HGCA

PROJECT REPORT No. 161

INTEGRATION OF ROW WIDTHS AND CHEMICAL AND MECHANICAL WEED CONTROL IN WINTER WHEAT

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INTEGRATION OF ROW WIDTHS AND CHEMICAL AND MECHANICAL WEED CONTROL IN WINTER WHEAT

by

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CONTENTS

INTEGRATION OF ROW WIDTHS AND CHEMICAL AND MECHANICAL WEED CONTROL IN WINTER WHEAT (LINK LK 0404, HGCA 0005/3/93A).

Abstract - J H Orson, ADAS, Oxford Spires, The Boulevard, Kidlington, Oxford.

Mechanical weeding is often viewed as a desirable alternative to chemical weed control and a method of reducing the reliance of modern agricultural systems on pesticides. However, experiments throughout Europe have proven that many passes of the weeders are required resulting in high costs and often reduced yields caused by physical damage to the crop.

This LINK project (funded by MAFF and HGCA) tested the hypothesis that low rates of herbicides would predispose weeds to mechanical damage.

Candidate herbicides were evaluated in the laboratory at IACR Long Ashton for their effect on weeds at rates significantly lower than those recommended on the product label (Section 2 of this report). Measurements were made on the effect of such rates on subsequent growth of weeds. Preference was given to those herbicides which do not appear to present a problem of pesticide movement to water and those which, at low rates, inhibit growth of weeds which were considered more difficult to control mechanically.

The most promising herbicides were then assessed for their ability, at low rates, to predispose weeds to mechanical damage in large containers and eventually in the field (Section 1 of this report). Field experiments were done at ADAS Boxworth, ADAS High Mowthorpe and IACR Long Ashton. It was concluded that for annual broad-leaved weeds, the application in the spring of 20% of the recommended rate of the appropriate herbicide (according to the weed present) 2-14 days before mechanical weeding provided adequate weed control. A higher rate may be required for cleavers control. The approach did not appear to be sufficiently robust for the control of annual grasses.

The machines used in the experiment were tined finger-weeders. These do not discriminate between crop row and inter-row gaps. It was suggested that widening row spacing would provide more competitive crops within the sown row, reducing weed competition in this area and deflecting the tines of the weeder between the rows. The results suggest that re-arranging crop rows does not improve crop safety or the control achieved by this type of weeder.

Limited experimentation suggested that populations ground beetle numbers recovered more quickly from mechanical weeding than from herbicides. Hence, particularly in areas where there is a need to minimise pesticides, there is an incentive to pursue this type of weed control. The project suggests that winter wheat can be grown in rows wide enough to avoid a significant yield loss and allow image analysis to be exploited to steer an inter-row weeder. This approach, by avoiding crop damage, would allow for a more rigorous physical disturbance of the weeds between the rows while maintaining crop yield. Weed control in the crop row could be achieved by either herbicide seed dressings of the application of herbicide granules at drilling. Such an approach is being researched in a MAFF project which commenced in April 1997.

SECTION 1 - GENERAL INTRODUCTION AND FIELD EXPERIMENTS

A.M.Blair, ADAS Boxworth, Boxworth, Cambridge, CB3 8NN & J.C.Caseley, IACR Long Ashton, Bristol, BS18 9AF

Summary

Low rates of herbicide followed by overall mechanical weeding in winter or spring wheat have been investigated over 4 seasons at ADAS Boxworth near Cambridge, ADAS High Mowthorpe in N. Yorkshire and at IACR Long Ashton near Bristol.

Herbicides appropriate to use in this system were selected in experiments under controlled conditions with different weed species at Long Ashton. These herbicides tended to be those with a mode of action which stopped plant growth e.g. sulfonylureas.

In the field at Boxworth wheat seed rate was shown to be less important than other factors and hence was not included in subsequent years.

Changing crop row arrangement did not have a major affect on wheat yield until the row spacing was increased to 33cm. Twin rows (widely spaced double rows) resulted in satisfactory yields and more weed biomass compared to the standard row width.

Mechanical weeding before was less effective than after herbicide application in controlling weeds.

Herbicide applied at 20% of label rate followed by mechanical weeding generally gave comparable annual broad-leaved weed control to the full rate of herbicide alone. Such a system would help meet MAFF policy objectives of reduced agrochemical inputs while maintaining a competitive agriculture. However, annual grass weeds were much more difficult to control than broad-leaved weeds using this system. Mechanical weeding in the autumn/winter benefited annual grass weed control but not annual broad-leaved weed control.

Ground beetles numbers tended to be recover more from treatments which were mechanically weeded than from those which contained a herbicide but plot size was small.

A suggested system involving low rates of herbicide followed by mechanical weeding for future investigation is proposed.

Introduction

It is for both economic and environmental reasons, particularly the need to reduce the risk of herbicides contaminating ground water, that it is desirable to reduce herbicide use in cereals.

Any system combining mechanical and chemical weeding (Caseley *et al.*, 1993) would offer the industry an alternative approach to weed control in winter wheat. Mechanical weed control alone is very expensive, requiring many passes, and is not reliable. A combined approach with herbicides could cost the farmer more to achieve effective weed control but there may be specific situations where the minimum use of herbicides is required.

The four main objectives of this project were:

a) To select in controlled environments, low cost sub-lethal herbicide treatments which may pre-dispose weeds to mechanical weed control and then measure the duration of growth inhibition by herbicides on weeds treated at several growth stages under contrasting conditions. The most effective treatments would be followed by simulated mechanical cultivations. Preference would be given to those herbicides which were also less likely to leach to water (Section 2 of report).

b) To evaluate candidate herbicides in the field in order to produce a low cost method of weed control that integrates chemical and mechanical approaches.

c) To measure the effect of changing crop row arrangement on weed growth, on weed recovery from sub-lethal rates of herbicides with or without mechanical weed control and on yield and quality of winter wheat.

d) To establish sites where the results of the initial studies would be used to measure environmental and agronomic benefits from systems where row widths are integrated with mechanical and chemical weed control.

Field experiments in 1993 harvest year started in the spring and were designed to test the technique of applying herbicides with or without subsequent mechanical weeding (Blair & Green, 1993). In 1994 harvest year the influence of row width and seed rate at Boxworth, a range of herbicide and mechanical weeding treatments at High Mowthorpe and at a range of rates and row widths at IACR Long Ashton were investigated. In 1995 and 1996 standard and widely spaced double rows (hereafter referred to as twin rows) were compared at all sites with a range of herbicide and mechanical weeding treatments. In 1996 pitfall traps were inserted in some plots to measure the effect of treatments on ground beetle numbers.

SECTION 1 - FIELD EXPERIMENTS

Materials and methods

Experiments were sited at ADAS Boxworth near Cambridge on a clay soil, at ADAS High Mowthorpe in North Yorkshire on silty clay loam with flints and at IACR Long Ashton near Bristol on a very fine sandy loam. Experiments were done for 4 seasons between harvest years 1993 and 1996.

Seedbeds were prepared as appropriate to the site and season and the sites managed according to the local best practice for nutrition, disease and pest control. Any overall herbicide applications will be detailed where appropriate.

The experiment layout at all sites was a randomised block design. The choice of herbicide for each site and year was made on the basis of the weeds present and as a result of the herbicide screening (Section 2). A mechanical weeding is defined as one pass in each direction. Tined mechanical weeders were used at all three sites. These imposed overall treatments, there being no discrimation between crop rows and inter-row gaps.

Boxworth site:

Winter wheat (WW) was drilled at Boxworth in October each year (Table 1.1). The variety varied between years. Different drills or drill-heads were used to obtain the different row configurations and densities, although the same drill was always used for all treatments in each experiment (Table 1.2). The actual choice of row widths was in some cases limited by the inflexibility of the drill.

Table 1.1 Boxworth site details.

	1993	1994	1995	1996
Crop	WW	WW	WW	WW
Variety	Soissons	Mercia	Hereward	Soissons
Drill date	30 Oct 92	25 Oct 93	18 Oct 94	16 Oct 95
Spray date	26 Mar 93	12 May 94	10 Apr 95	25 Apr 96
Weeding date GS30	16 Apr 93	-	21 Apr 95	-
Weeding date GS32	4 May 93	14 May 94	-	1 May 96
Drill	Accord	Accord	Fiona	Fiona
Plot size (m)	8 by 12	12 by 12	8 by 12	24 by 24
Replication	3	3	3	3

The predominant broad-leaved weeds at Boxworth are those typical of heavy soils, *Stellaria media* (common chickweed), *Veronica* spp. (speedwells) and *Galium aparine* (cleavers).

Table 1.2. Wheat row widths and seed rates at Boxworth.

Harvest year	Row width (cm)	Seed rate (kg/ha)
1993	12.5	180
1994	12.5	200
	16.6	200
	25.0	133,200,266
	33.0	200
	9.0 / 16.0*	133,200,266
1995	12.5	170
	10.0 / 25.0*	170
1996	12.5	175
	9.0 / 25.0*	175

* twin rows

Herbicide treatments (see appropriate Tables) were applied using a tractor mounted sprayer delivering a total volume of 200 l/ha. Mechanical weeding treatments were done using a 12m wide Einböck tine weeder. Plot size varied between years (Table 1.1).

Yields were measured using a Sampo plot combine with a 2.44m wide cut and are expressed at 85% moisture. Specific weights (at 85 % moisture) and thousand seed weights were also recorded. Details of other assessments are given with the appropriate Tables.

High Mowthorpe site:

In the first two seasons standard row widths were established at High Mowthorpe but in the subsequent seasons both the standard and the twin rows were used.

Table 1.3. High Mowthorpe site details.

	1993	1994	1995	1996
Crop	WW	WW	WW	WW
Variety	Mercia	Riband	Mercia	Buster
Seed rate	165	190	179	192 / 194
Drill date	9 Oct 92	23 Oct 93	17 Oct 94	25 Sept 95
Spray date	27 Apr 93	23 May 94	23 Jan 95	14 Nov 96
	11 May 93	6 June 94	30 May 95	5 June 96
	-	-	5 June 95	-
Weeding date	23 Apr 93	23 May 94	15 May 95	21 May 96
	4 May 93	6 June 94	5 June 95	-
	-	-	31 May 95	-
Drill	Accord	Accord	Accord	Accord
Plot size (m)	6m x 24m	12m x 18m	12m x 12m	24m x 24m
Replication	3	3	3	3

The predominant broad-leaved weeds at the High Mowthorpe were *S.media* (common chickweed), *G.aparine* (cleavers), *V.persica* (common field speedwell) and *Papaver rhoeas* (poppy).

Table 1.4. Wheat row widths and seed rates at High Mowthorpe.

Harvest year	Row width (cm)	Seed rate (kg/ha)
1993	12.0	165.0
1994	12.0	190.0
1995	12.0	179.0
	10.5 / 26.5*	179.0
1996	12.0	192.4
	10.5 / 25.0*	194.0

* twin rows

Herbicide treatments (see appropriate Tables) were applied and mechanical weeding done in the same way as at the Boxworth site but plot size varied between years.

Yields were measured using a Sampo plot combine with a 2.2m wide cut and are expressed at 85% moisture. Specific weights (at 85 % moisture) and thousand seed weights were also recorded. Details of other assessments are given in the appropriate Tables.

Long Ashton site:

At Long Ashton spring wheat was drilled in 2 of the 4 seasons (Tables 1.5 and 1.6) and either oats or rape were planted to simulate a grass and a broad-leaved weed respectively.

Table 1.5. Long Ashton site details.

Harvest year	1993	1994	1995	1996
Crop	SW	WW	WW	SW
Variety	Baldus	Hereward	Hereward	Baldus
Drill date	10 Mar 93	29 Sept 93	28 Sept 94	30 Mar 96
Spray date	27 Apr 93	17 Nov 93	28 Nov 94	13 May 96
Weeding date	5 May 93	29 Nov 93	29 Nov 94 and 29-30 Mar 95	13, 15 and 28 May 96
Drill	Farm-hand	Fiona	Fiona	Fiona
Plot size (m)	6 by 2.5	2.4 by 2.5	2.5 by 2.4	2.5 by 6
Replication	4	3	4	4

Table 1.6. Wheat row widths and seed rates at Long Ashton.

Harvest year	Row width (cm)	Seed rate (seeds/m²)
1993	12.5	381
1994	11.4	220
	22.9	
	34.3	
	9.4 / 24.8*	
1995	11.4, 10.0 / 25.0*	304
1996	11.4, 10.0 / 25.0*	353

* twin rows

Plots were sprayed using a hand-held sprayer with a 4m boom, using half of the boom width and 4 nozzles to deliver 200 l/ha. Mechanical weeding was done with a Hatzenbichler weeder.

Results

Harvest year 1993

Mechanical weeding gave as good control of large *V. hederifolia* (ivy-leaved speedwell) plants as thifensulfuron-methyl / metsulfuron-methyl mixed with mecoprop-P (Table 7) at Boxworth. The sequence of 20% label recommended rate of herbicide followed by mechanical weeding gave good control of *Aethusa cynapium* (fool's parsley) and gave wheat yields comparable with the full rate herbicide mixture.

