

Imazaquin (AC 252,214) formulated as Scepter is a new
selective herbicide that can be applied for control of a wide
spectrum of broadleaved weeds and some grasses (Orwick et al,
1982; Umeda et al, 1983). According to Shander (1982) the
greenhouse results exibit a high degree of tolerance of soy-
bean to post-em. applications at 63-100g a.i./ha. Imazaquin
was reported as a reliable herbicide for weed control in toba-
cco (Lolas,1985). Prior to this paper there are no trials
which reported efficacy and selectivity of imazaquin in new
plum orchards.

The effect of imazaquin alone and in combination with
pendimethalin on weeds, on the growth of the newly planted
plum trees and on the contents of leaf pigments is reported.

MATERIALS AND METHODS

Experiment 1

During 1985-87 field trials were carried out on light
soils (o.m. 1.98%, pH 5.3). One, two and three years old plum
trees cvKustendilska were used. The experiment was laid down
after the standard method of Konstantinov (1952), replicated
three times, the area of test plot being 35 m^2 (7 x 5). Imaza-
quin was used at 0.15 and 0.30 kg a.i./ha. The treatments were
applied on 15 May 85, 13 May 86 and 6 June 87. Weed control
was assessed 40 and 90 d during 85, 86 and 30 d in 87 after
spraying.

Experiment 2

Field experiment were conducted in 1986-87 on a grey
forest soil (o.m. 1.87%, pH 6.2). One and two year old trees
cv Kustendilska, Stanley, Strinava and Gabrovska were used. All
treatments were applied on 23 April 86 and 22 April 87 to plots
of 20 m^2 (5 x 4). The trial was randomized block design with
four replicates. Imazaquin 0.15 kg a.i./ha alone and in mixture
with pendimethalin (Stomp 33% a.i.) 0.15 + 1.32 kg a.i./ha were
used. Weed control assessments were made on 4 June 86 and 28
May 87. The herbicides were applied each year to the same area
with a hand sprayer Solo 455E-ZESSUR at a volume rate 800 l/ha.
The soil was cultivated in advance. Weed control was assessed

by counting the individual weed species present in a 1 m^2 area in each plot. Crop tolerance was evaluated visually at intervals using the EWRS scale 0-9 (9-healthiest control; 7-obvious damage; 5-50% growth inhibition; 3-severe leaf damage; 1-all leaf dead; 0-plant dead). Trunk diameters (c. 30 cm from ground level) and growth of four branches of each tree were measured at the end of October during 85 and 86. The effect of herbicides on chlorophyll a, chlorophyll b and carotene content in the leaves was determined 30 and 60 d after treatment by a spectrophotometer using wave lenghts of 663, 664 and 452 nm respectively.

RESULTS AND DISCUSSION

Weed control

TABLE 1

Effect of imazaquin on the control of annual weeds

| Weed species | Mean percent control | | | | | |
| | 1985 | | 1986 | | 1987 | |
	*0.15	0.30	0.15	0.30	0.15	0.30
Amaranthus retroflexus	85	93	93	100	100	100
Chenopodium album	88	100	91	100	100	100
Daucus carota	87	100	-	-	-	-
Galinsoga parviflora	91	100	-	-	-	-
Polygonum lapathifolium	80	90	-	-	-	-
Setaria viridis	90	95	90	100	100	100
Sinapis arvensis	60	80	67	84	-	-

Mean no. of weeds m^2
in untreated plots

grasses	20		30		30	
broadleaved	71		40		32	

*Rate of imazaquin kg a.i./ha

The data from Table 1 and 2 shows clearly that imazaquin performed well in reducing the naturally occuring weed population by 60-95%. Complete control of Amaranthus retroflexus, Chenopodium album, Daucus carota, Galinsoga parviflora and Setaria viridis was achieved.

A combination of imazaquin with pendimethalin gave better control of weeds than imazaquin applied alone at rate 0.15 kg a.i./ha. Imazaquin 0.15 + pendimethalin 1.32 kg a.i./ha provided seson long weed control (Table 2).

TABLE 2

Effect of imazaquin alone and in combination with pendimethalin on the control of annual weeds.

Weed species	Mean percent control			
	1986		1987	
	*0.15	0.15+1.32	0.15	0.15+1.32
Amaranthus retroflexus	93	100	100	100
Fumaria officinalis	87	97	100	100
Setaria viridis	90	97	100	100
Sinapis arvensis	85	100	-	-
Stellaria media	60	80	-	-
Xanthium strumarium	80	100	80	95

Mean no. of weeds m^2
in untreated plots
grasses	30		25	
broadleaved	50		30	

*Rate of imazaquin and pendimethalin kg a.i./ha

Plum growth

The observation completed of plum trees growth indicated that no tree injury had occured following treatment with either imazaquin alone or in combination with pendimethalin. In addition no phytotoxic effect on leaves had occured with either treatment.

A significant effect of herbicide application due mostly toincreasing of growth on tree receiving soil applications of imazaquin o.15kg a.i./ha alone as well combination with pendimethalin 1.32 kg a.i./ha, has been observed (Figure 1). Imazaquin at rate 0.30 kg a.i./ha, in comparing with 0.15 kg a.i./ha, reduced the branch lenght by 6 cm during 1985 and 12 cm in 1986 (Exp. 1).

