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ORYZALIN AND ORYZALIN COMBINATIONS FOR WEED CONTROL IN OIL SEED RAPE

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Summary Oryzalin, 3,5-dinitro-N^4,N^4-dipropylsulfanilamide, has shown excellent selectivity in oil seed rape when pre-emergence surface applied at 1.0 - 1.5 kg a.i./ha. The wide spectrum of weeds controlled by this herbicide at these dosages includes the following important broadleaf species: Chenopodium album, Matricaria spp., Polygonum aviculare, P. convolvulus, Stellaria media and Veronica arvensis. Additionally, oryzalin provided good to excellent control of most annual grasses, including Alopecurus spp., Apera spica-venti and Poa annua. Methods to increase initial activity against annual grass weeds are discussed.

INTRODUCTION

Oryzalin, 3,5-dinitro-N^4,N^4-dipropylsulfanilamide, is a new pre-emergence surface applied herbicide. This product was previously known under the code EL-119.

The toxicological, chemical and physical properties of oryzalin are discussed in detail by Snel et. al. (1974). These workers also discussed the leaching properties of oryzalin and arrived at the conclusion that a minimum amount of precipitation (rainfall or sprinkler irrigation) of 1.25 cm. is needed to "activate" the compound. A list of the weed species susceptible to oryzalin at the recommended rate is published elsewhere (Snel et. al. 1974).

When oryzalin was applied at rates of 1.12 - 1.5 kg a.i./ha pre-emergence in winter rapeseed in Sweden, this herbicide provided a very effective season-long control of the major weeds occurring in this crop under Swedish climatic and soil conditions, i.e. Matricaria spp., and Stellaria media (Snel et. al. 1974). Oryzalin displayed a high crop selectivity when applied to the Swedish low erucic acid variety "Simis" and significant yield increases were measured in treated plots. Early season control of annual grasses with oryzalin was occasionally less than optimal, especially when "activation" of the compound by rainfall was delayed for more than 7 days.

This less than optimal initial weed control could present potential problems under the conditions encountered in the Dutch and German winter rapeseed areas where annual grass weeds play a very important role in the weed spectrum.

Methods to improve the early season activity of oryzalin against grasses have therefore been investigated and are reported here.

METHOD AND MATERIALS

Oryzalin was applied pre-emergence to the soil surface after seeding winter rapeseed. The compound and the reference products were applied with Azo gasplot sprayers with a 2 metre spray boom fitted with Birchmeyer J60 nozzles. The spray volume ranged between 400 and 600 litres/ha. In all instances, the experiments were laid out in a randomized block design with 25-50 m^2 plots and 4-5 replications.

Trifluralin (treatments 6 and 7, tables 1, 2 and 3) was soil incorporated before sowing with a tractor mounted rotary cultivator or spring tooth harrow to a depth of 5-8 cm. In treatment 7, the trifluralin application was followed after seeding the crop with a pre-emergence surface application of oryzalin at 375 g a.i./ha. The entire experimental site was cultivated with the soil implement used for incorporation of trifluralin, since plots which receive different soil preparation treatments frequently have a slightly altered weed spectrum.

A total of 24 experiments in winter rapeseed has been conducted in Germany and the Netherlands since August, 1971. Soil types varied from sandy loam (for assessing possible phytotoxicity) to heavy clay soils with heavy infestations of Alopecurus. The experiments conducted in the Netherlands during the 1973/74 season are discussed in detail. Two trials were located in Zeeuws - Vlaanderen on sandy clay soils and three in the province of Groningen (one trial on sandy loam and two on clay-loam soils).

The herbicidal efficacy was assessed by weed counts, and/or weed control ratings. Crop selectivity was determined by crop stand counts, crop emergence and yield measurements.

The data from all experiments have been analyzed statistically using the Duncan's Multiple Range Test. In view of great differences in weed spectra, weed infestations, soil types and climatic conditions, it was decided not to carry out a pooled statistical analysis of all winter rapeseed experiments.

RESULTS

Oryzalin when applied at 1.12 kg a.i./ha in combination with 9.0 kg a.i./ha of TCA gave excellent season-long control of Alopecurus myosuroides (table 1). Oryzalin alone compared favourably with the soil incorporated herbicide trifluralin which had a better initial herbicidal efficacy (table 2) against Alopecurus myosuroides. The effect of TCA and TCA + Simazine against this grass weed was disappointing in the spring following the late summer application, notwithstanding good activity of TCA + Simazine observed in the autumn.

Oryzalin, alone or in combination showed very good crop selectivity in the Dutch winter rapeseed cultivars "Marcus" and "Rapol", as well as in some of the new German varieties with low erucic acid contents. The vigour of Alopecurus plants in the oryzalin treated plots was less than in the TCA, TCA + Simazine or

TABLE 1

Weed control in winter rapeseed in the Netherlands with oryzalin, oryzalin + trifluralin and oryzalin + TCA (average from 5 experiments conducted in 1973/74) 1/

Compound	Rate g a.i./ha	% control of Alopecurus myosuroides	% control of Matricaria inodora	% control of Stellaria media
Oryzalin	1125	77	90	81
Oryzalin + TCA	562 + 9000	80	84	63
Oryzalin + TCA	750 + 9000	85	93	69
Oryzalin + TCA	1125 + 9000	90	96	83
TCA	900	46	6	0
Trifluralin	960	73	32	69
Trifluralin + oryzalin	960 + 375	84	93	85
TCA + Simazine	9000 + 250	52	75	30
Untreated control	-	0 (71) 2/	0 (85) 2/	0 (38) 2/

1/ Weed control ratings carried out during the first week of April, 1974. Applications were made during the last week of August or the first week of September, 1973.

2/ Average number of plants/m^2 in untreated control plots.

trifluralin plots, which resulted in reduced tillering. It was observed in German trials that oryzalin severely injured the root systems of escaped volunteer winter wheat and winter barley plant. TCA aided the activity of oryzalin against volunteer cereals in winter rapeseed, but due to relatively low infestations, no accurate assessment of the oryzalin activity was carried out.

The effect of delayed activity of oryzalin against Poa annua is shown in table 2. Seven weeks after application, oryzalin was significantly less active against Poa annua than any of the oryzalin + TCA combinations, however, the activity of the compound alone was significantly superior to TCA alone. In the spring, however, control in the plots treated with 1.12 kg a.i./ha of oryzalin has improved greatly, and was equal to that observed in the plots treated with oryzalin + TCA.

Control of Matricaria inodora in the oryzalin, oryzalin + TCA applications, and trifluralin + oryzalin split application was not significantly different from the reference treatment either in the autumn or in the spring. The split trifluralin + oryzalin treatment gave significantly better control of Matricaria inodora than the trifluralin treatment, especially in the spring.