At High Mowthorpe metsulfuron-methyl + mecoprop-P at 5 or 20% of label rate applied on 11 May followed by cultivation at GS32 gave poorer control of *S.media* (common chickweed), *G.aparine* (cleavers), *V.persica* (common field speedwell) and *P. rhoeas* (poppy) than the full herbicide rate herbicide alone applied on 27 April (Table 1.8). Following 20% of label rate of herbicide by cultivation at GS30 improved the control of all species compared to that rate of herbicide alone and was equivalent to that from the full rate. Plots treated with the full rate herbicide gave the greatest yield.

Table 1.7. Wheat yield and weed numbers after treatment at Boxworth with thifensulfuron - methyl / metsulfuron-methyl + mecoprop-P, with and without cultivation (log. transformed data in parenthesis) counted on 7 June 1993.

Treatment	Yield	*V.hederifolia* / m^2	*A.cynapium* / m^2
Full rate herbicide mixture*	8.22	12.3	10.6(2.16)
5% herbicide mixture	8.33	59.3	27.6(3.34)
20% herbicide mixture	8.71	53.0	24.6(3.11)
5% pre-cultivation at GS30	8.43	29.6	26.3(3.20)
5% pre-cultivation at GS32	8.73	28.3	29.6(3.20)
20% pre-cultivation at GS30	8.25	23.6	6.0(1.92)
20% pre-cultivation at GS32	8.31	25.0	7.6(2.13)
Cultivation at GS30	7.84	18.3	28.3(3.33)
Cultivation at GS32	8.65	7.0	19.6(2.61)
Cultivation pre-20% herbicide	8.43	81.0	8.6(2.07)
Untreated	8.17	54.8	44.0(3.67)
SEM (22df)	0.180	5.5	(0.451)

* Full rate herbicide is thifensulfuron-methyl + metsulfuron-methyl as 60 g Harmony M + mecoprop-P as 2.3 l Astix / ha.

Table 1.8. Wheat yield and weed numbers / m^2 after treatment at High Mowthorpe with metsulfuron-methyl + mecoprop-P, with and without additional cultivation, counted on 9 or 23 June 1993 depending upon species.

Treatment	Yield	Plants / m^2							
	(t/ha)	Sm	Sm	Ga	Ga	Vp	Vp	Pr	Pr
		9/6	23/6	9/6	23/6	9/6	23/6	9/6	23/6
Full rate mixture*	11.32	0.7	-	7.3	-	2.0	-	3.3	-
5% mixture	9.97	1.3	-	14.0	-	8.0	-	12.7	-
20% mixture	10.76	2.7	-	18.7	-	8.7	-	8.7	-
5% pre-cult. at GS30	10.84	1.3	-	9.3	-	4.7	-	11.3	-
5% pre-cult. at GS32	8.29	-	31.3	-	7.3	-	5.3	-	30.7
20% pre-cult. at GS30	11.19	0.0	-	5.3	-	4.0	-	1.3	-
20% pre-cult. at GS32	10.01	-	26.0	-	4.0	-	7.3	-	12.7
Cultivation at GS30	7.38	9.3	-	6.7	-	4.0	-	14.0	-
Cultivation at GS32	8.26	14.7	-	8.0	-	8.0	-	37.3	-
Cult. Pre-20% herbicide	10.36	-	24.0	-	4.7	-	11.3	-	14.7
Untreated	5.87	22.3	31.0	15.7	14.7	11.5	5.7	47.0	51.4
SEM (16df)		2.23		4.27		3.05		4.57	
SEM (8df)			4.14		3.88		1.95		8.20

* Full rate herbicide is metsulfuron-methyl as 30 g Ally + mecoprop-P as 2.3 l Astix /ha.

Harrowing subsequent to imazamethabenz-methyl treatment did not adversely affect yield at Long Ashton (Table 1.9).

Table 1.9. Spring wheat yield (t/ha) at Long Ashton on plots contaminated with oats in 1993 and sprayed with a range of rates of imazamethabenz-methyl.

% full rate*	No mechanical weeding	Mechanical weeding
0	7.69	7.14
5	7.56	7.48
10	7.65	7.37
20	7.98	7.91
40	8.56	8.23
80	8.64	8.86
SEM (32df)	0.217	0.217

* Full rate herbicide is imazamethabenz-methyl as 2.0 l Dagger / ha.

In spring wheat, oat biomass was reduced by imazamethabenz-methyl treatment at less than 20% of label rate when followed by cultivation compared with no cultivation (Table 1.10).

Table 1.10. Oat biomass (data back-transformed) after treatment at Long Ashton with imazamethabenz-methyl with or without subsequent harrowing in 1993.

% full rate*	No mechanical weeding	Mechanical weeding
0	208.5 (5.340)	126.9 (4.844)
5	224.2 (5.413)	139.0 (4.935)
10	229.4 (5.435)	128.3 (4.855)
20	179.5 (5.190)	133.6 (4.895)
40	47.9 (3.869)	42.0 (3.737)
80	0.0	0.0
SEM (23df)	(0.1601)	(0.1601)

* Full rate herbicide is imazamethabenz-methyl as 2l Dagger / ha.

Harrowing subsequent to treatment with thifensulfuron-methyl/metsulfuron-methyl did not adversely affect spring wheat yield (Table 1.11).

Table 1.11. Spring wheat yield (t/ha) at Long Ashton on plots contaminated with oilseed rape in 1993 and sprayed with a range of rates of thifensulfuron-methyl / metsulfuron-methyl.

% full rate*	No mechanical weeding	Mechanical weeding
0	7.52	7.19
1.25	7.44	7.80
2.5	7.98	7.67
5.0	7.93	7.97
10.0	8.59	8.31
20.0	8.22	8.43
SEM (33df)	0.199	0.199

* Full rate herbicide is thifensulfuron-methyl + metsulfuron-methyl as 60g Harmony M/ha.

Rape biomass was reduced when thifensulfuron-methyl/metsulfuron-methyl treatment (at rates up to 10% of label rate) was followed by subsequent cultivation compared to no cultivation (Table 1.12).

Table 1.12. Oilseed rape biomass (g/m^2 back-transformed) after treatment at Long Ashton with thifensulfuron-methyl / metsulfuron-methyl with or without additional harrowing in 1993.

% full rate*	No mechanical weeding	Mechanical weeding
0	136.9 (4.919)	82.9 (4.418)
1.25	90.4 (4.504)	49.3 (3.897)
2.5	49.3 (3.897)	34.6 (3.544)
5.0	25.3 (3.230)	11.3 (2.428)
10.0	13.7 (2.616)	2.3 (0.845)
20.0	0.0	0.0
SEM (23df)	(0.2975)	(0.2975)

* Full rate herbicide is thifensulfuron-methyl + metsulfuron-methyl as 60g Harmony M / ha.

Harvest year 1994

There were very few weeds apart from a small number of *G.aparine* (cleavers) at the Boxworth site in 1994 and so the main assessments were measuring effects on crop yield.

The highest yielding plots were those with a row spacing of 16.6cm (Table 1.13). Overall, yields from plots which had a full rate of fluroxypyr were significantly ($p<0.001$) higher than those on plots which were mechanically weeded after a 20% rate of herbicide. The greatest reduction in yield due to mechanical weeding occurred in the plots with the narrowest spacing. Neither row width nor weed control method had any significant effect on thousand seed weight or fertile tiller number. Twin rows did not result in any yield advantage compared to standard rows, but yields of the two approaches to weed control methods were similar.

Some individual weed plants which were tagged immediately before mechanical weeding were partially pulled up or buried and some had part or all of their leaves removed or the stem cut at ground level.

Table 1.13. The effect of row width, and the control of weeds by mechanical or chemical means, on specific weight, thousand seed weight, and fertile tiller number at Boxworth in 1994.

Row width	Yield (t/ha)		Specific weight (kg/hl)		TSW (g)		Fertile tillers (/m^2)	
	Weed	Spray	Weed	Spray	Weed	Spray	Weed	Spray
12.5	8.95	9.53	80.91	80.66	36.35	38.74	289	300
16.6	9.33	9.70	81.38	81.15	38.79	35.17	295	272
25	9.27	9.56	81.22	80.54	39.31	38.10	292	303
33	8.95	9.18	81.66	80.96	40.42	37.66	308	272
9/16	9.73	9.49	81.07	80.92	38.82	39.28	276	296
SEM (17df)	0.12	0.12	0.25	0.25	1.51	1.51	12.91	12.91

Weed = 20% herbicide + weeder; Spray = full rate fluroxypyr (1 l/ha Starane 2).

Yield significantly ($p<0.001$) increased with increasing seed rate at both row combinations (Table 1.14). The highest yield was from the highest seed rates although it was not significantly greater than from the standard seed rate. Seed rate had no effect on specific weight or thousand seed weight. At all seed rates, yield was greater on those plots treated with the full rate of herbicide compared to those harrowed following a low rate of herbicide.

At High Mowthorpe there were no significant differences in yield, specific weight or thousand grain weight between any of the treatments but the lowest yields occurred where the full rate of herbicide was applied later in the season (Table 1.15). The lowest weed biomasses occurred when the herbicide treatment was applied at the full rate, either alone, prior to or post mechanical treatment. Mechanical weeding 2 weeks before or after application of reduced rate herbicide decreased the weed biomass more than the similar rates of herbicide alone.

Table 1.14. The effect at Boxworth in 1994 of seed rate, and the control of weeds by mechanical or chemical means, on wheat yield, specific weight, thousand seed weight (TSW), and fertile tiller number; a) 9+16 cm row width; b) 25cm row width.

Seed rate	Yield (t/ha)		Specific weight (kg/hl)		TSW (g)		Fertile tillers (/m²)	
	Weed	Spray	Weed	Spray	Weed	Spray	Weed	Spray
a)								
267	9.20	9.50	81.03	80.86	40.03	37.89	288	276
400	9.29	9.49	81.07	80.92	38.82	39.28	276	296
533	9.45	9.67	81.07	81.19	38.55	37.70	290	311
b)								
267	9.20	9.32	81.56	80.99	38.14	40.52	277	265
400	9.27	9.56	81.22	80.54	39.31	38.10	292	303
533	9.46	9.59	81.17	81.35	37.20	38.30	286	309
SEM (22df)	0.078	0.078	0.262	0.262	1.061	1.061	15.424	15.424

Weed = 20% herbicide + weeder; Spray = full rate fluroxypyr (1 l/ha Starane 2).

Table 1.15. Crop assessments at High Mowthorpe in 1994

Date	Date	Yield (t/ha)	Specific wt. (kg/hl)	Thousand grain wt.	Weed biomass
23 May	6 June				
MW	5% A/S	8.69	74.11	50.51	39.2
MW	20% A/S	8.91	75.30	51.43	20.5
MW	100% A/S	7.24	72.22	44.58	7.6
5% A/S		8.38	73.95	49.09	64.7
20% A/S		8.53	73.83	51.87	88.1
100% A/S		9.04	74.68	48.88	8.1
	5% A/S	8.41	73.52	50.47	104.7
	20% A/S	7.45	72.20	48.09	55.8
	100% A/S	7.14	72.06	48.36	8.5
5% A/S	MW	8.3	75.24	51.32	18.2
20% A/S	MW	8.27	74.53.	51.07	14.4
100% A/S	MW	7.4	75.00	50.12	2.8
Untreated		8.73	73.59	49.90	116.9
SEM (24df)		0.587	0.866	2.231	15.785

key: MW = mechanically weeded in both directions; A/S = Ally (metsulfuron-methyl) + Starane (fluroxypyr) - full rate = 30g + 1.0 l/ha

Yield at Long Ashton was significantly higher in the twin rows (9.4/24.8) than in the other row spacings (Table 1.16). This same row combination also resulted in more stems/m² and per plant and a greater 1000 grain weight.

Table 1.16. Crop assessments at Long Ashton in 1994 on weed free plots.

Row width	Yield (t/ha)	Stems/m^2	1000 grain wt.	Stems/plant
11.4	8.26	407	46.1	2.43
22.9	7.68	352	47.6	2.41
34.3	7.98	397	47.3	2.35
9.4/24.8	9.56	445	47.8	2.82
SEM	0.429	20.4	0.269	0.268
-harrow	8.30	393	47.3	2.50
+harrow	8.45	407	47.1	2.50
SEM	0.304	14.45	0.189	0.120

All herbicide rates decreased rape biomass but there was no additional benefit of increasing the rate beyond 10% (Table 1.17). The only significant difference between row widths was between that at 11.4cm and the twin rows.

Table 1.17. Rape biomass (g/m^2) on 10 May 1994 when treated with tribenuron (full rate, 15.0 g a.i./ha) at Long Ashton.

Herbicide rate (averaged over row width and harrowing)

% full rate	40%	20%	10%	5%	2.5%	0
	0	11.5	23.7	54.5	75.3	126.7

SEM = 8.68

Row width (averaged over herbicide rate and harrowing)

Row width (cm)	11.4	22.9	34.3	9.4/24.6
	36.7	48.6	50.3	56.3

SEM = 6.36

Harrowing (averaged over herbicide rate and row width)

No harrow	Harrow
51.0	44.9

SEM = 4.48

There was an apparent increase in oat biomass from the 10% rate of imazamethabenz-methyl (Table 1.18.). Rates of 20 and 40% rate significantly decreased oat biomass but the difference between 40 and 80% was not significant. Oat biomass was also significantly greater on the 34.3cm and twin row compared to 11.4 and 22.9 cm rows.

Table 1.18. Oat biomass (g/m²) on 20 June 1994 when treated with imazamethabenz-methyl (full rate, 600 g a.i./ha) at Long Ashton.