The trunk diameter of the plum tree grown on two years treated soil with imazaquin 0.15 kg a.i./ha was significantly more than that of untreated control (Figure 1).

Pigments content

Trials were carried out to determine the influence of imazaquin alone and in combination with pendimethalin on the content of the pigments in plum leaves. Analysis of the data (Table 3 and 4) shows that imazaquin alone or in combination with pendimethalin do not exert any essential influence on the chlorophyll or carotene contents of the plum leaves.
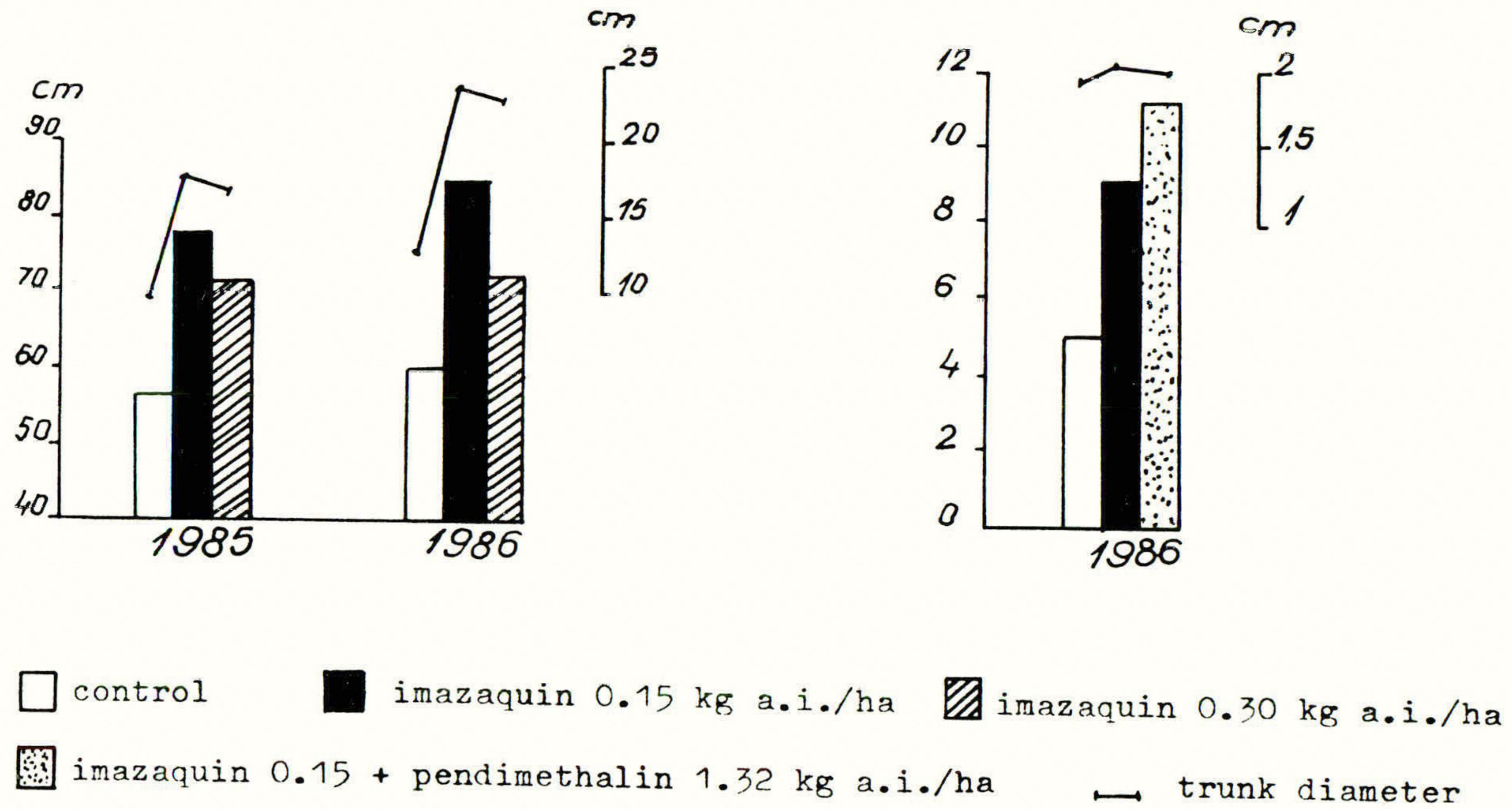
□ control   ■ imazaquin 0.15 kg a.i./ha   ▨ imazaquin 0.30 kg a.i./ha

▨ imazaquin 0.15 + pendimethalin 1.32 kg a.i./ha   ⊢⊣ trunk diameter

Fig. 1. Effect of imazaquin alone and in combination with pendimethalin
        on growth of brunches and trunk diameters

TABLE 3

Effect of imazaquin on content of pigments in plum leaves
mg/1 g fresh wt.