Slow initial activity of oryzalin against Alopecurus myosuroides is shown in table 3. Trifluralin when applied pre-plant incorporated either alone or followed by a pre-emergence surface application of oryzalin (0.375 kg a.i./ha) displayed a significantly greater activity against this weed than the oryzalin, oryzalin + TCA treatments three weeks after application. No significant difference was noted in activity against Alopecurus myosuroides between the trifluralin and TCA + Simazine. The additive effect of TCA on the control of Alopecurus with oryzalin became evident 7 weeks after application (treatments 3 and 4). In the spring, oryzalin (1.12 kg a.i./ha), trifluralin + oryzalin (0.96 + 0.37 kg a.i./ha), oryzalin + TCA (1.12 + 9.0 kg a.i./ha), and trifluralin (0.96 kg a.i./ha) all gave statistically similar control of Alopecurus myosuroides which indicates that control of Alopecurus myosuroides increased in plots treated with oryzalin applied at 1.12 kg a.i./ha either alone or in combination with TCA. This increased control was not observed at the lower rates of application of oryzalin in combination with TCA, (0.56 or 0.75 kg a.i./ha oryzalin + 9.0 kg a.i./ha TCA).

The activity against Alopecurus myosuroides decreased significantly with time in the TCA + Simazine treatment, and equalled that obtained with TCA alone at the time of the spring assessments (table 3, treatment 7 versus treatment 5). Similar patterns of weed control with oryzalin were observed in our German experiments.

DISCUSSION

Two methods were studied to combine the excellent season-long activity of oryzalin against dicotyledonous weeds in winter rapeseed (Snel et. al., 1974) with good initial activity against annual grass weeds occurring in this crop (especially against Alopecurus myosuroides). These methods were based on combining oryzalin treatments with those of herbicides used for control of annual grasses in winter rapeseed, trifluralin and TCA.

TABLE 2

Control of Poa annua and Matricaria inodora in winter rapeseed with oryzalin, oryzalin + trifluralin and oryzalin + TCA in the Netherlands: Experiment NL 73-202, St. Kruis Z.VL

Compound	Rate g a.i./ha	% control of Poa annua 22 Oct. 73	% control of Poa annua 22 Mar. 74	% control of Matricaria 22 Oct. 73	% control of Matricaria 12 Apr. 74
Oryzalin	1125 1/	78 a	100 a 4/	100 a 4/	98 a 4/
Oryzalin + TCA	562 + 9000 1/	90 a	100 a	98 a	93 a
Oryzalin + TCA	750 + 9000 1/	95 a	100 a	95 a	98 a
Oryzalin + TCA	1125 + 9000	95 a	100 a	100 a	100 a
TCA	9000 1/	58 c	43 c	20 c	10 c
Trifluralin	960 2/	97 a	100 a	84 b	45 b
Trifluralin + oryzalin	960 + 375 3/	99 a	100 a	100 a	98 a
TCA + Simazine	9000 + 250 1/	80 b	68 b	100 a	90 a
Untreated control	0	0	0	0	0
		(62) d 5/	(48) d 5/	(106) d 5/	(164) d 5/

1/ Pre-emergence surface application carried out on 31st August, 1973. Soil contained 16% clay and 1.6% organic matter.

2/ Pre-sowing incorporated carried out on 31st August, 1973.

3/ Trifluralin applied pre-sowing incorporated followed by a pre-emergence surface application of oryzalin.

4/ Figures followed by the same letter are not significantly different (P = 0.05)

5/ Figures in brackets indicate the mean number of weeds m^2 in the untreated control.

TABLE 3

Control of Alopecurus myosuroides in winter rapeseed in the Netherlands 1/
Experiment NL 73-201, Aardenberg, Z.VL

Compound	Rate g a.i./ha	Date of Observation 1 Oct. 73	31 Oct. 73	22 March 74
Oryzalin	1125	50 cd 2/	45 cd	74 abc
Oryzalin + TCA	562 + 9000	53 cd	53 cd	54 c
Oryzalin + TCA	750 + 9000	60 cd	60 cd	61 bc
Oryzalin + TCA	1125 + 9000	60 cd	58 bcd	80 ab
TCA	9000	45 d	43 d	59 bc
Trifluralin	960	80 ab	75 ab	74 abc
Trifluralin + oryzalin	960 + 375	88 a	88 a	87 a
TCA + Simazine	9000 + 250	65 bc	65 bc	53 c
Untreated control	0	0 e	0 e (66) 3/	0 d

1/ Date of application 6th September, 1973. Soil contained 26% clay and 2.0% organic matter.

2/ Figures followed by the same letter are not significantly different (P = 0.05)

3/ The figure in brackets indicates the number of plants/m^2 in untreated control plots.

First the results obtained by combining oryzalin and TCA as a pre-emergence surface application will be discussed.

In tables 2 and 3, it is shown that oryzalin alone always gave better initial activity against annual grass weeds than TCA alone, while tank-mix applications of oryzalin + TCA always surpassed the activity of oryzalin alone. Although a dosage related increase in activity against Alopecurus myosuroides with increasing oryzalin concentrations in the oryzalin TCA tank-mix pre-emergence applications was difficult to demonstrate in the early autumn, this response could be noted very clearly in the spring (table 3). It appeared that the most efficacious dosage was 1.12 kg a.i./ha of oryzalin combined with 9.0 kg a.i./ha of TCA as borne out in table 1, in which the season-long activity of all treatments obtained in 5 experiments is reviewed (see also table 3, treatments 2, 3, 4, observation date 22 March, 1974). A dose related response could also be demonstrated for control of Stellaria media and Matricaria inodora with oryzalin and TCA combinations (tables 1 and 2, treatments 2, 3 and 4). As anticipated, TCA contributed nothing towards the activity of oryzalin against these dicotyledonous weeds (table 1, treatment 5). The most desirable control of Stellaria media by oryzalin was obtained at 1.12 kg a.i./ha. Snel and co-workers (1974) reported that a similar application rate of oryzalin was required for control of these weeds under Swedish conditions.

The second method of improving the initial activity of oryzalin against Alopecurus myosuroides always proved significantly better than that of the tank-mix combinations of oryzalin and TCA, as shown for one particular experiment in table 3, treatment 7. The season-long activity of the split application against annual grasses was statistically comparable to that of oryzalin + TCA (1.12 + 9.0 kg a.i./ha), oryzalin alone (1.12 kg a.i./ha), tables 1 and 3) or trifluralin (0.96 kg a.i./ha), although the trend exists in our opinion that the split application is slightly better than any of these treatments.

