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TRIALS WITH PROPYZAMIDE IN NEWLY-PLANTED APPLES, PLUMS, BLACKCURRANTS AND RASPBERRIES

A.S. Peddie
Rohm and Haas (UK) Ltd., 2 Masons Avenue, Croydon, CR9 3NB
A.M. Nuttall
Pan Britannica Industries Ltd., Waltham Cross, Herts., EN8 7DY

Summary Propyzamide was applied at up to 3 lb a.i./ac to newly-planted fruit crops at 12 sites in England during 1972-74. It did not adversely affect the vigour of newly-planted apples, plums, raspberries or rooted blackcurrants but unrooted cuttings of blackcurrants showed a slight reduction in vigour.

INTRODUCTION

Results reported by Clarke et al (1972) indicated that top and bush fruits which had been planted for at least one year, were tolerant of up to 3 lb a.i./ac propyzamide.* As a result of this work, investigations were undertaken in 1972-74 into the safety of applications of propyzamide to non-established fruit i.e. plants which had been planted for less than 12 months at the time of spraying. The results of these trials are presented in this report.

METHODS AND MATERIALS

Details of crop cultivars and age at spraying, soil type and spray dates are included in Table 1.

A 50% formulation of propyzamide (KERB 50W) was used in all the trials; all doses quoted refer to the rate of active ingredient of the herbicide. Applications of propyzamide were made in winter at 1.25, 1.5 (commercial rate in top and bush fruit) and 3.0 lb/ac at all sites. Successive applications were made in the winter of 1972/73 and 1973/74 at sites 2 and 7. At several sites treatments were compared with farmer applications of 1.5 lb/ac simazine (as a 50% w.p.). A randomised block design was used with three replicates. Plot size was a 1 yard swath either side of a 10 yard row. In the plum trials herbicide applications were made by a PP knapsack sprayer using a cone nozzle. An Oxford Precision Sprayer with an Allman '00' jet was used in all of the other trials. A spraying pressure of 30 lb/in^2 and an application rate of 20 gal/ac was used in all of the trials.

Visual assessments were taken of crop vigour and weed growth and the results were scored on a 0-10 scale. In the case of vigour a score of 10 represents healthy and for weed control represents 100% weed kill.

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* pronamide

Table 1

Site Details and Spraying Dates

Site	Crop	Cultivar	Period Between Planting and Spraying	Soil Type*	Spray Dates
1 Hereford	Blackcurrants (rooted cuttings)	Baldwin	1 month	SCL	14.12.72
2 Essex	Blackcurrants (rooted cuttings)	Greens Black	(a) 1 month (b) 12 months	CL	(a) 19. 2.73 (b) 18.12.73
3 Norfolk	Blackcurrants (rooted cuttings)	Baldwin	3 months	L/SCL	24. 1.73
4 Norfolk	Blackcurrants (unrooted cuttings)	Baldwin	1 month	L/SCL	24. 1.73
5 Norfolk	Apples (2 yr old)	Mixed, Spartan, Queen Cox, Ida Red	4 months	SL	23. 1.73
6 Cambs.	Apples (Maidens)	Mixed, Crispin, Discovery, Ida Red	Planted Autumn 1972	SCL	11. 1.73
7 Essex	Apples (Maidens) (2 yr old)	Queen Cox, Lambourne	Planted January 1973	CL	(a) 17. 1.73 (b) 18.12.73
8 Suffolk	Apples (2 yr old)	Bramley	1 hour	L	20.12.73
9 Essex	Apples (2 yr old)	Discovery	1 hour	CL	18.12.73
10 Norfolk	Raspberries	Glen Clova	2 weeks	SL	23. 1.73
11 Kent	Plums (Maidens)	Victoria	Planted Autumn 1973	L	6.12.73
12 Kent	Plums (2 yr old)	Mixed, Victoria, Bell de Louvain, Majorie Seedling	Planted Autumn 1973	SL	4.12.73

* New Jersey System

Table 2

Assessments of Weed Control and Crop Vigour

Treatment										
Propyzamide - 1972/73 application		0	1.25	1.5	3.0	-	-	-	-	Farmers treatment - simazine 1.5 lb/ac
(lb/ac) - 1973/74 application		-	-	-	-	0	1.25	1.5	3.0	
		Assessed May 1973				Assessed May 1974				
Crop Vigour (10 = healthy)										
*Site 4		10	9.7	9.5	9.0	-	-	-	-	9.4
Sites 1-12 (excluding 4)		10	10	10	10	-	-	-	-	-
Sites 2 and 7		-	-	-	-	10	10	10	10	-
Weed Control (10 = 100% control)										
Site 1.	*Agropyron repens*	0	7.7	8.3	8.7	-	-	-	-	3
	Broadleaved Weeds	0	9.0	9.3	9.0	-	-	-	-	10
Site 7.	*Agrostis stolonifera*	0	9.0	9.0	9.3	0	10	10	10	0
Site 8.	*Agropyron repens*	0	7.7	8.3	9.0	0	10	10	10	-
	Broadleaved Weeds	0	9.2	9.8	10.0	-	-	-	-	-
Site 11.	*Poa annua*	0	9.5	10.0	10.0	-	-	-	-	-
	Broadleaved Weeds	0	8.0	8.5	7.0	-	-	-	-	-
Site 12.	*Agropyron repens*	0	6.8	8.5	9.0	-	-	-	-	-
	Broadleaved Weeds	0	9.0	9.5	9.5	-	-	-	-	-

* Site 4 - unrooted blackcurrants; all other sites relate to rooted crops of blackcurrants, apples, plums and raspberries.

RESULTS

The effects of treatment on crop vigour and weed control are given in Table 2. There are no weed control data for some of the sites as there were very few weeds present. These sites were chosen for this reason so that weed competition would not be a factor affecting crop vigour.

Apart from site 4 no adverse effects were noted from up to 3 lb/ac propyzamide on crop height, leaf colour or leaf size of newly-planted rooted blackcurrants cuttings, maiden apples, raspberries or plums. Two successive applications of up to 3 lb/ac propyzamide had no effect on growth of newly-planted apples and rooted blackcurrants. At site 4, propyzamide effected a slight reduction in vigour of unrooted blackcurrant cuttings. This was expressed in terms of a slight delay in growth in Spring.

1.25 - 3.0 lb a.i./ac propyzamide gave excellent control of Urtica urens, Veronica spp., Stellaria media, Poa annua and Agrostis stolonifera. On average, 84% control of Agropyron repens was achieved at the 1.5 lb/ac rate of propyzamide.

DISCUSSION

Propyzamide at up to 3 lb/ac had no effect on newly-planted rooted stock when used as a single application in the winter of 1972/73 and 1973/74. Both these seasons were, however, relatively dry. In wetter winters it is possible that the deeper penetration of propyzamide could result in crop damage. Further trials will be carried out to evaluate propyzamide in this situation.

Propyzamide was evaluated on newly-planted fruit in weedy and weed-free situations so that the effect on crop vigour could be evaluated in the absence of weed competition. No adverse effects were noted in either situation even where two successive annual applications of 3 lb/ac propyzamide were made (site 7).

There are no commercially available residual materials which can be used for couch control in newly-planted top and bush fruits. If further trials are successful propyzamide could prove to be a useful tool to the grower who does not manage to eradicate this weed prior to planting up.

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References

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NEW USES OF TRIFLURALIN IN STRAWBERRY AND RASPBERRY PLANTATIONS

J.H. Bryant and D.M. Farrant

Elanco Products Ltd., The Broadway, Wimbledon S.W.19 1RR

Summary Trifluralin at 1lb/ac. applied in the 14 days prior to planting strawberries and raspberry canes has proved safe and effective on soil types from sandy loams to silts, loams and clay loams.

Pre-planting incorporation of trifluralin combined with post-planting treatments of lenacil, chloroxuron or phenmedipham on strawberry resulted in much more reliable control of a wider range of annual weeds compared with the use of post-planting treatments alone.

In new raspberry plantings, trifluralin pre-planting followed by simazine or bromacil post-planting has proved most useful for weed control during dry planting periods.

Taint tests in 1972 and 1973 showed no adverse effects on canned or quick frozen strawberries or jam fruit picked from plants treated with trifluralin at 1 and2lb/ac.

INTRODUCTION

The spectrum of weed control given by trifluralin under varying weather conditions and soil types in the U.K. has been well documented (Tyson and Smith, 1966; Bartlett et al, 1970). Trifluralin is currently widely used on brassica and fodder crops in all areas of the U.K. and more recently on other vegetable crops (Farrant and Bryant, 1974).

In some of the fruit-growing areas of the U.K., failure of lenacil, chloroxuron and simazine to give adequate weed control were reported following the very dry spring planting periods in 1971 - 1973. Additionally, a number of weeds resistant to these herbicides were also becoming a problem.

It is known that many dicotyledenous plants already 'well rooted' can be successfully transplanted into trifluralin treated soil. It was suggested by Lawson (1971) that well rooted strawberry runners and raspberry canes had shown some tolerance to trifluralin in this context.

Therefore a series of replicated and 'grower scale' trials was begun in spring 1972 and the results of these trials are discussed in this paper.

MATERIALS AND METHODS

Details of the 13 trial sites are given in Table 1.

The replicated trials were of a randomised block design and the herbicides were applied using a Van der Weij sprayer at 30 gal./ac. Incorporation of trifluralin was achieved by hand guided or tractor mounted rotary cultivators. Planting was carried out by either hand trowel or machine.

In the grower scale trials, applications of herbicides were made by various farm sprayers and trifluralin was incorporated by one pass of rotary cultivators or two passes at right angles of spring-tined harrows or tandem disc harrows.

The following formulations of herbicides were used in the trials:- trifluralin, 48% e.c., chloroxuron, 50% w.p.; lenacil, 80% w.p.; simazine, 50% w.p., and bromacil, 85% w.p.

Details of the herbicides and rates used on strawberries and raspberries are shown in Tables 2 - 10. All rates of use quoted refer to "lb a.i./ac".

Strawberry plantings were assessed for number of plants surviving, plant vigour, average plant height and width at the end of the growing season, number of flowering crowns formed at the end of the growing season and weed control at varying intervals. Individual plant measurements were made on 10 plants per plot in the replicate trials and on 20 plants per treatment taken at random in the 'grower scale' trials. Plot vigour was assessed visually on a scale from 0 to 10 where 0 = plants dead or dying; 10 = vigour of best plot.

In the raspberry trials, assessments were made for number of new canes per stool, length of new canes and weed control. In small plot trials, all new canes were measured but in grower scale trials, assessments were made on 20 'stools' taken at random throughout the plots.

Strawberries were submitted for taint testing following quick freezing and canning at The Campden Preservation Research Association and for jam at B.F.M.I.R.A., Leatherhead.

In trials on raspberries, trifluralin was incorporated to a depth of 4 in. as opposed to 2 in. for strawberries to allow for deeper planting. Even so machine planting had to be carefully done or untreated soil could be brought to the surface, this was not always easy in field scale operations.

TABLE 1

Details of crop, soil type, plot size, replication and planting date

Trial no.	Crop, cv.	Soil type	Plot size	Replication	Planting date
1	S.* C.Favourite C.Vigour Gorella Redgauntlet	Sandy loam	3 x 5 yd	4	18 Sep '72
2	S. C.Favourite Redgauntlet	Sandy loam		4	23 Aug '72
3	S. C.Favourite	Medium loam	70 x 5yd	4	20 Apr '73
4	S. Redgauntlet	Sandy loam	1 ac	-	Aug '72
5	S. C.Vigour	Medium loam	0.5 ac	-	Apr '73
6	S. Marmion	Silty loam	0.5 ac	-	May '73
7	S. C.Favourite	Clay loam	0.5 ac	-	Apr '73
8	S. C.Favourite	Clay loam	0.125 ac	-	Apr '72
9	S. Redgauntlet	Clay loam with flints	0.125 ac	-	June '73
10	R. Malling Jewel Malling Promise	Medium loam	3 x 5yd	4	Mar '72
11	R. As site 10	Medium loam	0.125 ac	-	Mar '72

*S - Strawberry R - Raspberry

Trial no.	Crop, cv.	Soil type	Plot size	Replication	Planting date
12	R. Malling Jewel	Sandy loam	0.5 ac	-	Mar '73
13	R. Malling Jewel	Heavy loam	0.5 ac	-	Mar '73

RESULTS

The results of the trials are presented in Tables 2 - 9. Data from some of the trials was analysed statistically; in Tables 2 and 3, the mean figures followed by the same letters are not significantly different at $P = 0.05$ by Duncan's Multiple Range Test.

A. Dosage Trial

Site 1 The effect of trifluralin and residual herbicide treatments on survival and vigour is shown in Tables 2 and 3. The trial was hand planted 1 day after trifluralin was incorporated in September 1972 in very dry conditions and plants had to be watered twice to keep them alive. In March 1973, before rapid growth commenced, there appeared to be no differences but 2 months later, plots treated with trifluralin at 4lb/ac were growing poorly and a number of plants had died. The results in Tables 2 and 3 show this clearly especially for the cultivars C.Favourite and C.Vigour and there appeared to be only marginal tolerance to trifluralin at 2lb/ac. Combination treatments of trifluralin at 1lb/ac followed by chloroxuron at 4lb/ac or lenacil at 1.6lb/ac slightly reduced vigour compared to the untreated but usually no more than chloroxuron or lenacil alone.

TABLE 2

The effect of a range of doses of trifluralin on plant survival 8 months after treatment at Site 1

Herbicide treatment	Rate (lb/ac)	Plant no. as % of control				
		cv. Redgauntlet *	C.Favourite	Gorella	C.Vigour	Mean
1 trifluralin	0.75	119.6 a	100.5 a	113.7 abc	93.2 ab	106.7
2 trifluralin	1.0	119.2 a	95.3 a	101.8 abc	83.7 ab	100.0
3 trifluralin	2.0	86.4 a	100.5 a	123.8 abc	77.9 abc	97.1
4 trifluralin	4.0	94.0 a	60.9 a	87.1 abc	35.0 c	69.7
5 trifluralin + chloroxuron	1.0 4.0	94.0 a	94.7 a	87.1 abc	70.9 abc	89.2
6 trifluralin + lenacil	1.0 1.6	99.1 a	100.5 a	81.0 bc	74.8 abc	88.8
7 chloroxuron	4.0	95.3 a	62.3 a	106.3 abc	59.5 abc	80.8
8 lenacil	1.6	99.1 a	95.8 a	103.0 abc	92.1 ab	95.0
9 untreated-control (hand weeded)		100.0 a	100.0 a	100.0 abc	100.1 a	100.0
cv%		16.34	15.49	11.27	20.14	

* Duncan's Multiple Range Test.

TABLE 3

Plant vigour 8 months after treatment (Site 1)

Herbicide treatment	Rate (lb/ac)	Vigour (% best control plants) cv. Redgauntlet	C.Favourite	Gorella	C.Vigour
1 trifluralin	0.75	95.0 a	97.5 ab	82.5 a	80.0 ab
2 trifluralin	1.0	92.5 a	85.0 ab	77.5 a	82.5 ab
3 trifluralin	2.0	85.0 abcd	87.5 ab	82.5 a	70.0 bc
4 trifluralin	4.0	67.5 d	50.0 c	72.5 ab	57.5 cd
5 trifluralin + chloroxuron	1.0 4.0	90.0 ab	77.5 ab	80.0 a	80.0 ab
6 trifluralin + lenacil	1.0 1.6	87.5 abc	82.5 ab	77.5 a	82.5 ab
7 chloroxuron	4.0	92.5 a	85.0 ab	82.5 a	82.5 ab
8 lenacil	1.6	90.0 ab	80.0 ab	82.5 a	85.0 ab
9 untreated-control (hand weeded)		93.7 a	92.5 a	83.7 a	91.2 a
cv%		13.75	20.38	16.29	12.00

B. Weed control and plant vigour trials

Site 2. Autumn planting took place here and vigour ratings 3 and 9 months later showed no adverse effects except for a slight reduction in treatments 1 and 2 (Table 4). The mean number of flower trusses per plant recorded in May 1973 (Table 4) show slight reductions where chloroxuron followed trifluralin although lenacil alone on Redgauntlet gave the lowest mean number.

TABLE 4

Vigour ratings, flower truss no. and weed cover at Site 2

	Redgauntlet			C.Favourite			Mean % weed cover all plots	
	Vigour		Truss	Vigour		Truss		
	D1*	D3	D3	D1	D3	D3	D1	D3
1 trifluralin 1lb + chloroxuron 3lb	8.5	9.0	3.9	9.75	9.3	4.9	8.2	4.2
2 trifluralin 1lb + chloroxuron 4lb	8.75	8.8	4.0	9.5	9.5	4.7	1.8	3.5
3 trifluralin 1lb + lenacil 1.2lb	9.25	9.8	4.3	9.5	9.5	5.3	3.5	4.7
4 trifluralin 1lb + lenacil 1.6lb	9.5	10.0	4.3	9.75	10.0	5.1	4.7	8.2
5 lenacil 1.6lb + hand hoeing	9.3	9.5	3.8	9.25	10.0	5.5	6.0	2.0

*Date 1 - 9.11.72; Date 2 - 5.3.73; Date 3 - 31.5.73

At Site 3, the trifluralin combination treatments have not significantly reduced plant size or vigour but have given much better weed control. The only weeds on the trifluralin plots were *Viola arvensis* and *Senecio vulgaris* whereas on the lenacil plots, the same weeds were present as well as *Polygonum aviculare* and *Poa annua*.

TABLE 5

Weed control and effects on plant vigour at Site 3

Herbicide treatment	Rate (lb/ac)	% weed cover *D1	D2	plant vigour D1	D2	height x width (cm) D3
1 trifluralin + lenacil	1.0 1.2	0.7	3.5	9.5	10.0	13.2 x 35.2
2 trifluralin + lenacil	1.0 1.6	0	0	10.0	9.8	14.4 x 37.0
3 trifluralin + lenacil	2.0 1.2	0	0	8.8	9.3	12.6 x 34.2
4 trifluralin + lenacil	2.0 1.6	0	0	9.8	9.5	14.6 x 38.3
5 lenacil	1.6	4.2	23.7	10.0	10.0	14.0 x 35.4

10 = Vigour of best plot *Date 1 = 28.6.73. D2 = 23.7.73. D3 = 15.10.73

Critical assessments in spring planted strawberries are the number of runners and flower buds produced which will determine the cropping potential for the following season.

In Table 6, the lowest counts of flowering crowns were usually linked with the poorest weed control viz. phenmedipham Site 6 and no herbicide treatment Site 7. This accords with the findings of Lawson (1973) in that strawberries left unweeded for more than 1 month after planting become retarded in growth and runner production which results in reduced yields the following season. These effects appear to persist through the commercial life of the plants.

At Site 6 (Table 6), comparing trifluralin combination treatments with phenmedipham, the latter failed to control *Polygonum aviculare* and *Poa annua* adequately. In one small trial on cold stored runners at Site 9 (Table 6), Redgauntlet showed no adverse effects from trifluralin followed by lenacil compared to lenacil alone.

At Site 8 (Table 6), the main weeds in treatments a and b were *Senecio vulgaris*. *Capsella bursa-pastoris* and *Solanum nigrum*. The same weeds occurred in treatment c except for *C. bursa-pastoris*. In treatment d, the same weeds plus *Chenopodium album*, *Atriplex patula*, *Veronica spp.*, *Urtica urens*, *Solanum nigrum* and *Stellaria media* were not adequately controlled.