Herbicide rate (averaged over row width and harrowing)

% full rate	80%	40%	20%	10%	5%	0
	6.8	105.8	364.6	718.4	592.3	652.7

SEM for herbicide rate = 41.5

Row width (averaged over herbicide rate and harrowing)

Row width (cm)	11.4	22.9	34.3	9.4/24.6
	366.5	357.8	455.1	447.8

SEM for row width = 28.1

Harrowing (averaged over herbicide rate and row width)

No harrow	Harrow
379.8	433.7

SEM = 19.65

Harvest year 1995

In January 1995 plant counts at Boxworth showed very little difference between populations in the different row combinations with 265 on the standard and 270 plants/m² on the twin rows.

Yields at Boxworth in 1995 were highest on plots treated with the full herbicide rate on the standard row arrangement (Table 1.19). Untreated yields were lowest on the twin row plots.

Even the full rate of Cheetah R did not give good control of *A.myosuroides* heads at Boxworth (Table 1.20) but was better on the twin than the standard row arrangement especially when combined with the weeder.

Table 1.19. Wheat yields (t/ha) at Boxworth for harvest 1995.

Treatment	Weeder		No weeder	
	Twin	Standard	Twin	Standard
2.50l Cheetah R + 75g Harmony M / ha	4.7	5.9	5.1	5.9
1.90l Cheetah R + 30g Harmony M / ha	5.4	4.7	5.4	5.3
1.25l Cheetah R + 15g Harmony M / ha	5.0	5.7	4.8	5.4
0.63l Cheetah R + 7.5g Harmony M / ha	4.1	5.3	3.2	4.6
Untreated	2.9	4.4	3.5	4.1

SEM (38df) 0.489

Cheetah R is fenoxaprop-ethyl (60 g a.i./l)
Harmony M is metsulfuron-methyl + thifensulfuron-methyl (68 + 7% w/w)

Table 1.20. *A.myosuroides* panicles / m² (log transformed) at Boxworth for harvest 1995.

Treatments	Weeded		No weeder		
As Table 19	Twin	Standard	Twin	Standard	Mean
1	1.09	1.54	1.40	1.58	1.41
2	1.66	2.06	1.68	2.01	1.85
3	2.09	2.02	2.15	1.83	2.02
4	2.44	2.34	2.69	2.43	2.47
Untreated		2.38	2.78	2.71	2.67

SEM (38df) herbicide = 0.084
SEM (38df) Row width, herbicide and weeder interaction = 0.168

There was less total weed on the standard compared to the twin rows and there was little difference between % weed biomass between and within twin rows comparing before and after mechanical weeding (Appendix, Table C). Grass weed biomass was greater on the twin than standard rows and was little affected by mechanical weeding; broad-leaved weed biomass was reduced by about 50%, 10 days after mechanical weeding (Appendix, Table B).

When treated with the low rate of Panther (500g isoproturon + 50g diflufenican/l), yield was similar with or without subsequent harrowing at High Mowthorpe. Yield from the twin rows was markedly reduced when the full rate of herbicide was followed by weeding (Table 1.21). When full rate of Panther was followed by weeding the yield was less on the twin compared to the standard rows.

Table 1.21. Yield (t/ha) at High Mowthorpe for harvest 1995

Chemical	Weeder Twin	Weeder Standard	No weeder Twin	No weeder Standard
100% Panther	6.14	8.52	8.61	8.47
50% Panther	6.60	8.31	6.50	8.10
20% Panther	5.79	6.73	5.98	6.62
100% Ally/Starane	-	-	4.51	5.64
50% Ally/Starane	-	-	6.08	5.30
20% Ally/Starane	-	-	3.52	5.19
100% Ally/Starane before weeding	4.79	5.99	-	-
50% Ally/Starane before weeding	4.16	5.85	-	-
20% Ally/Starane before weeding	5.13	5.85	-	-
Weeding before 100% Ally/Starane	5.45	5.48	-	-
Weeding before 50% Ally/Starane	4.74	4.68	-	-
Weeding before 20% Ally/Starane	4.91	5.13	-	-
Untreated	-	-	4.69	4.94

SEM (73df) 0.288

Full rate Panther (500 g isoproturon + 50 g diflufenican/l) = 2.0 l/ha
Full rate Ally / Starane = 30 g Ally + 1.0 l Starane/ha

At High Mowthorpe weed biomass within the twin rows was similar on plots treated with full rate herbicide as on 20% Ally/Starane plots which were also harrowed (Table 1.22).

Table 1.22. Within-row weed biomass in twin-row spacing (t/ha) at High Mowthorpe 1995

Chemical	Weeder	No weeder
	Twin	Twin
100% Panther	0.09	0.05
50% Panther	0.49	0.68
20% Panther	1.27	1.57
100% Ally/Starane	-	1.22
50% Ally/Starane	-	1.14
20% Ally/Starane	-	1.41
100% Ally/Starane before weeding	0.83	-
50% Ally/Starane before weeding	0.61	-
20% Ally/Starane before weeding	1.12	-
Weeding before 100% Ally/Starane	0.83	-
Weeding before 50% Ally/Starane	1.35	-
Weeding before 20% Ally/Starane	1.19	-
Untreated	-	2.36

SEM (36 df) 0.188

Weeding after 20% Ally / Starane gave as good control of inter-row weeds as full rate herbicide (Table 1.23).

Table 1.23. Inter-row weed biomass in twin-row spacing (t/ha) at High Mowthorpe 1995

Chemical	Weeder	No weeder
	Twin	Twin
100% Panther	0.04	0.08
50% Panther	0.48	0.85
20% Panther	1.30	1.39
100% Ally/Starane	-	0.99
50% Ally/Starane	-	1.04
20% Ally/Starane	-	1.52
100% Ally/Starane before weeding	0.85	-
50% Ally/Starane before weeding	0.54	-
20% Ally/Starane before weeding	0.98	-
Weeding before 100% Ally/Starane	0.88	-
Weeding before 50% Ally/Starane	1.49	-
Weeding before 20% Ally/Starane	1.46	-
Untreated	-	1.80

SEM (36df) 0.100

Weeding before treatment with Ally/Starane resulted in better weed control than after and was as good as the full rate on normal row spaced crop (Table 1.24 and 1.25).

Table 1.24. Weed biomass in normal row spacing (t/ha) at High Mowthorpe in 1995

Chemical	Weeder	No weeder
	Standard	Standard
100% Panther	0.07	0.06
50% Panther	0.47	1.14
20% Panther	1.89	2.27
100% Ally/Starane	-	1.66
50% Ally/Starane	-	2.63
20% Ally/Starane	-	3.09
100% Ally/Starane before weeding	0.84	-
50% Ally/Starane before weeding	1.52	-
20% Ally/Starane before weeding	1.87	-
Weeding before 100% Ally/Starane	2.15	-
Weeding before 50% Ally/Starane	2.19	-
Weeding before 20% Ally/Starane	2.60	-
Untreated	-	3.35

SEM (36 df) 0.273

Table 1.25. Total weed biomass (t/ha @ 100% DM) at High Mowthorpe - 1995

Chemical	Weeder	Weeder	No weeder	No weeder
	Twin	Standard	Twin	Standard
100% Panther	0.13	0.07	0.14	0.06
50% Panther	0.97	0.47	1.53	1.14
20% Panther	2.57	1.89	2.96	2.27
100% Ally/Starane	-	-	2.21	1.66
50% Ally/Starane	-	-	2.18	2.63
20% Ally/Starane	-	-	2.93	3.09
100% Ally/Starane before weeding	1.67	0.84	-	-
50% Ally/Starane before weeding	1.15	1.52	-	-
20% Ally/Starane before weeding	2.10	1.87	-	-
Weeding before 100% Ally/Starane	1.71	2.15	-	-
Weeding before 50% Ally/Starane	2.84	2.19	-	-
Weeding before 20% Ally/Starane	2.65	2.60	-	-
Untreated	-	-	4.15	3.35

SEM (74 df) 0.264

Yield at Long Ashton in 1995 was greater on the standard compared to the twin rows. Harrowing in the spring resulted in the lowest yield (Table 1.26).

Table 1.26. Long Ashton yields 1995

Row spacing	Yield t/ha)	Stems/m^2	TGW	Stems/plant
11.4	8.28	351	41.29	1.24
9.4 / 24.8	7.63	367	40.51	1.35
SEM	1.754 (3df)	7.47 (4df)	0.374 (4df)	
No harrow	7.92			
Autumn harrow	8.89			
Spring harrow	7.39			
Autumn + spring harrow	7.63			
SEM (3 df)	1.754			

At both the highest application rate and in the absence of herbicide, all harrowing regimes yielded similar rape biomass (Table 1.27). However with all other herbicide rates, the best rape control was achieved without harrowing or with harrowing in the spring only. Treatments including autumn harrowing were not so effective as those without.

Table 1.27. Long Ashton rape biomass (log. transformed) when grown in wheat plots 1995

Harrow regime	Application rate of tribenuron-methyl (g/ha)					
	0	0.38	0.75	1.5	3.0	6.0
None	4.57	1.25	-0.37	-2.16	-3.00	-3.00
	(96.49)	(3.44)	(0.64)	(0.07)	(0.0)	(0.0)
Autumn	3.75	3.14	1.89	1.29	-0.76	-1.84
	(42.47)	(23.05)	(6.57)	(3.58)	(0.42)	(0.11)
Spring	4.45	1.38	-0.51	-1.00	-2.62	-3.00
	(85.58)	(3.92)	(0.55)	(0.32)	(0.02)	(0.0)
Autumn + spring	3.91	2.74	2.19	0.23	-0.83	-2.63
	(49.85)	(15.44)	(8.89)	(1.21)	(0.39)	(0.02)

SEM (34df) 0.543 when comparing different rates in different harrow regimes
SEM (34df) 0.547 when comparing rates within harrowing regimes
SEM (34df) 0.501 when comparing harrowing regimes at a particular rate

Oat biomass was significantly affected by both harrowing and herbicide rate (Tables 1.28 and 1.29). Harrowing in both autumn and spring significantly reduced oat biomass compared to not harrowing. Harrowing on only one occasion however did not significantly reduce biomass.

Table 1.28. Long Ashton oat biomass (log. transformed) when grown in wheat plots 1995

No harrowing	Autumn harrowing	Spring harrowing	Autumn + spring harrowing	SEM (5 df)
5.99	5.86	5.85	5.65	0.059
(400.2)	(351.1)	(347.9)	(282.9)	

Table 1.29. Long Ashton oat biomass when grown in wheat plots 1995

% of recommended rate of imazamethabenz-methyl						
0	15	30	45	60	75	SEM (9 df)
6.18	6.13	6.02	5.68	5.56	5.46	0.035
(481.1)	(460.8)	(411.2)	(292.4)	(260.1)	(234.2)	

Harvest year 1996

At Boxworth in 1996, the highest yield was on the standard row width plots treated with full rate herbicide and the other treated plots all yielded similarly (Table 1.30). There was no significant effect on any of the other parameters measured.

Table 1.30. Plant counts and yield measurements at Boxworth in 1996.

Treatments	Yield (t/ha)	Specific wt.	TGW
Standard rows / full herbicide*	9.14	84.53	41.21
Twin rows / full herbicide	8.65	84.56	41.30
Twin rows / mechanical weeding	8.79	84.59	42.15
Twin rows / low herbicides / mech. weed	8.72	84.45	41.36
SEM (11df)	0.230	0.095	0.776
Treatments	**Plant counts**	**Fertile tillers**	**Harvest index**
Standard rows / full herbicide	249	483	51.4
Twin rows / full herbicide	203	483	47.8
Twin rows / mechanical weeding	219	473	48.5
Twin rows / low herbicides / mech. weed	202	428	50.9
SEM (11df)	15.5	18.0	1.63

* full herbicide = Harmony M (metsulfuron-methyl + thifensulfuron-methyl) + Astix (mecoprop-P) at 30g + 1.15 l/ha.

Analysis of pitfall samples at Boxworth (Table 1.30) indicated that beetle numbers may have recovered more quickly where mechanical weeding occurred than where herbicide was used.

Table 1.31. Boxworth - pitfall samples (beetles/day)

Treatments	Sampling	Ground beetles	Rove beetles	Spiders
Standard rows / full herbicide*	1	14.6	16.0	16.7
	2	16.8	10.8	10.8
	3	8.0	14.1	11.3
Twin rows / full herbicide	1	13.1	16.3	14.0
	2	9.4	9.9	3.0
	3	3.9	18.9	37.3
Twin rows / mechanical weeding	1	17.3	11.0	18.0
	2	7.9	8.1	4.1
	3	18.0	19.7	6.3
Twin rows / low herbicides / mech. weed	1	19.8	16.1	13.1
	2	7.4	9.1	6.0
	3	6.9	13.1	9.7
Field adjacent to expt.	1	21.2	13.8	17.4
	2	11.9	7.0	6.6
	3	5.7	6.1	14.7

1= sample 1 week pre-spray; 2=sample between spray and cultivation; 3= sample 1 week post cultivation.
* full herbicide = Harmony M (metsulfuron-methyl + thifensulfuron-methyl) + Astix (mecoprop-P) at 30g + 1.15 l/ha.

At High Mowthorpe the full rate herbicide applied to standard rows yielded best (Table 1.32) with the twin rows mechanically weeded yielding least.