A most remarkable feature of the split application was the activity against Matricaria inodora and Stellaria media. Namely, in the split application technique, only 0.375 kg a.i./ha of oryzalin was required to obtain the same season-long control of these dicotyledonous weeds as that obtained with 1.12 kg a.i./ha of oryzalin alone, i.e. (tables 1 and 2, compare treatments 1, 4 and 7). Trifluralin is only moderately active against Matricaria species (tables 1 and 2) especially in the spring, which would suggest that a higher concentration of oryzalin should be required for good control of this species. Apparently, however, this particular weed is very sensitive to oryzalin since an average control of 84% could be obtained in the spring with 0.56 kg a.i./ha in the 1973/74 trial programme in the Netherlands (table 1). Therefore, presumably trifluralin provided a small additive effect when oryzalin was applied at 0.375 kg a.i./ha. Stellaria media appeared less sensitive to oryzalin than Matricaria, however, trifluralin applied alone exhibited good activity against Stellaria which complemented the low application rate of oryzalin.

In summary, when soil type and cultural techniques make soil incorporation of trifluralin feasible, the addition of oryzalin as a pre-emergence treatment at a very low rate of 0.375 kg a.i./ha provided excellent control of both annual grass and broadleaf weeds, surpassing the herbicidal efficacy of established treatments such as TCA, TCA + simazine and trifluralin (Table 1).

When oryzalin was applied pre-plant incorporated as a tank-mix with trifluralin, the activity against Matricaria species was greatly decreased (Brandes and Snel, unpublished data), necessitating a split application technique.

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CONTROL OF ANNUAL GRASSES AND BROAD-LEAVED WEEDS IN WINTER OILSEED RAPE WITH PROPYZAMIDE

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Summary The results of experiments carried out over two years with post-crop emergence applications of propyzamide to winter oilseed rape are reported. Comparisons were made with 3.3 lb a.i./acre dalapon and 1.87 lb a.i./acre carbetamide.

0.5 lb a.i./acre propyzamide gave excellent control of volunteer cereals, Avena fatua and Alopecurus myosuroides but the slightly higher rate of 0.63 lb a.i./acre was required to give consistently good control of Stellaria media and Veronica persica. October applications resulted in lower weed population levels during the crop establishment period from January to April than did later applications.

Yields from propyzamide plots were consistently higher than those from dalapon plots. Dalapon gave poor or no control of broad-leaved weeds and retarded flowering by 7-10 days. Carbetamide gave inferior weed control in comparison with propyzamide.

Résumé Les résultats de deux années d'expériences sur des applications post-levées de propyzamide au colza d'hiver sont exposés. On a établit des comparaisons avec des doses de 3 lb/acre de matière active (m.a.) de dalapon et de 1.87 lb/acre m.a. de carbetamide.

On a obtenu un excellent contrôle des céréales adventices, Avena fatua et Alopecurus myosuroides, avec 0.5 lb/acre m.a. de propyzamide, mais il a fallu la dose légèrement plus élevée de 0.63 lb/acre m.a. pour obtenir un contrôle régulièrement efficace de Stellaria media et Veronica persica. Des applications effectuées en Octobre, comparées à des applications plus tardives, ont eu pour résultat de réduire la population des plantes adventices pendant la période d'établissement de la culture de Janvier à Avril.

Les parcelles traitées à la propyzamide ont produit des rendements régulièrement plus élevés que ceux des parcelles traitées au dalapon. Le dalapon n'a eu que peu on pas d'effet sur les plantes adventices feuillues et a retardé la floraison de 7 à 10 jours. Le contrôle des plantes adventices par le carbetamide s'est révélé inférieur à celui obtenu avec la propyzamide.

INTRODUCTION

Oilseed rape is playing an increasingly important part in supplying the world with oil and protein. The crop is well suited to UK climatical conditions and is now a very attractive break crop, there being an estimated 50,000 acres harvested in 1974 and a forecast of 100 - 125,000 acres for 1975. This increased interest has led to a demand for a herbicide to control annual grass and broad-leaved weeds.

In the later stages of growth the crop is most effective in smothering weeds but it can suffer severely from competition during its establishment period. The weed species which are most commonly found in winter rape were listed by Hughes (1973) as being volunteer cereals (especially winter barley), Stellaria media, Avena fatua, Alopecurus myosuroides, other broad-leaved weeds (mainly annuals which grow faster than dormant rape, such as Veronica spp) and rhizomatous grasses.

Propyzamide, as the 50% w.p. commercial formulation Kerb 50W, was found to be effective at 0.6 lb a.i./acre for controlling problem weeds in winter rape in France (Sumpter, 1973). The material was subsequently test marketed in 1972 and given full commercial clearance in 1973. The first United Kingdom evaluations carried out by Bryant (1973) in the 1972/73 season showed that post-crop emergence applications of 0.5 and 0.75 lb a.i./acre propyzamide controlled Stellaria media and Veronica persica and checked the growth of Sinapis arvensis.

METHODS AND MATERIALS

Five replicated experiments were carried out on commercial crops, three in East Anglia and two in Wiltshire. The experimental design was three replicates in randomised blocks. The plots at the East Anglian sites, designed for yields to be taken, were 8 yd x 25 yd in size. Treatments were applied with an Oxford Precision Sprayer fitted with Allman '00' jets. The volume rate was 20 gal/acre and the pressure 30 lb/in^2. Plot size at the Wiltshire sites was 5 yd x 10 yd. Treatments were applied with a Van der Weij sprayer at 50 gal/acre and 30 lb/in^2 pressure. All treatments were applied post-crop emergence. The rates of use and times of applications are given in Tables 1, 2 and 3. Propyzamide treatments were compared with either 3.3 lb/acre dalapon (4 lb/acre product) or 1.87 lb a.i./acre carbetamide (2.75 lb/acre product). Other site details are given in Table 1. Assessments were made of treatment effect on crop growth and on weeds. Yields were taken at three sites by taking one or two combine swaths down the length of each plot.

Table 1

Site Details

Trial Reference	A	B	C	D	E
Location	Royston, Herts.	Attleborough, Norfolk.	Chelmsford, Essex.	Downton, Wiltshire.	Standlynch, Wiltshire.
Soil type	Chalky silty clay loam	Loamy sand	Silty clay loam	Stony medium loam over chalk	Light to medium loam over chalk
Crop variety	Lesira	Lesira	Janetzkis	Hector	Hector
Spraying dates	1) 24.10.73 2) 28.11.73 3) 21. 1.74	1) 1.10.73	1) 22.10.73 2) 24.11.73 3) 14. 2.74	1) Propyzamide - 29.10.73 2) Carbetamide - 28.11.73	1) Propyzamide - 29.10.73 2) Carbetamide - 28.11.73
Crop stage (no. of true leaves) at spraying	1) 4 2) 6 3) 6	1) 7	1) 3-4 2) 5-7 3) 5-7	1) 3 2) 4	1) 4 2) 5
Drilling date	4th week August 1973	4th week August 1973	4th week August 1973	3 September 1973	4th week August 1973
Seed bed preparation	Ploughed	Minimum cultivation	Discs followed by reciprocating power harrow	Direct drilldd	Direct drilled
Weeds present at spraying	Volunteer barley, Af, Vp, Sm, Tm, Fo.	Agr, Cbp, Sm, Vp.	Volunteer barley, Sm	Volunteer barley, Af, Sm, Vp.	Volunteer wheat, Af, Sm, Vp, Agr.
Date of harvest	29 July 1974	25 July 1974	26 July 1974	-	-

Af = Avena fatua, Vp = Veronica persica, Sm = Stellaria media, Tm = Tripleurospermum maritimum, Fo = Fumaria officinalis, Agr = Agropyron repens, Cbp = Capsella bursa-pastoris.