TABLE 6

Weed control and plant measurements in grower scale trials

	Herbicide treatment	Rate (lb/ac)	% weed cover 4 months after planting	mean height x width (cm)	Runners+	Crowns+
				(7 months after planting)		
Site 4	a trifluralin + lenacil	1.0 1.6	2.3	18.2x41.4	-	4.9
	b lenacil	1.6	9.4	18.3x42.7	-	4.65
Site 5	a trifluralin	1.0	37.5	12.6x31.5	1.45	2.5
	b trifluralin + lenacil	1.0 1.6	2.3	14.1x33.0	1.45	2.3
	c lenacil	1.6	18.8	13.3x32.0	1.8	1.55
Site 6	a trifluralin + chloroxuron	1.0 3.0	0	16.9x40.1	5.85	4.85
	b trifluralin + lenacil	1.0 1.2	0	16.3x39.6	6.25	4.90
	c phenmedipham + 1 hand hoeing	1.0	9.4	15.6x38.6	5.35	4.65
Site 7	a trifluralin + chloroxuron	1.0 3.0	2.3	18.9x40.7	9.6	4.25
	b trifluralin + lenacil	1.0 1.2	4.7	17.0x38.5	7.6	3.35
	c no herbicide hand hoeing x 2	-	90.6	14.3x35.7	7.1	2.95
Site 8	a trifluralin	1.0	9.4	11.6x31.6	6.4	1.3
	b trifluralin + chloroxuron	1.0 4.0	2.3	10.6x31.6	5.8	1.5
	c trifluralin + lenacil	1.0 1.6	4.7	9.9x32.3	3.8	1.1
	d lenacil	1.6	54.4	10.4x29.5	5.7	1.1
Site 9	a trifluralin + lenacil	1.0 1.6	3.5	*10.4x39.0	*8.4	*1.85
	b lenacil	1.6	18.8	*9.5x39.2	*8.6	*1.80

* assessed 4 month after planting + mean no. per plant

RASPBERRIES

In 1972, two small scale trials were carried out and in this very dry season, trifluralin at 1.0lb/ac had no adverse effects on the cultivars Malling Jewel and Malling Promise.

TABLE 7

Effect of trifluralin on growth of raspberries 1972 (Site 10)

Herbicide treatment	Rate (lb/ac)	New cane length (cm)		Cane quality (% > 60cm)	
		*J	P	J	P
1 trifluralin	1.0	52.0	75.5	44.4	90.0
2 trifluralin	2.0	60.0	53.0	33.3	36.4
3 trifluralin	4.0	52.0	79.0	11.1	76.9
4 untreated		40.5	67.5	20.0	63.6

*J = Malling Jewel P = Malling Promise

TABLE 8

Effect of trifluralin on growth of raspberries 1972 (Site 11)

Herbicide treatment	Rate (lb/ac)	Cane no. per stool		New cane length (cm)	
		*J	P	J	P
1 trifluralin	1.0	4.5	1.3	88.75	66.5
2 trifluralin + simazine	1.0 1.0	3.8	2.5	97.5	74.5
3 trifluralin + simazine	1.0 2.0	3.4	1.4	101.0	57.5
4 simazine	2.0	3.3	2.8	102.6	43.9

In 1973, two larger scale trials (Sites 12 and 13) were laid down and the results in Table 9 again show no adverse effects on new cane production and quality except at Site 13, where the trifluralin was incorporated only to 2in. At planting, untreated soil was brought to the surface and coupled with the fact that the simazine was applied 8 days later than on the comparison plot, this resulted in very poor weed control and reduced new cane growth (Table 9).

TABLE 9

Effect of trifluralin on growth of raspberries cv. Malling Jewel, Sites 12 and 13 - 1973 trials

	Herbicide treatment	Rate (lb/ac)	New canes per stool	New cane length (cm)	Cane quality (% canes >1m.)
Site 12	a trifluralin + simazine	1.0 1.0	2.05	91.4	39.9
	b trifluralin + bromacil	1.0 1.0	2.05	83.7	34.1
	c bromacil	1.0	2.05	80.8	22.0
Site 13	a trifluralin + simazine	1.0 1.0	2.1	72.8	2.4
	b simazine	1.5	1.65	91.4	42.4

DISCUSSION

The results of these trials on strawberries indicate the safety of trifluralin incorporated at 1lb/ac prior to planting. This appears to hold for plantings in spring, summer and autumn and for a range of commonly grown cultivars. Safety was also not affected by post planting applications of lenacil or chloroxuron. Where higher rates of trifluralin were used damage did occur (Tables 2 and 3). Trifluralin at 2lb/ac in combination with lenacil also reduced plant vigour in cv. Cambridge Favourite (Table 5) but at 1lb/ac in combination with lenacil no real adverse effects have been noted (Tables 3 and 4). Chloroxuron following a pre-planting treatment of trifluralin on cv. Redgauntlet (Table 3) slightly reduced plant vigour.

None of the trifluralin combination treatments has significantly reduced plant size, number of runners or number of flowering crowns produced as shown by the counts in Tables 5 and 6. However, where weed control was poor, the number of flowering crowns produced was reduced (Table 6).

Taint tests with fruit from these trials carried out at Campden Preservation Research Association and B.F.M.I.R.A., Leatherhead over 2 years have shown no adverse effects of the trifluralin treatments on canned or quick frozen strawberries or strawberry jam.

The results on weed control in these experiments demonstrate the value of trifluralin as part of a herbicide programme for strawberries.

Commonly occurring weeds such as Sinapis arvensis, Senecio vulgaris, Capsella bursa-pastoris and Matricaria spp. are resistant to trifluralin but these can be controlled by lenacil or chloroxuron.

Where Veronica spp., Viola arvensis or Lamium amplexicaule are likely to be problem weeds, then the use of trifluralin prior to lenacil should give "commercial control" of these weeds which are resistant to lenacil.

Similarly, chloroxuron often gives poor control of annual grasses, Fumaria officinalis, Lamium amplexicaule, Lamium purpureum, Polygonum aviculare, Polygonum convolvulus and Atriplex patula which are well controlled by trifluralin. If trifluralin is properly incorporated it will control many of the commonly occurring weeds for 10 to 14 weeks, regardless of weather conditions whereas lenacil and chloroxuron can control weeds for a similar period but only provided rain occurs or irrigation is given soon after application.

With the high cost of labour, the recommendation for a more reliable weed control programme based on trifluralin pre-planting and lenacil or chloroxuron post-planting is economically sound especially on a high cash value crop such as strawberries. The choice of lenacil or chloroxuron as a follow up treatment will depend on the anticipated weed spectrum.

On raspberries, trifluralin at 1lb/ac alone or followed up by simazine at 1 or 2lb/ac post planting had no adverse effect on growth in 1972 (Table 8) nor where used in combination with simazine at 1lb/ac or bromacil 1.0 lb/ac at Site 12 in 1973 (Table 9).

Trifluralin has proved safe and effective for new plantings of raspberries especially in dry seasons when low rates of simazine fail to control weeds such as Polygonum aviculare and Atriplex patula. To control trifluralin resistant weeds, a follow up treatment with simazine or bromacil is necessary. However care must be taken with the working depth of incorporation and planting machines to ensure satisfactory weed control.

Acknowledgements

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THE USE OF CYANAZINE FOR THE CONTROL OF WEEDS IN NARCISSUS AND TULIP CROPS

R. G. Jones and B. C. Haddow

Shell Chemicals (U.K) Ltd., Ely, Cambridgeshire

Summary In 1973 and 1974 cyanazine was evaluated as a herbicide for use in narcissi and tulips at rates from 1.12 to 4.48 kg/ha. It was used either pre- or post-crop emergence or as a split application. Acceptable weed control was achieved with rates from 2.80-3.36 kg/ha pre-emergence, 2.24-2.80 kg/ha early post-emergence and from split applications which totalled from 2.80-3.36 kg/ha. At the optimum application timings there were no commercially unacceptable effects on crop growth, flower quality or bulb yield on a range of cultivars.

INTRODUCTION

Cyanazine was introduced at the 9th British Weed Control Conference by Chapman et al (1968) as a herbicide showing promise on a range of crops. It is now recommended for use on peas (Sandford et al, 1970 and Morris, 1972) and its use on brassicas has been reported (Haddow et al, 1972). In view of promising selectivity in leeks and onions (Allen et al, 1974) the work was extended to flower bulbs.

In bulb-growing long-term weed control is desirable because the crop provides poor ground cover even when mature and dies back relatively early. It is not therefore very competitive with weeds and these can grow rapidly and cause a reduction in bulb yield and difficulty with harvesting. Trials were undertaken with cyanazine in order to ascertain the length of weed control that could be obtained and the tolerance of narcissi and tulips to the herbicide, in particular the latest crop stage at which the chemical could be applied. Later applications would be expected to give the best weed control prior to harvest.

METHODS AND MATERIALS

The trials reported were undertaken in 1973 and 1974 on narcissi and tulips in Angus and Lincolnshire; site details are shown in Table 1. A 50% S.C.* formulation of cyanazine was used; all rates are given in terms of active ingredient. Treatments were applied either prior to crop emergence, post crop emergence or in two stages, and pre-emergence followed by a second post-emergence application. Application rates ranged from 1.12 to 4.48 kg/ha applied pre or post-emergence whilst in the split applications the total dose applied ranged from 2.80 to 3.36 kg/ha. Treatment details for the sites are shown in Tables 2 and 3.

Four of the trials were observation plots (sites 1, 2, 10 and 11) the remaining eleven being randomised block layouts of three or four replicates. Plot size varied from 6 to 20m^2 and application was in 280, 340 or 570 l/ha at 2.1 kg/cm^2 pressure using a knapsack precision sprayer.

An appropriate commercial herbicide at the recommended rate was used as a standard where possible. Trials 1, 2 and 11 had been treated with chlorpropham + linuron in the December prior to treatment with cyanazine.

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* Suspension Concentrate

Table 1

Details of soil, crop and herbicide treatment dates at each site

Site	Location	Cultivar	Sprayed pre-em	 post-em	post-em crop stage height, cm	Soil type	O.M.%
		Narcissi					
1	Lincs	Carlton		16/3/73	15	ZL +	8.9
2	"	Semper avanti		13/3/73	6	ZL	4.0
3	"	Havelock		13/3/73	15	ZL	4.0
4	Angus		19/12/72	3/4/73	9	SL	2.5
5	"			28/2/73	6	SL	2.3
6	Lincs	Rembrandt	18/12/73	25/1/74	1-5	SL	2.7
7	"	Carlton	3/1/74	25/1/74	3	SCL	2.8
8	Angus	Virginia Right	18/2/74	1/4/74	17	SL	2.5
9	"	Carlton	19/2/74	5/4/74	6	SL	2.5
		Tulips					
10	Lincs	Texas Gold		16/3/73	*	ZL	2.9
11	"	Halcro		15/3/73	*	ZL	11.2
12	Angus		12/1/73	12/4/73	7.5	SL	3.7
13	Lincs	Elmus	27/12/73	26/2/74	*	SL	2.6
14	Angus	Rose Copeland		18/2/74	*	SL	2.5
15	"	Madam Spoor		19/2/74	*	SL	3.5

*Furled-leaf stage + New Jersey system

In addition four farmer user trials of 0.25 ha were carried out in which the following cultivars were treated at 2.10 kg/ha:-

Narcissi

Edward Buxton
Semper avanti
Actea
Golden Harvest
Mount Hood
Verger
Barrett Browning
Fortune
Dutch Master
Lethario
Texas

Tulips

Texas Gold
Halcro

Weed control was assessed visually as percentage ground cover on at least two occasions after spraying and visible crop damage was assessed on the E.W.R.C. scale. Measurements of flower stem length and corolla size were made in trials 2, 3 and 13 and in trial 13 the flowers were counted. Trials 2, 3, 6, 7, 10, 11 and 13 were taken to yield. Bulbs were retained from trials 2, 3 and 11 to be grown on in the following year in the field and from trials 2 and 3 to be forced under glasshouse conditions. Measurements were made of stem length and corolla size when these plants reached maturity in 1974.

RESULTS

Weed Control Overall weed control results are set out for the observation plots in Table 2 and in Table 3 for the replicated trials. The responses of the principal weeds are shown in Table 4. The following code is used for species names in the table

Polygonum aviculare = Pav
Veronica spp = Vr
Viola spp = Vi
Matricaria spp = Ma
Poa annua = Poa
Stellaria media = Sm
Capsella bursa-pastoris = Cbp
Spergula arvensis = Sp
Fumaria spp = Fa

The weed control in all tables is expressed as a percentage of the cover on the controls; 85% weed control was taken as being commercially acceptable.

Table 2

Weed control (%) with post-emergence applications of cyanazine on observation plots assessed 73 or 101 days from spraying (D.S.)

Herbicide	Rate (kg/ha)	Site 1 73 D.S.	Site 2 101 D.S.	Site 10 73 D.S.	Site 11 101 D.S.	Mean
Cyanazine	1.68	68	95	90	87	84
	2.24	82	96	89	100	92
	3.36	50	99	64	96	77
	4.48	64	100	89	92	86
Linuron + lenacil	1.00 + 0.74	65	80	-	-	73
Pyrazone + chlorbufam	1.10 + 0.90	-	-	72	75	74
Control (% weed cover)		(74)	(100)	(95)	(24)	(73)

Of the three application timings employed i.e. pre-em., split application or post-em., the split applications generally gave the best weed control at equivalent total rates of chemical (Table 3): 1.68 kg/ha pre-em followed by the same rate post-em gave long lasting weed control. As a pre-em treatment, rates of 2.80-3.36 kg/ha were adequate whilst 2.24-2.80 were adequate post-em. At these rates cyanazine gave a performance comparable with or superior to that of the standards.

Table 4

Control (%) of individual weed species by cyanazine

Treatments	Rate (kg/ha)	Pav	Sm	Vr	Cbp	Vi	Sp	Ma	Fa	Poa
Pre-emergence										
Cyanazine	1.12	33	93	65	99	52	100	96	62	-
	1.68	77	93	80	100	62	-	98	69	-
	2.24	56	94	84	100	78	100	99	86	-
	2.80	54	89	89	100	-	100	98	-	-
	3.36	-	98	82	-	-	100	100	92	-
	4.20	47	99	91	100	-		99	-	-
Chlorproham + linuron	2.91+ 1.57	23	95	70	100	-	-	48	-	-
Split applications										
Cyanazine (total)	2.28-3.36	65	99	99	100	100	100	100	98	-
Post emergence	1.12	50	86	89	100	-	99	99	-	-
Cyanazine	1.68	79	86	91	-	-	91	100	100	98
	2.24	70	94	95	98	83	-	98	-	100
	2.80	70	99	98	99	91	100	98	97	100
	3.36	86	94	97	100	-	-	100	-	100
	4.48	77	99	99	100	-	-	100	-	100
Linuron + lenacil	1.00 0.74	0	90	80	-	-	-	-	-	93
Pyrazone + chlorbufam	1.10+ 0.90	-	-	66	100	-	-	100	-	-
Controls (% cover)		(8)	(12)	(14)	(15)	(7)	(7)	(27)	(12)	(47)

Table 3

Weed control (%) in narcissi and tulips in the replicated trials

Treatment	Rate (kg/ha)	Narcissi Site 3	4	5	6	7	8	9	Tulips 12	13	14	15	Mean (all sites)
Pre-emergence													
Cyanazine	1.12	-	85	-	49	-	70	93	50	-	-	-	69
	1.40	-	-	-	63	83	-	-	-	8	-	-	51
	1.68	-	89	-	-	-	82	97	76	-	-	-	86
	2.10-2.24	-	95	-	78	82	87	96	78	52	-	-	81
	2.80	-	-	-	-	87	-	-	-	82	-	-	85
	3.36	-	-	-	84	-	90	99	-	-	-	-	91
	4.20	-	-	-	-	91	-	-	-	90	-	-	91
Chlorpropham + linuron	2.91+1.57	-	-	-	77	77	-	-	-	0	-	-	51
Split applications													
Cyanazine	1.12+1.68	-	95	-	-	-	-	-	88	-	-	-	92
	1.12+2.24	-	98	-	-	-	-	-	90	-	-	-	94
	1.40+1.40	-	-	-	97	87	-	-	-	98	-	-	94
	1.68+1.68	-	98	-	-	-	99	99	92	-	-	-	97
Post-emergence													
Cyanazine	1.12	-	-	83	-	-	-	-	-	-	74	83	80
	1.40	-	-	-	96	89	-	-	-	27	-	-	71
	1.68	97	-	68	-	-	98	98	-	-	82	87	88
	2.10-2.24	97	94	92	96	92	97	99	98	75	83	91	92
	2.80	-	-	-	96	90	-	-	-	83	-	-	90
	3.36	98	96	-	-	-	-	-	93	-	92	95	95
	4.20	-	-	-	98	95	-	-	-	98	-	-	97
	4.48	99	-	-	-	-	-	-	-	-	-	-	99
Linuron + lenacil	0.74	-	-	-	94	75	-	-	-	-	-	-	85
Pyrazone + chlorbufam	1.10+0.90	-	-	-	-	-	-	-	-	5	-	-	5
Control (% ground cover)		100	78	37	45	70	56	45	40	100	23	57	59
Assessment date, days after post-em. app.		101	65	118	81	167	84	80	57	94	126	125	

There was a good control of most annual weeds where the treatments were applied before or soon after weed emergence and excellent control of Stellaria media, Matricaria spp, Capsella bursa-pastoris and Spergula arvensis resulted from the use of 2.24 kg/ha of cyanazine. Veronica spp, Viola spp and Poa annua were well controlled by higher rates. Control of Polygonum aviculare by the pre-crop-emergence and split applications was poor but was acceptable at the higher post-em rates. At site 13 an assessment on 31.5.74 showed that weed control had deteriorated markedly from an assessment 2 months earlier at all but the 4.20 kg/ha rate of cyanazine. At this site weed growth was dense and very advanced at the time of application.

In the farmer user applications weed control by cyanazine compared very favourably with that of the commercial standards.

Crop effects At no time were any foliar effects recorded on narcissi or on tulips treated up to the furled leaf stage; at site 12 where applications to tulips were made beyond this stage, immediately after a hard frost, some effects became apparent.

Damage appeared as chlorosis and then severe necrosis of parts of the leaves about two weeks after application. The plants flowered normally but were unmarketable due to blemishes of the leaves and stem.

Stem length and corolla diameter were measured at sites 2 and 3 (narcissi) and stem length, corolla length and number of flowers recorded at site 13 (tulips). The results are presented in Tables 6 and 7.

Table 6

Flower growth at two sites following post-emergence cyanazine applications to narcissi

Treatments	Rate (kg/ha)	Stem length Site 2	(cm) Site 3	Corolla diam. Site 2	(cm) Site 3
Cyanazine	1.68	29.8	41.8	9.4	9.1
	2.24	30.0	45.0	8.8	9.6
	3.36	34.6	44.8	9.6	9.5
	4.48	30.2	42.5	8.6	9.4
Linuron+ lenacil	1.00 + 0.74	37.7	43.9	9.1	9.5
Control (untreated)		33.6	41.1	8.7	9.5
L.S.D. (P= 0.05)			3.4		0.5

Table 7

Effect of cyanazine on the flower growth of tulips (Site 13)

Treatments	Rate (kg/ha)	Stem length (cm)	Corolla length (cm)	Flower No.
Pre-emergence Cyanazine	1.40	30.5	4.7	159
	2.10	32.0	4.8	141
	2.80	30.7	4.7	145
	4.20	32.0	4.7	139
Chlorpropham + linuron	2.91+ 1.57	30.6	4.6	152
Split application Cyanazine	1.40/1.40	33.3	4.6	143
Post emergence Cyanazine	1.40	32.3	4.6	157
	2.10	32.7	4.7	163
	2.80	32.1	4.7	142
	4.20	31.3	4.6	156
Pyrazone + chlorbufam	1.10+ 0.90	32.9	4.6	150
Control (untreated)		36.2	4.3	101
Hoed control		36.4	4.8	163
L.S.D. (P = 0.05)		3.8	0.5	28

In the two narcissi trials differences in stem length and corolla diameter were slight. All treatments in the tulip trial gave reduced stem length compared with either control (generally significant at P = 0.05), but they also resulted in greater corolla lengths than on the untreated control. Flower number was increased significantly by all treatments compared with the untreated control.

Measurements were made of flowers from bulbs harvested from three of the 1973 trials and either grown on the following year or forced in a glasshouse; these are shown in Table 8.

Table 8

Flower growth of bulbs grown on or forced the year after treatment with cyanazine

Cyanazine	Site 2		Site 3		Site 11		Site 2		Site 3	
(kg/ha)	SL	CD	SL	CD	SL	CL	SL	CD	SL	CD
1.68	37	10.1	36	9.7	35	6.2	42	8.8	49	8.9
2.24	-	-	-	-	31	6.4	-	-	-	-
3.36	-	-	-	-	34	6.5	-	-	-	-
4.48	38	10.4	38	10.0	30	6.6	43	9.0	49	8.6
Control (untreated)	38	10.2	38	10.2	27	5.8	41	8.9	48	8.6

SL = Stem Length, CD = Corolla diameter, CL = Corolla length (cm).

No unacceptable effects from the previous applications of cyanazine were apparent. The stem lengths of all bulbs, the corolla diameters of narcissi and the corolla lengths of tulips from treated bulbs were comparable to or better than those from bulbs from untreated control plots.