Analysis of the pitfall samples at High Mowthorpe also indicated that beetle may have recovered more quickly in the mechanically weeded plots than where herbicide had been used (Table 1.33).

Table 1.32. Yield measurements at High Mowthorpe 1996

Treatments	Yield (t/ha)	Specific wt.	TSW
Standard rows / full herbicide*	7.15	80.02	45.47
Twin rows / full herbicide	6.43	79.47	47.00
Twin rows / mechanical weeding	4.91	77.30	43.96
Twin rows / low herbicides / mech. weed	6.95	78.40	45.99
SEM	0.213	0.311	0.761
Treatments	Fertile tillers	DM of crop (t/ha)	DM of weed (t/ha)
Standard rows / full herbicide	226.7	8.90	3.11
Twin rows / full herbicide	452.2	6.76	3.73
Twin rows / mechanical weeding	409.2	4.92	4.19
Twin rows / low herbicides / mech. weed	446.3	8.02	2.37
SEM	15.313	0.728	0.282

* Full rate herbicide = Panther at 2 l/ha followed by Ally / Starane at 30g + 1l/ha.

Table 1.33. High Mowthorpe - pitfall samples (beetles/day)

Treatments	Sampling	Ground beetles	Rove beetles	Spiders
Standard rows / full Herbicide*	1	19.1	1.3	6.9
	2	6.9	0.3	1.4
	3	3.9	1.1	5.7
Twin rows / full	1	19.0	0.9	7.1
	2	7.7	0.1	1.9
	3	3.4	1.3	5.4
Twin rows / mechanical Weeding	1	38.6	1.4	4.0
	2	15.0	0.4	0.7
	3	35.6	3.9	10.3
Twin rows / low / mech. Weed	1	35.6	1.1	7.4
	2	12.1	0.7	1.6
	3	21.3	3.3	6.7

1= sample 1 week pre-spray; 2=sample between spray and cultivation; 3= sample 1 week post cultivation.
* Full rate herbicide = Panther at 2 l/ha followed by Ally / Starane at 30g + 1l/ha.

At Long Ashton an initial population of 32 rape plants/m² was established in 1996. Harrowing on the same day as spraying resulted in a higher rate of mecoprop being required to achieve 50% reduction compared with no harrowing (Table 1.34). Delays in harrowing seemed to augment the herbicide effect.

Table 1.34. Long Ashton rape dry weight/m² in July (ln (x+1)) in 1996

Mecoprop-P (g/ha)	Harrowing				Mean
	None	Same day	2 days	15 days	
0	272.6	202.4	208.5	156.4	
	(5.54)	(5.31)	(5.31)	(4.98)	(5.28)
69	142.7	112.1	109.5	79.5	
	(4.82)	(4.70)	(4.67)	(4.38)	(4.64)
124	75.8	53.9	34.3	28.2	
	(4.08)	(3.96)	(3.32)	(3.27)	(3.66)
262	17.9	46.3	11.6	2.7	
	(2.16)	(3.54)	(2.34)	(0.93)	(2.24)
524	0.0	2.0	0.4	2.4	
	(0.0)	(0.75)	(0.31)	(0.59)	(0.41)
1035	0.0	0.0	0.0	0.0	
	(0.0)	(0.0)	(0.0)	(0.02)	(0.01)
Mean	(2.77)	(3.04)	(2.66)	(2.36)	

SEM (9df) 0.120
SEM (60df) herbicide rate means 0.161
SEM (69df) rate/harrow 0.316

Wheat population of 286 and 275 plants/m² were established for the conventional and double rows respectively. Although there appeared to be a downward yield trend with harrowing, these yield reductions were not significant (Table 1.35). Yields were not significantly affected by row configuration.

Table 1.35. Yields from plots with different row configurations and harrowed on different dates at Long Ashton in 1996.

	Harrow date				
	No harrow	13 May	15 May	28 May	Mean
Conventional	7.26	6.94	7.04	7.23	7.12
Twin	7.28	7.09	6.68	6.85	6.97
Mean	7.27	7.01	6.86	7.04	

SEM (21df) for means over dates 0.133
SEM (21df) for means over row arrangement 0.188
SEM (21df) for row width / harrow interaction 0.266

Over the whole trapping period at Long Ashton *Nebria brevicollis* was the most abundant species caught (Appendix 2). The main and most significant response from these studies was the systems effect in the conventional system (system B). An autumn insecticide, routinely applied on 3 November 1995 dramatically reduced catches of adult Carabidae on 9 November and 16 November by 83% and 94%

respectively. Later catches which were mostly larvae of *N. brevicollis* were again significantly lower.

Early harrowing in system D on 8 November 1995 may have been responsible for later reduced catches of *Nebria* larvae, by disturbing eggs and smaller larval instars exposing them to the cold and possible predation. A reduction in the numbers of larvae trapped in system C after harrowing was also observed on 29 January 1996.

Population activity was very low in early spring, therefore the effects of spring harrowing could not be evaluated.

Discussion and Conclusion

In this series of field experiments several aspects of managing a combined treatment of low rate of herbicide followed by mechanical weeding have been considered. There are many references to mechanical weeding in different crops (e.g. Rasmussen, 1992) but only Caseley *et al.* (1993) appear to have explored this combination approach.

The key questions in the field investigation were a) can a good level of weed control be achieved using a low rate of herbicide combined with subsequent mechanical weeding b) can row arrangement be modified and maintain an economic yield and c) does the modified row arrangement facilitate a more effective mechanical weeding system.

The combination of low rate herbicide with subsequent mechanical weeding gave effective weed control in the first (Blair & Green, 1993) and in subsequent seasons in these experiments except when there was a major grass weed problem. The selection of the appropriate herbicide for the situation was therefore the key to the system (Section 2 of the report).

Yields varied between seasons and sites (Table 1.36). The particularly low yields in 1995 harvest year at Boxworth were probably a reflection of the severe black-grass (*A.myosuroides*) black-grass competition over the winter prior to treatment in April coupled with below average rainfall. Other experiments have shown that yield loss occurs if black-grass competition is not removed by this time of the season. The site was selected for its grass weed problem. The experience with black-grass on this site, along with oats at Long Ashton suggest that less but probably still significant herbicide reduction will be possible on sites where annual grass weeds are the target. The Boxworth 1995 site also suggested that smaller reductions in herbicide rate can be employed with mechanical weeding to control cleavers than the other annual broad-leaved weeds.

Where broad-leaved weeds were the main problem and where it was possible to compare yields from standard rows with full herbicide with that from twin rows with 20% herbicide, then yields were generally comparable. The occasional slight yield penalty from altering row combinations supports the results of Andersson (1986) working in Sweden. He averaged the yields over a range of seed rates but an 18cm width between bands was the widest used.

It is difficult to cost those treatments which include the mechanical weeder since there are other uses on the farm against which the weeder could also be charged. On no occasion did the mechanical weeding cause severe visual damage to crop and within a week it would have been difficult to see that this operation had taken place.

Table 1.36. Wheat yield (t/ha) at different sites in different years when grown under different row configurations and sprayed with full rate herbicide.

Site	Year	Row arrangement		
		12.5	9+16	10+25
BX	1993	8.22	-	-
	1994	9.53	9.49	-
	1995	5.9	-	5.1
	1996	9.14	-	8.65
HM	1993	11.32	-	-
	1994	9.04	-	-
	1995	8.52	-	6.14
	1996	7.15	-	6.43
LARS	1994	8.26	-	9.56
	1995	8.28	-	7.63
	1996	7.26	-	7.28

In the 1994 season when seed rate was investigated there was no significant benefit from increasing the seed rate above the standard and seed rate was therefore standardised in all subsequent experiments.

The different row arrangements were included in this study to test the hypothesis that a wider row spacing between twin crop rows might deflect the tines into the wide inter-row and give better weed control.

With the twin row arrangement there was less competition from the crop against weeds in the wide gap between compared to within the closely spaced rows. Hence there was a larger weed biomass between the wide rows supporting the results reported by Wilson *et al.* (1995) that weed biomass declined as crop density increased.

Different forms of mechanical damage to a range of weeds have been investigated in another project (Jones *et al.*, 1995 & 1996) and results form this should enable a better weeder design. In the future, if the weeder could be guided accurately between the rows then more rigorous weeding in the wide spacing may be possible and this is being investigated in a new MAFF funded project.

Limited information suggests that herbicide application should precede mechanical weeding by at least two days. There is also limited results to suggest that control of annual grass weeds will be enhanced by mechanical weeding in the autumn or winter.

It appeared that there was no advantage in annual broad-leaved weed control in mechanically weeding before the spring.

The very limited information on the effect on ground beetles suggested that the herbicide had more effect than mechanical weeding. Hence an arrangement of twin rows with herbicide only applied in the close rows might leave an untreated pathway for beetles in the wide gap between the twin rows. However as the field plots were smaller than would be ideal to investigate beetle movement and it would be relatively easy for re-invasion of plots to occur, this needs further investigation.

The reduced impact on ground beetles and the effect on the crop of an overall mechanical weeder suggest that a system for widely spaced bands or twin rows with a guided rigorous weeding in the wide row space may provide adequate weed control, with significantly reduced herbicide use and good crop safety. Such a system requires efficient weeding within the crop rows or band. This could take the form of a band herbicide granule application or herbicide treated seed, a technique reported by Dawson (1981). This will be further explored in the new project.

The use of low rates of herbicide followed by mechanical weeding would result in reduced herbicide use. It also offers a means of weed control in areas where herbicide use must be reduced for other reasons e.g. near water courses.

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Appendix 1. Additional data from Boxworth, harvest year 1995

Boxworth 1995

Table A. Plant counts in non herbicide treated plots pre and post weeding numbers m^{-2}.

	Pre-weeding		Post-weeding	
	Broad-leaves	Grasses	Broad-leaves	Grasses
Row width				
Standard	64	44	44	35
Twin	45	78	27	58

Table B. Biomass assessments pre and post weeding (g/m^2).

	Pre-weeding		Post-weeding	
	Twin	Standard	Twin	Standard
Total dry weight	312	257	338	270
Crop dry weight	191	176	228	209
Total weed dry weight	121	81	110	62
Grass dry weight	92	38	95	39
Broad-leaf dry weight	28	43	14	23

Table C. Position of weeds in relation to the row in combination spacing (%).

	Pre-weeding		Post-weeding	
	Between	In	Between	In
All weeds	54	46	56	44
Grass weeds	49	51	53	47
Broad-leaved weeds	60	40	50	50

Table D. Crop component dry weights (g/m^2).

	Pre-weeding		Post-weeding	
	Combination	Standard	Combination	Standard
Leaves	364	339	438	406
Stems	357	338	516	494
Dead material	62	50	59	45

Table E. Green area / m^2.

	Pre-weeding		Post-weeding	
	Twin	Standard	Twin	Standard
Total	1.33	1.32	1.91	1.74
Leaves	1.15	1.15	1.67	1.52
Stems	0.18	0.17	0.24	0.22

Table G. Total dry weight of all above ground plant material (g/m^2) June 1995.

	Weeded		No weeder	
	Twin	Standard	Twin	Standard
1	832	791	820	800
2	860	758	901	795
3	943	764	990	915
4	998	812	1006	956
Untreated	999	873	1207	921

SEM (38 df) for interaction between row spacing, herbicide rate and weeder use = 53.44

Table H. Crop dry weight (g/m^2) June 1995.

	Weeded		No weeder	
	Twin	Standard	Twin	Standard
1	817	750	776	772
2	814	671	846	692
3	786	654	856	816
4	749	623	535	665
Untreated	609	593	749	556

SEM (38 df) for interaction between row spacing, herbicide rate and weeder use = 70.98

Row spacing ($P<0.05$) and herbicide rate ($P<0.01$) significantly affected crop dry weight.

Table J. Square root transformed total weed biomass (g/m^2) June 1995.

	Weeded		No weeder	
	Twin	Standard	Twin	Standard
1	3.75	6.09	5.77	4.60
2	6.25	9.20	7.03	10.12
3	11.56	10.02	11.10	9.88
4	15.46	12.77	21.43	15.92
Untreated	19.70	16.65	21.15	18.81

SEM row width herbicide interaction (38df)=1.175

Table K. Log transformed grass weed biomass (g/m²) June 1995

	Weeded		No weeder	
	Twin	Standard	Twin	Standard
1	2.48	3.50	2.58	2.64
2	3.45	4.37	3.27	4.42
3	4.62	4.46	4.64	4.28
4	5.38	4.85	6.04	5.10
Untreated	5.76	5.01	5.55	5.36

SEM herbicide row width interaction (38df)=0.281

Appendix 2. Long Ashton pitfall data, harvest year 1996

System A - herbicide 08/01; harrow 28/03, 02/04.

Caribidae	09/11/95	16/11/95	18/12/95	22/01/96	29/01/96	22/02/96	25/03/96	01/04/96	10/04/96
Nebria (adult)	29	78	3	4	0	1	3	0	0
Nebria (larvae)	17	18	21	101	113	66	31	1	1
Pterostichus (adult)	3	3	0	0	0	0	0	1	1
Pterostichus (larvae)	0	0	0	0	0	0	0	0	0
Others (adult)	11	12	6	8	3	11	2	1	0
Others (larvae)	3	15	0	0	0	0	0	0	0

System B - herbicide 12/10; no harrow.