| Year | Rate kg a.i./ha | D A T* | | | | | |
| | | 30 | | | 60 | | |
		Chlorophyll a	b	Carotene	Chlorophyll a	b	Carotene
1985	Control	0.612	0.340	0.157	0.603	0.374	0.146
	A*0.15	0.602	0.277	0.111	0.522	0.365	0.128
	A 0.30	0.522	0.245	0.108	0.494	0.210	0.145
1986	Control	0.570	0.552	0.117	0.496	0.560	0.115
	A 0.15	0.516	0.496	0.087	0.458	0.545	0.090
	A 0.30	0.503	0.434	0.061	0.445	0.525	0.086
1987	Control	0.622	0.540	0.212	-	-	-
	A 0.15	0.542	0.532	0.175	-	-	-
	A 0.30	0.523	0.500	0.148	-	-	-

* D A T - Days after treatment
* A - imazaquin

TABLE 4

Effect of imazaquin alone and in combination with pendimetha-
lin on content of pigments in plum leaves mg/1 g fresh wt.

| Year | Herbicides rate kg a.i./ha | D A T* | | | | | |
| | | 30 | | | 60 | | |
		Chlorophyll a	b	Carotene	Chlorophyll a	b	Carotene
1986	Control	0.483	0.399	0.173	0.523	0.500	0.101
	A*0.15	0.535	0.496	0.140	0.458	0.602	0.150
	A 0.15 B*1.32+	0.523	0.500	0.139	0.540	0.571	0.116
1987	Control	0.665	0.486	0.170	0.686	0.478	0.212
	A 0.15	0.564	0.484	0.200	0.540	0.571	0.185
	A 0.15 B 1.32+	0.546	0.453	0.155	0.503	0.500	0.143

* D A T - Days after treatment
* A - imazaquin
* B - pendimethalin

The results of this work shown that imazaquin 0.15 kg
a.i./ha and imazaquin 0.15 + pendimethalin 1.32 kg a.i./ha
is a promising herbicide for pre-em. control of annual grass
and broadleaved weeds in managment of plum orchards.

ACKNOWLEDGMENTS

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ALLELOPATHY OF WEEDS IN VINEYARDS

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ABSTRACT

The weed flora of vines has changed considerably due
to the regular use of fertilizers, herbicides and me-
chanical cultivation methods. According to observation
and investigation we suggest that allelopathy plays an
important role in the control of weed succession of
vineyards. These effects have favoured some weeds such
as Agropyron repens, Cynodon dactylon, Digitaria san-
guinalis, Cirsium arvense and Conyza canadensis. Weed
control approaches to allelopathy was studied in our
examinations. D. sanguinalis and C. canadensis exert
sufficent allelopathic activity against some vine-
yards weeds to eliminate them from weed succession of
vineyards. Chlorogenic and sulfosalicylic acids, alle-
lochemicals of D. sanguinalis, exert their phytotoxi-
city on photosynthesis according to fluorescence in-
duction measurements.

INTRODUCTION

Allelopathy is a fast broadening area of chemical ecology
and according to our observations, it seems to play an impor-
tant role in control of weed succession of vineyards /Mikulás,
1976; Mikulás, 1981/, acting together with various human in-
terventions.

Current evidence indicates allelopathic inhibition most
often results from the combined action of several different
chemicals. A specific allelochemical may be present at a con-
centration below its growth inhibition threshold and still af-
fects growth. Several combinations of allelochemicals have been
shown to have either additive or synergistic action /Einhellig,
1987/.

An important aspect concerning allelopathy is that its ef-
fect depends on chemical compound being added to the environ-
ment. Evidence indicates that allelopathic compounds are re-
leased from plants by volatilization /Elakovich, 1987/, exu-
dation from roots /Stevens and Tang, 1985/, leaching from
plants or residues by rain /Kanchan and Jayachandra, 1980/, or
decomposition of residues /Chou and Patrick, 1976; Rice, 1984/.

Allelochemicals, chemical compounds produced by a plant
species may operate directly on another plant species, indi-
rectly on its symbiotic organisms, or through modification of
the ecosystem.

The role of human activity may be surprising when using
additional chemicals to the plant ecosystem. Mikulás /1976/
found heavy Sorghum halepense infestation on maize fields with

soils of high seed content of Amaranthus retroflexus but with no plants of this species present. After destroying S. halepense the fields became covered by A. retroflexus in more than 80 % of total but with only few seedlings of S. halepense.

The first part of our work reported here was to investigate biological effects by means of laboratory test methods. Most workers using biotests for allelopathic investigations employ specially sensitive plant species as indicator plants. In this study, however, both donor and acceptor plant species were chosen from the same ecosystem. C. arvense, C. canadensis and D. sanguinalis were used as donor weed species examined in such biological situations during this study. A. retroflexus, Ambrosia elatior, D. sanguinalis, Chenopodium album, Lepidium sativum and C. canadensis appeared as test plant species. Extracts of different plant parts and phenolic acids found in such extracts were used for these investigations.