RESULTS

Weed control

Details of the weed control assessments are given in Tables 2 and 3.

October/November applications of both propyzamide at 0.38 - 1.0 lb a.i./acre and dalapon at 3.3 lb/acre gave excellent control of germinating and established annual grass weeds such as volunteer wheat and barley, Avena fatua and Alopecurus myosuroides. Carbetamide at 1.87 lb a.i./acre gave only moderate control of these species when applied at the recommended time (November). Later applications of propyzamide made in January/February generally gave equally good grass control where moderate infestations were present. At site C, however, where there was a severe infestation of volunteer barley, February applications of propyzamide resulted in poor control.

Growth of Agropyron repens (site E) was suppressed 20% and 40% by 0.5 and 1.0 lb propyzamide/acre respectively when applied in October.

Consistently good control of germinating and established Stellaria media and of Veronica persica (up to seedling stage) was achieved by 0.63 - 1.0 lb/acre propyzamide; lower rates of 0.38 and 0.5 lb/acre were not quite so effective. Dalapon and carbetamide gave only poor control of these species. The addition of 0.1 lb/acre diuron to 0.5 lb/acre propyzamide improved the control of Capsella bursa-pastoris significantly, this species being normally only moderately susceptible to propyzamide alone. There were insufficient numbers of Compositae spp. present at the sites where propyzamide/diuron was applied to be able to confidently conclude that the addition of diuron had adequately controlled members of this group (more or less resistant to propyzamide alone).

At sites D and E, assessments of % weed cover of each treatment were made on seven occasions from application (29 October 1973) until 26 July 1974. The mean results are given in Table 2.

Table 2

% weed cover (means of sites D and E)

	Assessment Date						
	1973		1974				
Treatment	29/10*	28/11**	4/1	7/3	30/4	24/5	26/7
Untreated control	7.5	7.5	15	77.5	100	100	100
0.5 lb/acre propyzamide	10	10	12.5	10	22.5	20	22.5
0.75 " "	7.5	10	12.5	12.5	10	10	10
1.0 " "	7.5	7.5	10	10	7.5	7.5	10
1.87 " carbetamide	7.5	7.5	12.5	67.5	87.5	100	100

* Date of application of propyzamide ** Date of application of carbetamide.

The data in Table 2 shows that there was sufficient propyzamide remaining in the soil up until the period when the rape crop met in the row and could thereafter compete successfully with any newly germinating weeds. Carbetamide was not persistent enough to keep the crop clean up until this period. 0.75 lb/acre propyzamide generally gave better weed control than did 0.5 lb/acre propyzamide.

At all sites dalapon was farmer-applied at 2.5 - 3.3 lb/acre to the remainder of the field. Control of annual grass weeds was good but there was little or no control of Stellaria media and Veronica persica which dominated the annual broad-leaved weed spectrum.

Effect on crop

Details of the effect of treatment on oilseed rape are given in Table 4. None of the propyzamide treatments affected crop growth. After January/February the rape in the control plots began to be affected by weed competition and the plants grew less vigorously than in the propyzamide plots.

Table 3

Effect of treatments on weeds
(0-10 scale; 0 = no control, 10 = complete control)

Chemical		Date applied	Untreated control*	lb a.i. per acre											
Propyzamide		October '73		-	-	0.38	0.5	0.63	0.75	1.0	0.5	-	-	-	-
"		November '73		-	-	-	-	-	-	-	-	0.5	1.0	-	-
"		Jan/Feb '73		-	-	-	-	-	-	-	-	-	-	0.5	1.0
Diuron		October '73		-	-	-	-	-	-	-	0.1	-	-	-	-
Dalapon		" '73		3.3	-	-	-	-	-	-	-	-	-	-	-
Carbetamide		November '73		-	1.87	-	-	-	-	-	-	-	-	-	-
Weed	**Trial ref.**	**Assessment date (1974)**													
Volunteer barley	A	20 March	0(M)	10	-	10	10	10	10	10	10	10	10	10	10
	C	21 March	0(H)	10	-	9.3	8.7	10	9.3	10	10	9.3	8.7	4	3
	D	24 May	0	-	7	-	10	-	10	10	-	-	-	-	-
Volunteer wheat	E	7 March	0	-	5	-	9	-	10	10	-	-	-	-	-
Avena fatua	A	20 March	0(L)	10	-	10	10	10	10	10	10	10	10	10	10
	D	24 May	0	-	7	-	10	-	10	10	-	-	-	-	-
	E	24 May	0	-	7	-	9.5	-	10	10	-	-	-	-	-
Alopecurus myosuroides	A	20 March	0(L)	10	-	10	10	10	10	10	10	10	10	10	10
Stellaria media	A	20 March	0(M)	4	-	10	8	10	10	10	10	10	10	8	7
	B	22 January	0(L)	5	-	7	9	9	9	9	8	-	-	-	-
	C	23 January	0(M)	2	-	8	9	9	10	10	10	5	8	4	5
	D	7 March	0	-	3	-	8	-	9	9	-	-	-	-	-
	E	7 March	0	-	2	-	8	-	10	10	-	-	-	-	-
Veronica persica	A	20 March	0(M)	3	-	9	9	10	10	10	9	4	8	7	7
	B	22 January	0(M)	5	-	7	9	9	9	9	8	-	-	-	-
	D	24 May	0	-	2	-	7	-	9	10	-	-	-	-	-
	E	24 May	0	-	1	-	8	-	8	9.5	-	-	-	-	-

* L = light infestation, M = moderate, H = heavy.