Caribidae	09/11/95	16/11/95	18/12/95	22/01/96	29/01/96	22/02/96	25/03/96	01/04/96	10/04/96
Nebria (adult)	6	6	4	6	0	4	6	2	4
Nebria (larvae)	2	11	25	27	20	27	24	1	0
Pterostichus (adult)	2	1	0	0	0	0	1	0	6
Pterostichus (larvae)	0	0	1	0	0	0	2	0	0
Others (adult)	3	0	0	0	0	1	4	0	1
	0	0	0	0	0	0	0	0	0

System C - herbicide 01/04; harrow 08/12, 22/01.

Caribidae	09/11/95	16/11/95	18/12/95	22/01/96	29/01/96	22/02/96	25/03/96	01/04/96	10/04/96
Nebria (adult)	46	92	7	4	1	0	1	0	0
Nebria (larvae)	2	14	32	101	37	40	33	1	6
Pterostichus (adult)	0	1	0	0	0	0	0	0	7
Pterostichus (larvae)	2	0	1	1	0	0	0	0	0
Others (adult)	4	3	0	3	2	5	0	0	1
Others (larvae)	0	0	0	0	0	0	0	0	0

System D - no herbicide; harrow 08/11, 08/12, 22/01, 28/03, 02/04.

Caribidae	09/11/95	16/11/95	18/12/95	22/01/96	29/01/96	22/02/96	25/03/96	01/04/96	10/04/96
Nebria (adult)	33	111	11	0	3	2	0	0	1
Nebria (larvae)	22	39	7	10	6	4	4	0	0
Pterostichus (adult)	0	0	0	0	0	0	0	0	0
Pterostichus (larvae)	1	1	1	0	0	0	0	0	0
Others (adult)	7	2	0	6	0	8	1	3	4
Others (larvae)	0	0	0	0	0	0	0	0	0

SECTION 2 - GLASSHOUSE EXPERIMENTS

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Summary

The glasshouse and controlled environment studies identified some robust low dose herbicide treatments suitable for use alone or in conjunction with mechanical cultivation. For autumn treatments, mecoprop-P alone (12.5% of recommended dose) suppressed shoot and root growth of many important cereal weeds and performance was not affected by cultivation within a few hours of spraying. Low doses were relatively rainfast and growth suppression was longer lasting under cool conditions. Although not available alone in the UK, diflufenican was a useful mixture partner for mecoprop-P, particularly if pansies are a problem.

Reduced dose efficacy of metsulfuron-methyl (Ally) and tribenuron-methyl (Quantum) was generally better than that of Logran (triasulfuron). Uptake of tribenuron appeared to be slower than metsulfuron and mecoprop-P and an interval of one to two days are required between spraying and cultivation. Tribenuron performance was also reduced by rain soon after application, in contrast to metsulfuron and mecoprop-P which were rainfast in two hours.

Introduction

Earlier work in the MAFF project 'effective weed control with economy of herbicide use' showed that the sulfonylurea herbicides, including metsulfuron and metsulfuron plus thifensulfuron, inhibited root and shoot growth of many of broad-leaved weed species at low doses and this class of herbicide is ideal for combination with mechanical weed control. However, not all species are controlled and higher doses are required to control larger plants. Furthermore to avoid or delay herbicide resistance it is prudent to use sequences or mixtures of herbicides with different modes of action and chemistry. In addition, in 1994 (when the experiments was done) no sulfonylurea herbicides were registered for autumn application, thus we evaluated mecoprop-P alone and in mixture with fluoroglycofen. Fluoroglycofen has good low temperature activity against cleavers (*Galium aparine*) and solanum species (e.g. black nightshade).

Information on the performance of low doses of fenoxaprop-P (Cheetah S) for black-grass (*Alopecurus myosuroides*)and wild-oats (*Avena fatua*) were also obtained in the MAFF project 'Effective weed control with economy of herbicide use' showed prolonged stunting could be achieved with 20-40% of the recommended dose. Some preliminary work was done in this project of the effect of dew on the efficacy of low doses of pendimathalin (Stomp) and tri-allate (Avadex). Unlike some current MAFF funded research at Long Ashton with isoproturon, dew did not affect the efficacy of either pendimethalin or tri-allate. The information on isoproturon became available too late for it to be included in the field trials.

Glasshouse Experiment 1

The effects of mecoprop-P alone and in mixture with fluoroglycofen on several broad-leaf weed species.

Objectives

1. To achieve dose responses of mecoprop-P, fluoroglycofen and a mixture of both chemicals on fat-hen *(Chenopodium album),* scentless mayweed *(Matricaria perforata),* charlock *(Sinapis arvensis),* black nightshade *(Solanum nigrum),* common chickweed *(Stellaria media)* and common field-speedwell *(Veronica persica).*

2. To determine whether there are any synergistic effects when using these chemicals in mixtures on any of the species tested.

3. To determine, whether the chemical mixture enables a wider range of control on the above species.

4. To observe how long after spraying that regrowth commences.

Methods

Fat-hen, mayweed, charlock, black-nightshade, common chickweed and common field-speedwell seeds were pre-germinated in seed boxes, then transplanted into 3.5" pots filled with WRO (sandy loam) soil, with one plant per pot. Plants were maintained under 'normal' glasshouse conditions throughout the experiment. The plants were sprayed when they reached: two leaves, third and fourth expanding (fat-hen, nightshade and speedwell), four to five leaves, sixth expanding (mayweed, two leaves, some with the third leaf expanding (charlock) or three to six leaves (chickweed). Fat-hen, mayweed, charlock and speedwell were sprayed at the same time, nightshade and chickweed were sprayed separately at later dates due to slower germination times.

For each species, plants were sprayed with 3.125, 6.25, 12.5, 25, 50 or 100% of the recommended field rate of either mecoprop-P or fluoroglycofen (field rate of mecoprop-P was 2.3 l/ha product or 1380 g a.i./ha); fluoroglycofen alone is not a registered chemical in the UK. Therefore the 100% recommended rate was taken as 150 g/ha). Further plants were sprayed with 50/50 mixtures of the recommended rates of both chemicals. The mixture was sprayed at 3.125, 6.25, 12.5, 25, 50 and 100% rates, where 100% rate included 50% of the recommended rates of both mecoprop-P and fluoroglycofen The herbicides were applied using a track sprayer set at an application rate of 200 l/ha and 2.1 bar pressure.

After spraying, all plants were returned to the glass house. The four species which were sprayed on the same date were fully randomised within replicates. Each of the following two species were randomised separately in randomised block designs.

A foliage score (Richardson and Dean, 1974) was carried out at 7, 14 and 21 days after spraying to indicate when plant regrowth had started. At 21 days after spraying, fresh weight of foliage was measured. Analyses of variance were carried out on all fresh weight data.

Results

Table 2.1.1. The effects of mecoprop-P and/or fluoroglycofen on four broad leaf weed species (g fresh wt)

		% of recommended dose						
Species	Chemical	0	3.125	6.25	12.5	25	50	100
C. album	Mec.		1.336	1.112	0.735	0.603	0.287	0.117
	Fgf.	1.643	1.563	1.719	1.511	1.476	1.655	1.276
	Mec/fgf		1.492	1.308	0.798	0.605	0.302	0.020
M. perforata	Mec.		1.956	1.812	1.534	1.663	0.945	0.951
	Fgf.	1.932	1.750	1.822	1.817	1.482	1.284	1.040
	Mec/fgf		1.786	1.892	1.797	1.454	1.093	0.741
S. arvensis	Mec.		1.314	1.092	0.162	0.288	0.390	-0.646
	Fgf.	1.769	1.846	1.795	1.810	1.434	1.305	0.898
	Mec/fgf		1.122	0.979	0.835	0.704	-0.179	-0.824
V. persica	Mec.		0.641	0.102	-0.193	-0.198	-1.315	-1.838
	Fgf.	1.562	1.364	1.382	1.335	1.024	0.645	0.336
	Mec/fgf		1.042	0.825	-0.385	-0.404	-0.720	-1.475

LSD (p=0.05) 0.440[a], 0.381[b], 0.311[c]

Table 2.1.2. The effects of mecoprop-P and/or fluoroglycofen on *S. nigrum* and *S. media* (g fresh wt)

		% of recommended dose							LSD
Species	Chemical	0	3.125	6.25	12.5	25	50	100	(p=0.05)
S. nigrum	Mec.		1.692	1.396	1.232	0.940	0.436	0.430	
	Fgf.	1.981	2.001	2.000	1.813	1.631	1.436	1.145	0.217[a]
	Mec/fgf		1.783	1.638	1.214	1.041	0.762	0.743	0.188[b]
S. media	Mec.		0.990	0.078	-1.340	-2.690	-3.514	-3.505	
	Fgf.	1.907	1.788	1.688	1.587	1.715	1.174	1.041	0.492[a]
	Mec/fgf		0.952	0.631	-0.691	-1.496	-3.260	-3.359	0.426[b]

Discussion

Mecoprop-P alone and at low doses (Tables 2.1.1 and Tables 2.1.2) gave good control of all the species tested. Weekly visual assessment of damage showed that growth of all species was arrested for 21 days by 25% and above of the recommended dose while for charlock, black nightshade and common chickweed this was achieved with 6% of the recommended dose (Table 2.1.3)

2.1.3. Duration of control of several broad leaf weed species after treatment with mecoprop-P and/or fluoroglycofen

Species	Chemical	Duration of control
C. album	Mec.	Up to 25% of recommended rate, plants controlled for at least 8 days; above 25% of rec. rate, plants still controlled at harvest (21 days after spraying (DAS)).
	Fgf.	Overall, plants were controlled for at least 8 days.
	Mec/fgf	At 3 and 12% of rec. rate, plants were controlled for at least 8 days; at 6 and 25% of rec. rate, plants were controlled for at least 14 days; above 25%, plants were still controlled at harvest.
M. perforata	Mec.	At 3% of rec. rate, plants controlled for at least 8 days; above this rate, plants were controlled for at least 14 days.
	Fgf.	Overall, plants were controlled for at least 8 days.
	Mec/fgf	Overall, plants were controlled for at least 8 days.
S. arvensis	Mec.	Across all doses plants were still controlled at harvest (21 DAS).
	Fgf.	Up to 50% of rec. rate plants were controlled for at least 8 days; at rec. rate plants were controlled for at least 14 days.
	Mec/fgf	At 3% of rate, plants were controlled for at least 14 days, at all other doses, plants were still controlled at harvest.
S. nigrum	Mec.	At 12% and over, plants still controlled at harvest (21 DAS).
	Fgf.	At 12% and over, plants still controlled at harvest.
	Mec/fgf	At 12% and over, plants still controlled at harvest.
S. media	Mec.	At 3% of rec. rate, plants controlled for at least 15 days; at all other doses, plants still controlled at harvest (22 DAS).
	Fgf.	At all doses plants controlled for at least 8 days.

Glasshouse Experiment 2

The effect of mecoprop-P alone with simulated harrowing (uprooting and burying) on cleavers (*Galium aparine*) and rape (*Brassica napus*)

Objectives

1. To achieve a dose response to mecoprop-P.

2. To slow or stop plant growth (using mecoprop-P) and then to simulate harrowing by burrowing or uprooting plants 7 days after spraying (DAS).

3. To slow or stop plant growth and to simulate harrowing at a further date, depending on the amount of time the plants are kept in check by the herbicide.

Methods

Weeds were planted as one plant per pot (transplanted as seedlings), in WRO soil and with a gap 2 cm below the normal soil height (to allow for burying). All plants were sprayed at 2 true leaves or two whorls. Burrowing consisted of folding the plant flat from the base of the stem, then covering the plant to a depth of 2 cm. Uprooting was carried out by first dragging a spatula through the soil once each side of the plant. The plant was then dug up carefully, using the spatula, and laid across the soil surface. All plants were maintained in a gauze house from spraying to harvest. Watering was carried out via capillary matting. Plants were arranged in replicates parallel to the gauze sides of the house. All pots were fully randomised within species.

Treatments

1-8	No uprooting or burying.
9-16	No uprooting or burying.
17-24	Uprooting 7 DAS.
25-32	Burying 7 DAS.
33-40	No uprooting or burying.
41-48	Uprooting approx. 14 DAS.
49-56	Burying approx. 14 DAS.

Treatments 1-8 harvested 21 DAS. Treatments 9-32 harvested 28 DAS.
Treatments 33-56 harvested 35 DAS.

Note - All treatments were in groups of eight. These refer to the six doses and two control treatments.

Doses

100%, 50%, 25%, 12.5%, 6.25%, 3.125% of recommended dose of 1380 g a.i./ha of mecoprop-P.

Spraying

Spraying was done with a tracksprayer at a total volume of 200 l/ha and a pressure of 2.1 bar.

Assessments

Visual assessments (0-7 score) (Richardson and Dean, 1974) were done on the days of burying/uprooting. Visual scores were also done on the day of harvest.

Fresh weights of foliage and stems (cut plants at base of stems) was done for 21 DAS for trts. 1-8 and 21 days after harrowing for all other treatments. (N.B. Harvesting of trts. 9-16 was done at the same time as trts. 17-32 and harvesting of trts. 33-40 at same time as trts. 41-56).

Root visual scores (0-7 scores)were carried out after fresh weight harvest.