The second area of study was the investigation of possible mechanisms affecting germination and plant development. Ferulic, vanillic and p-coumaric acids can depress chlorophyll content /Einhellig and Rasmussen, 1979/ and extracts or leachates from allelopathic weeds may also depress chlorophyll /Kanchan and Jayachandra, 1980; Colton and Einhellig, 1980/. It follows therefore that such reactions would inhibit photosynthesis. Among different possible approaches the investigation of the effects on the photosynthetic apparatus /photosystems/ was chosen for this study and this was made by means of fast fluorescence induction, a dynamic instrumental method. There are several publications in this area /Einhellig and Rasmussen, 1979; Colton and Einhellig, 1980; Moreland and Novitzky, 1987/ however further efforts are needed to understand possible roles of allelochemicals at the biochemical level.

The third part of our study involved the application of weed-weed allelopathic interactions in manipulated agricultural ecosystem. Investigations using either whole plants in the fields or allelochemicals produced by means of microorganisms or plant tissue cultures /Bu'Lock et al., 1955; Norton and Towers, 1986/ were employed.

MATERIALS AND METHODS

Plant materials
Weed plants were grown under field condition near Kecskemét, Hungary. The plants were harvested at several stages of growth and broadleaved plants separated into leaf, stem and root tissue. The grass plant D. sanguinalis was separated into leaf and root tissue.

Seed germination
Effects on seed germination were evaluated with extracts of dried tissue prepared by shaking 10 g of ground tissue with 100 ml distilled water for 48 h at 25 °C. The extracts were filtered and 10-fold dilutions prepared. A hundred seeds were placed in Petri dishes containing the test substance. Germination was registered after 7 d at 25 °C.

Growing test

Seeds of L. sativum were germinated in Petri dishes containing water extracts of D. sanguinalis at 20 $^{\circ}$C. Lengths of the roots were measured after treatment for 72 h.

Field experiments

Weed supression effect of C. canadensis and D. sanguinalis desiccated with paraquat in vineyards plots /10m^2/ was examined. Percentage emergence of eight vineyards weeds in response to residues of C. canadensis and D. sanguinalis was also investigated.

Fluorescence induction measurements

In order to study the effect of allelochemicals of D. sanguinalis on photosynthesis detached leaves of C. album were treated with chlorogenic acid 10^{-4} M, sulfosalicylic acid 10^{-4} M and water extract /30 mg/ml dry wt/vol/ respectively.

Fluorescence induction measurements on excised leaves were carried out with a laboratory built apparatus after a 30 min dark adaptation /Lehoczki et al., 1984/. A xenon lamp of 650 W was used to produce the actinic beam. Blue actinic light of 5 mW/cm^2 intensity was transmitted by a Schott BG 12 filter /Schott, Mainz, FRG/. The opening of the shutter was completed within 2 milliseconds /ms/. Fluorescence emitted at 90 $^{\circ}$C was detected with a photomultiplier through a red SIF 675 interference filter /VEB C. Zeiss, Jena, GDR/ and recorded with a transient recorder. The dwell time between 1024 samplings was 1 ms and 300 ms in the fast and slow fluorescence induction measurements, respectively. In each experiment, 16 independent curves were recorded and averaged automatically with an averaging unit attached to the transient recorder.

RESULTS

Germination and growing tests

The germination of the important broadleaved weed of vineyards, A. retroflexus in response to extracts is shown in Table 1.

TABLE 1

Germination response of Amaranthus retroflexus seeds to water extracts of Conyza canadensis, Digitaria sanguinalis and Cirsium arvense

| Weeds | Germination as percentage of control | | | | | |
| | Undiluted | | | 1/10 Dilution | | |
	Leaf	Stem	Root	Leaf	Stem	Root
Conyza canadensis	35	82	63	47	105	82
Digitaria sanguinalis	-	-	11	-	-	24
Cirsium arvense	27	-	9	39	-	17

Water extracts of C. canadensis leaves, D. sanguinalis roots
and C. arvense roots are sufficiently strong to inhibit ger-
mination of A. retroflexus. Root extracts of C. arvense and
D. sanguinalis proved to be particularly efficient. As shown
in Table 2 C. canadensis also displays an inhibitory effect on
its own seed germination.

TABLE 2

Autotoxic effect of Conyza canadensis crude extracts on its
own germination

Tissue	Germination as percentage of control		
	Undiluted	1/10 Diluted	1/100 Diluted
Leaf	5	12	28
Stem	34	58	97
Root	12	26	51

The growth inhibitory effect of D. sanguinalis on L. sativum
is presented in Table 3. An increase in concentration of ex-
tracts caused a reduction in root growth of L. sativum.

TABLE 3

Effect of D. sanguinalis root extracts
on growing of L. sativum

Dry matter content of extracts /ug/ml/	Root length of L. sativum
0.0	46.4
1.9	42.7
3.8	38.5
7.5	36.3
15.0	25.0
30.0	19.0
37.5	19.0

Field experiments
     Residues of D. sanguinalis and C. canadensis produced by
desiccation can act as weed supressors in vineyards /Table 4/.