Table 9

The effect of cyanazine on yield of narcissus(N) and tulip (T) bulbs at seven sites

Treatment	Rate (kg/ha)	Yield (% untreated control) Site 3 (N)	10 (T)	11 (T)	Yield (% hoed control) 2 (N)	6 (N)	7 (N)	13 (T)
Pre-emergence								
Cyanazine	1.40	-	-	-	-	94	87	-
	2.80	-	-	-	-	-	86	119
	4.20	-	-	-	-	-	94	130
Chlorpropham + linuron	2.91+ 1.57	-	-	-	-	-	89	-
Split application								
Cyanazine	1.40 + 1.40	-	-	-	-	99	86	132
Post emergence								
Cyanazine	1.40-1.68	91	100	93	79	94	82	122
	2.10-2.24	85	113	87	76	-	93	116
	2.80	-	-	-	-	-	88	120
	3.36	84	113	73	85	-	-	-
	4.20-4.48	85	100	100	98	97	86	116
Linuron + lenacil	1.00+ 0.74	77	-		102	98	93	-
Pyrazone + chlorbufam	1.10+ 0.90	-	69	97	-	-	-	-
Control (untreated)		100	100	100	-	-	80	80
Control (hoed)		102	-	-	100	100	100	100
L.S.D. (p = 0.05)		21	-	-	-..	20	20	16

There was no significant reduction in yield in any of the replicated trials following cyanazine treatment. Results on the yield of bulbs from seven trials is presented in Table 9 and at site 13 (tulips) the mean yields from all plots were increased compared with both hoed and untreated controls.

DISCUSSION

The trials reported showed that cyanazine can provide effective weed control together with good crop selectivity in both narcissi and tulips when used pre- or post-crop emergence or as a split application on a range of soil types. Both of these crops require weed control over a long period and rates of cyanazine at 2.80-3.36 kg/ha pre-em., 2.24-2.80 kg/ha post-em or a split dose totalling 3.36 kg/ha (e.g. 1.68 + 1.68 kg/ha) provided this. However, at site 11 where there was a heavy weed population at a relatively advanced growth stage, a rate of 4.20 kg/ha was shown to be necessary. Control of a good spectrum of weed species was achieved but Polygonum aviculare was an important exception.

At all sites cyanazine at optimum rates compared favourably with the commercial standards.

No commercially unacceptable crop effects were seen except at site 12 where cyanazine was applied after the furled leaf stage and was followed by a severe frost. This suggests that post-em applications on tulips should be made before the leaves unfurl whereas narcissi appear tolerant at a more advanced growth stage thought the incidence of frost is still likely to induce damage.

Cyanazine had no more effect on flower quality than the commercial standards, either in the year of application or in the following season after bulbs had been grown on or forced. Similarly there were no statistically significant yield reductions in bulb weight in comparison with untreated controls, hoed controls or the commercial standards in any of the harvested replicated trials. The different spray volumes employed had no noticeably different effects on weed control or crop growth.

Cyanazine has only been tested on some of the many cultivars of both narcissi and tulips. Care should therefore be taken in applying the results reported to other cultivars. Likewise there are varying methods of growing on and forcing bulbs after harvest and the effect of cyanazine under all the different regimes has not been investigated.

The activity of cyanazine on weeds occurs in two main stages, contact action resulting in leaf scorch, followed by root uptake and subsequent death. The second stage depends on soil moisture conditions and can be delayed by drought or cold weather following spraying. The spring of 1973 was cold and dry and that of 1974 was cold and wet, resulting in a slow death of emerged weeds in both years. A quicker effect could be expected in a warm moist spring, but with a reduced residual activity of the chemical.

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THE RESPONSE OF CONVOLVULUS ARVENSIS (BINDWEED) TO 2,4-D, MCPA, MCPB, DICHLORPROP, MECOPROP, 2,4,5-T, DICAMBA AND GLYPHOSATE AT VARIOUS DOSES AND APPLICATION DATES

J.G.Davison and J.A.Bailey

ARC Weed Research Organization, Begbroke Hill Farm, Yarnton, Oxford, OX5 1PF

Summary Eight translocated herbicides were applied to Convolvulus arvensis at various doses and application dates in two field experiments. Maximum differences between treatments developed in July and August of the year after application.

Each herbicide tested gave complete or near complete initial kill and significantly reduced regrowth the next year. The amount of regrowth was influenced by the herbicide used, the dose and the time of application.

There was less regrowth with 2,4-D at 1.1 than at 2.2 kg/ha but larger doses (up to 9.0 kg/ha) had no greater effect. There was less regrowth with 2,4-D, MCPA and MCPB at 2 kg/ha than with dichlorprop, mecoprop and glyphosate at the same dose and dicamba at 0.25 kg/ha. Larger doses of these herbicides were as effective as 2,4-D, MCPA and MCPB in reducing regrowth.

When 2,4-D was applied at different dates during the summer there was least regrowth from the June spray and most from September. Regrowth from May and July applications was intermediate.

INTRODUCTION

Convolvulus arvensis (bindweed) is an important weed of British orchards. It grows vigorously in the herbicide-treated strips under the tree rows in the absence of competition from other weeds and can cover the branches of fruiting trees. This causes shading, which reduces fruit quality, and increases the difficulty of picking. It may also result in broken branches.

Growth of C.arvensis can be reduced with chlorthiamid and dichlobenil (Davison, 1970) but most growers use a foliage-applied growth regulator herbicide. 2,4-D is widely used, at 2.5 kg/ha it kills the foliage in the year of application & reduces amount of regrowth in the year after treatment (Davison, 1972a). Commercially, control with 2,4-D is often unsatisfactory in Britain and reports from other countries also indicate variable results. In France it was reported that with 2,4-D at 1 kg/ha there was only 10% regrowth in the following year (Ferand et al, 1969). From California good control was reported with 1.1 kg/ha and no improvement in control by increasing the dose to 3.3 kg/ha (Lange and Suthers, 1969). It has also been reported from California that application for five successive years did not significantly reduce weed growth in the sixth year (Hamilton et al, 1971). 2,4-D is most effective against C.arvensis when applied just before flowering (Agulhon et al, 1971; Fryer and Makepeace, 1972).

In Britain other herbicides such as MCPA, MCPB and 2,4,5-T are recommended (Fryer and Makepeace, 1972). Elsewhere complete control has been claimed for dicamba at 2 kg/ha (Klyueva <u>et al</u>, 1972) and 4.5 kg/ha (Schweizer and Swink, 1971). Of the newer herbicides, results with glyphosate have been variable (Appleby <u>et al</u>, 1972; Davison, 1972b; Evans, 1972 and Hodkinson, 1973).

Growers frequently want to control several weed species with a single spray. Some weeds however, eg <u>Galium aparine</u> and <u>Stellaria media</u> are not susceptible to 2,4-D. Others may require a different dose and the best time for the control of <u>C.arvensis</u> may not be the best time for other weeds. The optimum treatment for a mixed weed population can only be decided with knowledge of the requirements of individual species.

The object of the two experiments reported here was to determine whether differences in herbicide, dose and timing of application were important in controlling <u>C.arvensis</u>. Glyphosate was the only herbicide included that is not already used in British orchards. The other herbicides are all used, though often at lower doses than those used in these experiments. Dicamba is normally used in mixture with other growth-regulator herbicides.

METHOD AND MATERIALS

Table 1

Details of herbicides, application dates and growth-stage of C.arvensis

Herbicide salt	Dose (kg a.i./ha)	Applic. date	Growth stage of weed
<u>Experiment 1</u>		<u>1970</u>	
2,4-D diethanolamine	1.1,2.2,4.5,9.0	18 May	vegetative, still emerging
		19 June	flowering
MCPA potassium	2.2	29 July	post-flowering, older leaves senescent
2,4,5-T triethanolamine	2.2		
dicamba sodium	2.2	23 Sept.	most foliage senescent, shoots still growing
MCPB sodium	3.3		
<u>Experiment 2</u>		<u>1972</u>	
2,4-D diethanolamine	2, 4, 8		
MCPA potassium	" " "		
MCPB sodium	" " "		
dichloprop potassium	" " "	14 July	still flowering, older leaves senescent
mecoprop potassium	" " "		
dicamba amine	0.25,0.5,1,2		
glyphosate isopropylamine	1, 2, 4, 8		

The experiments were on uncropped plots of <u>C.arvensis</u> that had been established in sandy loam soil at Begbroke Hill in July 1968. The plots were 3.5 x 3.5 m and separated by 1.5 m paths. To prevent the <u>C.arvensis</u> spreading to adjacent plots the paths were deeply cultivated in winter and chlorthiamid was incorporated each spring. Annual weeds were controlled with simazine applied at 2 kg/ha each spring.

Treatments were applied with a knapsack sprayer fitted with fan jets. In Expt.1 the volume was 560 or 670 l/ha and in Expt.2 it was 900 l/ha. Each experiment consisted of three randomised blocks. Details of the herbicides, doses and date of application are in Table 1.

Initial kill and regrowth were both assessed visually by scoring for the percentage of the ground covered with green leaf. Assessments were made at approximately monthly intervals during the growing season; the most relevant ones are presented.

The results were analysed statistically after transformation (arc sin). For the convenience of the reader actual means are presented. Differences refer to the 5% probability level.

RESULTS

Experiment 1 Five herbicides applied on four dates

Only two treatments failed to give more than 95 per cent kill of the sprayed shoots. The exceptions were the May applications of 2,4-D at 1.1 kg/ha and 2,4,5-T at 2.2 kg/ha. There was very little regrowth in the year of treatment. The most regrowth was 19% ground cover by late summer following 1.1 kg/ha of 2,4-D applied in May. Another two May treatments, 2,4-D at 4.5 kg/ha and 2,4,5-T at 2.2 had 8 and 7% ground cover respectively but on the remainder there was less than 5%.

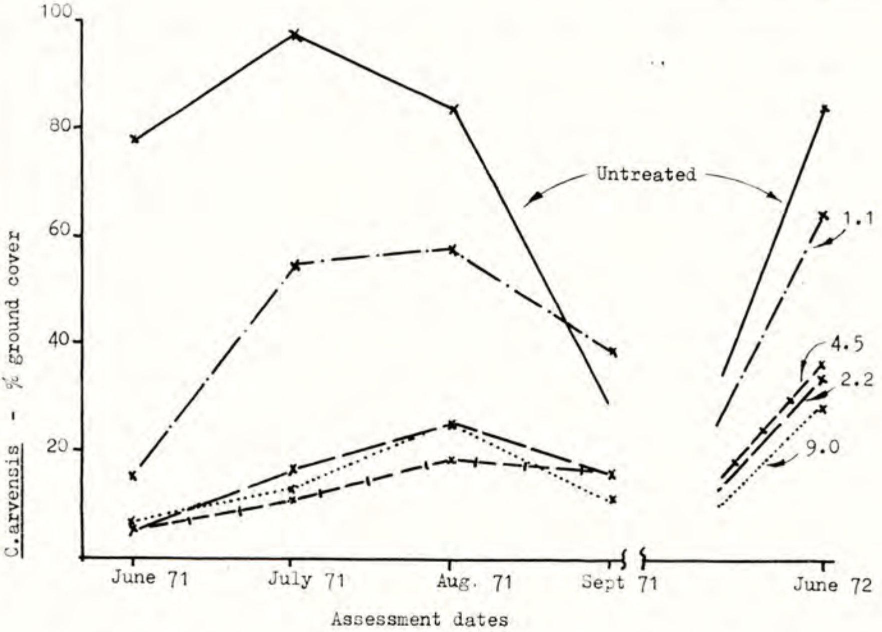

Figure 1 Amount of C.arvensis regrowth, as % ground cover, after treatment with 2,4-D at four doses (kg/ha) in 1970 (Expt. 1) The results are the means of four application dates.

In the year after treatment the C.arvensis on control plots became senescent earlier than on the treated plots on which it had emerged later. This accounts for the reduction in C.arvensis on the control plots in September. The results are shown in Figs.1-3.

Where 2,4-D was applied at four doses on four dates the amount of regrowth in 1971 and 1972 was affected by both the amount of 2,4-D applied and the date of application. There was however no interaction between them and only the mean results for all dates at the four doses and vice versa are presented. Figure 1 shows considerable differences between the control, 1.1 and 2.2 kg/ha. There was significantly less regrowth with 1.1 kg/ha compared with the control at each assessment date. There was a further significant reduction in regrowth from increasing the dose to 2.2 kg/ha. Differences for doses between 2.2 and 9.0 kg/ha were not significant.

Figure 2 shows the big differences in regrowth with different application dates. There was a significant reduction of regrowth with all application dates up to the final assessment in June 1972, two years after treatment There was least regrowth with the June application. It gave significantly better control than the other three application dates at all assessment dates, apart from June 1971, when it did not differ from the July application. The May and July applications gave significantly less regrowth than the September application at the mid-season assessment dates.

Where 2,4-D, MCPA, MCPB, 2,4,5-T and dicamba were compared the amount of regrowth was significantly affected by both the herbicide applied and the date of application. As there were no interactions between the effects of different herbicides applied at the four dates the results for herbicides shown in Figure 3 are the means for all application dates. The results for 2,4-D are for the 2.2 kg/ha dose as in Figure 1.

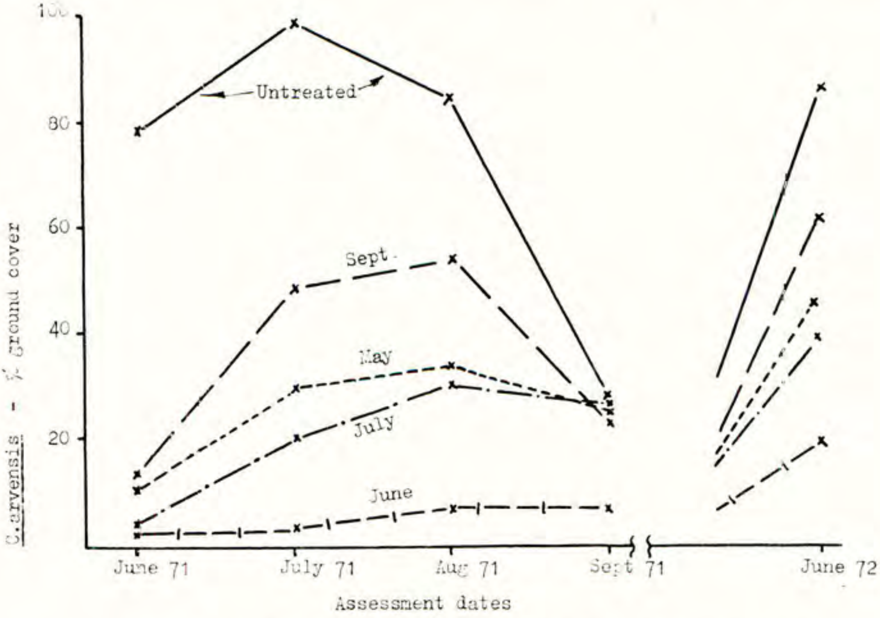

Figure 2 Amount of C.arvensis regrowth, as % ground cover after treatment with 2,4-D on four dates in 1970 (Expt. 1)
The results are the means of four doses.

All herbicides significantly reduced the amount of regrowth, and there were also significant differences between herbicides. There was less regrowth with dicamba at 2.2 kg/ha than with any other herbicide. There was a similar amount of regrowth with 2,4-D and MCPA at 2.2 kg/ha and at most assessment dates there was significantly more regrowth with 2,4,5-T at 2.2 kg/ha. There was no significant difference between the regrowth from MCPB at 3.3 kg/ha and 2,4-D at 2.2 kg/ha, but there was more regrowth with MCPB than with MCPA in June and July 1971.

Experiment 2 Seven herbicides applied at three or four doses

The results in Table 2 show that most treatments gave almost complete shoot kill in the year of treatment. Dichlorprop and mecoprop at 2 and 4 kg/ha were slower acting than 2,4-D, MCPA and MCPB at 2 kg/ha, all of which gave complete shoot kill in 4 weeks. Dicamba at 0.25 kg/ha and glyphosate at 1 and 2 kg/ha also acted more slowly and failed to give complete kill.

Plots treated with glyphosate produced abnormal regrowth the year after treatment. At 1 and 2 kg/ha approximately half the ground-covered area recorded in June consisted of small dense clumps of miniature leaves.

Differences in the overall effectiveness of the various herbicides can be determined from the mean amount of regrowth from all doses of herbicide. There were no differences in the amounts of regrowth with 2,4-D, MCPA and MCPB. There was significantly less regrowth with 2,4-D and MCPB than with dichlorprop, mecoprop, dicamba and glyphosate. There was also significantly less regrowth with MCPA than with these four herbicides, but the results were not consistent for the two dates that have been analysed.

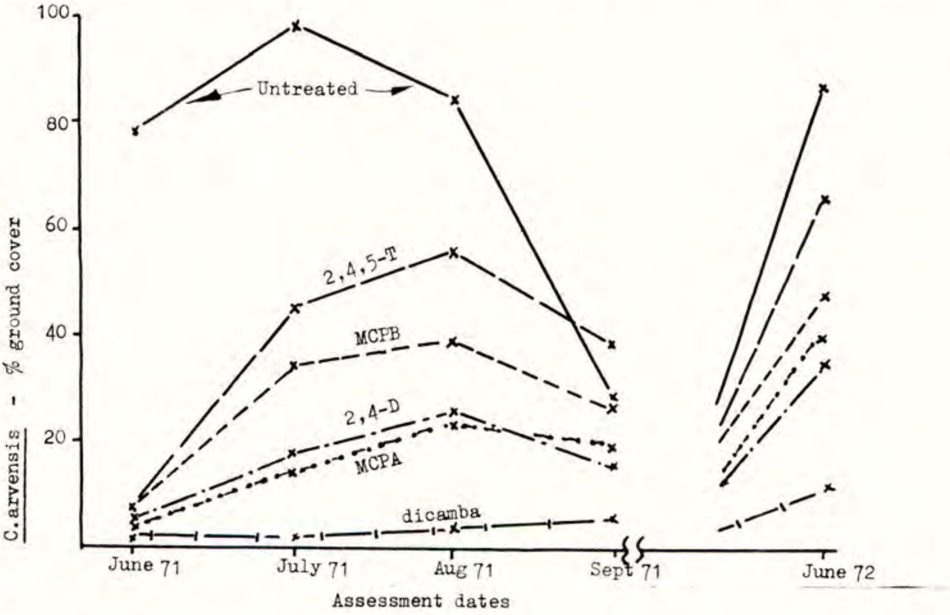

Figure 3 Amount of C.arvensis regrowth, as % ground cover, after treatment with 2,4-D, MCPA, 2,4,5-T, dicamba and MCPB in 1970 (Expt. 1) The results are the means of four application dates.

Table 2

Amount of C.arvensis, as % ground cover, at and during the 12 months after treatment with herbicides in July 1972 (Expt.2)

		Date of assessment						
		1972				1973		
Herbicide	Dose (kg/ha)	July (pre-spray)	Aug.	Sept. (early)	Sept. (late)	May	June	July
							ø	ø
control		96	85	73	52	72	98 (1,49)	66 (0.97)
2,4-D	2	98	0	<1	1	1	4 (0.20)	19 (0.43)
	4	93	0	<1	<1	1	3 (0.17)	14 (0.36)
	8	98	0	<1	0	2	4 (0.19)	10 (0.31)
MCPA	2	93	0	1	1	2	7 (0.26)	17 (0.42)
	4	97	0	0	0	1	4 (0.18)	37 (0.63)
	8	93	0	0	<1	1	6 (0.20)	25 (0.44)
MCPB	2	95	0	<1	1	2	6 (0.22)	17 (0.48)
	4	97	0	0	<1	1	2 (0.11)	6 (0.24)
	8	93	0	0	0	1	2 (0.14)	7 (0.26)
dichlorprop	2	95	11	2	1	4	38 (0.67)	70 (1.01)
	4	87	2	0	0	1	6 (0.24)	48 (0.76)
	8	98	<1	<1	0	0	2 (0.14)	15 (0.38)
mecoprop	2	93	7	1	<1	5	48 (0.78)	72 (1.04)
	4	97	3	1	<1	2	8 (0.29)	47 (0.75)
	8	95	0	0	0	1	3 (0.17)	27 (0.54)
dicamba	0.25	97	32	5	2	37	80 (1.18)	77 (1.07)
	0.5	97	1	0	0	1	8 (0.29)	37 (0.65)
	1.0	95	0	<1	1	1	2 (0.14)	9 (0.30)
	2.0	90	0	0	0	1	1 -	5 -
glyphosate	1	95	47	13	9	9 x	53 (0.82)	73 (1.03)
	2	90	40	15	6	6 x	21 (0.42)	57 (0.87)
	4	88	5	2	2	2	8 (0.28)	23 (0.49)
	8	97	<1	1	1	2	4 -	15 -
SE means ±							(0.092)	(0.128)

ø Figures in parenthesis are transformed values (arc sin)

x includes abnormal growth

The amount of regrowth was not affected by increasing the dose of 2,4-D, MCPA and MCPB from 2 to 8 kg/ha, but there was a dose response with the other herbicides. In the June after treatment the lowest doses of dichlorprop, mecoprop, dicamba and glyphosate all significantly reduced regrowth. Increasing the dose gave a further reduction in regrowth. One month later however, at the end of July 1973, none of the lowest doses of these herbicides differed significantly from the control plots. But there were still significant reductions in regrowth with dichlorprop and mecoprop at 8 kg/ha, dicamba at 0.5 and above, and glyphosate at 4 kg/ha.