Table 4

Effect of treatments on oilseed rape

Chemical		Date applied	Untreated control	lb a.i. per acre												L.S.D. (3)	S.E. (±)
Propyzamide		October '73		-	-	0.38	0.5	0.63	0.75	1.0	0.5	-	-	-	-		
"		November '73		-	-	-	-	-	-	-	-	0.5	1.0	-	-		
"		Jan/Feb '73		-	-	-	-	-	-	-	-	-	-	0.5	1.0		
Diuron		October '73		-	-	-	-	-	-	-	0.1	-	-	-	-		
Dalapon		October '73		3.3	-	-	-	-	-	-	-	-	-	-	-		
Carbetamide		November '73		-	1.87	-	-	-	-	-	-	-	-	-	-		
Trial ref.	**Parameter**	**Assessment date**															
A	Vigour (1)	21.1.74	6.3	9.3	-	5.7	5.7	6.7	6.7	6.0	7.0	7.0	7.0	7.7	6.7		
		20.3.74	6.3	8.3	-	6.3	6.3	7.0	6.8	6.3	7.8	7.0	6.3	7.3	7.3		
	Yield change over control (cwt/ac)		(22.3)	+2.0	-	+1.9	+4.2	+4.4	+3.3	+3.2	+3.1	+1.5	+4.1	+0.8	+3.7	N.S.*	6.0
B	Plant height (2) (% change over control)	4.4.74	(68.4 cm)	-13.5	-	+4.7	-1.6	-0.3	-1.9	+1.2	-5.3	-	-	-	-	7.9***	1.9
	Yield change over control (cwt/ac)		(22.4)	-3.8	-	-1.1	-0.7	-2.9	-1.4	-0.4	-1.9	-	-	-	-	N.S.*	6.4
C	Vigour	23.1.74	10	8	-	10	10	9.3	10	8	8	10	10	-	-		
		21.3.74	6	9	-	9	10	10	10	9.3	10	10	10	10	9		
	Yield change over control (cwt/ac)		(19.5)	+9.3	-	+9.7	+12.3	+10.5	+10.2	+8.9	+7.5	+9.4	+9.0	+9.2	+7.9	5.9*	2.8
D	Vigour	4.1.74	10	-	9	-	9	-	9.5	9	-	-	-	-	-		
		26.7.74	4	-	6	-	9	-	10	10	-	-	-	-	-		
E	Vigour	4.1.74	9	-	7	-	7.5	-	8	7	-	-	-	-	-		
		26.7.74	4	-	5.5	-	10	-	10	9.5	-	-	-	-	-		

(1) Vigour: 0-10 scale; 0 = dead, 10 = healthy.

(2) 30 plants measured/treatment.

(3) * = p at 0.05, *** = p at 0.001.

Where moderate to heavy weed infestations were present (sites A and C) propyzamide treatments resulted in yield increases (significant at $p = 0.05$ at site C) in the order of 3-4 cwt/acre at site A and 9 - 12 cwt/acre at site C. 3.3 lb/acre dalapon also increased yields at both these sites but not to the same extent as did October applications of propyzamide. All treatments reduced yields slightly at site B (not significant, $p = 0.05$) but increases were not expected as the weed population was low initially and the majority of the weeds were removed in February when the field was virtually inter-row hoed by liquid ammonia injection equipment. As at sites A and C, lower yields were recorded on the dalapon plots than on the propyzamide plots. Plant height was reduced 13.5% (significant at $p = 0.001$) by dalapon at this site (pigeon damage was negligible) and the date of flowering was retarded by 7 to 10 days at all 5 sites.

Sites A, D and E suffered heavy overall pigeon damage in January and February except where dalapon was used. Dalapon residues on plant foliage are known to repel birds.

Table 5 shows how crop vigour of plants treated with propyzamide or carbetamide compared with plants treated with dalapon in the remainder of the field (farmer's treatment), in relation to pigeon damage and weed control.

Table 5

The effect of pigeon damage and weed control on crop vigour under different treatment regimes (means of sites D and E)

(0 - 10 scale; 0 = dead, 10 = healthy)

	Assessment Date						
	1973		1974				
Treatment	29/10	28/11	4/1	7/3	30/4	24/5	26/7
Untreated control	10	10	9.5	3.3	4.5	4.5	4
0.5 lb/acre propyzamide	10	10	8.3	3	6.5	9.3	9.5
0.75 " "	10	10	8.8	2.8	6.8	8.3	10
1.0 " "	10	10	8	3.3	7	9.3	9.8
1.87 " carbetamide	-	10	8	3	5.8	6	5.8
3.3 " dalapon (farmer's treatment)	10	10	10	9.5	9	8	8

Pigeons effected damage between January and March in the propyzamide and carbetamide plots at sites D and E, whereas the non-trial area which was treated with dalapon suffered little damage. Despite this, the plants in the propyzamide plots recovered quickly during April and May because of the excellent weed control achieved and crop vigour was eventually better than that of dalapon treated plants. The lack of broad-leaved weed control by dalapon resulted in a reduction of crop vigour from March onwards. Plants in the carbetamide and untreated control plots never recovered from the pigeon damage because of weed competition.

DISCUSSION

The recent increase in the popularity of winter oilseed rape has resulted in the evaluation of a number of herbicides for this crop. Dalapon has been the main material used commercially until recently but only gives control of annual grass weeds and a temporary check to some broad-leaf weeds. Hence there has been a need for a herbicide which controls both grass and broad-leaved weeds as both groups usually occur together. The data presented in this paper confirms the French work in which it was found that 0.63 lb a.i./acre propyzamide applied post-crop emergence in October after the 3 leaf stage controlled all the important weeds of winter rape.

Carbetamide gave inferior weed control to propyzamide and although yields were not recorded, crop vigour assessments at the end of July showed that plants in the propyzamide plots were much healthier than those in the carbetamide plots.

Crop vigour and control of grass weeds was not affected by the date of application of propyzamide but it appears that at some sites the best control of chickweed and speedwells and the best increase in yield was achieved from the earlier applications. The benefits from the earlier application probably arise from the suppression of weeds prior to the important crop establishment period of January to April. Propyzamide breaks down fairly rapidly when the soil starts to warm up in April, but there was no further need for chemical weed control in the propyzamide plots as the crop by this stage could compete successfully with germinating weeds.

Populations of weeds which are moderately susceptible or resistant to propyzamide were unfortunately too low to be able to draw firm conclusions on whether the addition of diuron to propyzamide improved their control. Indications were promising, however, and warrant further evaluations. A mixture of the two herbicides is already marketed in France.

Taking chemical costs into account, yield assessments showed that where moderate to heavy grass weed or grass/broad-leaved weeds were present, propyzamide gave better nett returns than did dalapon. Although dalapon had the advantage of repelling pigeons, the improved broad-leaved weed control and absence of crop damage from propyzamide resulted in higher overall beneficial effects.

As a result of this work, commercial recommendations will be made in the U.K. for winter (October-January) applications of propyzamide at 0.63 lb a.i./acre to control annual grass and broad-leaved weeds in oilseed rape.

Acknowledgments

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CONTROL OF AVENA FATUA AND A. LUDOVICIANA (WILD OATS) IN OIL SEED RAPE WITH BENZOYLPROP-ETHYL

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Summary Five years of trials work using benzoylprop-ethyl against *Avena fatua* and *Avena ludoviciana* in oil seed rape in France is reported.

Good wild oat control was obtained from benzoylprop-ethyl applied at 1 kg a.i./ha during the active growth period of the crop i.e. during stem elongation (shooting). When applied too early (rosette stage) or too late (early flowering) the treatment was less active. Benzoylprop ethyl was well tolerated by winter and spring sown oil seed rape and high yield increases were recorded.