TABLE 4

Weed supression of C. canadensis and C. sanguinalis in field plots of vineyards

Weed species	Reduction of weed dominance /%/	
	with C. canadensis	with D. sanguinalis
Amaranthus retroflexus	45	92
Chenopodium album	52	94
Conyza canadensis	90	NS
Digitaria sanguinalis	75	NS
Portulaca oleracea	100	98
Polygonum aviculare	50	75
Senecio vulgaris	63	NS
Setaria viridis	71	81

Effects on photosynthesis of phenolic type allelochemicals

It was observed that D. sanguinalis exerts sufficient al-lelopathic activity against some vineyards weeds to eliminate them from weed succession. Chlorogenic, isochlorogenic and sul-fosalicylic acids were identified in whole plant extracts /Rice, 1984/. In the study the possible mechanism of action of these allelochemicals was investigated. The photosynthetic electron transport capacities of the triazine resistant C. al-bum in the presence of chlorogenic acid, sulfosalicylic acid and whole plant extract of D. sanguinalis by means of fast fluorescence induction were characterized. It can be used as a sensitive assay of PS-II inhibitors /like phenol type herbici-des/ on photosynthesis. These investigations revealed that chlo-rogenic acid, sulfosalicylic acid and water extracts of D. sanguinalis caused alteration in the fluorescence characteris-tics kinetics of C. album /Fig.1/.

The values of the ratio $F_m - F_i / F_m$ calculated from the fluorescence induction curves were 0.41 ± 0.03 and 0.010 ± 0.004 for the untreated and chlorogenic acid treated plants, respec-tively.

DISCUSSION

In the agroecosystem there are two types of chemical inter-ference from natural sources such as allelochemicals and synthe-tic sources such as herbicides /Einhellig, 1987/. According to our results, and those of others /Rice, 1984/, it was concluded that favoured weeds of vineyards have an allelopathic effect. It appears that C. canadensis, D. sanguinalis and C. arvense exert their phytotoxicity in germination and plant development. The inhibitory effect against weeds of vineyards was observed

in field experiments. Allelochemical action of C. canadensis and D. sanguinalis can synergize with the activity of herbicides. These weeds were selected by continued triazine herbicid treatment. Atrazine resistance or tolerance appeared. If C. canadensis and D. sanguinalis are destroyed by a contact herbicide its residues will act as an allelochemical and show inhibitory effect on its own seedlings or other weeds. Reduced or no tillage operation will result in increase of levels of allelochemicals. C10-polyacetylenes as allelopathic substances of C. canadensis were identified by Kobayashi et al. /1980/.

The effect of phenolic type allelochemicals on photosynthesis was investigated via fluorescence induction measurements. It is known that fast fluorescence induction gives information about the functioning of PS-II units, the redox state of the first stable quinone type electron acceptor of PS-II /Q/ and the rate of electron flow between Q and the plastoquinone /PQ/ pool, where the phenol type herbicides also act to prevent the electron transport from Q_A to Q_B without affecting the reduction of Q_A. The calculated ratio $F_m - F_i /F_m$ may be a useful measure for estimation of the rate of Q reoxidation. The values of the ratio $F_m - F_i /F_m$ were different for the control and treated plants indicating that the rates of Q_A-reoxidation was inhibited by allelochemicals. From these results, it was concluded that allelochemicals of D. sanguinalis act on photosynthesis.

In conclusion it is suggested that allelochemicals of some weeds in combined action with herbicides have a role to play in weed control strategy of vineyards.

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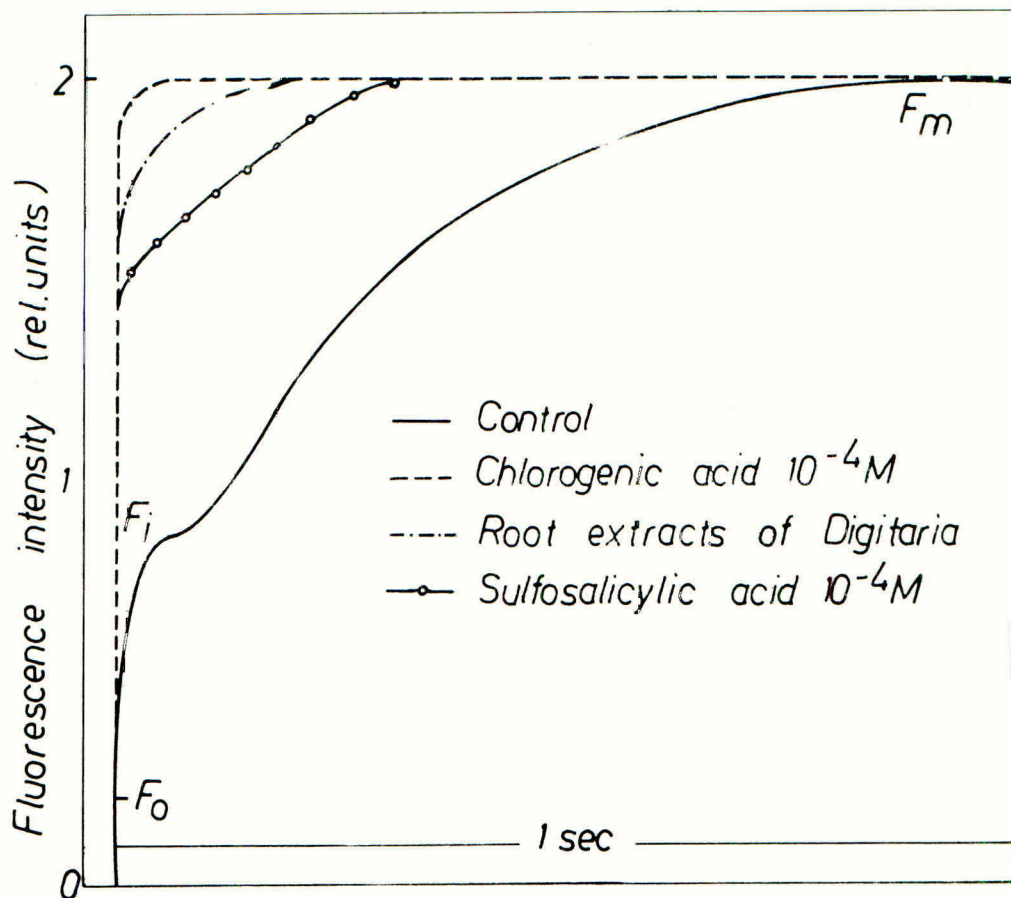
Fig.1. Fluorescence induction curves of excised <u>Chenopodium album</u> infiltrated with chlorogenic, sulfo salicylic acids 10^{-4} M and water extracts of <u>Digitaria sanguinalis</u> roots for 6 h.