There was significantly less regrowth with 2,4-D, MCPA and MCPB at 2 kg/ha than with dichlorprop and mecoprop at 2 kg/ha, dicamba at 0.25 kg/ha and glyphosate at 1 and 2 kg/ha. Larger doses of these four herbicides did not differ from 2,4-D, MCPA and MCPB.

DISCUSSION

Nearly all the herbicide treatments gave almost complete shoot kill and very little regrowth in the season of treatment Regrowth on all treated plots in June, one season after treatment was significantly less than on the control plots. Therefore, there is a wide choice of herbicides, doses and application dates that give acceptable initial kill and a reduction in the regrowth the following year However, the duration of acceptable control in the year following treatment varied being influenced by three factors - herbicide, dose and timing.

Dicamba was the outstanding herbicide in Expt. 1, but at the relatively high dose of 2.2 kg/ha. Expt. 2 showed that all the other herbicides tested can be as effective in preventing regrowth if the dose is increased. The differences between 2,4-D and either MCPB or MCPA were not significant. There was a significant difference between MCPA and MCPB in Expt. 1 and an opposite but non-significant trend in Expt. 2. However, in practical terms the three herbicides were equally effective in controlling C.arvensis. It is more important to apply the correct dose than to select the correct herbicide.

The critical dose for 2,4-D, beyond which no further reduction in regrowth occurred, was between 1.1 and 2.2 kg/ha. This differs from the findings of Lange and Suthers (1969) who found no increase between 1.1 and 3.3 kg/ha. The similar behaviour of 2,4-D, MCPA and MCPB in these experiments at doses between 2 and 8 kg/ha and the evidence of a dose response with the other herbicides, suggests that lower doses of MCPA and MCPB would also give less effective long term control. The results show that as the dose was increased to a certain level the amount of regrowth was reduced, but that above this dose there was no increased effect in regrowth.

The results in Expt. 1 show that there is a long period during the summer when application will have a significant effect on regrowth the following year. But the much greater response that was obtained with the June application also indicates the benefit of more precise timing, similar to that suggested by Agulhon et al, (1971) and Fryer and Makepeace (1972).

The practical implications for growers from these experiments is that there are many treatments that can be applied between May and September that should fulfil the dual role of killing C.arvensis shoots in the year of treatment and reducing regrowth the next season. But none of the treatments gave complete absence of bindweed in the year after treatment. The decision on which is the most suitable treatment should be influenced by a number of factors which include:- the safety of the herbicide to the crop (Davison, 1973), - the period of year when the application can be made, - the other weeds that have to be controlled, - the degree of weed control required and the cost of the treatment. In many situations in top fruit crops the answer will be 2,4-D or MCPA at 2 kg/ha in June.

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VARIATION IN THE SUSCEPTIBILITY TO SIMAZINE IN THREE SPECIES OF ANNUAL WEEDS

R.J. Holliday and P.D. Putwain

Hartley Botanical Laboratories, University of Liverpool, L69 3BX.

Summary Populations of Senecio vulgaris, Cnenopodium album, and Capsella hursa-pastoris were sampled from soft and top fruit farms in the United Kingdom and were tested for susceptibility to simazine. The populations of Chenopodium album and Capsella bursa-pastoris tested were less susceptible to simazine than those of Senecio vulgaris. Variation was found in the susceptibility of different populations and was related to the number of years of simazine application. The results, however, show no evidence of the evolution of simazine-tolerant populations of Senecio vulgaris in the United Kingdom comparable to those reported elsewhere.

INTRODUCTION

Predictions made two decades ago, that the widespread use of herbicides might lead to the evolution of genetically resistant strains of weed species (e.g. Blackman, 1950; Harper, 1956), have not generally been fulfilled. There is relatively little evidence of widespread evolution of resistance in weeds (see review by Hammerton, 1968). However, evolution of resistance to simazine and atrazine in a population of Senecio vulgaris was reported by Ryan (1970) in a nursery where these two herbicides had been used regularly for a period of twelve years. The resistant population was unaffected by simazine or atrazine at a rate of 17.9 kg/ha whereas a normal, non resistant population was eradicated by an application of 1.1 kg/ha of simazine. Subsequently Radosevich (1973) showed that the nursery population was also tolerant to all commonly used triazine herbicides. More recently, a strain of redroot pigweed (Amaranthus retroflexus) tolerant to atrazine has been reported in maize crops in Washington State, U.S.A. (Peabody, 1973). Thus it is possible that evolution of resistance to triazine herbicides in populations of annual weeds could become a more widespread problem in the future.

The investigation now reported was made to determine whether populations of annual weeds are becoming resistant to simazine in the United Kingdom. Weed populations, from soft and top fruit plantations where simazine has been used regularly for up to twelve years, have been sampled, and subsequently tested for tolerance to simazine.

METHOD AND MATERIALS

Sampling of populations

Seed of annual weeds, normally susceptible to simazine, was collected from at least 30 individual plants growing in situ on commercial holdings in Cheshire, Kent

East Anglia, Worcestershire and Berkshire and from several experimental stations. At most sites simazine had been applied annually for periods ranging from one to twelve years. In addition seed was collected from populations growing in adjacent areas where simazine had not been used. Most control samples were collected from plantations within a few miles of the treated sites. However, in certain situations, e.g. horticultural experiments, samples of seed were collected from more closely adjacent treated and untreated plots often separated by a distance of only a few metres. Populations of Senecio vulgaris, Capsella bursa-pastoris and Chenopodium album formed the majority of the seed samples.

Test of simazine susceptibility

The seed populations were tested for susceptibility to simazine by growing them in pots of John Innes No. 1 potting compost with and without a standard amount of simazine incorporated. Dry compost components were sieved (64 mm mesh) before mixing. Simazine (50% wettable powder) was added to a measured volume of compost at a rate of 0.7 kg/ha a.i. calculated on the surface area of the pots. Following hand mixing of small fractions, the material was bulked and agitated in a cement mixer for 20 minutes. Untreated compost was prepared in a similar way. Pots, 11.5 cm in diam., were filled with the mixture or with untreated compost to a depth of 5 cm and seed was sown on the surface. The number of seed to be sown in each pot was calculated from a laboratory germination experiment, for each population, so that approximately 150 individuals germinated. The pots were placed in a heated greenhouse and watered from above with a fine rose as necessary.

Senecio vulgaris, Chenopodium album and Capsella bursa-pastoris were tested in separate experiments, the latter two species were tested two months later than Senecio vulgaris. The experiments were laid out as randomised blocks with five replicates of both treated and control compost. Dead seedlings were removed and recorded at frequent intervals for three months when, in all cases, mortality had ceased . Seedlings which emerged more than two weeks after sowing were removed and were not included in the calculation of percentage mortality. The number of seedlings which emerged after two weeks was less than 1% of the number emerging in all populations tested. Mortality was expressed as a percentage of the total number which germinated. The numbers of populations of each species tested were; S. vulgaris, 46, C. album, 8, and C. bursa-pastoris, 9.

RESULTS

Mean percentage mortality for a few of the populations of the three species are given in Table 1. For the sake of clarity a representative sample are given to illustrate the overall trends in the data.

The mortality data show a trend for a reduction in susceptibility to simazine with an increase in the number of years of simazine application. In Senecio vulgaris and Capsella bursa-pastoris populations sampled from sites with 9-12 years of simazine application were significantly different from control populations ($p = 0.05$). Populations of Chenopodium album showed the same trend except two populations sampled from West Peckham. One came from an apple orchard where simazine had been used regularly for nine years and the other from an adjacent untreated area. The latter population showed a surprisingly low percent mortality which was not significantly different from the treated population. It is possible that pollen flow or seed flow from the orchard population caused more tolerant individuals to be dispersed into the surrounding area. This problem of interference between sites will be examined when a more detailed analysis of the data is made. However, the overall trend in the populations tested was an increase in tolerance with increase in years of simazine application.

Table 1.

Mean percentage mortality of populations of Senecio vulgaris, Capsella bursa-pastoris and Chenopodium album tested in simazine at a rate of 0.7 kg/ha a.i.

SPECIES	POPULATION	CROP	YEARS OF SIMAZINE	MORTALITY(%)
Senecio vulgaris	Sudbury	Apples	None	92.6
	Wisbech	Apples	1	95.4
	Gt.Welnetham	Pears	8	64.4
	Sudbury	Apples	9	71.9
	Gt.Welnetham	Apples	10	54.4
	Kelsall	Blackcurrants	12	44.3
	L.S.D. (p = 0.05) = 21.0			
Chenopodium album	W.Peckham	-	None	42.2
	Selby	Raspberries	1	87.6
	Maidstone	Apples	4	23.1
	Maidstone	Pears	4	24.1
	W.Peckham	Apples	9	24.5
	L.S.D. (p = 0.05) = 21.2			
Capsella bursa-pastoris	Wisbech	Plums	None	85.9
	Bristol	Apples	1	85.8
	Bristol	Apples	2	68.1
	Sevenoaks	Gooseberries	5	63.1
	W.Peckham	Apples	9	24.9
	L.S.D. (p = 0.05) = 23.8			

The relationship between percentage mortality of a population and the number of uninterrupted years of simazine application was examined by linear regression analysis. The populations of Senecio vulgaris were grouped according to the number of years of continuous simazine application. The mean percentage mortality of each group was calculated and the means plotted against years of simazine application. The relationship is shown in Figure 1. Variance due to the regression was highly significant (P 0.01). Clearly there is a marked relationship in Senecio vulgaris between susceptibility and number of years of selection by simazine. Whilst, for Chenopodium album and Capsella bursa-pastoris, there are insufficient data for regression analyses, the data suggest a similar relationship.

DISCUSSION

Senecio vulgaris, Chenopodium album and Capsella bursa-pastoris growing in mineral soils are normally controlled successfully by pre-emergence applications of simazine at 1-2 kg/ha (Fryer and Makepeace, 1972). However, these three species have shown considerable variation in susceptibility to simazine in these experiments. The least susceptible populations appeared to be those which occurred in commercial fruit plantations where simazine had been applied regularly for ten years or more. Where variation in susceptibility to herbicides exists there must be a potential for evolution of resistance and the appearance of these less susceptible populations

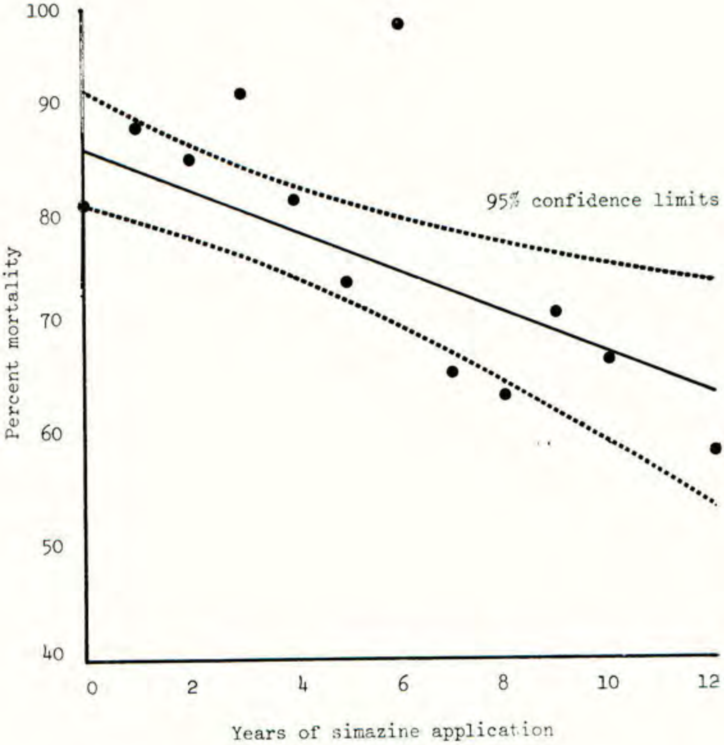

Figure 1

Relationship between susceptibility to simazine in <u>Senecio vulgaris</u> and number of years of continuous simazine application.

Regression equation:

$Y = 87.14 - 1.895\ x\ (P<0.01)$

Y = percent mortality
x = years of simazine application

does suggest that such evolution may be occurring. There is evidence that deliberate selection for herbicide tolerance can be achieved experimentally. Warwick (1973) has shown that the level of tolerance of mustard (Brassica nigra) and rape (Brassica napus) to simazine can be considerably increased in just three generations of artificial selection. Despite these indications of development of herbicide tolerance through selection there is no evidence from the work reported here that fully tolerant populations have evolved in the U.K. similar to the population of Senecio vulgaris reported by Ryan (1970) in the USA. There may be a number of reasons why fully tolerant populations have not evolved in this country. It is very rare for fruit growers to rely entirely on simazine for weed control. Paraquat is frequently used once or twice a year to eradicate any build up of annual weeds and often other herbicides (e.g. aminotriazole, diuron) are applied with or instead of simazine as an overall treatment. Spot treatments with a range of herbicides are used on localised weed infestations. Thus any surviving genotypes which might be tolerant to simazine would probably be destroyed by another herbicide before a tolerant population could become widespread. In contrast to this situation, the resistant population of Senecio vulgaris reported by Ryan (1970) was found in a nursery where triazine herbicides alone had been used for weed control. In this nursery simazine was used pre-emergence and atrazine was applied for post-emergence weed control. Thus only individuals relatively tolerant to triazine herbicides could survive the selection process. Harper (1956) stressed the importance of using herbicides which inhibit different biochemical pathways in the plant since it would be most unlikely for a mutant with multiple resistance to occur spontaneously.

It is highly likely that the resistance of the Ryan population of Senecio vulgaris is conferred by a single major gene (c.f. maize, Grogan et al, 1963) giving biochemical resistance by detoxification of the herbicide. Some of the populations we have tested showed a limited increase in tolerance which is probably controlled by polygenic inheritance. Changes in biochemical pathways may be involved but it could also be the result of changes in plant morphology. For example, larger seeds may produce more tolerant seedlings which have greater physiological vigour (Andersen, 1970; Warwick, 1973). However, it is difficult to envisage how morphological changes, even those associated with root development, could substantially affect susceptibility to soil acting herbicides.

Natural populations of annual weeds possess characteristic patterns of germination and dormancy (Roberts and Feast, 1970). Some species which produce an autumn flush of seedlings (e.g. Stellaria media)will escape the herbicidal activity of an early spring application of simazine. Only a minority of soft fruit growers control annual weeds with a spring and autumn application, thus there may be strong selection for later germination. However, such evolutionary changes in the phenology or morphology of annual weeds would not be expected to lead to a serious increase in weed populations such as would occur with the evolution of resistance based on detoxification.

The rate of evolution of resistant populations will partly depend on the breeding system of a weed species. A rapid build-up of resistance is likely to occur in a sexually reproducing species with an efficient outbreeding system, (Harper, 1956). Chenopodium album and Capsella bursa-pastoris are both outbreeders whereas Senecio vulgaris is predominantly self pollinated. Whilst control populations of all three species showed a similar level of susceptibility, some populations of Chenopodium and Capsella were considerably less susceptible to simazine than Senecio populations from sites with comparable herbicide histories. This suggests that development of resistance in Chenopodium and Capsella may be more rapid than in Senecio.

The evidence we have presented shows clearly that a few populations of Senecio vulgaris, Chenopodium album and Capsella bursa-pastoris which were collected from soft and top fruit plantations are less susceptible to simazine than populations collected from areas which have never been treated with simazine. The most tolerant populations were sampled from crops where simazine had been used regularly for many years. However, all the populations tested showed a relatively low inherent tolerance to simazine, suggesting that evolution of extreme resistance to triazine herbicides will probably not be a problem. Despite these results a suggestion made by Harper (1956) holds good, that any failure of previously successful weed control measures should be critically examined. If resistance is detected, the resistant population can then be rapidly isolated and eliminated.

Acknowledgements

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THE RESPONSE TO GLYPHOSATE OF CIRSIUM ARVENSE, HERACLEUM SPHONDYLIUM, HYPERICUM PERFORATUM, POLYGONUM AMPHIBIUM, RUMEX OBTUSIFOLIUS AND URTICA DIOICA IN ORCHARDS

J.A.Bailey and J.G.Davison

ARC Weed Research Organization, Begbroke Hill, Yarnton, Oxford, OX5 1PF

Summary Glyphosate was compared with other foliage-applied herbicides in eight experiments on six species of orchard weeds. It gave almost complete shoot kill in the year of treatment. This was achieved with 0.5 kg/ha on Cirsium arvense and Hypericum perforatum, 1 kg/ha on Polygonum amphibium and Rumex obtusifolius, 2.5 kg/ha on Heracleum sphondylium and 4 kg/ha on Urtica dioica.

In the year after treatment there was almost no regrowth of Cirsium arvense with doses as low as 0.5 kg/ha. Two years after treatment there was almost no regrowth of Polygonum amphibium with 2 kg/ha. Both mecoprop and 2,4,5-T amine at 2 kg/ha were equal to or better than glyphosate at 4 kg/ha in killing shoots of U.dioica in the year of treatment.

Germination and establishment of H.sphondylium, R.obtusifolius and U.dioica after glyphosate was applied prevented an assessment of the extent of regrowth from treated plants of these species. The practical implications are discussed.

The absence of glyphosate symptoms on apples and pears suggested that trunk base treatments may be safe to the crop.

INTRODUCTION

Soil-acting herbicides are widely used under apple and pear trees in Britain but they usually have to be supplemented by a post-emergence treatment of aminotriazole, a growth-regulator herbicide or paraquat. Davison (1972) reported the response of a wide range of both grass and broad leaf weeds to glyphosate in the year of treatment. More information is needed on the response, particularly in the year following application, of the perennial broad leaf weeds which occur in British orchards.

In this series of eight experiments, the response of six perennial broad leaf weeds to glyphosate was compared with treatments used by growers.

METHOD AND MATERIALS

In all these experiments, glyphosate was applied as the isopropylamine salt using the Mon 2139 formulation which contained a wetter.

The experiments were on commercial fruit farms in Kent, Suffolk or Worcestershire. The Rumex obtusifolius and Urtica dioica experiments were in pears and apples respectively in which there was an overall sward and no herbicides were applied by the grower. The Cirsium arvense experiment was in a fallow in which no other herbicides were applied. The other five experiments were all in apples in which there was a herbicide strip under the trees which received simazine.

Plot size was determined by tree spacing and the width of the herbicide strip where applicable. It varied between 3.6 m x 1 m and 8.3 m x 2.4 m. In the C.arvense plots were 5 x 4 m. A randomised block design was used throughout with three replicates in all experiments except on C.arvense where there were four. Where the weed density varied the plots were assigned to blocks according to the amount of weed on them.

The treatments applied at each site are given in the relevant tables of results. For each weed glyphosate was compared with herbicides that are in commercial use, but the dose in the experiments was sometimes greater than used by growers. The treatments used were activated aminotriazole (2.5 to 10 kg/ha) with or without additional 2,4-D amine (2.5 or 5 kg/ha); 2,4-D amine (2.5 to 10 kg/ha); 2,4,5-T amine (2 to 4 kg/ha); mecoprop (2 and 4 kg/ha) and dicamba (0.5 and 1 kg/ha). In most experiments the control plots were either cut down or sprayed with paraquat.

Treatments were applied with a knapsack sprayer fitted with fan nozzles and generally using a pressure of 0.2 bars. In the C.arvense experiment the pressure was 0.7 bars and in the 1973 Heracleum sphondylium experiment (B) the 2,4,5-T amine in diesel oil was applied at 3 bars, through a small hollow cone nozzle. The volume rate ranged from 300 to 1800 l/ha. This and the stage of weed development is given with each table of results.