INTRODUCTION

Benzoylprop-ethyl has been under experimentation in France since 1969 where its specific activity against *Avena fatua*, *A. ludoviciana* (wild oat) showed promise in wheat crops.

The mode of action of benzoylprop-ethyl described by Chapman *et al* (1969) is such that the herbicidal activity is better when complemented by strong crop competition after application, Bowden *et al* (1970), Loubaresse *et al* (1971) and Mouillac and Jolie (1972).

Benzoylprop-ethyl can be used for *Avena* spp control in any crop which presents this ability, provided suitable crop selectivity has been demonstrated.

As oil seed rape possesses this "stifling" ability and is frequently infested with *Avena* spp, benzoylprop-ethyl was evaluated by CETIOM in France in 1970.

The first results were mostly encouraging and led to a larger trials programme in 1971 with the objective of defining the conditions under which to use benzoyl-prop-ethyl for wild oat control in oil seed rape.

METHOD AND MATERIALS

The study, started in 1970 by CETIOM, continued jointly with Shell Chimie until 1974. Designs of experiments varied according to the precise aim of the trials.

Table 1

Year	Organisation	Number of trials	Type	Design
1970	CETIOM	1	C	Randomised blocks 2 replicates
1971	CETIOM	1	C	Square lattice 3 x 3. 3 replicates
	CETIOM	2	R	Square lattice 3 x 3. 3 replicates
	Shell Chimie	1	C	Randomised blocks 2 replicates
1972	CETIOM	1	C	Square lattice 4 x 4. 3 replicates
	CETIOM	8	R	Square lattice 4 x 4. 3 replicates
1973	CETIOM	10	R	Rectangular lattice 4 x 5. 3 replicates
	Shell Chimie	1	C	Randomised blocks 4 replicates
	Shell Chimie	2	R	Randomised blocks 4 replicates
1974	Shell Chimie	2	C	Randomised blocks 4 replicates
	Shell Chimie	5	R	Randomised blocks 4 replicates

C: Efficacy trials
R: Yield trials

Plot sizes varied from 30 to 80 m^2

The different doses of benzoylprop-ethyl, used as a 20% e.c. (Suffix 20), are listed in Table 2.

Table 2

		Benzoylprop-ethyl doses (kg a.i./ha)										
		0.50	0.60	0.65	0.75	0.80	1.00	1.20	1.30	1.50	2.00	4.00
1970	CETIOM					x	x	x				
1971	CETIOM						x	x			x	
	Shell Chimie						x				x	x
1972	CETIOM			x					x			
1973	CETIOM			x			x		x		x	
	Shell Chimie	x			x		x			x	x	
1974	Shell Chimie		x			x	x				x	

In all trials an untreated control was included.

Herbicidal activity was assessed either by counts of wild oat panicles, by visual scoring on an arithmetic scale 0-10 (0: no effect. 10: complete control), or by assessment of percentage weed cover.

Crop effect was assessed visually according to a bi-logarithmic scale 0-10, CEB type and by yield determinations. Statistical analysis was used, where appropriate, to help interpretation of yield results.

RESULTS

a) Herbicidal activity: results for the trials from 1971 to 74 are presented in Table 3.

b) Crop effect: No symptoms of phytotoxicity were observed in winter sown oil seed rape.

In spring sown oil seed rape (1971) when benzoylprop-ethyl was applied before "shooting", the crop reacted moderately to dosage rates of 2 and 4 kg a.i./ha. An increased lodging was observed in these plots.

c) Results of yield determinations are presented in Table 4.

DISCUSSION

a) Herbicidal activity

Early or late treatments provided mediocre weed control.

Treatments applied at the beginning or during shooting provided good weed control; the weed population reduction being 80% from 0.75 kg a.i./ha.

It is confirmed, as in the case of cereals, that period of application is a critical factor of the product action: the optimal time being during the crop stem elongation, called "shooting" by analogy with cereals. Before this stage (rosette stage) or after (beginning flowering) the efficacy of the compound is markedly reduced.

Though a dose of 0.75 kg a.i./ha frequently provides a high level of efficacy, 1 kg a.i./ha is required for more regular results.

b) Effect on crop stand

Benzoylprop-ethyl was well tolerated by autumn sown oil seed rape whatever the dose used or the timing of application.

In spring sown oil seed rape, doses of 2 kg a.i./ha and above gave phytotoxicity symptoms when the compound was applied before shooting. The symptoms consisted in leaf deformation and increased lodging.

At 1 kg a.i./ha or less no phytotoxicity was recorded in spring rape.

c) Effect on yield

From results presented in Table 4, yield means, expressed as control percentages, are presented in Table 5.

Table 3

Herbicidal activity as weed control score (N) or as % control (E)

Site	Treatment: Date	Treatment: Crop stage	Method	Benzoylprop-ethyl dose (kg a.i./ha): 0.50	0.60	0.65	0.75	0.80	1.00	1.20	1.30	1.50	2.00	4.00	Control plot infestation
	1971														
59	10.5	Before shooting	N						8	8.2			8.8		$38/m^2$
80	10.5	Before shooting	N						4.5	3.5			4.5		$87/m^2$
02	10.5	Before shooting	N						1.5	6.5			8.5		$40/m^2$
	1972														
47	12.3	Beginning shooting	E						100				100	100	25%
16	-	-	N			6.6					7.5				$49/m^2$
	1973														
24	13.4	Shooting	E	79			86		85			90	90		$160/m^2$
47 L	30.3	Shooting	E	51			85		93			99	100		$75/m^2$
47 M	30.3	Shooting	E	63			82		89			85	87		$56/m^2$
	1974														
47	26.4	Beginning flowering	E						26						50%
31 L	28.3	20% flowering	E						67						20%
82 B	2.4	Beginning flowering	E						51						40%
82 M	21.3	Beginning shooting	E		84			83	83						25%
33 1	26.3	Pre flowering	E		20			42	25						75%
33 2	26.3	Pre flowering	E		58			54	46						70%
31 B	2.4	Pre flowering	E		31			0	25						70%