Legend: F_o: initial fluorescence intensity;
F_i^o and F_m: fluorescence intensities at 40 ms and 1 s, respectively.

EXTENDED AVAILABILITY OF PROPACHLOR FOR HORTICULTURAL CROPS

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ABSTRACT

Extended delivery forms could be very useful in manipulating the
availability of soil applied herbicides giving less crop damage
early in the season and prolonging the period of weed control.
Leaching and other losses may be reduced. This paper describes
the design of kraft lignin-based formulations of propachlor
which modify and extend the availability of the active agent.
The characteristics of these formulations and their release
profiles in laboratory and soil environments are assessed. The
bioactive availability of the herbicide in soil was shown for
the lignin formulations to be more than 9 weeks when compared
with less than 3 weeks, under experimental conditions, for
conventional methods. Manipulation of soil concentrations could
improve the utilization of propachlor, and other herbicides, in
horticultural crops.

INTRODUCTION

Many soil-applied herbicides suffer losses in use due to breakdown,
leaching or evaporation. Persistent herbicides, on the other hand can
cause problems of leaching, pollution and carry-over effects in following
crops. The availability of soil-applied herbicides can be manipulated by
the use of controlled or slow release systems to provide localised soil
concentrations of the herbicide.

The residual herbicide, propachlor, provides an excellent example of
a short-lived herbicide with numerous minor crop applications including
brassicas, leeks, onions and strawberries. To provide protection for these
weed-susceptible crops throughout the growing period, expensive herbicide
programmes, often including propachlor applied pre-emergence, are needed
(e.g. in the case of leeks, Wiseman and Lawson, 1976). In the swede crop
where   long-lasting herbicides are needed, a herbicide programme is
expensive in relation to the value of the crop. An additional problem is
crop injury if rain follows applications of propachlor.

Improving the availability of propachlor could also help overcome the
critical timing of application in relation to weed emergence, as control by
propachlor after weed emergence is poor.

Thus, propachlor, as a soil-applied herbicide, could be improved by
formulation to regulate its availability to crop and weeds. Current
approaches to achieve this, and particularly for another chloroacetanilide,
alachlor, have been based on microencapsulation (Tsuji, 1987) but polymer
matrix methods offer advantages for granule formulations (Kydonieus, 1980).
The biological and physical properties of alkali lignins (Wilkins, 1984a)
can make these byproduct polymers useful as formulating bases for herbicide
granules, as shown with 2,4-D for forest weed control (Wilkins, 1981), and
also for simazine (Dellicolli, 1977).

The purpose of the work reported here was to investigate the preparation of lignin-based granule formulations of propachlor and to evaluate these for controlling the availability of the active ingredient, with potential for horticultural crops.

MATERIALS AND METHODS

Preparation of the lignin formulations

The kraft lignin matrix was prepared by mixing under melt conditions (Wilkins, 1984b). Technical grade propachlor was melted in an aluminium dish at 60-65° and powdered pine kraft lignin (Indulin AT, Westvaco Inc.) was added with stirring to produce a uniformly plasticised mix. This was formed and cooled to make a sheet (1mm thick) which was then cut into discs (10mm diameter) or cooled and granulated (0.5-1.0mm). Formulations were prepared containing from 20 to 50% propachlor.