Assessments were mainly by means of scores for the percentage ground covered by green weed foliage or the percentage green leaf. The latter is a combination of both ground cover and height of the weeds. Where the weed population included both regrowth from treated plants and seedlings of the same species no attempt was made to distinguish between the two except where counts were made of H.sphondylium in Experiment B when the total number of treated plants remaining on each plot were counted at each assessment date. The regrowth of C.arvense was assessed by counting the number of shoots in ten 30 x 30 cm quadrats per plot.

RESULTS

Heracleum sphondylium (hogweed)

Glyphosate gave a more rapid leaf kill than aminotriazole as shown in the assessments 3 and 5 weeks after application (Tables 1 and 2). 2,4,5-T amine in diesel oil also gave more rapid leaf kill than aminotriazole. In Expt. B the response to May and July applications of glyphosate was similar.

The maximum reduction in leaf cover in Expt. A (Table 1) was recorded 3 and 8 weeks after treatment. Sixteen weeks after treatment leaf cover had increased, approaching that at the start of the experiment. The scores include the foliage of H.sphondylium seedlings that germinated after the treatments were applied. In Expt.B very few of the plants that had been treated with either glyphosate or aminotriazole + 2,4-D had any green foliage by the end of September (Table 2). There was less reduction in leaf with 2,4,5-T amine in diesel oil. In April 1974, 11 months after application, all treatments were still showing greater than 80% reduction in plant numbers. These results do not include seedlings which germinated after the treatments were applied.

Hypericum perforatum (common St.John's wort). Glyphosate at 2 kg/ha and above gave complete leaf kill with no regrowth that season (Table 3). Lower doses of 0.5 and

Table 1

The effect of glyphosate on % ground covered by H.sphondylium (Expt.A)

Herbicide (applied 3.5.72)	Dose (kg/ha) in 1200 l/ha	% ground cover at successive dates in 1972			
		3.5	25.5	4.7 ø	24.8 ø
Control	-	9[+]	23	57	63
Aminotriazole	5	48	33	6	28
Glyphosate	2	30	6	22	57
"	4	18	2	8	17
"	8	40	1	7	25

+ Weed stage of growth: 50 cm, 4-6 leaves. ø including seedlings

Table 2

The effect of glyphosate on the number of H.sphondylium plants (Expt.B)

Herbicide	Dose (kg/ha) 500 l/ha	Date of application	Number of plants at successive dates 1973				1974
			16.5	21.6	23.7	11.9	25.4
Control	-	-	40[+]	31	37[+]	33	45
Aminotriazole + 2,4-D	2.5 + 2.5	16.5.73	37	16	3	2	5
2,4,5-T in diesel oil	3 ø	"	42	7	7	9	7
Glyphosate	2.5	"	40	3	2	2	3
Glyphosate	2.5	23.7.73	-	-	41	1	9

ø in 750 l/ha. + weed stage of growth: 16.5 - vegetative - 40 cm tall.
23.7 - flowering - 100 cm tall.

Table 3

The effect of glyphosate on shoots of Hypericum perforatum

Herbicide	Dose ø (kg/ha)	Date of application	% ground cover at successive dates in 1972			
			3.5	25.5	4.7	24.8
Control	-	-	14[+]	33[+]	50	14
Aminotriazole	5	3.5.72	13	13	6	10
2,4,5-T	2.5	"	13	25	37	13
Glyphosate	2	"	12	0	0	0
"	4	"	13	0	0	0
"	8	"	13	0	0	0
Glyphosate	0.5	25.5.72	-	37	6	3
"	1	"	-	32	3	1
"	2	"	-	25	0	0
"	4	"	-	30	0	0

ø Volume rate: 3.5.72 - 1200 l/ha
25.5.72 - 1000 l/ha

+ Weed stage of growth: 3.5.72 - vegetative - 30 cm tall
25.5.72 - vegetative - 50 cm tall

Table 4

The effect of glyphosate on the shoots of Polygonum amphibium (Expt.A)

Herbicide	Dose (kg/ha) in 1800 l/ha	Date applied	% green leaf at successive dates						
			1972			1973			1974
			8.6	13.7	18.8	23.5	18.6	14.9	24.7
Control	-	-	35	56	24	25	39*	1	1
Aminotriazole + 2,4-D	5 +2.5	8.6.72	24	4	3	3	8	15	5
Glyphosate	2	25.4.72+ & 18.6.73ø	7	23	43	27	63	2	1
Glyphosate	1	8.6.72+	57	53	14	1	4	23	10
"	2	"	40	43	4	1	1	1	1
"	4	"	40	40	2	1	1	1	1

* Control sprayed with glyphosate at 2 kg/ha. ø 300 l/ha

\+ Height of weed: 25.4.72 - 15 cm; 8.6.72 - 40 cm; 18.6.73 - 60 cm.

Table 5

The effect of glyphosate on the shoots of Polygonum amphibium (Expt.B)

Herbicide applied 24.5.73	Dose (kg/ha) in 300 l/ha	% green leaf at successive dates					
		1973				1974	
		24.5	18.6	26.7	13.9	21.5	24.7
Control	-	43 +	73	28	32	53	70
Aminotriazole	5	45	8	11	15	17	40
"	10	40	6	9	11	17	27
Dicamba	0.5	38	18	2	3	1	3
"	1	42	2	1	1	1	2
Glyphosate	1	42	22	3	3	2	3
"	2	48	20	2	1	1	1

\+ Weed stage of growth: 20 cm tall vegetative

Table 6

The effect of glyphosate on the foliage of Rumex obtusifolius

Herbicide applied 20.4.72	Dose (kg/ha) in 1600 l/ha	% green leaf at successive dates							
		1972					1973		
		20.4+	17.5	13.6	18.7	16.8	29.3	1.5	4.6
Control	-	52	45	63	73	23	23	50	60
Aminotriazole	4.5	53	13	5	0	3	3	6	24
2,4,5-T	2	50	25	50	57	7	18	33	50
Glyphosate	1	47	13	4	0	1	6	13	42
"	2	57	6	1	0	2	15	32	63
"	4	43	3	1	0	1	10	22	53

\+ Weeds 30 cm tall and vegetative
Seedling foliage is included in the scores on and after 16.8.72

1 kg/ha gave incomplete shoot kill but without recovery by the end of the season. Aminotriazole slightly reduced the ground cover but 2,4,5-T amine was without effect.

Polygonum amphibium (amphibious bistort). It was generally 4 to 8 weeks after an application of glyphosate before there was a substantial reduction in the amount of green leaf (Tables 4 and 5). This occurred more quickly in 1973 than in 1972. Aminotriazole, with or without 2,4-D amine, gave a faster leaf kill than glyphosate. Dicamba at 0.5 kg/ha was as fast as glyphosate but at 1 kg/ha it was faster.

The only treatments with which there was any increase in leaf cover in the year of treatment after the initial reduction were glyphosate at 2 kg/ha applied in April (Expt.A) and aminotriazole at 5 and 10 kg/ha applied in May (Expt.B).

Twelve months after application there was very little regrowth following May or June applications of glyphosate. There was almost no regrowth 2 years after treatment with 2 and 4 kg/ha in June 1972 whereas with 1 kg/ha there was a big increase in regrowth between 12 and 15 months after treatment. There was almost no regrowth 14 months after dicamba was applied; there was more regrowth with aminotriazole.

Rumex obtusifolius (broad-leaved dock). Glyphosate at 2 and 4 kg/ha gave a more rapid kill than aminotriazole at 4.5 kg/ha which was similar to glyphosate at 1 kg/ha. Three months after application there was a complete leaf kill with both herbicides. 2,4,5-T amine gave an initial check to the weeds but thereafter they recovered. In the year after treatment there was little difference between the leaf scores for the control, glyphosate at 2 and 4 kg/ha, and 2,4,5-T amine treatments. Only aminotriazole resulted in a substantial reduction in the amount of green leaf. These assessments did not distinguish between regrowth from treated plants and those plants which germinated after the treatments were applied (Table 6).

Table 7

The effect of glyphosate on the shoots of Urtica dioica

Herbicide applied 20.4.72	Dose (kg/ha) in 1600 l/ha	% green leaf at successive dates							
		1972				1973			
		20.4$^+$	17.5	13.6	4.10	29.3	4.6	20.7	9.8
Control	-	93	100	100	53	83	100	83	100
Mecoprop	2	80	13	1	7	6	24	25	37
"	4	93	3	1	2	3	12	7	17
2,4,5-T	2	85	2	0	1	2	1	2	3
"	4	77	0	0	0	1	0	1	1
Glyphosate	1	90	67	43	32	50	93	77	87
"	2	90	37	27	11	8	48	57	67
"	4	87	15	6	5	12	31	40	83

+ Weeds 40 cm tall and vegetative.
Seedling foliage is included in the scores on and after 4.10.72.

Urtica dioica (stinging nettle). Both mecoprop and 2,4,5-T amine gave an almost complete leaf kill within one month of treatment (Table 7). Leaf kill with glyphosate was slower and incomplete in the year of treatment.

In the year after treatment there was a substantial amount of *U.dioica* on the glyphosate plots. Some of this had glyphosate symptoms (small yellow leaves). Some of the normal leaves belonged to plants of *U.dioica* that had germinated after the treatments were applied. There was very little *U.dioica* on the plots sprayed with 2,4,5-T amine. The greater amount of *U.dioica* with the mecoprop treatment resulted from extensive regrowth on one plot.

Cirsium arvense (creeping thistle). Four weeks after treatment most of the glyphosate treated shoots were dead (Table 8). 2,4-D amine, with or without aminotriazole, took longer to kill the sprayed shoots. All treatments eventually gave complete kill of treated shoots and the leaf cover recorded in September was all regrowth.

Both the shoot counts and the percentage green leaf assessments in the year after treatment show almost complete absence of regrowth with any of the glyphosate treatments. 2,4-D amine (10 kg/ha) and aminotriazole + 2,4-D amine (5 + 5 kg/ha) also resulted in very little regrowth. There was more regrowth with lower doses of these treatments.

Table 8

The effect of glyphosate on shoot growth of Cirsium arvense

Herbicide	Dose (kg/ha) in 400 l/ha	Date applied	% green leaf		Shoot no. as % of control	% green leaf
			22.6.73	11.9.73	23.4.74	20.6.74
Control	-	-	73+	93	100	50
Paraquat	2	22.6.73	68	16	47	20
2,4-D	2.5	"	66	2	21	7
"	5	"	75	2	11	5
"	10	"	74	2	4	1
Aminotriazole + 2,4-D	5 + 2.5	"	76	2	15	11
"	5 + 5	"	70	3	0	1
Glyphosate	2.5	"	69	2	0	0
"	5	"	74	5	2	3
"	10	"	71	3	1	0
Glyphosate	0.5	25.7.73	23	0	0	0
"	1	"	23	0	0	0

\+ Weeds: 22.6 - 60 cm tall with flower buds
25.7 - 100 cm tall and flowering

Crop tolerance

In the experiments under apples and pears the basal part of some trunks was sprayed. Close examination of the foliage both in the year of and the year after treatment failed to reveal any glyphosate symptoms. Dicamba produced symptoms in established Cox's Orange Pippin in the only experiment in which it was applied. These symptoms, which developed in the year of treatment, were most severe at 1 kg/ha and were confined to vigorous growth in the centre of the trees. No symptoms were detected in the year after treatment.

DISCUSSION

Glyphosate has given promising results on a number of perennial weeds. In comparison with herbicides currently used in apples and pears it gave greater initial shoot kill or reduction in regrowth of H.perforatum, P.amphibium and C.arvense. Under the conditions of these experiments it was comparable to currently available herbicide treatments against H.sphondylium and R.obtusifolius but was poorer on U.dioica.

Glyphosate has shown no residual activity in soil (Baird et al, 1971) and does not appear to prevent germination. In this series of experiments, U.dioica, R.obtusifolius and H.sphondylium seeds germinated. They soon developed in the absence of competition from other weeds to a level that would be unacceptable to growers. In the case of U.dioica and R.obtusifolius no residual herbicide had been applied whilst H.sphondylium is resistant to simazine which had been applied. These three examples draw attention to the need for a suitable soil-acting herbicide to be used in conjunction with glyphosate, even though it may not be advisable to apply it simultaneously (Baird et al, 1971).

In intensive orchards access with conventional sprayers is limited to the period before the branches are weighed down by the developing crop. With P.amphibium the June treatments (Expt.A) could not have been applied with a conventional sprayer while the April application gave only a temporary check to the weed. The May application in Expt.B was both feasible and effective in reducing the amount of regrowth. U.dioica can be killed if it is sufficiently well developed when it is sprayed (Davison, 1972). Applications earlier in the year in these experiment and by others (Perry, 1974) have also given unacceptable control.

Spray volume ranged from 300 to 1800 l/ha which is greater than the 200-250 l/ha suggested by the manufacturers (Monsanto, 1974). None of the experiments were designed to investigate the effect of volume rate on the response to glyphosate but different volumes were used in the two experiments on both H.sphondylium and P.amphibium. The H.sphondylium results are inconclusive because of the development of seedlings but the P.amphibium results show that good control of regrowth is possible with volumes greater than those normally used by growers. The results with H.perforatum and R.obtusifolius also indicate good control at high volumes. Baird and Begeman (1972) have reported that the control of Agropyron repens can be improved by reducing the volume rate from 1000 to 200-300 l/ha.

The speed of action of glyphosate varied with the weed species and the year of application. H.perforatum shoots were killed in less than three weeks but there was still some green leaf on P.amphibium after two and a half months. P.amphibium shoots were killed more rapidly in 1973 than in 1972. In some experiments glyphosate was quicker than aminotriazole, but in others in was slower. These differences in initial shoot kill have not been found to affect the amount of regrowth.

The usefulness of glyphosate in orchards will be determined by its effect on the crop plants. Since it is reported that there is no soil activity with glyphosate (Baird et al, 1971) any damage to the crop will come from applications to their aerial parts. It is encouraging that symptoms of glyphosate injury as described by Clay (1972) have not been observed in these experiments. This can only be taken as an indication of the tolerance of established fruit trees to bark applications thus confirming earlier work of Clay (1972).

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PROPERTIES OF METHAZOLE FOR DEVELOPMENT AS A SELECTIVE HERBICIDE IN ORCHARDS AND VINEYARDS

W.Furness and M.H.Halawi
Velsicol Chemical Corporation, Box 110922, Beirut, Lebanon
J.N.Barlow
Velsicol Chemical Limited, 66 Tilehurst Road, Reading, Berkshire

Summary Formulated as 75% w.p., methazole exhibits contact activity upon the foliage of many plants besides residual activity in the soil. It is strongly adsorbed on most soils so that, after application pre- or post-emergence of weeds, it remains in the upper layer of soil. Selectivity in orchards and vineyards depends on the deeper roots established by these crops. Methazole at 10 kg a.i./ha controlled Convolvulus arvensis for at least three months; many other weeds listed were controlled by its contact or residual action in pome or citrus orchards and vineyards. Winter and summer weeds in stone fruits were controlled in light to medium soils, where selectivity is attributed to strong adsorption of methazole at 2-4.5 kg/ha. Formulation of methazole with other residual herbicides or with emulsifiable oils affords limited possibilities for economy in use of methazole.

Résumé L'activité du methazole poudre mouillable à 75% de m.a. se manifeste de deux manières : par contact direct sur le feuillage, et par désorption à partir des particules du sol permettant une diffusion au travers de la phase aqueuse vers les racines des plantes. Sa sélectivité à l'égard des arbres fruitiers et de la vigne est permise par la profondeur de leurs racines. Le methazole, appliqué à 10 kg m.a./ha, détruit une grande diversité de mauvaises herbes déjà levées et empêche l'apparition de nouvelles espèces; il permet un contrôle efficace du liseron pendant au moins trois mois. Certaines mauvaises herbes d'hiver et d'été dans les vergers d'arbres fruitiers à noyaux sont contrôlées grâce à l'activité residuelle du methazole a 2.25-4.50 kg m.a./ha dans les sols légers ou argilo-sableux ou par son action de contact. Sa sélectivité est attribuée à son adsorption tenace par ces sols. L'emploi de formulations incorporant d'autres herbicides résiduels ou une huile émulsionnable rend l'application du methazole plus économique.

INTRODUCTION

The relevant chemical, physical, and toxicological properties of methazole were outlined by Barlow and Furness (1972) in their introduction to research which led to the commercial use of methazole as a post-emergence herbicide for onions. The solubility of methazole in water is rather less than 2 ppm and its solution is basic. Bosch (1970) showed that its partial vapour pressure at 25° C is too low to permit herbicidal activity through the vapour phase. Methazole is stable in the atmosphere. When adsorbed uniformly on a substrate of soil its herbicidal activity persists for 12 weeks or longer depending on many ambient conditions. Methazole resides in the surface layer, being subject only slightly to leaching either down the soil profile or laterally beyond the area of its application. These properties effectively limit the residual herbicidal activity of methazole to those plants which germinate near the surface of the soil; the same properties contribute also to the selectivity of methazole as a residual herbicide in orchards and vineyards where most of the roots of trees and vines are at lower depths in the soil.

Methazole is also active when applied to the foliage of many plants. Numerous annual broad-leaf weeds and some grasses are killed by this action although there are certain important exceptions. Methazole can also suppress or control, during the season of application, many deep-rooted perennial weeds with probability of killing if this treatment should be repeated in a second or third season.

The purpose of this report is to review some investigations by our collaborators who have shown how these properties of methazole could be used to advantage. Just as requirements differ from one country to another, so do techniques; however, we shall try to point out principles so that those who are interested will be able the more easily to apply their detailed knowledge of local circumstances to the further evaluation of methazole as a herbicide in vineyards, pome, citrus, and stone fruits.

METHODS AND MATERIALS

Lines of research which converge on this problem are :

(a) to ascertain the times and dosages at which methazole can have greatest effect against *Convolvulus arvensis* and many other weeds, taking into account the range of winter and summer weeds which germinate in southern Europe and the eastern Mediterranean countries,

(b) to take advantage of the known properties of many kinds of soil for tenaciously adsorbing methazole, for example by discovering how to use it selectively in orchards of stone fruits which might be susceptible to damage by certain other soil-applied herbicides,

(c) to investigate possible advantages in using methazole mixed with emulsifiable oils or with auxiliary herbicides.

In the countries of western and central Europe, for example in France, Italy, and Switzerland, the more common weed species in orchards and vineyards include :

Agropyron repens
Agrostis stolonifera
Alopecurus myosuroides
Amaranthus spp.
Capsella bursa-pastoris
Chenopodium spp.
Cirsium arvense
Convolvulus arvensis
Cynodon dactylon
Digitaria spp.
Erigeron (Conyza) canadensis
Glechoma hederacea
Lamium purpureum
Lolium spp.
Mentha spp.
Mercurialis annua
Potentilla reptans
Portulaca oleracea
Raphanus raphanistrum
Senecio vulgaris
Setaria viridis
Solanum nigrum
Sonchus arvensis
Sonchus oleraceus
Stellaria media
Tussilago farfara
Polygonum aviculare
Veronica spp.

In many vineyards of these countries *Convolvulus arvensis* is the weed of greatest economic importance. This being so, methazole was evaluated primarily for its efficacy against this weed and then for its usefulness against other species. Because of the probable depth of the root system of *C.arvensis*, it was thought that the contact activity of methazole would be likely to have most effect if the herbicide could be applied when young shoots had freshly developed. Application at this time would result also in some methazole reaching the soil and exerting residual activity against susceptible annual weeds.

The range of important weed species is frequently wider in orchards than in vineyards, and all of those in the preceding list may occur. Investigations in these orchards were planned so as to gain control over as many as possible of them by a single application of methazole.