Table 4

Yield expressed as a % of control

	Site	Benzoylprop-ethyl dose (kg a.i./ha)										Control yield (q/ha)	CV	LSD ($p < 0.05$)
		0.50	0.60	0.65	0.75	0.80	1.00	1.20	1.30	1.50	2.00			
1971	59*						110	102			101	22.21	3.47	6.6
	02*						132	147			149	11.00	14.47	NS
1972	86			104					93			30.52	9.42	14.4
	36			99					93			41.61	4.55	NS
	26			113					88			15.96	15.83	33.6
	16*			104					95			22.41	7.91	23.4
	17			104					101			26.18	4.17	7.3
	11			78					93			21.64	11.11	NS
	18			91					100			29.55	6.48	NS
	01			98					94			30.	9.42	14.7
1973	32			80					100			21.35	10.85	NS
	17			103					106			20.45	7.70	15.6
	37			107					106			28.16	6.80	NS
	55			108					115			10.00	15.78	37.3
	36			103					99			24.47	6.28	NS
	86			111					107			20.73	4.62	8.7
	26			107					81			11.43	12.74	37.1
	77			94					96			14.26	11.03	24.7
	11			98					85			22.42	11.17	NS
	01			85					84			25.70	6.42	11.1
	24*	128			136		132			130	144	18.80	13.90	NS
	47*	105			114		107			112	109	20.20	9.00	NS
1974	47*						121					10.50		
	82 M*		103			93	104					25.00		
	01						103				105	35.50		
	24						99				91	28.50		

*parcels wild oat infested

Table 5

Herbicide treatment Mean yields as percentage of control plot yields

Trial type	Benzoylprop-ethyl doses (kg a.i./ha)									
	0.50	0.60	0.65	0.75	0.80	1.00	1.20	1.30	1.50	2.00
Clean crop trials										
mean			99			101		97		98
number			(17)			(2)		(17)		(1)
Other trials										
mean	117	103	104	125	93	118	125	95	121	126
number	(2)	(1)	(1)	(2)	(1)	(6)	(2)	(1)	(2)	(4)

The absence of effect on yield in clean crops confirms the very good selectivity of the product in rape crops.

The mean yield increase obtained in 6 trials resulting from an application of benzoylprop-ethyl at 1 kg a.i./ha is 18% above the control yield, indicating the value of the use of the chemical.

The conclusion after 5 years of trials is that benzoylprop-ethyl is a useful herbicide for controlling *Avena* spp in rape with post-emergence application.

To assure a regular high level of wild oat control, benzoylprop-ethyl should be used at 1 kg a.i./ha when the rape elongates its stem, preferably at the start of this elongation.

At this dose and at this period, the crop tolerance to the compound is good and the weed control results in substantially increased yields.

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SWEDE HERBICIDE TRIALS IN THE WEST OF SCOTLAND, 1971-1974

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Summary In trials 1971-1974 trifluralin at 2 kg/ha or dinitramine at 0.5 kg/ha generally gave acceptable weed control in swede crops. Napropamid also gave good weed control and high yields especially in mixtures with either trifluralin or cycloate. Best results were obtained when natural weed infestations were low; late developing infestations of Capsella bursa-pastoris were troublesome at some sites. Herbicide damage to swede crops was slight; no damage to succeeding crops was observed.

INTRODUCTION

Trials 1962-1970 (Waterson, 1970) failed to find a herbicide treatment adequate for fully mechanised swede production. Further work 1971-1974 continued the quest mainly with soil incorporated herbicides but with the continued inclusion of herbicide mixtures applied pre- and post-emergence of the crop. In 1974 selected treatments were evaluated on a field scale.

METHOD AND MATERIALS

The herbicides used were, or later became, commercial formulations, although not all have been marketed in the U.K.:

Chlorpropham (CIPC 40)	Nitralin (Planavin)
Cycloate (Ro-Neet)	Nitrofen (Tok E25)
Dinitramine (Cobex)	Propachlor (Ramrod)
Napropamid (Devrinol)	Trifluralin (Treflan)

Plots were 9m long by 4m wide and 1m discards were left between plot ends. Randomised block layouts with 2-4 replications were used for the trials and untreated control plots were always included. Herbicides were applied by Drake and Fletcher knapsack sprayers at a volume rate of 450 l/ha and the soil acting materials (see table 2) were incorporated by rotovation immediately after application (1972-1974). Three of the 1971 trials were grown on ridges but the trial in Ayrshire in 1971 and all trials subsequently were sown on the flat to give better distribution of the soil-incorporated herbicides.

Weed cover was assessed three and six weeks after treatment by the dual scoring method used in earlier trials (loc. cit.), and crop plants were observed for abnormality of size or number; crop yields were estimated in six trials by sample harvesting. Hand weeding was necessary in certain trials, but where they were to be harvested (Ayr 1972, 1973, Dumfries 1972) this was restricted to the removal of flowering Chenopodium album and Sinapis arvensis; otherwise weeding was done as convenient after the six-week observations had been made.

1971 Four trials tested a mixture developed from earlier work of nitrofen + propachlor + chlorpropham applied pre- and post-emergence of the crop at two dosage rates. Pre-emergence the higher rate was more satisfactory and was continued into later trials; the lower rate, and post-emergence applications - which caused excessive crop damage - are not reported here. Two rates of napropamid were soil incorporated (by harrowing) before sowing on the flat at the Ayrshire site.

1972 Four trials included the high rate pre-emergence mixture from 1971 (see above) and ten soil-acting treatments incorporated by rotovator (table 2).

1973 Treatments at four sites were based upon those of 1972 with the introduction of a napropamid + cycloate mixture incorporated pre-sowing.

1974 Unreplicated field scale plots were established at a site in Ayrshire and one in West Perth, each site testing three soil incorporated treatments (kg/ha):

Ayrshire	West Perth
Napropamid 1 + trifluralin 1	Napropamid 1 + trifluralin 1
Napropamid 2 + cycloate 1	Trifluralin 1
Dinitramine 0.5	Dinitramine 0.35

These treatments were applied at a volume rate of 280 l/ha.

In 1973 and 1974 the trial sites from the preceding year were inspected for visible damage caused by herbicide residues.

RESULTS

Results are available from 12 trials 1971-1973. Their locations and the main weed species found in each are shown in table 1. *Polygonum persicaria* and *Stellaria media* occurred most frequently, followed by *Capsella bursa-pastoris* and *Tripleurospermum maritimum* ssp. *inodorum*. Several species not listed appeared sporadically. Table 1 indicates potential weed cover at each site by the control plot weed scores, and soil 'loss on ignition' is quoted as an indicator of soil organic matter content.

Table 2 reports for selected treatments the weed cover scores six weeks after sowing and the yields of swede roots (dry matter basis) for the six trials harvested 1972-1973. Table 3 summarises the observed susceptibility of individual weed species in these trials to selected herbicide treatments.

Pre-emergence herbicides

Nitrofen + propachlor + chlorpropham (high rate) gave the best compromise between weed control and crop damage in 1971 and was again satisfactory in 1972. In 1973, like other treatments, it gave poorer results so that, overall, acceptable weed control was obtained in 8-9 of 12 sites. Yields of swede dry matter were on average 27% higher than from the untreated controls. *Polygonum persicaria* was controlled well but *Fumaria officinalis* and *Capsella bursa-pastoris* were often troublesome. *Stellaria media* frequently survived in a stunted form.

Soil incorporated herbicides

Cycloate at 2 kg/ha was included in the 1973 trials for comparison with the napropamid + cycloate mixture. Cycloate alone was not a wholly satisfactory treatment but it had useful activity against *Capsella bursa-pastoris* and *Galeopsis tetrahit*.