Monitoring of temperature and relative humidity in the gauze house was carried out throughout the experiment.

Results

Table 2.2.1. Comparison of assessment scores of *Galium aparine* after various doses of mecoprop-P and with simulated harrowing (7 DAT)

		% of recommended dose of mecoprop-P						
Type of assessment	Trt.	0	3.125	6.25	12.5	25	50	100
	None	100	89	32	36	11	0	0
Foliage score	Uprooted	80	57	68	0	0	0	0
	Buried	-	-	-	-	-	-	-
	None	100	63	4	11	2	1	1
Fresh weight	Uprooted	38	25	30	1	1	1	1
(g)	Buried	1	1	0	0	0	0	0
	None	100	94	21	55	17	0	17
Root score	Uprooted	78	77	72	17	13	0	17
	Buried	32	26	4	9	0	4	0

N.B. the results are presented as % of untreated control plants to enable comparison of the various assessment types (28 DAS)

Table 2.2.2. Comparison of assessment scores of *Galium aparine* after various doses of mecoprop-P and simulated harrowing at 14 days after spray.

Type of assessment	Trt.	% of recommended dose of mecoprop-P						
		0	3.125	6.25	12.5	25	50	100
Foliage score	None	100	79	63	29	0	0	0
	Uprooted	113	83	75	50	0	0	0
	Buried	-	-	-	-	-	-	-
Fresh weight (g)	None	100	52	42	5	1	1	1
	Uprooted	102	57	37	14	1	1	1
	Buried	36	30	7	2	0	0	0
Root score	None	100	50	74	33	17	17	6
	Uprooted	108	78	56	50	6	22	22
	Buried	92	78	17	11	0	6	6

N.B. The results are presented as % of untreated control plants to enable comparison of the various assessments (35 DAS)

Table 2.2.3. Comparison of assessment scores of rape after various doses of mecoprop-P and simulated harrowing at 14 days after spray.

Type of assessment	Trt.	% of recommended dose of mecoprop-P						
		0	3.125	6.25	12.5	25	50	100
Foliage score	None	100	25	46	18	0	0	0
	Uprooted	0	0	0	0	0	0	0
	Buried	-	-	-	-	-	-	-
Fresh weight (g)	None	100	35	42	20	4	3	2
	Uprooted	16	10	8	8	4	3	2
	Buried	56	27	2	0	0	0	-
Root score	None	100	51	66	51	31	16	23
	Uprooted	64	51	35	35	35	23	16
	Buried	102	62	58	47	43	39	-

N.B. The results are presented as % of untreated control plants to enable comparison of the various assessments (35 DAS).

Discussion

Table 2.2.1 shows that both burying and uprooting seven days after spraying enhanced the control of cleavers whorls of leaves and assessed 28 days after spraying. At 12.5% of the recommended dose the visual assessment of the foliage was 36% of the untreated plant without simulated harrowing while with uprooting or burying complete control was achieved. Simulated harrowing 14 days after spraying tended to have less effect for complete control 25% of the recommended dose of mecoprop-P was required (Table 2.2.3). Very similar trends were seen with rape (Table 2.2.3)

Glasshouse Experiment 3

The effect of mecoprop-P with uprooting on large cleavers cleavers (*Galium aparine*)

Objectives

1. To achieve a mecoprop-P dose response on cleavers at 4 whorls.

2. To slow growth using mecoprop-P and then simulate harrowing by uprooting plants 7 days after spraying (DAS).

Methods

Weeds were planted with one plant per pot (transplanted seedlings), in WRO soil. All plants were sprayed at approximately 4 whorls. Treatments were applied as detailed below. Uprooting was carried out at 7 DAS, when the soil was slightly moist. Uprooting was achieved by dragging a spatula through the soil either side of the plant and then carefully digging up using the spatula, then lying the plant across the top of the pot. All plants were maintained in the gauze house from spraying until harvesting (3 weeks after uprooting). All pots were randomised within replicates.

Treatments

1-6: Sprayed at increasing doses.
7-12: Sprayed at increasing doses; uprooted 7 DAS.

All treatments were harvested 3 weeks after uprooting.

Each replicate included two 'normal' controls and two uprooted controls.

Doses

100%, 50%, 25%, 12,5%, 6.25%, 3.125% of recommended dose of 1380 g a.i./ha mecoprop-P.

Spraying

Spraying was done with tracksprayer at a total volume of 200 1/ha and a pressure of 2.1 bar.

Assessments

Visual assessments (0-7 score; Richardson and Dean, 1974) was done at 7 day intervals, commencing 7 DAS. Foliage fresh weights was measured 3 weeks after uprooting date. Root visual scores (0-7 scores) was carried out after fresh weight harvest.

Notes

Monitoring of temperature and relative humidity in the gauze house was carried out throughout the experiment.

Results

Table 2.3.1. Comparison of assessment scores of *Galium aparine* after various doses of mecoprop-P and with simulated harrowing.

		% of recommended dose of mecoprop-P						
Type of assessment	Trt.	0	3.125	6.25	12.5	25	50	100
	None	100	71	68	32	18	11	7
Foliage score	Uprooted	50	29	32	18	14	7	4
	None	100	44	45	21	12	7	10
Fresh weight (g)	Uprooted	31	16	16	11	11	6	5
	None	100	98	89	60	43	38	34
Root score	Uprooted	57	38	38	34	38	38	34

N.B. Table results are presented as % of untreated control plants to enable comparison of the various assessment types.

Discussion

Cleavers with four whorls of leaves were sprayed with mecoprop-P and one set of plants were uprooted 7 days later. Mecoprop-P at 12.5% alone gave incomplete control, but with uprooting a complete kill was achieved (Table 2.3.1).

Glasshouse experiment 4

The effect of mecoprop-P with and without diflufenican plus simulated harrowing on cleavers (*Galium aparine*), field pansy (*Viola arvensis)* and volunteer rape (*Brassica napus* cv. Ariana).

Objectives

1. To achieve dose responses for mecoprop-P alone, mecoprop-P with diflufenican and diflufenican alone, with cleavers, field pansy and volunteer rape.

2. To determine whether there are any synergistic effects when using these chemicals in mixtures.

3. To determine the effect of simulated harrowing (uprooting or burying) at a specified interval after spraying (to be determined by time for half the plants showing signs of regrowth).

4. Hence to compare the effect of 'harrowing' after spraying compared to spraying alone. Also to compare adding herbicide applications to 'harrowing' compared to harrowing alone.

Methods

All plants were planted in WRO soil, to a depth 2 cm below normal soil height. Cleavers and pansy were transplanted to one plant per pot. Rape was direct sown with three seeds per pot. The latter was thinned to one plant per pot at a later date.

Plants were sprayed at 2 true leaves or 2 whorls. Treatments were applied as described below. Simulated harrowing to be carried out as described in pot experiment. 2. All plants were maintained in a glasshouse from spraying to fresh weight harvest. Watering was carried out *via* overhead watering (with dishes). Plants were arranged in replicates parallel to the gauze sides of the house if feasible. All pots were fully randomised within species.

Treatments

Dose responses:

1-6	Mecoprop-P alone. No uprooting
7-12	Mecoprop-P with diflufenican. No uprooting
13-18	Diflufenican alone. No uprooting

No harrowing:

19-24	Mecoprop-P alone. No uprooting
25-30	Mecoprop-P with diflufenican,. No uprooting
31-36	Diflufenican alone. No uprooting

Uprooting treatments:

37-42	Mecoprop-P alone. Uproot.
43-48	Mecoprop-P with diflufenican. Uproot.
49-54	Diflufenican alone. Uproot.

Treatments 1-18 were harvested 21 days after spraying (DAS).
Treatments 19-72 to be harvested approximately 28 DAS.

All treatments were in groups of six referring to the six doses. There were also two no spray treatments per group of 24 treatments.

Doses

100%, 50%, 25%, 12.5%. 6.25%, 3.125% of recommended doses (1380 g a.i./ha mecoprop-P; 400g a.i./ha diflufenican). Mixtures were half rate of each chemical.

Spraying

Spraying was done with a tracksprayer at a total volume of 200 1/ha and a pressure of 2.1 bar.

Assessments

Fresh weight harvest 3 weeks was done after spraying or after burial/uprooting. Visual assessments (0-7 score - Richardson and Dean, 1974) were carried out just prior to simulated harrowing treatments and also just prior to fresh weight harvest. The visual scores of roots were done after the fresh weights of the foliage was determined.

Notes

Monitoring of temperature and relative humidity was done from spraying onwards.

Results

Table 2.4.1. Comparison of assessment scores of *Galium aparine* after various chemical treatments and uprooting 7 days after spray.

	Type of assessment	Action	% of recommended dose: 0	3.125	6.25	12.5	25	50	100
	Foliage score	None	100	96	86	21	0	0	0
		Uprooted	100	57	39	4	0	0	0
Mec.	Fresh weight (g)	None	100	65	51	13	1	2	2
		Uprooted	62	29	14	3	2	2	2
	Root scare	None	100	93	84	23	14	19	14
		Uprooted	60	19	19	5	9	5	9
	Foliage score	None	100	82	82	75	75	79	68
		Uprooted	100	79	79	71	64	75	57
Dff.	Fresh weight (g)	None	100	84	78	62	66	65	45
		Uprooted	62	59	51	47	39	43	36
	Root scare	None	100	107	88	102	112	102	84
		Uprooted	60	65	28	33	23	56	14
	Foliage score	None	100	86	75	64	32	11	7
		Uprooted	100	68	71	50	21	4	0
Mec. + Dff.	Fresh weight (g)	None	100	80	57	40	13	4	3
		Uprooted	62	46	44	23	7	2	2
	Root scare	None	100	88	60	37	23	9	9
		Uprooted	60	33	19	0	5	0	5

Note: These results are expressed as % of untreated control plants (i.e. no chemical or uprooting treatment).

Table 2.4.2. Comparison of assessment scores of rape after various chemical treatments and uprooting 7 days after spray.

	Type of assessment	Action	% of recommended dose: 0	3.125	6.25	12.5	25	50	100
Mec.	Foliage score	None	100	75	54	18	4	0	0
		Uprooted	89	32	32	7	4	0	0
	Fresh weight (g)	None	100	89	71	48	7	6	6
		Uprooted	62	37	26	10	5	5	5
	Root scare	None	100	86	78	63	27	31	24
		Uprooted	86	55	35	51	27	27	16
Dff.	Foliage score	None	100	75	86	82	86	86	86
		Uprooted	89	75	71	75	75	68	71
	Fresh weight (g)	None	100	82	87	83	92	83	95
		Uprooted	62	55	66	60	52	46	46
	Root scare	None	100	90	86	106	98	94	90
		Uprooted	86	67	90	74	74	55	74
Mec. + Dff.	Foliage score	None	100	75	79	64	18	14	0
		Uprooted	89	61	57	21	14	0	0
	Fresh weight (g)	None	100	95	97	84	28	16	10
		Uprooted	62	49	55	29	10	5	5
	Root scare	None	100	86	67	51	39	35	43
		Uprooted	86	67	47	59	43	39	35

Note: These results are expressed as % of untreated control plants (i.e. no chemical or uprooting treatment).

Table 2.4.3. Comparison of assessment scores of *Viola arvensis* after various chemical treatments and uprooting 7 days after spray.

	Type of assessment	Action	% of recommended dose 0	3.125	6.25	12.5	25	50	100
	Foliage score	None	100	96	93	86	82	68	43
		Uprooted	96	79	61	61	50	29	29
Mec.	Fresh weight (g)	None	100	90	92	86	67	50	22
		Uprooted	59	57	54	42	25	13	13
	Root scare	None	100	90	90	71	63	35	20
		Uprooted	20	27	16	8	16	0	4
	Foliage score	None	100	82	68	79	75	54	54
		Uprooted	96	50	61	39	50	50	11
Dff.	Fresh weight (g)	None	100	78	51	70	71	40	34
		Uprooted	59	28	42	32	33	33	15
	Root scare	None	100	75	59	67	59	55	43
		Uprooted	20	16	20	16	16	16	16
	Foliage score	None	100	79	71	57	46	46	36
		Uprooted	96	54	43	46	25	21	14
Mec. + Dff.	Fresh weight (g)	None	100	71	61	36	26	24	16
		Uprooted	59	39	28	32	17	12	10
	Root scare	None	100	71	67	39	31	24	16
		Uprooted	20	16	8	16	12	4	12

Discussion

Diflufenican had little relatively little effect on cleavers and rape and tended to slightly reduce the mecoprop-P activity when applied as a mixture (Tables 2.4.1 and 2.4.2), but it was phytotoxic against pansy (Table 2.4.3) and its activity enhanced by uprooting seven days after spraying.