In several countries bordering the eastern Mediterranean, for example in Greece, Turkey, Cyprus, Lebanon, it is more convenient to classify common weeds of orchards and vineyards according to the times of their emergence, as follows :

Winter weeds

Avena fatua and A.sterilis
Beta vulgaris
Daucus spp. and other Umbelliferae
Diplotaxis spp. and other Cruciferae
Emex spinosa
Fumaria officinalis
Lamium spp.
Malva spp.
Phalaris paradoza
Senecio vulgaris
Sonchus oleraceus
Stellaria media
Urtica dioica and U.urens

Summer weeds

Amaranthus spp.
Chenopodium spp.
Convolvulus arvensis
Digitaria sanguinalis
Erigeron spp.
Oxalis cernua
Oxalis corniculata
Portulaca oleracea
Solanum nigrum
Solanum villosum
Tribulus terrestris

In these countries methazole was evaluated for treatment of the winter weeds during November or December and the summer weeds during April or May. As the foregoing classification is not rigorous and as various weeds are emerging in all seasons, it became desirable to decide or to discover :

(i) whether methazole should be so applied that the prime benefit is derived from its contact activity upon freshly-expanded and tender foliage of the established broad-leaf perennial weeds, with the secondary effects of residual activity of that portion of the methazole which falls upon the soil,

or(ii)whether, in the expectation that the more important weeds would be annual broad-leaf weeds or annual grasses, it might be better to apply methazole before the emergence of those weeds which (like Malva spp. for example) are more easily controlled pre-emergence than post-emergence.

The wettable powder formulation PROBE® containing 75% of methazole was used in almost all the investigations summarised in this report. All doses quoted refer to the amounts of active ingredient used. Experiments with methazole 75% w.p. in association with an emulsifiable oil (Sun Oil 11 E) were carried out; methazole has also been used in mixture with wettable powder formulations of other herbicides, such as simazine, diuron or napropamid, in order to lower the dose of methazole that might otherwise have been needed or to extend the range of weeds that might be controlled.

RESULTS

(a) Methazole alone in vineyards and orchards of pome and citrus fruits

Introductory work by Rossi (1969) showed that, by its contact activity, methazole at 6-8 kg/ha could selectively control established C.arvensis. Research was continued in French vineyards leading to the papers by Cognet (1970), Cognet and Muller (1971), Roâ and Lhoste (1972), and in Italian vineyards and orchards by Perugia and Hirst (1971) and Perugia (1973 a,b). The outcome of these researches can be summarised as follows :

(i) Timing: A given dosage of methazole was more effective for control of C.arvensis if it had been applied when the new shoots had grown to a length of 20-30 cm and when the new leaves were well expanded. This timing ensured complete suppression of C.arvensis within a few days of treatment, and provided the longest period of effective control.

(ii) Rate:The useful dose of methazole was found to be from 5.5-10.0 kg/ha, preferably towards the upper end of this range, applied in 250-500 litres water/ha as a directed spray, avoiding contact with branches and foliage.

(iii) Selectivity: Although the risk of phytotoxicity to vines or to apple, pear, orange or lemon trees from a directed spray was found to be very slight, even at 20 kg/ha, any risk to vines could be reduced still further by applying methazole in advance of their flowering. This is normally consistent with the timing recommended in (i).

Table 1

Susceptibilities of weed species in vineyards of France and in vineyards and apple orchards of Italy towards methazole at 10 kg a.i./ha in most instances applied post-emergence of weeds

Agropyron repens	MR-R
Agrostis stolonifera	S-MS
Allium ursinum	R
Allium vineale	R
Alopecurus agrestis	S
Amaranthus retroflexus	S-MS
Aristolochia clematis	MR-R
Arrhenatherum bulbosum	R
Atriplex hastata	S
Bromus mollis	S
Bromus sterilis	S
Capsella bursa-pastoris	S
Chenopodium album	S
Cirsium arvense	MS
Convolvulus arvensis	S
Convolvulus sepium	MR-R
Cynodon dactylon	R
Cyperus rotundus	R
Daucus carota	R
Digitaria sanguinalis	S-MS
Echinochloa (Panicum) crusgalli	S
Epilobium spp.	S
Equisetum arvense	MS-MR
Erigeron canadensis	R
Erodium cicutarium	MS
Fumaria officinalis	S
Geranium dissectum	MS
Glechoma hederacea	S
Helminthia echioides	MR
Holcus lanatus	MS
Lamium purpureum	S
Lolium multiflorum	S-MS
Medicago maculata	S
Mentha spp.	MR
Mercurialis annua	MS
Picris hieracioides	S
Plantago lanceolata	R
Plantago major	R
Poa annua	S
Poa trivialis	S
Polygonum amphibium	MR-R
Polygonum aviculare	S-MR
Polygonum convolvulus	MS
Polygonum persicaria	S-MS
Portulaca oleracea	S
Potentilla reptans	R
Ranunculus repens	S-MS
Raphanus raphanistrum	S
Reseda lutea	R
Rubus spp.	MR
Rumex acetosella	MS-MR
Rumex crispus	MS-MR
Sambucus ebulus	R
Senecio jacobaea	S
Senecio vulgaris	S
Setaria viridis	S
Sinapis arvensis	S
Solanum nigrum	S
Sonchus oleraceus	S
Stellaria media	S
Taraxacum officinale	R
Trifolium spp.	S
Tussilago farfara	MR
Valerianella carinata	S
Verbena officinalis	R
Veronica agrestis	S
Veronica persica	S-MS
Vicia sativa	MS

Definition of categories

S	Susceptible	Complete kill
MS	Moderately susceptible	Nearly complete kill
MR	Moderately resistant	Only part or temporary control
R	Resistant	No useful effect

Although methazole at 5.5 kg/ha provided a useful control of C.arvensis, especially during a rainy season, 10 kg/ha was needed in the general conditions in France to provide complete control for four months. However, Perugia (1973) has commented favourably on the persistence of weed control during nine months. The effects of methazole at 10 kg/ha, at the timing detailed above, were comparable with those of terbuthylazine/terbumeton at 7.5 kg/ha. In vineyards where treatment with methazole at 10 kg/ha has been repeated during two or three consecutive seasons its cumulative effects caused gradual regression of C.arvensis (Juillard, 1973) but no evidence of phytotoxicity was detected among the vines.

The performance of methazole on a range of weeds is shown in Table 1. Many of the perennial broad leaf weeds were more susceptible than C.arvensis towards methazole; and, where C.arvensis was absent, a rate of methazole of 3-6 kg/ha was effective. For residual activity of methazole against germinating annual or perennial weeds, the dosage required varied according to soil type. The required dose was greater on a clay soil than on a sandy soil and larger still on soils of high organic matter content. A given dosage of methazole was more effective if applied to a thoroughly moistened soil, and could be maintained more effective by irrigation. Effective residual activity was found with doses of 2.5-5.0 kg/ha, according to the composition and condition of the soil, when sprayed in at least 500 litres of water/ha.

(b) Methazole alone in orchards of stone fruits

The greater part of our planned research in orchards of almond, apricot, cherry, olive, and peach was conducted by the late Mr.I.Tobolsky (1972). Methazole was used safely where diuron or simazine had caused phytotoxicity to these trees, and effectively against Erigeron spp. where linuron had failed to control this weed.

Methazole was applied in the late autumn or early winter pre-emergence of those species listed in the preceding section as winter weeds. All those indigenous winter weeds were prevented from germinating by the residual activity of methazole in the soil. The effective rates, dependent on soil type, were for light to medium soils 2.25-3.38 kg/ha and for medium to heavy soils 3.00-4.50 kg/ha. Some of the species listed, eg Malva and Phalaris spp., were not well controlled post-emergence,but were controlled by pre-emergence application early in November before germination.

Some residual activity of methazole from the November application was still found after three months. This residual activity sometimes prevented the germination of those species listed as summer weeds, but these were also susceptible to the contact activity of methazole. Two such applications, in autumn and in spring,could be timed to keep stone fruit orchards free from important weeds throughout the year. Tests in these circumstances have revealed no evidence of phytotoxicity to almond, apricot, cherry, olive, or peach. In Lebanon the efficacy of methazole (3 kg/ha) against the prevalent Oxalis cernua has been confirmed by Najjar (1974).

(c) Methazole with emulsifiable oils and with auxiliary herbicides

Rossi et al.(1972) improved the contact activity of methazole upon the foliage of C.arvensis and of certain other perennial weeds by spraying methazole in an emulsion of aliphatic oil, such as Sun Oil 11 E. Rossi et al (1973) found that a tank mixture providing methazole 75% w.p. at 7.5 kg/ha + diuron 80% w.p. at 1.6 kg/ha + Sun Oil 11 E at 5 litres/ha provided the best control of C.arvensis and they correlated this use of methazole with satisfactory yields of apple and grapes.

To economise in use of methazole without losing the benefits of its persistent residual properties, methazole was used in mixture with other herbicides or in sequential applications. Meyer (1972) worked with a mixture coded S1444 comprising 37.5% methazole 75% w.p. and 60% simazine 50% w.p. During trials in Swiss vineyards and orchards S1444 and methazole alone were applied early post-emergence of C. arvensis,Glechoma hederacea and other species. The activity of S1444 at 10 kg/ha was as good as that of methazole at 10 kg/ha, and there were claims of synergism between methazole and simazine. Furness (1973) reported the successful use of mixtures of methazole/napropamid in orchards of almond and peach, also with surfactant in citrus.

DISCUSSION

The experiments reviewed here demonstrate that methazole combines the properties of a contact herbicide with those of a rather stable residual soil-applied herbicide. By contact with their new leaves it kills many annual weeds, and can suppress for a period of at least 3 months a range of perennial weeds whose presence would otherwise be detrimental to yields of fruit from orchards and vineyards. Because of its strong adsorption on soils and the susceptibility of many important weeds that germinate near the soil surface, methazole can be used selectively and effectively where trees of pome, citrus, stone fruits and vines have established deeper roots.

The more important practical consequences include: a 3 to 9 month period of control over C.arvensis and certain other perennial and annual weeds following a single treatment with methazole at 10 kg/ha; the ability to control Erigeron spp. selectively in stone fruit orchards of the eastern Mediterranean, despite an earlier French observation that Erigeron canadensis was resistant; the ease of control over Fumaria officinalis and Oxalis cernua; the lack of phytotoxicity to vines and fruit trees at specified rates even after several annual treatments; the safety and efficacy of methazole treatments during November and April in stone fruit orchards on light soils where the selectivity of other herbicides may be inadequate.

Certain limited economies should accrue from the use of diuron, simazine, or emulsifiable oils in association with methazole.

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EXPERIMENTS ON THE TOLERANCE OF NEWLY-PLANTED RASPBERRIES AND STRAWBERRIES TO TRIFLURALIN

H.M. Lawson & J.S. Wiseman

Scottish Horticultural Research Institute, Invergowrie, Dundee DD2 5DA.

Summary In a series of experiments with spring-planted raspberries and strawberries trifluralin was sprayed and incorporated as an immediate pre-planting treatment. A high level of tolerance was exhibited by both crops, although checks to early growth and reduced runner production occurred in some experiments, particularly at higher rates of application. These effects were generally outgrown in the second year. The normal application rate of 1.1 kg a.i./ha for field crops in the United Kingdom was shown to have an adequate safety margin for both crops and there was no indication of cumulative adverse effect when pre-planting incorporation of trifluralin was followed by post-planting application of a residual herbicide. The combined herbicide programmes gave worthwhile improvements in weed control compared with the performance of the individual components.

INTRODUCTION

Recent research (Lawson & Wiseman, 1972, 1973) has shown that competition from weeds during the establishment year can severely affect the survival and growth of young raspberry and strawberry plantations and that the effects are likely to persist into subsequent years. In Eastern Scotland, most soft fruit crops are planted in the spring. Dry weather after planting is not uncommon and, if prolonged, may not only adversely affect crop establishment but also result in poor performance by surface-applied residual herbicides. The reliability of weed control in spring-sown brassica and carrot crops has been considerably improved in recent years by the inclusion of the soil-incorporated herbicide trifluralin in weed control programmes. A series of experiments was therefore carried out to assess the tolerance of raspberries and strawberries to trifluralin incorporated just prior to planting.

METHOD AND MATERIALS

Six experiments were carried out at Invergowrie on sandy loam soils with organic matter percentages (as determined by loss on ignition) of between 6 and 8%. Raspberry plots consisted of single rows of 12 canes of cv. Malling Jewel planted 60 cm apart with 180 cm between rows. Strawberry plots consisted of single rows of 15 plants of cv. Cambridge Favourite planted 45 cm apart, with 90 cm between rows. All experiments were laid out as randomised blocks, with three to five replicates depending on the number of treatments.

Herbicide application was made by Oxford Precision Sprayer in 730 l water/ha to a band centred on the crop row. This band was 180 cm and 90 cm wide for raspberries and strawberries respectively. Trifluralin was incorporated to 10 cm depth within 30 minutes of application, the whole experimental area being rotary cultivated at this time to maintain uniformity of planting conditions. The formulation of trifluralin used in these experiments was a 48% w/v emulsifiable concentrate. Rates of application of this and other herbicides given in the text refer to active ingredient. Details of trifluralin applications and crop planting dates for raspberry (R) and strawberry (S) experiments were as follows:

Expt. No.	Trifluralin application		Crop planting
	Rates (kg/ha)	Date	Date
R1	0, 1.1, 2.2, 4.5	29 March 1971	29 March 1971
R2	0, 1.1, 2.2, 4.5	21 March 1972	30 March 1972
R3	0, 1.1, 1.1	21 March 1972	30 March 1972
S1	0, 0.6, 1.1, 2.2, 4.5	31 March 1971	31 March 1971
S2	0, 0.6, 1.1, 2.2, 4.5	28 March 1972	29 March 1972
S3	0, 1.1, 1.1, 1.1	28 March 1972	29 March 1972

Both crops were planted into spade-slits, with minimal soil disturbance and the rows were not subsequently ridged. All raspberry canes produced in the first year were retained, without tipping, for fruiting in the second year. Thinning of young cane was not carried out during the second year so that total cane production could be assessed. Strawberry plants were de-blossomed in the first year. Runners were also removed, so that the plots could be maintained as rows of single plants during the second year. During the first year weeds on Expts. R1, R2, S1 and S2 were removed regularly by application of paraquat and by hand-hoeing. On Expts. R3 and S3 hand-hoeing was carried out as a supplementary treatment whenever visual scoring of ground cover by weeds on any treatment reached 20%. In the second year, all experiments were treated with a residual herbicide in late winter (bromacil 1.1 kg/ha for raspberries, lenacil 2.2 kg/ha for strawberries) and resistant weeds were controlled by supplementary treatment with paraquat in the alleys and hand-hoeing in the rows.

Winter records taken on raspberries included numbers and heights of all canes produced in the previous year. Yield of fruit was recorded in the second year, as were the numbers of canes retained for fruiting in the third year. Strawberry records included measurements of plant size, runner production, crown and truss numbers and fruit yield.

RESULTS

Expt. R1

New canes were slow to emerge and a proportion of the planted canes failed to survive. There were no significant differences between treatments in percentage survival or in numbers and heights of new canes measured in November 1971 (Table 1). The low and variable yield of fruit in 1972 reflected the poor cane growth in 1971. There was a general indication that plots originally treated at 4.5 kg/ha were less productive of canes and fruit than any of the other treatments. Because of the variability of plant establishment, differences between this treatment and the untreated control were not, however, significant except when assessed in terms of number of canes produced per live station in 1972. The 1.1 and 2.2 kg/ha rates had no adverse effect on any aspect of growth or yield. Because of the low numbers of canes produced in 1972, virtually all of them were required for fruiting in 1973.

Expt. R2

Cane growth in this experiment was vigorous and the survival rate was high. Cane numbers recorded at the end of the growing season were not affected by treatment but average height was significantly lower on all plots treated with trifluralin than on untreated plots (Table 2). This height difference resulted in higher yields on the untreated plots in the subsequent fruiting year (1973). There were no significant differences in yields from plots treated with different rates of trifluralin. None of the treatments significantly affected the canes produced during 1973, either in total numbers or in the percentage retained for subsequent fruiting.

Expt. R3

Details of trifluralin applications are given above. Simazine at 2 kg/ha was applied a few hours after planting to two sets of plots, one with and one without previous application of trifluralin (Table 3). Cane growth was vigorous and the survival rate was high. Differences in cane numbers and heights in November 1972 were not significant and there were no indications of treatment differences in fruit production in 1973. Numbers and average heights of canes produced in 1973 and the percentage retained for fruiting in 1974 were also unaffected by treatment. There was no indication of any check to growth following the application of trifluralin at 1.1 kg/ha alone or in association with simazine.

In 1972, untreated plots reached 20% weed cover and were hoed on May 15, while those treated with trifluralin, simazine and both together reached this stage on June 1, June 8 and July 12 respectively. Myosotis arvensis and Fumaria officinalis were the major weeds on plots treated with trifluralin; Polygonum aviculare was the main species resistant to simazine. The combined treatment required no supplementary weeding for 16 weeks after planting.

Expt. S1

Plant mortality was negligible and was unrelated to treatment. Treatment at 2.2 and 4.5 kg/ha checked early crop growth (Table 4), but the lower rates were not significantly different from the untreated control. There was also visual evidence of delayed or reduced runner production on plots treated at 2.2 and 4.5 kg/ha. Differences in crown counts at the end of the growing season and in plant height measurements and truss counts in summer 1972 were, however, not significant. Fruit records also showed no significant reductions due to any rate of trifluralin and in fact yield per truss was significantly higher on plots treated at 2.2 kg/ha than on the control treatment. This increased yield per truss to some extent offset the suggested smaller plant size on this treatment in the previous year.

Expt. S2

Plant mortality was negligible and was unrelated to treatment. All rates of trifluralin checked early growth to some extent, significantly so at 2.2 and 4.5 kg/ha. (Table 5). Visible differences between treatments in runner production were again evident, so all runners were removed and recorded in mid-August. Numbers of runners per plant were found to be significantly lower on plots treated with 2.2 and 4.5 kg/ha. Further removal of runners in November showed a continuing effect at the 4.5 kg/ha rate. Crown numbers were slightly lower on all plots treated with trifluralin but this was significant only at the 4.5 kg/ha rate.

Although growth and fruit records in 1973 suggested a continuing effect of treatment at the 2.2 and 4.5 kg/ha rates, reductions were not significant in comparison with the untreated control. There was no indication that adverse effects of the high rates would persist into another year.

Expt. S3

Details of trifluralin applications are given above. On April 11 lenacil at 2.2 kg/ha and chloroxuron at 5.6 kg/ha were each applied to two sets of plots, one with and one without previous application of trifluralin (Table 6). Plant mortality was low and there was no evidence of any check to early growth of the crop due to trifluralin, lenacil, chloroxuron or to the combined treatments. Runners were removed in mid-August and again in early November. No significant differences between treatments were detected, nor were there any differences in crown counts taken in November. There were no significant differences between treatments in crop growth and fruit production in 1973 and no evidence of adverse effect of trifluralin alone or in combination with the other two herbicides. The untreated plots reached 20% weed cover and were hoed on May 25. All three single herbicide treatments reached this level and were hoed on June 1, but the two combined treatments did not require to be hoed until June 16. Dry weather in April impaired the performance of lenacil and chloroxuron. Galeopsis tetrahit and Polygonum aviculare were not adequately controlled by either treatment, while Matricaria spp & Capsella bursa-pastoris were major weeds on plots treated with trifluralin. Although the single herbicide treatments had to be hoed again on July 4, plots treated with either of the combined herbicide treatments required no further treatment until early August. There were no appreciable differences in performance between lenacil and chloroxuron whether used alone or in combination with trifluralin.

DISCUSSION

In none of these experiments did trifluralin cause death or permanent injury to raspberry and strawberry plants, even at 4.5 kg/ha, i.e. four times the current standard dosage for vegetable crops in the United Kingdom. There would therefore appear to be an adequate margin of safety at least for the two major cultivars tested. However, the possibility that trifluralin at 1.1 kg/ha may occasionally check the early growth of both crop species requires further attention. It was of interest that the symptoms, when they occurred, did not increase in proportion to the rate of application of the herbicide. The mode of action of this herbicide against weeds is associated with the inhibition of root development (Elanco, 1974). The checks to early plant growth in several of these experiments are consistent with a temporary effect of this kind on the crop. Since the planting technique, mode and depth of incorporation, and planting interval after treatment were similar in all the experiments, but crop injury occurred in only some of them, the effects are likely to be associated with environmental conditions. The extent to which the plant roots were exposed to trifluralin would however, be influenced by these management factors in the experiments. It is therefore desirable that further investigations be carried out into depth of incorporation in relation to planting method and into the optimum timing of crop planting after treatment.