Study of release kinetics

To determine the possible mechanisms involved in release of propachlor, discs of the formulation with known surface area and weight were prepared. Five discs of each formulation were weighed and placed in 200ml static distilled water at $30\pm 1°C$. The water was sampled (10ml) daily and then at every 5 days, with the volume maintained at 200ml by adding fresh water. The released propachlor was estimated at each time up to 60 days by UV spectroscopy of the sampled water at 260 nm. The reliability of this method was checked by analysing the remaining propachlor content of the discs by (a) weight loss of the dried discs, and (b) extracting the disc with acetone, and separating the propachlor from the lignin on alumina, using dichloromethane followed by ethyl acetate-hexane mixtures. The fractions were combined, the solvents removed and the extracted propachlor quantified by weight.

Persistence of availability in soil

The biological activity of propachlor in a friable soil of low organic matter was measured by using a bioassay based on the emergence of annual meadow-grass (Poa annua) seedlings. The response of P. annua to propachlor was determined by placing seeds in soil (200g dry weight) in pots treated with different levels of propachlor, replicated seven times. The pots (7.5cm diameter) were maintained in the greenhouse at 20°C, 75% relative humidity and continuous light. At 7 days, counts were made on the number of emerged seedlings more than 4mm long.

In a similar way the persistence of action in soil of the lignin formulations were evaluated. The treatments were:

10.6mg technical grade propachlor
26mg 40% propachlor-lignin granules (containing 10.6mg a.i.)
52mg 20% propachlor-lignin granules (containing 10.6mg a.i.)
0 control (no propachlor)

The granules were lightly mixed into the surface of the soil in the pots. Technical grade propachlor in acetone solution was pipetted evenly onto the soil and mixed in. Pre-soaked seeds (20 per pot) of P. annua were placed into the soil surface and emergence counts made 7 days later. Any seedlings that had emerged were removed and the pots were resown. This was repeated until the end of the experiment. The moisture content of the soil was maintained at 60% of field capacity, without causing any drainage. Treatments were replicated 5 times and placed in a randomised block design.

RESULTS

Compatability in formulation with lignin

The ability of the active agent to dissolve or plasticise the kraft
lignin can be predicted from a comparison of their respective solubility
parameters. Using Small's constants (Small, 1953), the calculated
solubility parameter for propachlor is 12.35 (density = 1.249, 20°). This
is close to the estimated solubility parameter for pine kraft lignin of
12.8 (Roberts, 1974). In fact, propachlor was compatible with kraft lignin
and readily formed a glassy matrix from 50 down to 20% active ingredient.

Release from disc formulations into water

The release of propachlor into distilled water is presented in
Figure 1. The release profile generated for each of the formulations is
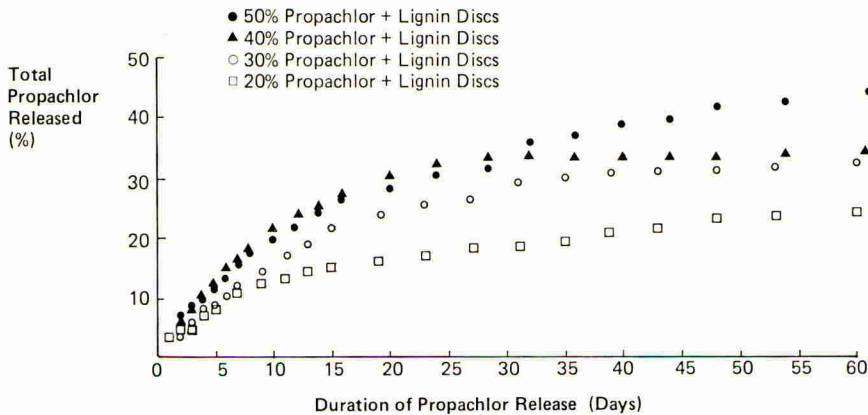
Figure 1. The cumulative release of propachlor from kraft lignin discs
into static distilled water

typical where diffusion within the matrix is the rate controlling step
providing an initial rapid rate followed by a gradually decreasing release.
This is shown for the 50% formulation in Figure 2, which following the
initial "burst effect", was releasing about 0.3% or 0.15mg/day under the
test conditions.

Persistence of propachlor availability from lignin granules in soil

The biological persistence of propachlor from lignin granules was
compared with a freely available application using a P. annua bioassay
conducted in pots. The inhibition of emergence of seedlings over a 9 week
period is shown in Figure 3. Both lignin granular formulations gave good
weed control throughout the test period. After 21 days, there was
significant (p = 0.05) difference between the means for the lignin
granules and the technical propachlor application. Although the experiment
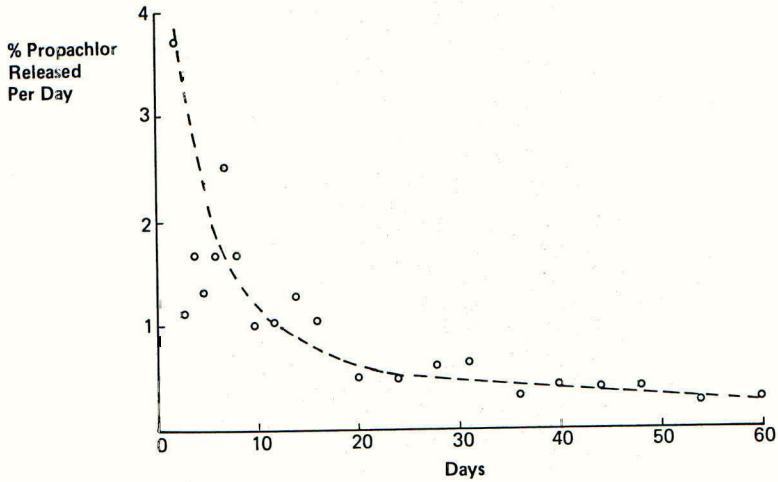was terminated at 63 days, good weed control is likely to persist
further.