Glasshouse experiment 5

The effect of the length of interval between application of tribenuron-methyl and mecoprop-P and simulated harrowing on the control of rape (*Brassica napus*)

Objectives

1. To measure the effect of the length of interval between application of tribenuron-methyl and mecoprop-P and simulated harrowing on the control of rape (*Brassica napus*)

Methods

Oilseed rape *cv.* Apex was germinated in seed trays, then planted into 5" pots filled with a sandy loam (WRO) soil, with one plant per pot. The pots were maintained in a cool glasshouse (12/8 °C +/- 5°C) with the soil kept at field capacity *via* capillary matting. Once the plants had reached 2 leaves, they were sprayed using a tracksprayer with 2 bar pressure and calibrated to deliver a total volume of 200 l/ha. The pots were sprayed with 1.88, 3.75, 7.50 or 15.00 g/ha tribenuron-methyl/ha (12.5, 25, 50 or 100% of the recommended field rate of Quantum) or 138, 276 and 552 g/ha mecoprop-P (10, 20 or 40% of the recommended field rate of Duplosan). The plants were then subjected to simulated harrowing techniques at known intervals 0 (day of spray), 1, 7, 10 or 14 days after spraying for tribenuron or 0, 1, 2, 6 and 24 hours and 2, 7 or 10 days for mecoprop-P. Simulated harrowing took the form of either burying with 80 cm^3 of soil (tribenuron-methyl + mecoprop-P), or the leaves were damaged using a stiff brush (tribenuron-methyl only).

The plants were assessed by scoring them at weekly intervals throughout the experiment. The brush damaged and non-damaged plants were assessed using a foliage score (Richardson and Dean, 1974) whilst the buried plants were assessed by the degree of foliage resurfacing, using a separate score described below. 5 weeks after spraying, the foliage fresh weight was determined and a score of the visible root system was also carried out. Both fresh weight and root scores were analysed using an analysis of variance.

Burial scoring regime:

0	no leaves visible
1	part of leaf visible
2	whole leaf visible
3	1-2 leaves visible
4	2-3 leaves visible
5	3+ leaves visible
6	moderate regrowth (beginning to look like a whole plant again)
7	much regrowth

Results

Table 2.5.1. Effect of altering the time between spray application and simulated harrowing on rape fresh weight (g), mean of all doses of tribenuron-methyl

Presence of herbicide	Cultivation method	Time interval (days) 0	1	7	10	14
yes	None	11.09	-	-	-	-
no	Brush	2.44	4.58	5.86	5.88	9.08
	Bury	5.14	4.95	18.26	11.54	16.07
yes	Brush	2.25	2.95	3.27	3.26	3.20
	Bury	3.22	3.60	5.83	5.53	6.62

LSD (p=0.05) = 3.220[a], 2.494[b]

[a] = when comparing within a cultivation method and herbicide method (i.e. along a row)
[b] = when comparing between cultivation methods and/or herbicide method (i.e. down a column)

Table 2.5.2. The effect of altering the time interval between spray application and simulated harrowing on rape root growth, mean of all doses of tribenuron-methyl

Presence of herbicide	Cultivation method	Time interval (days) 0	1	7	10	14
yes	None	5.87	-	-	-	-
no	Brush	5.00	5.67	6.67	5.67	5.33
	Bury	3.00	2.67	7.00	5.38	5.67
yes	Brush	3.75	4.17	5.16	5.42	5.08
	Bury	2.42	2.91	5.09	3.93	5.00

LSD (p=0.05) = 2.054[a], 1.591[b]

[a] = when comparing within a cultivation method and herbicide method (i.e. along a row)
[b] = when comparing between cultivation methods and/or herbicide method (i.e. down a column)

Table 2.5.3 The reduction in fresh weight of rape at (32 DAS) after application of mecoprop-P followed by burial to 1 cm at various intervals after spraying.

% of rec. rate	No cultivation	Time interval between herbicide application and burial					
		1 hour	6 hours	24 hours	2 days	7 days	10 days
0	2.625	-0.752*	-	-	-	-	-
10	1.603	-3.167	-1.727	-1.999	-3.223	0.106	1.241
20	1.602	-2.642	-3.011	-3.215	-3.791	0.749	0.946
40	1.220	-2.793	-3.984	-2.741	-2.512	0.161	0.578

LSD (p=0.05) 1.0458

* = burial only - occurred on day of spray

Discussion

Tribenuron-methyl (Quantum) was applied at 12.5, 25, 50, and 100% of the recommended dose to rape plants with two leaves. Burying the plants immediately or one day after spraying did not significantly reduce plant weight compared to burying without herbicide treatment (Table 2.5.1). At 7, 10, and 14 days after treatment burying plus herbicide resulted in significantly greater reduction than burying only. Thus more than one day is required between spraying tribenuron-methyl and cultivation to allow time for herbicide uptake. The root scores support this hypothesis (Table 5.2.2). In contrast, mecoprop-P increases damage over burial alone in one hour (Table 5.2.3).

Glasshouse experiment 6

The effect of 5mm of rain applied two hours after spraying Quantum (tribenuron-methyl), Ally (metsulfuron-methyl), Logran (triasulfuron) and Duplosan (mecoprop-P) and simulated harrowing on the control of rape (*Brassica napus*)

Objectives

1. The measure the effect of 5 mm of rain applied two hours after spraying Quantum (tribenuron-methyl), Ally (metsulfuron-methyl), Logran (triasulfuron) and Duplosan (mecoprop-P) and simulated harrowing on the control of rape (*Brassica napus*).

Methods

Oilseed rape *cv.* Apex, cleavers (*Galium aparine*), field poppy (*Papaver rhoeas*) and common field-speedwell (*Veronica persica*) seeds were germinated in seed trays and then transplanted into 3.5" pots filled with a sandy loam (WRO) soil, with one seedling per pot. The pots were maintained under 'normal' glasshouse (temperate) conditions with overhead watering. Once the rape had reached two true leaves, cleavers were at two to three whorls, poppy had grown to six to seven true leaves and the speedwell had developed one to two pairs of leaves, the plants were sprayed with sulfonylurea herbicides. The herbicides used were Quantum, Ally, Logran and Duplosan, applied at either 20, 40, 60, 80 or 100% of the recommended field rate (i.e. 3,6,9,12 or 15 g tribenuron methyl/ha; 1.2, 2.4, 3.6, 4.8, 6.0 g metsulfuron-methyl/ha; 1.5, 3.0, 4.5, 6.0, or 7.5 g triasulfuron/ha; 276, 552, 828, 1104 or 1380 g mecoprop-P/ha). They were applied using a track sprayer set at 2 bar pressure and calibrated to deliver 200 l/ha. After spraying, plants were left to dry for 1, 2 or 6 hours before being subjected to rain (using a rain simulator) set at 5 mm/hr for one hour. The plants were then left to dry before being returned to the glasshouse environment. A capillary matting system was used to maintain plants at field capacity throughout the rest of the experiment. This avoided re-wetting the leaves and thus possibly affecting the rain treatments.

The plants were assessed weekly using a foliage score (Richardson and Dean, 1974). This was carried out to provide some indication of how quickly the plants died or began to regrow. Three weeks after spraying (28-29 May 1996), the foliage fresh weight per pot was determined. A visual root score was also carried out. Analyses of variance were carried out on the fresh weight data.

Results

Appendix 2.6.1. Effect of 5 mm of rain applied two hours after spraying Ally, Logran and Quantum on four broadleaved weeds (g fresh weight of shoots)

		cleavers		poppy		rape		speedwell	
		- rain	+ rain	- rain	+ rain	- rain	+ rain	- rain	+ rain
no herbicide		8.44	5.99	6.76	7.80	19.49	20.53	5.59	7.23
herbicide*									
	20	2.25	9.09	6.86	6.61	6.08	14.89	0.65	2.51
	40	2.19	7.22	5.65	7.46	4.15	11.69	0.29	2.10
Quantum	60	1.82	7.65	5.25	6.28	6.37	11.55	0.44	2.11
	80	1.50	5.47	2.17	3.02	4.60	6.66	0.32	1.12
	100	1.15	4.99	1.24	1.32	4.06	5.80	0.42	0.96
	20	7.32	5.57	8.79	2.11	21.59	12.63	1.53	1.78
	40	8.24	7.79	2.45	0.35	19.24	3.49	0.19	0.07
Ally	60	7.69	5.08	2.46	0.65	14.15	1.66	0.43	0.21
	80	7.09	5.52	0.53	0.36	11.34	1.30	0.10	0.12
	100	6.37	5.79	0.74	0.29	5.07	1.92	0.26	0.09
	20	4.80	4.73	7.96	5.58	12.21	9.56	2.55	7.00
	40	4.89	2.91	4.84	3.33	10.08	2.99	2.63	4.15
	60	0.92	2.83	2.43	2.74	7.34	3.57	1.53	2.20
Logan	80	1.50	2.50	2.13	1.41	6.83	2.77	2.42	3.36
	100	0.68	1.49	1.72	1.74	4.77	2.31	1.93	1.83

* % of recommended dose

Appendix 2.6.1. Effect of 5 mm of rain applied two hours after spraying Ally, Logran and Quantum on four broadleaved weeds (g fresh weight of shoots)

		cleavers		poppy		rape		speedwell	
		- rain	+ rain	- rain	+ rain	- rain	+ rain	- rain	+ rain
no herbicide		14.61	18.13	10.67	12.82	25.09	37.65	17.31	12.44
herbicide*									
	20	2.60	4.68	6.05	6.50	7.86	9.68	1.62	0.22
	40	0.30	1.34	3.18	1.89	3.69	8.70	0.19	0.34
Duplosan	60	0.40	0.19	6.76	1.76	0.84	2.14	0.08	0.18
	80	0.14	0.47	2.10	1.59	0.56	1.86	0.19	0.15
	100	0.19	0.28	2.15	0.53	2.65	1.35	0.18	0.18

* % of recommended dose

Discussion

The effect of 5 mm of rain applied two hours after spraying on shoot fresh weight 21 days after treatment (DAT) depended on the herbicide and to a lesser extent the weed species. The activity of Quantum at all doses was greatly reduced by rain and a similar trend was seen with rape, but the adverse effect of rain was less pronounced at higher doses. Activity against speedwell was also reduced. Rain had the least effect on the performance of Quantum against poppy.

In contrast, the activity of Ally, was greatly improved against poppy and rape following rain, but performance against cleavers and good activity on speedwell was relatively little affected. This suggest that Ally, but not Quantum, enters the foliage relatively quickly and/or enters the plant *via* the soil. Rain tended to have a slightly negative effect on Logran activity on rape and reduced its efficacy, particularly at lower doses, against speedwell. However, against poppy and particularly rape rain increased its phytotoxicity. Duplosan activity against cleavers and rape was only reduced by rain at lower doses. In contrast, control of poppy tended to be increased following rain. These results suggest mecoprop-P uptake by the foliage is relatively fast.

Glasshouse experiment 7

The effect of temperature and burial depth on the activity of mecoprop-P against cleavers (*Galium aparine*) and common field-speedwell (*Veronica persica*)

Objectives

1. The effect of temperature and burial depth on the activity of mecoprop-P against cleavers (*Galium aparine*) and common field-speedwell (*Veronica persica*)

Methods

Cleavers and speedwell plants were grown in 9 cm pots of a sandy loam soil, under normal glasshouse conditions, until they reached the two whorl or leaf stage, when they were transferred to controlled environment cabinets set at 22/12°, 1517° and 10/5 ° C light/dark, respectively. Cabinets were maintained with a 16 hour photoperiod and 60-70% humidity. Plants were acclimatised to these conditions for two days. Sets of plants from each cabinet were then sprayed in a track-sprayer with 0, 69 or 207 g mecoprop-P/ha (0, 5 and 15 % recommended field rate of Duplosan, respectively), at an application rate of 200 1/ha and 2 bar pressure. All plants were then returned to the cabinets. Seven days after spraying, cultivation was simulated by burying plants from each herbicide treatment under additional soil to a depth of 0, 0.5, 1 and 2 cm. Plants were observed each week to determine when regrowth commenced. Once the untreated plants had developed eight whorls (cleavers) or five-six pairs of leaves (speedwell), fresh weights of shoots above soil level were recorded.

The weed species were arranged in a randomised block design within each temperature regime. There were four replicates of each species. Analyses of variance using 1n transformations were carried out on all fresh weight data.

Results

Table 2.7.1. Duration of suppression (days) of *G. aparine* and *V. persica* after treatment with mecoprop-P at 0, 5% or 15% of the recommended rate under various treatment regimes (means across all burying regimes).

Temp. Regime (°C)	*G. aparine*			Time to harvest (days)	*V. persicaria*			Time to harvest (days)
	0	5%	15%		0	5%	15%	
22/12	-	14	20*	20	-	21	21*	21
15/7	-	14	27	27	-	14	27*	27
10/5	-	28	35	43	-	43	43	37

* = no regrowth at harvest

Table 2.7.2. Effect of mecoprop-P on the final fresh weights (g) of *G. aparine*, at the eight whorl stage.

	% of recommended rate of mecoprop-P		
	0	5	15
Fresh Weight	0.927 (2.476)	0.023 (0.973)	-1.732 (0.127)

LSD (P=0.05) = 0.351

Note: Means and LSD are presented on a 1n scale. Back-transformed means are shown in parentheses.

Table 2.7.3. Combined effects of mecoprop-P and burial depths on the final fresh weights (g) of *v. persica*, at the five to six pairs of leaves stage.

	Depth of burying (cm)			
	0	0.5	1	2
0	2.462 (11.678)	1.659 (5.205)	-0.120 (0.837)	-1.698 (0.133)
5	1.871 (6.444)	-2.450 (0.036)	-2.996	-2.996
15	0.646 (1.858)	-2.996	-2.930 (0.003)	-2.996

LSD (p=0.05) = 0.613

Note: Means and LSD are presented on a 1n scale. Back-transformed means are shown in parentheses.