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Table 1
Expt. R1 - Cane & fruit records

Treatment	1971 cane growth		1972 fruit yield		1972 cane growth		
trifluralin kg a.i./ha	No. per plot	Mean height (cm)	kg per plot	g per cane	Total no.per plot	No.per live stool	Mean height (cm)
0	15	58	0.88	58	51	5.1	93
1.1	16	58	0.84	50	62	5.6	86
2.2	15	63	0.97	63	66	6.0	89
4.5	14	52	0.67	46	35	3.4*	89
S.E. mean ±	1.7	4.3	0.203	12.9	6.3	0.38	3.0

Table 2
Expt. R2 - Cane & fruit records

Treatment	1972 cane growth		1973 fruit yield		1973 cane growth		
trifluralin kg a.i./ha	No. per plot	Mean height (cm)	kg per plot	g per cane	Total no.per plot	Mean height (cm)	% tied in (1974)
0	15	103	4.77	333	86	128	69
1.1	15	91**	3.86*	263	80	130	70
2.2	16	83***	3.58**	223*	67	131	72
4.5	16	84***	3.35**	210*	72	131	75
S.E. mean ±	1.3	2.7	0.276	28.5	7.5	1.1	3.4

Table 3
Expt. R3 - Cane & fruit records

Treatment	1972 cane growth		1973 fruit yield		1973 cane growth		
herbicide kg a.i./ha	No. per plot	Mean height (cm)	kg per plot	g per cane	Total no.per plot	Mean height (cm)	% tied in (1974)
0	15	92	4.72	308	81	132	74
Simazine 2.2	16	92	4.30	274	72	133	76
Trifluralin 1.1	14	95	4.47	331	80	133	72
Trifluralin 1.1 + Simazine 2.2	14	93	4.27	306	80	133	73
S.E. mean ±	1.0	5.2	0.389	15.8	7.6	0.9	3.0

*   5%
** significantly different from treatment 0 at the 1% level
*** 0.1%

Table 4
Expt. S1 - Plant & fruit records

Treatment	1971 growth		1972 growth		1972 fruit records			
trifluralin kg a.i./ha	Plant height (cm) Jun.3	Crowns per plant Dec.13	Plant height (cm) Jun.16	Trusses per plant Jul.11	Yield per plot (kg)	Yield per plant (g)	Yield per truss (g)	Mean berry wt. (g)
0	9.1	3.7	21.0	8.2	4.68	328	40	8.9
0.6	9.8	3.4	21.8	8.1	5.01	345	43	8.8
1.1	9.8	3.6	21.6	7.9	4.88	335	43	8.8
2.2	7.5*	3.5	20.2	7.8	5.46	381	49*	10.1
4.5	7.2*	3.0	20.4	7.7	5.00	364	48	9.1
S.E. mean ±	0.45	0.16	0.95	0.62	0.576	31.1	2.5	0.72

Table 5
Expt. S2 - Plant & fruit records

Treatment	1972 growth			1973 growth		1973 fruit records		
trifluralin kg a.i./ha	Plant height (cm) Jul.17	Crowns per plant Nov.1	Runners per plant Aug.17	Plant height (cm) Jun.15	Trusses per plant Jul.2	Yield per plot (kg)	Yield per plant (g)	Yield per truss (g)
0	18.3	2.6	13.7	22.7	10.1	6.84	464	46
0.6	16.4	2.4	11.5	20.2	11.4	6.36	424	39
1.1	15.7	2.2	11.3	20.8	9.8	6.05	426	45
2.2	14.3*	2.2	8.8**	20.6	9.9	5.23	354	36
4.5	13.5**	1.9**	7.7***	19.8	9.5	5.53	369	39
S.E. mean ±	0.93	0.16	0.93	0.96	0.82	0.644	43.1	5.5

Table 6
Expt. S3 - Plant & fruit records

Treatment herbicide	kg a.i./ha	1972 growth			1973 growth		1973 fruit records		
		Plant height (cm) Aug.18	Runners per plant Aug.18	Crowns per plant Nov.1	Plant height (cm) Jun.15	Trusses per plant Jul.2	Yield per plot (kg)	Yield per plant (g)	Yield per truss (g)
0		17.1	9.2	2.1	20.8	8.7	4.62	384	45
Trifluralin	1.1	17.8	9.3	2.1	21.2	7.9	5.51	411	54
Trifluralin + Lenacil	1.1 2.2	19.1	10.0	2.4	21.6	8.2	5.72	421	51
Trifluralin + Chloroxuron	1.1 5.6	17.3	9.6	2.3	21.1	7.4	4.97	365	49
Lenacil	2.2	18.2	10.5	2.3	21.9	7.9	6.18	430	54
Chloroxuron	5.6	18.8	11.2	2.3	22.0	8.8	5.99	408	48
S.E. mean ±		1.09	1.02	0.15	0.66	0.68	0.572	29.8	3.3

* 5%
** significantly different from treatment 0 at the 1% level
*** 0.1%

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A COMPARISON OF CULTIVATION AND NON-CULTIVATION SYSTEMS OF RASPBERRY GROWING

N. Rath and T. F. Cleary*
Soft Fruit Research Station, Co. Wexford, Ireland

Summary A long-term trial comparing cultivated and non-cultivated systems of weed control in raspberries was carried out over eight cropping years at the Soft Fruit Research Station, Clonroche. The results confirmed that raspberries can be grown satisfactorily without soil cultivation where herbicides are used to control weeds. This system did not result in increased yields but weed control was more convenient and effective. Mulching the cane rows with farmyard manure reduced the growth of young canes and crop yield.

INTRODUCTION

Reports on a number of trials in different parts of the British Isles investigating the effect of eliminating cultivation in raspberries have given conflicting results. Results from Northern Ireland (Robinson, 1964) and England (Clay and Ivens, 1966) indicated that raspberries can be grown without cultivations with no reduction in crop yield. However, in a long-term experiment in Scotland Lawson and Waister (1972) found raspberries receiving some form of cultivation out-yielded those receiving no cultivations by 12%. To compare cultivation and non-cultivation systems of raspberry growing under conditions in the South of Ireland, a trial was laid down at Clonroche in 1965. The effect of mulching with farmyard manure was also studied.

METHOD AND MATERIALS

The experiment was carried out at the Soft Fruit Research Station, Clonroche on a slightly sloping site. Raspberries, cv. Malling Jewel, were planted in October 1964, 0.45 m apart in lines 1.83 m apart and grown on the hedge system. The soil was a loam or clay loam derived from Ordovician shale and drift material and contained in the 0.15 cm layer approximately 22% coarse sand, 12% fine sand, 37% silt, 25% clay and 4% organic matter. Fertilisers containing nitrogen, phosphorus and potash were applied each spring, the rates being varied according to soil analysis and the appearance of the crop.

Treatments comparing systems of non-cultivation with conventional cultivations were established in 1965. A randomised block design with split plots was used, with main plot treatments being applied to the alleys and sub-plot treatments to lengths of row adjacent to these alleys. The main plot was 19.5 m long, two rows wide with two guard rows. The main plot treatments were applied to the centre 0.91 m of each alley. The sub-plots were one quarter the length of the main plots and the sub-plot

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*Present address: Co. Kildare Committee of Agriculture, Rathstewart, Athy, Co. Kildare.

treatments applied to a band 0.46 m wide on each side of the cane rows. The same four cultural treatments were applied to both alleys and rows as appropriate, namely: cultivation ± farmyard manure (FYM) and non-cultivation ± FYM.

In the non-cultivated plots simazine and paraquat were used to control weeds. In the early years of the trial simazine was usually applied twice each year with a total dose of 4.5 kg a.i./ha. Later the total yearly dose was increased to 6.7 kg/ha. Paraquat was applied annually at 1.1 kg a.i./ha during the dormant season. Spot treatments with chlorthiamid and dichlobenil were used as required to control occasional perennial weeds.

In the cultivated alleys weeds were controlled by shallow rotary cultivation and in the cane rows by hand hoeing. In the early years of the trial six cultivations were required each year to give adequate weed control while in the last 2 years four cultivations were sufficient.

The FYM treatments were applied three times at 25 tonnes/ha during the experiment, namely: April 1965, January 1967 and March 1970.

Suckers were controlled on the non-cultivated plots by cutting twice each year with a rotary mower when the suckers were about 0.25 m high. A band about 7 cm wide along each side of the cane row was left uncut. Excess canes were removed from the row by hand during winter. The suckers were controlled by the weed control treatments on the cultivated plots.

RESULTS

Throughout the duration of the experiment weed control was more effective and more easily achieved by means of herbicides. On several occasions during wet periods in the first 4 years of the experiment from half to three quarters of the area of the cultivated plots was covered with annual weeds, mainly Senecio vulgaris and Poa annua. These were always removed before they appeared to have interfered with the growth of the plantation. In the later years of the experiment the control of annual weeds on the cultivated plots was more easily achieved due to the shading effect of the raspberry foliage and in the last 2 years of the trial the number of cultivations required to obtain adequate weed control could be reduced from six to four per annum.

The simazine and paraquat treatments gave good control of annual weeds for the duration of the experiment without any build up of resistant weeds. On the three occasions when FYM was applied the subsequent application of simazine did not give complete control of Senecio vulgaris and Poa annua. A directed application of paraquat gave control of these weeds. During the course of the experiment occasional plants of Vicia cracca, Rumex obtusifolius and Urtica dioica were controlled satisfactorily with chlorthiamid or dichlobenil.

Fruit yield for cane row treatments is shown in Table 1. Cultivation of the cane row gave a small but significant ($p = 0.01$) increase in 1966. The cultivation treatments to the cane row had no effect on crop yield in any of the other cropping years or on total crop yield for the eight years.

FYM mulching of the cane rows reduced crop yield in four years and total crop yield for the eight years. Reduced growth of new canes on these plots was observed in 1967 and 1971.

Table 1

Effect of cane row treatments on fruit yield of raspberries cv. Malling Jewel

Fruit yield (tonnes/ha)

	FYM treatment		Cultivation treatment			
Year	-FYM	+FYM	Cultivation	Non-cultivation	S.E.± (df = 36)	L.S.D. (p = 0.05)
1966	0.67	0.61	0.70	0.58	0.031	0.09
1967	4.36	3.91	4.16	4.11	0.153	0.44
1968	12.23	11.05	11.90	11.38	0.360	1.03
1969	9.79	9.28	9.23	9.85	0.365	1.05
1970	11.74	11.23	11.27	11.70	0.324	0.93
1971	11.17	11.50	11.45	11.22	0.167	0.48
1972	9.80	8.67	9.24	9.22	0.144	0.41
1973	10.40	9.19	9.44	10.15	0.215	0.62
Total	71.16	65.44	67.39	68.21	0.830* (* df = 20)	2.95

The fruit yield for alley treatments is given in Table 2. The alley treatments did not affect yield significantly in any year.

Table 2

Effect of alley treatments on fruit yield of raspberries cv. Malling Jewel

Fruit yield (tonnes/ha)

	FYM treatment		Cultivation treatment			
Year	-FYM	+FYM	Cultivation	Non-cultivation	S.E.± (df = 9)	L.S.D. (p = 0.05)
1966	0.64	0.65	0.62	0.66	0.055	0.17
1967	4.03	4.24	4.07	4.20	0.365	1.17
1968	11.21	12.07	11.70	11.58	0.701	2.24
1969	9.20	9.88	9.70	9.39	0.383	1.22
1970	11.51	11.46	11.20	11.77	0.447	1.43
1971	11.44	11.23	11.12	11.55	0.216	0.69
1972	9.09	9.37	8.94	9.52	0.186	0.59
1973	10.16	9.43	9.68	9.90	0.295	0.94
Total	67.28	68.35	67.03	68.57	1.449	4.64

In three of the years there were significant interactions between a single sub-plot and main plot treatment but these were not repeated in other years and no interactions between treatments were found in the cumulative crop yield data.

DISCUSSION

The most notable feature of this trial is the absence of any difference in total crop yield resulting from the cultivation and non-cultivation treatments of the cane row. The slight yield differences recorded in 1966 are of no economic importance. This result agrees closely with the results obtained by Robinson (1964) at Loughgall and by Clay and Ivens (1966). However, Lawson and Waister (1972) found that cultivated raspberries outyielded uncultivated raspberries by 12% in a trial cropped for eight years. This yield difference was considered to be caused mainly by differences in the frequency and efficiency of control of unwanted raspberry suckers in the two systems. In the trial at Clonroche sucker growth was moderately vigorous but was always rigorously controlled with a rotary mower. Also, the higher rainfall at Clonroche may have ensured less competition for moisture between new and fruiting canes.

At Clonroche FYM mulch to the cane row reduced cane growth in 2 years and crop yield in several years. This is in contrast with results at Loughgall (Robinson, 1964) where the manure mulch had no effect on cane growth or crop yield. Clay and Ivens (1966) found that mulching with straw reduced cane number but this reduction was accompanied by an increase in crop yield. The reduction in crop yield at Clonroche may have been associated with the moderately vigorous nature of the cane growth. As might be expected, the alley treatments had only small and inconsistent effects on crop yield.

As most raspberries in Ireland are grown under soil conditions similar to those at Clonroche or Loughgall, a system of soil management based on the use of herbicides appears to be superior to one based on cultivations. The advantage of this system lies in the large reductions in the cost of weed control and in the ease and reliability of management.

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FURTHER EVALUATION OF CYANAZINE AND CYANAZINE MIXTURES FOR SELECTIVE WEED CONTROL IN NEWLY-PLANTED RASPBERRIES

M. G. Allen

Shell Chemicals (UK) Ltd, Ely, Cambridgeshire

Summary In 1974, three replicated trials were laid down in Scotland in newly planted raspberries, in order to confirm previous work with formulated cyanazine and atrazine mixtures; two formulations of cyanazine + atrazine *S.C. and w.p. were compared. Chlorthiamid and bromacil were used as standards.

Weed control with the two formulations of the cyanazine and atrazine mixture used, (1.35 + 1.35 kg a.i./ha), was generally comparable to or better than the standards. Cyanazine (4.4 kg a.i./ha) gave similar weed control to the standard treatments.

Chlorthiamid gave superior weed control to bromacil at two sites. At one site treatments containing chlorthiamid gave an effective control of volunteer potatoes.

None of the treatments used appeared to have any detrimental effect upon the crops.

INTRODUCTION

A large proportion of the U.K. raspberry acreage is grown in Scotland, with some 1000 acres of new canes being planted each year; although weed control is essential in the establishment period of young canes, it is only recently that any herbicides have been recommended for this purpose.

New canes are usually planted in late spring, often coinciding with long periods of dry weather. The necessity for better herbicides in newly-planted canes has been underlined by the poor activity of many residual herbicides in these conditions; in addition some of the most prevalent Scottish weeds are Polygonum aviculare and other polygonaceous weeds and these are semi-resistant to the herbicides at present recommended.

The work described in this paper was designed to confirm earlier trials reported by Allen et al (1974). New candidate herbicides have been compared with chlorthiamid and bromacil which are already in common use in established raspberries and are tentatively used in young canes. In this work cyanazine and formulated mixtures of cyanazine with atrazine were tested as broad-spectrum residual herbicides for selective use in newly-planted raspberries.

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*Suspension concentrate

METHOD AND MATERIALS

Three trials were commenced in spring 1974. Details of the sites, crops and planting and treatment dates are shown in Table 1 as well as the dominant weeds that developed during the trials.

Each trial consisted of four randomised blocks with an untreated control plot in each block. The plot size was 9.1 x 1m. A ridge of earth was thrown up onto the base of the canes prior to herbicide application. All the sites were weed free at the time of treatment. The crop was observed periodically for any signs of herbicide injury.

The herbicide formulations used in the three trials were:-

Cyanazine, 50% S.C.; Cyanazine + atrazine, 40% + 40% w.p. & 25% + 25% S.C.

Chlorthiamid, 7.5% granule; Bromacil, 80% w.p.

Rates of use are shown in Tables 2-4. All herbicide rates given are in terms of active ingredient of the chemical.

Table 1

Details of crop and weeds at the three sites

	Site 1	Site 2	Site 3
Location	Angus	Angus	Perthshire
Soil type	Sandy loam	Sandy clay loam	Sandy loam
% O.M.	3.2	4.6	3.5
Cultivator	Glen Clova	Glen Clova	Glen Clova
Planting date	2 May	15 May	1 April
Application date	10 May	21 May	18 April
Main weed species	Matricaria spp. Chenopodium album Fumaria officinalis Spergula arvensis Urtica urens Stellaria media	Matricaria spp. Chenopodium album Polygonum persicaria S.media Polygonum aviculare S.arvensis	S.media P. persicaria F. officinalis P. aviculare C. album Matricaria spp

The w.p. and S.C. formulations were applied by means of an Oxford Precision Sprayer to a width of 1 m in a volume of 620 l/ha.

The granular formulations were applied by means of the Horstine Farmery Airflow granular applicator as a continuous 1 m band over the canes.

Weed control was assessed some 10 weeks after application at each site: a visual assessment was made, by four assessors, of the % ground cover of individual weed species that remained in each plot.

RESULTS

The results of the weed cover assessments are shown in Tables 2-4, the figures being a mean of the four assessor's score. Because of the very light infestation of some species only the cover by the predominant weed and the overall % weed cover are presented. The weed cover figures were transformed to logarithms before analysis and the tables show detransformed treatment means.

Table 2

Weed cover 10 weeks after herbicide application (Site 1)

		Weed Cover(%)		
Herbicide	Rate (kg/ha)	S.media	Matricaria spp	Total
Cyanazine S.C.	4.48	0	0	0.4
Cyanazine + atrazine w.p.	0.90 + 0.90	0.5	0	1.5
" "	1.35 + 1.35	0	0	0.3
Cyanazine + atrazine S.C.	0.90 + 0.90	0	0	0.3
" "	1.35 + 1.35	0	0	0
Chlorthiamid	4.62	2.1	0.9	5.8
Bromacil	1.12	0	0	1.0
Control (untreated)		27.5	51.3	100.0

At site 1 both the dominant species (Matricaria spp and S.media) were almost completely controlled by all treatments. There was virtually no weed at all in the plots receiving cyanazine, cyanazine + atrazine or bromacil.

Table 3

Weed cover 10 weeks after herbicide application (Site 2)

		Weed Cover (%)	
Herbicide	Rate (kg/ha)	S.media	Total
Cyanazine + atrazine w.p.	0.90 + 0.90	2.5	4.1
" " "	1.35 + 1.35	2.0	2.0
Cyanazine + atrazine S.C.	0.90 + 0.90	6.1	8.2
" " "	1.35 + 1.35	3.1	3.4
Chlorthiamid	4.62	1.9	2.1
Bromacil	1.12	5.6	7.6
Control (untreated)		48.0	92.0
L.S.D. (P=0.05)			

At site 2 the dominant species in the untreated control plots were Matricaria spp and S.media with a 30% and 48% cover respectively. In all the treated plots there was 3% or less cover of Matricaria. All treatments significantly controlled S.media; chlorthiamid treatment was superior to bromacil.

Weed control with the w.p. formulation of cyanazine + atrazine appeared slightly superior to the S.C.

The results for overall cover reflected those for S.media

Table 4

Weed cover 10 weeks after herbicide application (Site 3)

Herbicide	Rate (kg/ha)	Weed Cover % P. persicaria	Total
Cyanazine	4.48	4.1	14.0
Cyanazine + atrazine	0.90 + 0.90	2.7	16.0
" "	1.35 + 1.35	2.6	7.5
Chlorthiamid	4.62	0.7	2.3
Bromacil	1.12	1.9	9.3
Control (untreated)		13.0	97.0
L.S.D. (P=0.05)		3.6	2.6

At site 5 the dominant species was S.media accounted for 50% of the cover on control plots, but in all treated plots it averaged 3% or less; P. persicaria was an important weed at this site, its control is therefore shown in the table. All treatments significantly controlled P. persicaria; there were small but non-significant differences between the effect of the treatments. Chenopodium album was present in the control plots (8%) but this was completely controlled by all treatments. All the herbicides gave very good overall weed control, the most effective being chlorthiamid.

Crop health was assessed at the same time as the weed cover at all sites but none of the treatments caused any visual effect on the crop.

DISCUSSION

All the treatments gave an adequate degree of weed control when assessed 10 weeks after treatment.

Cyanazine S.C. applied at 4.48 kg/ha did not give consistent results, weed control at site 1 was excellent but was poor at site 3.

Both formulations of cyanazine + atrazine gave a degree of weed control comparable to bromacil, and at the higher rate (1.35 + 1.35 kg/ha) results were comparable to chlorthiamid. There was no consistent difference in the effectiveness of the two formulations used. The level of weed control produced by both formulations of cyanazine + atrazine mixture demonstrated its value as a candidate herbicide for use in newly-planted raspberries and confirmed the earlier work (Allen et al, 1974).