Figure 2. The rate of release (percent per day) of propachlor from a 50% disc formulation into static water
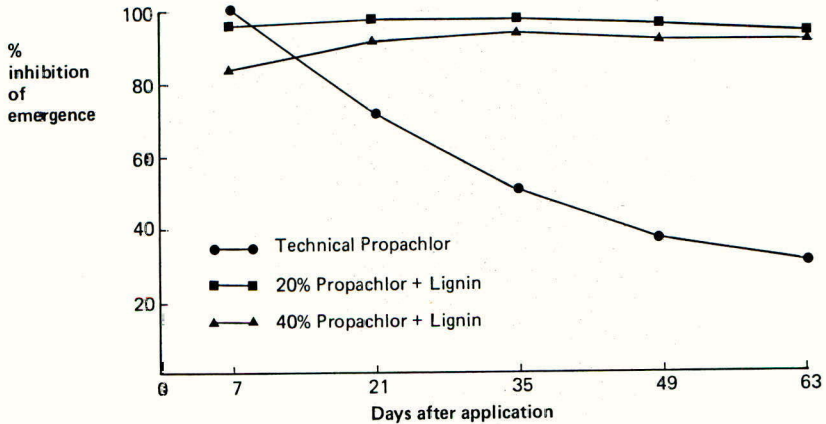

Figure 3. Inhibition of Poa annua emergence after soil treatment with different propachlor formulations.

Estimation of freely-available propachlor in soil

The results of the standardization of the P. annua emergence bioassay are represented in the equation (I). This is a regression of probit percent inhibition of emergence against log dosage of propachlor per pot. This regression allows estimation of the biologically-active amounts of herbicide available in the soil (mg per pot) using the relationship:

Probit % inhibition = 2.75 + 2.06 (log dose + 1)   (I)

with a correlation coefficient of 0.9999 and where the dosage causing 50% inhibition was 1.23mg per pot (95% confidence limits 0.71-2.11mg).

The amounts of freely-available propachlor in the soil for the three treatments are thus estimated as follows (Table 1).

TABLE 1

Amount of biologically-available propachlor in the surface soil at various times after application.

treatment	propachlor concentration,mg per pot (equivalent g/m^2)				
	days after application				
	0-7	14-21	28-35	42-49	56-63
tech. grade propachlor	10.58 (2.40)	1.76 (0.40)	1.22 (0.28)	0.91 (0.21)	0.76 (0.17)
40% propachlor-lignin	2.06 (0.47)	2.26 (0.51)	2.31 (0.52)	2.26 (0.51)	2.26 (0.51)
20% propachlor-lignin	2.31 (0.54)	2.38 (0.54)	2.33 (0.53)	2.28 (0.52)	2.28 (0.52)

Applied dosage: 10.58mg/pot propachlor. Area of soil surface in pot: 4.4 x 10^{-3} m^2. Estimated half-life of propachlor under test conditions: 14 days.

DISCUSSION

The use of lignins as controlled release formulating agents exploits their protective properties against light, biodegradation, water and evaporative loss. Propachlor is a short lived herbicide and can be easily formulated with kraft lignin without the need of processing aids. This is facilitated by the relatively high melting point of the active ingredient (67-76°C), in contrast to its analogue, alachlor, which melts at 40-41°C. However, the preliminary formulations described here are experimental only, with many practical requirements not considered.

The use of disc or sheet formulations for studying the release kinetics allows consideration of surface area relative to the size and is not intended for practical soil application, although there may be appropriate applications for tablet size herbicide dispensers, particularly for weed control in potted ornamentals (Ruizzo et al., 1983). Also, there are many different regimes for evaluating release rates in the laboratory and the use of static water has provided useful information for lignin systems in previous studies (Wilkins, 1984b). In practice, different rate controlling steps may operate depending on the nature of the microenvironment of the dispenser. Electron micrographic studies of the

depleted propachlor-lignin matrix indicated a progressive extension of a porous structure with propachlor release, suggesting a dissolution-diffusion process operating.

In the soil experiments the granular controlled release formulations showed no decline in high levels of control of P. annua for 9 weeks. Although high equivalent dose rates of propachlor were used, the technical grade application only gave control for less than 3 weeks. The release from the granules was clearly higher than from the discs used in the water immersion tests but none-the-less demonstrated extension in the active life of the herbicide. Thus the results of these preliminary pot tests indicate the potential for unsophisticated extended release formulations for propachlor, and other soil-applied herbicides and their possible application to a range of horticultural crops.

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