Discussion

The duration of weed control varied with weed species and temperature (Table 2.7.1). In general, the interval between spraying and commencement of plant regrowth increased as herbicide dose increased and as temperature decreased. Cleaver plants in the 15/7° regime weighed more than those in the other regimes (Table 2.7.2), suggesting that this regime was closest to the optimum growing conditions for this weed.

Cleavers were affected by an interaction between mecoprop-P and burying depth. This was due to minor changes in the size of effect rather than an overall pattern. The individual effects of burial depth and herbicide dose were much more significant ($p < 0.001$) (Tables 2.7.3 and 2.7.4). Fresh weights declined significantly with each increase in herbicide dose and with each increase in burial depth.

Temperature had a marked effect on the duration of weed growth suppression. Leaf curl symptoms of mecoprop-P were visible within hours of spraying. These effects lasted longer in the lowest temperature regime than in the warmer environments. This may well be due to an increased plant metabolic rate in warmer conditions, enabling the herbicide to be degraded more quickly.

As with cleavers the duration of growth suppression of speedwell increased as temperature decreased (Table 1). At the 15/7° regime, the plants appeared to grow much more quickly than plants in the 22/12° regime. However, plants were only assessed once each week, thus the 22/12° regime may have been controlled for any time between 14 and 21 days. Control of speedwell was affected by an interaction between dose of mecoprop-P applied and burial depth (Table 2.7.5). The fresh weights of unsprayed plants decreased with increasing burial depth. However, after spraying, control was equally good at all burial depths. The effect of applying 5% of the recommended rate of mecoprop-P alone did not significantly reduce fresh weight compared to not spraying, but 15 % of the recommended rate of mecoprop-P did reduce the fresh weights.

Glasshouse experiment 8

The effect of mecoprop-P and diflufenican, with and without harrowing, on five weed species grown in trays

Objectives

1. The measure the effect of a range of doses of mecoprop-P and diflufenican, with and without harrowing, on five weed species grown in trays

Methods

Rape *(Brassica napus cv.* Apex), field poppy (*Papaver rhoeas),* common field-speedwell (*Veronica persica),* field pansy (*Viola arvensis)* and cleavers (*Galium aparine)* seeds were germinated in seed trays, then transplanted into 60 x 40 cm plastic trays filled to the rim with a sandy loam (WRO) soil. The seedlings were sown in rows within each tray, with 15 seedlings per row. The trays were then moved to an open-ended polythene tunnel and maintained at field capacity *via* overhead watering. Once these seedlings had established, each tray was thinned to 10 plants per species.

The plants were sprayed using a track sprayer set at 2 bar air pressure, using an 8001 E nozzle and calibrated to deliver 200 l/ha. At this time rape had grown to 2-3 leaves, cleavers were at 1-2whorls, speedwell had 2-3 leaves, poppy had 5 leaves and pansy had 1-2 leaves. The trays were sprayed with either Duplosan, diflufenican (research chemical) with 0.1% v/v Agral or a 50/50 v/v mixture of Duplosan and diflufenican with 0.05% Agral. Duplosan was applied at 230, 460, 920 or 1840 ml product/ha (138, 276, 552 or 1104 g mecoprop-P/ha). Diflufenican was applied at 40, 80, 160 or 320 g a.i./ha and the mixture contained 69/20, 130/40, 276/80 or 552/160 g mecoprop-P/diflufenican/ha and each of the mixtures included 0.05% Agral.

The trays were then returned to the polythene tunnel and starved of water for 2 days. After 2 days, half of the trays were harrowed using a Hatzenbichler spring tine harrowcomb at setting 5 and driven at 10 Km/hr. The trays were then arranged in a pseudo-latin square design with 3 replicates of each treatment. Overhead watering was resumed to maintain each tray at field capacity for the rest of the experiment.

Forty two days after spraying, a count of the number of plants survived and plant fresh weights were assessed. An analysis of variance was carried out on the fresh weight data.

Results

Table 2.8.1. The effect of harrowing on the fresh weight of several broad leaf weed species, mean of all herbicides and doses.

Species		'Normal'	Harrowed	LSD (p=0.05)
	log	2.373	1.842	0.120
B. napus	back-transformed	10.73	6.31	-
	log	1.528	1.210	0.093
G. aparine	back-transformed	4.61	3.35	-
	log	0.952	0.225	0.228
P. rhoeas	back-transformed	2.59	1.25	-
	log	0.243	-0.044	0.079
V. arvensis	back-transformed	1.28	0.96	-

Table 2.8.2. The effects of mecoprop-P and diflufenican on *B. napus* fresh weight, mean of all herbicide doses and harrowing treatments.

Species		Control	Mecoprop-P	Diflufenican	Mixture	LSD (p=0.05)
B. napus	log	3.143	2.188	2.239	1.376	0.195[a],0.159[b]
	back-transformed	23.17	8.92	9.38	3.96	-
G. aparine	log	2.334	1.058	1.495	1.072	0.151[c],0.123[d]
	back-transformed	10.32	2.88	4.46	2.92	-

[a, c] = when comparing control to herbicide treatments
[b, d] = when comparing between herbicide treatments

Table 2.8.3. The effect of mecoprop-P and/or diflufenican alone on the fresh weight of *P. rhoeas*

Herbicide	% of recommended rate					LSD
	0	10	20	40	80	(p=0.05)
Mecoprop-P	1.002	1.450	1.080	0.820	0.142	
Diflufenican	1.002	0.538	0.639	0.563	0.788	0.6044[a],
Mixture	1.002	0.457	0.109	-0.295	-0.055	0.523[b]

Discussion

Harrowing significantly reduced the fresh weights of all species with and without herbicide treatment except speedwell (Table 2.8.1). For rape, poppy and cleavers the mixture of mecoprop-P and diflufenican was more effective than either herbicide used individually (Tables 2.8.2 and 2.8.3). This experiment was conducted under cool conditions in the winter and the mecoprop-P and diflufenican mixture performed well. In the glasshouse pot experiment conducted in the spring under warmer conditions this mixture was less effective than mecoprop alone (glasshouse experiment 2).

Glasshouse Experiment 9

Effect of three sulfonylurea herbicides with and without harrowing on several broad leaved weed species.

Objectives

1. To measure the effect of a range of doses of three sulfonylurea herbicides, with and without harrowing, on several broad leaved weed species.

Methods

Rape *(Brassica napus cv.* Apex), cleavers *(Galium aparine),* field poppy *(Papaver rhoeas),* black nightshade *(Solanum nigrum)* and common field speedwell *(Veronica persica)* seeds were germinated in seed trays, then transplanted into 60 x 40 cm plastic trays filled to the rim with a sandy loam (WRO) soil. The seedlings were sown in rows within each tray, with 15 seedlings per row. The trays were then moved to an open-ended polythene tunnel and maintained at field capacity *via* overhead watering. Once these seedlings had become established, each tray was thinned to 10 plants per species, except speedwell which was thinned to 8 plants per species (due to poor establishment). Nightshade seedlings did not establish at all well and therefore were not included in the experiment.

The plants were sprayed using a track sprayer set at 2 bar air pressure, using an 8001 E nozzle and calibrated to deliver 200 l/ha. At this time all species had grown to approximately two true leaves. The trays were sprayed with 5, 10, 20 or 40% of the recommended field rates of either Quantum, Ally or Logran (0.75, 1.50, 3.00 or 6.00 g tribenuron-methyl/ha; 0.3, 0.6, 1.2 or 2.4 g metsulfuron-methyl/ha or 0.375, 0.750, 1.50 or 3.00 g triasulfuron/ha). The trays were then returned to the polythene tunnel. Two days after spraying, half of the trays were harrowed using a Hatzenbichler spring tine harrowcomb at setting 1, travelling at 9.5 kph. The trays were harrowed perpendicular to the line of plants in the trays. Afterwards the trays were returned to the polythene tunnel and arranged in a pseudo-Latin square arrangement with three replicates of each treatment. Overhead watering was used to maintain each tray at field capacity throughout the experiment.

Twenty nine days after spraying, the number of surviving plants were counted and the plant fresh weights per species per tray were determined. An analysis of variance was carried out on the fresh weight data.

Results

Table 2.9.1. The effect of harrowing on the fresh weight of *B. napus* and *P. rhoeas* (log analysis).

Species	No harrowing	Harrowing	LSD (p=0.05)
Rape	5.333	5.275	0.0309
Poppy	3.229	3.015	0.1876

Table 2.9.2. The effect of sulfonylurea herbicides with harrowing on the fresh weight of *V. persica* (log analysis).

Harrowing	Control	Quantum	Ally	Logran	LSD (p=0.05)
None	3.447	2.278	1.826	3.115	0.5423[a]; 0.496[b];
Yes	3.364	1.768	1.647	3.619	0.3835[c]

[a] when comparing controls; [b] when comparing controls with herbicides; [c] when comparing herbicides.

Table 2.9.3. The effect of sulfonylurea herbicides and harrowing on the fresh weight of cleavers (log analysis).

Harrowing	Control	Quantum	Ally	Logran	LSD (p=0.05)
None	3.874	3.834	3.890	3.826	0.3466[a]; 0.3001[b];
Yes	3.829	3.674	3.834	4.124	0.2451[c]

[a] when comparing controls; [b] when comparing controls to herbicides; [c] when comparing herbicides and harrowing regimes.

Table 2.9.4. The effect of sulfonylurea herbicides on fresh weight of poppy (log analysis).

Herbicide	% of recommended field rate					LSD
	0	5	10	20	40	(p=0.05)
Quantum	3.761	3.286	2.148	1.240	1.276	
Ally	3.761	4.121	3.671	2.789	1.824	0.4964[a];
Logran	3.761	3.959	4.048	4.227	3.603	0.4299[b]

[a] when comparing herbicides or doses; [b] when comparing control to herbicide dose

Table 2.9.5. The effect of sulfonylurea herbicides alone on the fresh weight of speedwell (log analysis)

Herbicide	% of recommended field rate					LSD
	0	5	10	20	40	(p=0.05)
Quantum	3.405	2.778	2.528	1.762	1.024	
Ally	3.405	3.173	2.324	1.300	0.149	0.5423[a;]
Logran	3.405	3.482	3.267	3.482	3.235	0.4696[b]

[a] when comparing herbicides or doses; [b] when comparing control to herbicide doses

Table 2.9.6. The effect of sulfonylurea herbicides on the fresh weight of rape (log analysis).

Herbicide	% of recommended field rate					LSD
	0	5	10	20	40	(p=0.05)
Quantum	5.786	5.081	4.950	4.491	4.092	
Ally	5.786	5.847	5.763	5.658	5.390	0.1419[a;]
Logran	5.786	5.770	5.676	5.324	4.644	0.1638[b]

[a] when comparing herbicides or doses; [b] when comparing control to herbicide doses

Discussion

This experiment was conducted in the spring (March/April) and the harrowing had less effect than in glasshouse experiment 8, which was conducted in the winter. Harrowing had a significant but small effect on rape and poppy (Table 2.9.1) which contributed to their control. Harrowing had little effect on the activity of Ally and Quantum on speedwell and cleavers and reduced the performance of Logran against these species (Table 2.9.2 and 2.9.3). Quantum performed well against poppy and speedwell (Tables 2.9.4 and 2.9.5) but activity was low on the rape which was growing fast and probably protected by a well developed waxy cuticle (Table 2.9.5)

Glasshouse Experiment 10

The effect of tri-allate granules applied pre-emergence to three grass weed species.

Objectives

1. To assess the effects of sub-lethal doses of tri-allate granules pre-emergence of several grass species.

Methods

Germination tests were carried out on black-grass (*Alopecurus myosuroides),* spring wild-oat *(Avena fatua)* and barren brome *(Bromus sterilis).* From these results the number of seeds required to expect twenty seedlings to germinate was calculated.

Forty eight trays of size 54 x 35 cm were, filled with sandy loam soil (WRO soil). Grass seeds were sown in each tray such that one half of each tray contained one of the species mentioned in the germination tests. Each species was sown at the depth required for optimal germination. The number of seed sown per species varied such that twenty seedlings were anticipated in each half tray. The trays were maintained in an open ended polythene tunnel and arranged in three replicates parallel to the sides of the tunnel, in a split-plot design.

One clay after sowing, granules of Avadex granules (10% w/w tri-allate) were evenly sprinkled on each tray at rates of 0, 4.5, 9.0, 13.5, 18.0 and 22.5 kg a/ha product. The trays were maintained at field capacity and monitored daily (except weekends) to determine the number of seedlings germinated and the time taken to appear above the soil surface. Three weeks after herbicide applications the fresh weights of seedlings were determined. Analyses of variance were carried out on natural log. transformed fresh weight data and on number of seedlings data.

Results

Table 2.10.1. Variation in plant fresh weight and seedling emergence between species (mean of all herbicide doses).

	A. myosuroides	*A. fatua*	*B. sterilis*	LSD
In fresh weight	-1.221	0.509	-0.115	0.278
b-trans. F. wt.	0.295	1.664	0.891	-
seedling emergence	19.37	23.38	20.67	2.58

Discussion

The dose response of all three species was similar and the effect of tri-allate on shoot fresh weight has been pooled in Table 2.10.1. The 40% dose (9.0 kg/ha granules) halved shoot and root size while 60% of the recommended dose performed as well as the full dose. Thus tri-allate has the potential for inclusion in a reduced dose/herbicide cultivation weed management programme.

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