Of the two standard herbicides used, chlorthiamid at 4.62 kg/ha was more consistent than bromacil at 1.12 kg/ha. At site 3 there were a large number of volunteer potatoes; while these were not taken into consideration in the weed counts, chlorthiamid was the only herbicide to reduce the number of potato plants present to an acceptable level.

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EFFECT OF WEEDS AND HERBICIDES IN YOUNG RASPBERRY PLANTATIONS

H.M. Lawson & J.S. Wiseman

Scottish Horticultural Research Institute, Invergowrie, Dundee

Summary In a series of experiments on young raspberries, simazine, atrazine, diuron, chlorthiamid and bromacil were applied shortly after planting. The effect of regular removal of any weeds that developed subsequently, was compared with allowing unchecked weed growth. Cane production was assessed at the end of the first and the second year's growth. Bromacil, atrazine and chlorthiamid gave the most reliable overall weed control, while simazine and diuron gave more variable results. At only one site was there any evidence of direct adverse effect of herbicide treatment on crop growth. Weeds, on the other hand, had very severe effects on crop survival and growth in the first year especially if ground cover was extensive early in the season. Second year cane production and potential fruit production in the third year were also affected.

INTRODUCTION

Before 1972, there were no herbicide treatments officially recommended by chemical manufacturers for use in newly-planted raspberries. Growers had either to rely on soil cultivation during spring and summer or to apply simazine at their own risk. Lawson & Waister (1968) found that newly-planted raspberries, cv. Malling Jewel, were not adversely affected by atrazine or bromacil at 2.2 kg a.i./ha or chlorthiamid at 4.5 kg a.i./ha in comparison with simazine at 2.2 kg a.i./ha. They also found that regular treatment with relatively low rates of these herbicides prevented the build-up of perennial weeds, which rapidly became a problem on plots treated with simazine. Reduced availability of labour for soil cultivation and the restricted weed spectrum of simazine suggested that a wider choice of treatment for the newly-planted crop was desirable. A series of experiments at different locations and under varying management techniques was therefore laid down in 1971 to evaluate the above herbicides, together with diuron, for safety and efficacy in young plantations. At the same time, the effects of weeds on crop establishment and growth were examined.

METHOD AND MATERIALS

Experiments were laid out on five fruit holdings in Perth and Angus in spring 1971. Plot size was one single row length of 12 planting stations. Rows were 180 cm apart and the distance between stations varied from 60 to 90 cm. Plots were arranged in a split-plot randomised block design with four replicates. The cultivar Malling Jewel was planted at all sites, using stock or certified canes cut down to 10 cm above ground level after planting. Total numbers and heights of all raspberry canes produced during 1971 were measured at the end of the growing season. All except broken and very weak cane was retained for fruiting in 1972. Cane production during 1972 was also measured just prior to thinning and tying-in fruiting cane for 1973, and an estimate was made of cane quality. Weeds were assessed at intervals during 1971 by visual scoring of percentage ground covered by weed foliage on individual plots.

Individual site details and herbicide treatments were as follows:

Expt. No. Site	I Arbroath	II Alyth	III Rosemount	IV Liff	V Invergowrie
Soil type	Sandy loam	Sandy loam	Loam	Sandy loam	Sandy loam
O.M.%	6.9	8.3	6.9	8.0	6.9
Planting date	Mar.12	Mar.18	Apr.16	Apr.20	Mar.25
No. of canes /station	1	2	2	2	1
Planting method	Spade	Spade	Spade	Machine	Spade
Rows ridged after planting	no	yes	yes	yes	no
Date of herbicide application	Mar. 16	Mar.24	Apr.29	Apr.24	Mar.26

Herbicide treatments kg a.i./ha

A	Untreated		D	Diuron	2.7
B	Simazine	2.2	E	Chlorthiamid	4.5
C	Atrazine	2.2	F	Bromacil	1.1

Chlorthiamid was applied as a 7½% granular formulation. Wettable powder formulations of the other herbicides were used. Chlorthiamid granules were diluted with sand and broadcast by hand over a 180 cm band centred on the crop row. The other herbicides were sprayed by Mistifier knapsack sprayer in 730 l water/ha over a similar area. Sufficient rain fell in April and May 1971 at all sites to permit the effective action of the residual herbicides.

Each main treatment was split for supplementary weed control. Hand-hoeing along the rows, together with flailing and the application of paraquat in the alleys was carried out on half of the experimental plots in each experiment several times during 1971 to avoid competition between the crop and weeds. The other plots were allowed to become weedy and were not cleared of weeds until the late autumn. In 1972 the trial sites were given the normal routine weed control management practised by the individual growers concerned. No further experimental treatments were imposed.

RESULTS

1971 cane records are summarized in Table 1, and records taken after the end of the 1972 growing season are summarized in Table 2.

Expt. I (Arbroath)

In early April a very dense population of Polygonum aviculare emerged on untreated plots. By mid-May, 70% of the ground area on these plots was covered by weeds, compared with 15% on plots treated with simazine, 7% on those treated with diuron and 2-3% on other treatments. The first supplementary hoeing was carried out at this time and further weed removal took place in mid-July and in mid-September.

Table 1

The effect of herbicide and weeding treatments on cane growth in 1971

Treatment		Expt.I Arbroath			Expt.II Alyth			Expt.III Rosemount			Expt.IV Liff			Expt.V Invergowrie		
		%	N	H	%	N	H	%	N	H	%	N	H	%	N	H
Untreated	a)	67	10	47	71	11	38	100	30	77	31	4	48	46	6	44
	b)	88	27	70	79	17	51	100	29	85	25	4	48	90	16	73
Simazine	a)	94**	19*	59	69	16	46	98	29	88	52	10	81*	81**	12	47
	b)	96	27	77	81	17	50	94	33	89	88^{+++}	20^{++}	73	77	16	74
Atrazine	a)	88*	23**	70**	92	19*	50	100	27	89	81***	21**	74	85***	15**	79***
	b)	96	25	73	83	21	54	96	30	89	90^{+++}	23^{++}	91^{++}	90	17	65
Diuron	a)	90*	17	67**	73	15	49	96	29	85	56	10	48	23*	3	41
	b)	71	18^{+}	74	75	15	50	98	28	87	75^{+++}	16^{+}	58	90	18	72
Chlorthiamid	a)	96**	28***	77***	85	18*	44	98	28	86	73**	13	71	94***	17**	78***
	b)	83	20	73	85	16	51	98	31	87	90^{+++}	19^{++}	85^{+}	90	16	71
Bromacil	a)	83	17	70***	98*	21**	51	98	28	91*	85***	18**	74	98***	21***	81***
	b)	85	19^{+}	75	88	23	57	92	28	85	90^{+++}	23^{+++}	75	96	17	79
S.E. mean (1) ±		6.2	2.9	3.9	8.0	1.9	4.2	3.0	2.1	3.6	7.8	2.4	6.7	6.4	1.9	4.5
S.E. mean (2) ±		6.6	2.8	4.2	8.7	2.4	5.1	3.2	2.5	4.0	8.9	3.2	9.3	6.5	2.0	4.4

(1) for comparison of a) & b) within main treatments
(2) for other comparisons

a) = no supplementary weeding
b) = with supplementary weeding

* 5%
** a) significantly different from untreated a) at the 1% level
*** 0.1%

\+ 5%
++ b) significantly different from untreated b) at the 1% level
+++ 0.1%

% = % survival
N = Total number of canes produced
H = Mean height (cm)

The removal of weeds from untreated plots in mid-May improved plant survival and prevented significant reductions in numbers and heights of canes (Table 1). Without supplementary weeding, the weed cover on plots treated with diuron and simazine expanded rapidly during June until by mid-July weeds covered almost the whole plot area. Emergence of young canes was virtually completed by this time and the survival of planted material was much better than on untreated plots. Cane numbers on plots treated with simazine, and cane height on those treated with diuron, were also significantly better than on untreated plots. Supplementary weeding improved cane height on simazine-treated plots but not on those treated with diuron. Chlorthiamid, bromacil and atrazine kept plots relatively free from weed growth during the emergence and early growth of young canes. They greatly reduced the population of P. aviculare, and surviving weeds took a long time to spread over the plot area, reaching a maximum of 40% cover on plots treated with chlorthiamid and only 25-30% on those treated with atrazine and bromacil, before flowering and senescence. These weeds never shaded the crop and there were no significant differences between the weeded and unweeded plots treated with these three herbicides. Comparison of cane records on plots receiving supplementary weeding shows that plots treated with bromacil and diuron produced significantly fewer canes per plot than did untreated plots. Cane height was not affected. None of the other herbicide treatments showed evidence of injury.

In 1972, cane numbers showed significant influence of previous treatments, but cane heights did not (Table 2). Totally untreated plots produced only 37% as many canes as plots given supplementary weeding in 1971. Plots treated with diuron and simazine still showed a reduction in cane numbers when they had not received supplementary weeding, but there was no indication of carry-over of herbicide injury due to either diuron or bromacil. Plots treated with simazine and given supplementary weeding in 1971 produced more new canes than any other treatment in 1972. Numbers of canes of potentially high fruiting capability for 1973 (those over 120 cm height) also showed the continuing effects of 1971 treatments.

Expt. II (Alyth)

Weed emergence was relatively slow, with the untreated plots reaching only 12% ground cover by mid-May, when the first supplementary hoeing was carried out. Further weeding in mid-August ensured that these plots remained fairly clean throughout 1971. Without supplementary weeding, ground cover by weeds on untreated plots rose to 88% by mid-June. This contrasted with 21-25% on plots treated with simazine and diuron and 8-13% on other treatments at this time. Thereafter weeds on all plots spread to cover virtually the whole ground area by mid-August, but only on the untreated plots did they cause severe shading of the crop. Weed cover declined rapidly after mid-August as annual weeds seeded and senesced. The main weed species on untreated plots were Stellaria media, Spergula arvensis, Chenopodium album and Polygonum persicaria. Variations in control of the last two was largely responsible for differences in performance between herbicides.

Cane records were made variable by sporadic severe grazing of young canes by hares. Other than on the untreated plots, canes emerged in advance of weed cover becoming dense and remained well above it. This is reflected in 1971 records (Table 1). All unsupplemented herbicide treatments produced more canes than on totally untreated plots, but the difference was not significant on the two weediest treatments i.e. simazine and diuron. Supplementary weeding significantly improved cane numbers and height on untreated plots. Although cane height overall was improved by supplementary weeding on herbicide-treated plots, individual differences were not significant. Comparison of cane records on plots receiving supplementary weeding showed no evidence of injury to the crop by any of the herbicide treatments.

In 1972, untreated plots which had had supplementary hoeing in 1971 produced significantly more canes than when left unweeded (Table 2). Bromacil produced more canes than any other treatment but other differences attributable to herbicide

Table 2

The effect of 1971 herbicide and weeding treatments on cane growth in 1972

Treatment		Expt.I Arbroath			Expt.II Alyth			Expt.III Rosemount			Expt.IV Liff			Expt.V Invergowrie		
		N	Q	H	N	Q	H	N	Q	H	N	Q	H	N	Q	H
Untreated	a)	25	8	99	23	3	84	45	43	160	12	2	88	19	2	94
	b)	67	24	112	41	10	92	44	40	157	13	4	101	76	10	94
Simazine	a)	47*	16	102	31	7	90	45	42	154	33	18	110	29	2	88
	b)	100^{++}	26	107	37	10	101	48	41	148^{+}	55^{++}	31^{+}	122	76	13	96
Atrazine	a)	64***	25*	112	41	9	95	40	35	152	58**	37**	126**	58**	13*	95
	b)	78	27	109	46	18	102	47	40	151	68^{+++}	45^{+++}	127^{+}	77	12	97
Diuron	a)	35	10	103	31	7	91	45	39	153	23	10	105	14	1	89
	b)	66	15	104	42	9	94	43	39	151	40^{+}	21	116	88	8	93
Chlorthiamid	a)	70***	24*	109	38	7	97	49	42	150*	31	15	113*	73***	8	93
	b)	67	18	106	36	9	101	51	45	156	42^{+}	23	117	70	9	94
Bromacil	a)	59**	17	104	50**	10	91	46	40	148**	49**	30*	121**	93***	12*	90
	b)	71	22	107	52	17	105	42	36	147^{+}	59^{++}	42^{++}	130^{+}	91	12	92
S.E. mean (1)	±	6.4	3.5	3.8	4.4	2.0	3.3	2.9	2.2	2.4	6.1	4.4	5.2	8.8	3.0	2.9
S.E. mean (2)	±	6.9	4.3	3.7	6.2	3.4	5.2	4.4	3.6	2.7	8.4	7.2	8.0	9.1	2.8	3.1

(1) for comparison of a) & b) within main treatments
(2) for other comparisons

a) = no supplementary weeding
b) = with supplementary weeding

* a) significantly different from untreated a) at the 5% level
** a) significantly different from untreated a) at the 1% level
*** a) significantly different from untreated a) at the 0.1% level
\+ b) significantly different from untreated b) at the 5% level
++ b) significantly different from untreated b) at the 1% level
+++ b) significantly different from untreated b) at the 0.1% level

N = Total number of canes produced
Q = Number of canes over 120cm in height
H = Mean height (cm)

treatments were few. Overall, plots receiving supplementary hoeing in 1971 consistently produced more canes exceeding 120 cm in height during 1972 than on unhoed plots, despite the fact that several of the herbicide treatments had given relatively good weed control.

Expt. III (Rosemount)

Weed growth on untreated plots reached only 7% by mid-June, when the first supplementary hoeing took place. Untreated plots were again hoed in mid-August and remained relatively clean thereafter. Without supplementary weeding, weeds on untreated plots spread to give complete ground cover by mid-August, but cover declined very rapidly thereafter as weeds flowered and senesced. All herbicides except diuron gave virtually complete weed control throughout 1971 and required little hoeing. Weeds on plots treated with diuron reached a maximum of 16% ground cover. The survival rate of planted canes was very high. Totally untreated plots produced slightly shorter canes than all other treatments, but the difference was significant only in the case of bromacil. Cane numbers on untreated plots were as high as on herbicide-treated plots. There were no indications that weeds or herbicides on other treatments had had any adverse effect on crop growth (Table 1).

In 1972 the farmer removed young canes growing outside the stool area at least once during the growing season. This was reflected in the low numbers but increased average height of the canes recorded during the following winter. The great majority of canes were over 120 cm in length and there were no significant differences between treatments in numbers of this quality or in total numbers. Untreated plots produced the tallest canes (Table 2).

Expt. IV (Liff)

This was a very weedy site, planted later than any of the others. One month after planting, weed cover on untreated plots had reached 40%. This increased to virtually 100% by mid-June, with annual weeds severely shading young canes. The first supplementary hoeing at this site was not carried out until mid-July and despite further weed removal later in the summer, supplementary weeding had no beneficial effect on cane production on untreated plots. All the herbicide treatments checked initial weed growth, but diuron was much less effective than the others. By mid-June, weed cover on the diuron-treated plots was 56%, compared with 32% and 24% for simazine and chlorthiamid and 9% and 4% for bromacil and atrazine respectively. Without supplementary weeding, all herbicide treatments became very weedy as the summer progressed, until after early September when weeds started senescing. Young canes on plots treated with bromacil and atrazine had emerged and grown above the weeds before the cover became too dense. On other treatments, early competition from weeds had a major effect on the survival of planted canes. Over two-thirds of the planting material on both sets of untreated plots was lost (Table 1). Plots treated with simazine and diuron without further weeding lost over 40% of planting material, compared with only 10% on the cleanest plots. The only herbicide treatments which produced, without further hoeing, canes of comparable number and height to those on the best hoed plots were atrazine and bromacil. Supplementary hoeing had a significant effect on survival and hence on cane numbers on plots treated with simazine but other treatments were not improved by further weeding.

In April 1972 the farmer replaced missing canes, and young growth produced by these replacements is included in the records taken per plot at the end of the year (Table 2). Nevertheless, the severe effects of weediness in 1971 still showed up very clearly, both in cane numbers and quality. Untreated plots produced only 20-25% as many canes as on the most effective herbicide-treated plots. The benefit of supplementary hoeing on cane production on simazine-treated plots was still apparent and all supplemented herbicide treatments significantly outyielded the untreated plots.

Expt. V (Invergowrie)

This site also showed early weed emergence and rapid growth, so that during May, weed cover on untreated plots rose from 5% to 80%, severely shading many plots before young canes had emerged. The first supplementary weeding was carried out on May 7 and was repeated at approximately monthly intervals. Diuron had virtually no effect on weeds, and ground cover was similar to that on untreated plots throughout the year. Simazine controlled all annual species except Polygonum aviculare, which spread to cover 20% of the plot area by the end of May, rising to 85% and severely shading the crop by the end of July. This weed was also the only species present on atrazine-treated plots, although the level of control was sufficient to restrict ground cover to 10% by late June. Survivors spread to give 60% cover by late August, by which time, however, the young canes were well above the weeds. A mixture of late-germinating weeds on plots treated with chlorthiamid contributed to ground cover of 10% in late June, which reached a maximum of 25% in later months. Bromacil gave almost complete weed control during the whole of 1971.

Cane numbers and height were reduced on untreated plots and on those treated with diuron (Table 1). Crop growth on plots treated with atrazine, chlorthiamid and bromacil was similar to that on the equivalent hoed plots. Supplementary weeding significantly improved cane production on plots treated with simazine and diuron. There was no evidence that herbicide treatments adversely affected crop growth on plots receiving supplementary hoeing. In 1972, mean cane height was unaffected by 1971 weed levels, but cane numbers reflected earlier differences. Supplementary weeding in 1971 resulted in four times as many canes being produced on untreated plots in 1972 (Table 2). There was again much greater cane production on plots treated with simazine and diuron and given supplementary hoeing in 1971; plots originally treated with chlorthiamid and bromacil again produced the highest numbers and best quality of canes on any of the unsupplemented treatments.

DISCUSSION

The success or failure of the herbicides in controlling weeds was the main factor contributing to treatment differences. Direct phytotoxic effects were few, despite wide variations in planting date, planting technique, site, spraying date, weed density and subsequent management. Bromacil, atrazine and chlorthiamid gave the best overall weed control, in all cases delaying the spread of weeds until the young canes had emerged and made some growth. Diuron was consistently the least effective herbicide, while simazine was only slightly more reliable. Timely supplementary weeding removed most of the differences between herbicide treatments, but leaving treated plots without further weeding indicated clearly the risks of poor herbicide performance leading to severe weed competition.

Dense weed cover before mid-July in Expts. IV & V resulted in the death of much of the planting material. Similar weed cover reached later in the year, due either to better herbicide activity or to the slow development of a sparse weed population, generally reduced neither survival rate nor numbers, but could affect cane height. The critical period for protection of the crop from weed competition was therefore during the period of emergence and early growth of the young canes. Supplementary hoeing carried out 2 months after planting at four of the sites avoided crop loss but when delayed until 3 months after planting in Expt. IV, was too late to avoid severe injury to the crop. Other investigations at SHRI into competition between young raspberries and annual weeds (Lawson & Wiseman, 1972) have shown that provided weeds were removed in early June from plots planted in late March, cane numbers were unaffected, but where weed removal was delayed until early July or early August, cane numbers were reduced by 28% and 77% respectively. Death of planting material was a major factor involved in these cane losses. Replacement of dead planting canes in 1972 in Expt. IV failed to remove the large differences between treatments by the end of the year, although this would gradually improve cane numbers on affected plots.

Since the adverse effects of early competition from weeds in both sets of experiments carried over into the second year's cane production and hence affected the subsequent year's fruiting potential, the economic necessity of maintaining a high level of weed control in the establishment year is made even more apparent. While repeated and timely soil cultivations can achieve this objective, treatment with a residual herbicide shortly after planting should protect the crop during its most vulnerable stages of growth and reduce the necessity for cultivation. Choice of the most effective herbicide for the individual weed situation was critical in these experiments, but those giving the most reliable results overall were bromacil, atrazine and chlorthiamid.

Even these herbicides, however, at the relatively low rates tested, were usually unable to give complete weed control for the whole growing season. Visual observations of the weed flora in 1972 at each site indicated that, regardless of the weed control techniques practised by the growers, plots which were allowed to become weedy during 1971 consistently had a larger nucleus of perennial weeds than those which had remained relatively free from weeds. Timely and effective supplementary weeding in the year of establishment is therefore an essential part of any integrated weed control programme for this crop.

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