Dinitramine was used in 1972 at 0.5 and 1 kg/ha, the higher rate giving better weed control but causing some thinning and checking of the swedes. Despite this yields of swede dry matter were over 30% higher than those from the controls and did not differ significantly between rates. The lower rate was continued in 1973 and gave less consistently good weed control but the yield improvement over the controls still approached 30%.

Napropamid was applied at 1 and 2 kg/ha in 1971 and 1972, and 2 kg/ha in 1973. Results in 1971 after incorporation by harrowing were poor but both rates gave good weed control and high yields (46% and 49% above controls) in 1972. Weed control was poorer in 1973 but yields were again good. Over the six harvested trials 2 kg/ha of napropamid gave a 51% yield increase over the control plots. Control of Capsella bursa-pastoris, Sinapis arvensis, Galeopsis tetrahit and Polygonum persicaria was poor.

Nitralin was tested at 1 and 2 kg in 1972 and 2 kg/ha in 1973. Its general efficiency as a swede herbicide was similar to that of trifluralin, as was species susceptibility. Yields were some 41% above those of the untreated controls.

Trifluralin was applied at 1 and 2 kg/ha in 1972, 2 kg/ha only in 1973. Even at the higher rate its efficiency was no more than equal to the best of the other treatments. Although its weed control spectrum is broad the duration of control appears to be restricted. Capsella bursa-pastoris and Sinapis arvensis were not controlled by this treatment. Yield of swede dry matter over six trials was 31% above that from the controls.

Napropamid + cycloate at 2 kg/ha of each constituent remedied the species control deficiency of napropamid noted above, with the possibility of a synergistic effect against Polygonum persicaria which was resistant to both individual herbicides. Crop yield was somewhat lower than from napropamid alone over the two trials for which data are available.

Napropamid + trifluralin used at 1 kg/ha of each constituent gave good control of weeds, and over six sites 1972-1973 swede dry matter yields were 50% above the unsprayed controls. Table 3 notes only Sinapis arvensis as completely resistant to this treatment.

The nine trial sites 1971-1973 where soil incorporated herbicides had been used were inspected in the year following the trial for signs of damage in the next crop. These crops were barley (sites G, K), oats (sites F, L, M), grass (sites H, J) and swedes (site E). No damage was observed.

DISCUSSION

Allen (1970) suggested that prospects for the swede crop were not such as to stimulate much new research and development effort directed towards herbicides for this specific crop. On a national basis few would argue with this conclusion, but swedes are capable of high yields under conditions where cereal growing can be difficult; an effective herbicide treatment would be the key to full use of the mechanisation techniques available for the crop (Waterson, 1974). Such a herbicide treatment was not available in 1970 (Lawson and Wiseman, 1970; Leonard, 1970; Scragg, 1970; Waterson, 1970) hence the trials now reported.

Several general points have arisen from this and the earlier trial series (loc. cit.). Scragg (1970) pointed out that on many fields little weed control is required. These are fields where herbicides can give excellent results, but unfortunately there are other fields where the need for drastic and long lasting weed control is acute, and where existing herbicides are of little avail.

Hill (1974) noted the necessity for incorporation of dinitramine after application. The need for incorporation to be efficient was emphasised by the contrasting results from napropamid worked in by harrowing in 1971 and by rotovation in 1972 and 1973. Earlier experience with trifluralin was similar.

Waterson (1970) suggested that when using soil-incorporated herbicides, growing swedes on the flat might help to avoid uneven distribution of 'treated' soil, and Graham (1974) noted that commercial results with trifluralin were usually superior and longer lasting where the crop was grown on the flat. Growing on the flat was practiced in this later trial series without causing any problems.

The erratic occurrence of weed species over the trial sites restricted the conclusions which could be drawn regarding species susceptibility. Five species shown in table 1 are omitted from table 3 for this reason, the most significant agriculturally being Chenopodium album for which additional information is obviously needed.

Three weed species attracted special notice. Capsella bursa-pastoris was adequately controlled only by cycloate and at several sites became an unsightly problem when competition was removed by other herbicides. Gnaphalium uliginosum was not recorded in the 26 trials 1964-1970 but was widespread in the trial at Dumfries 1972 and was noticed at several other sites. Sinapis arvensis was not controlled by any of the herbicides tested.

The trials have shown that various herbicides and mixtures are capable of giving acceptable weed control in a reasonable proportion of cases. Broadly speaking the soil incorporated materials have been a little more reliable than the mixture of nitrofen, propachlor and chlorpropham applied pre-emergence (cf Graham, 1974). Unfortunately the field scale plots grown in 1974 have reinforced the view that on an inherently weedy site such as Ayrshire (1974) acceptable weed control cannot be obtained solely by the use of herbicides. On sites with less acute weed problems the choice of a herbicide to counter the most common weed species should result in tolerably weed-free swedes.

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Table 1

Location of trials, and weeds in each trial as main species (+) and as well distributed but less numerous species (o). Control plot weed cover 6 weeks after sowing on 0-10 scale (0 - no weeds, 10 - full weed cover)

	1971				1972				1973			
	Ayr	Dumfries	Lanark	W. Perth	Ayr	Dumfries	Lanark	W. Perth	Argyll	Ayr	Dumfries	W. Perth
	A	B	C	D	E	F	G	H	J	K	L	M
Capsella bursa-pastoris		+			+	+	+			+	o	
Chenopodium album	o	o								+	o	
Fumaria officinalis			+									+
Galeopsis tetrahit			+					+				+
Gnaphalium uliginosum						+					o	
Polygonum convolvulus	+		o									
Polygonum persicaria				+	+	o		+	+	o		+
Ranunculus repens							o	+	+			
Sinapis arvensis					o	o		o				+
Spergula arvensis							o	o			o	o
Stellaria media	o	o		+	o		+		o	+		
Tripleurospermum maritimum ssp. *inodorum*		+				o	+	o		o	+	
Viola arvensis											+	
Weed cover on control plots	9	10	4	6	8	10	9	6	4	10	10	10
Soil 'loss on ignition'	8.2	7.5	10.5	6.6	8.0	7.4	7.8	8.6	8.0	7.4	7.1	7.9

Table 2

Weed cover scores 0-10 (0 - no weeds, 10 - full weed cover) and yields of swede dry matter

Treatment	Rate a.i. kg/ha	Weed cover score 1971 A	B	C	D	1972 E	F	G	H	1973 J	K	L	M	Roots, mean yields d.m. tonne/ha (E,F,G,H)	(K,M)
Control - unsprayed		9	10	4	6	8	10	9	6	4	10	10	10	5.1	4.5
SOIL INCORPORATED															
Cycloate	2.0									2	9	10	5		5.8
Dinitramine	0.5					2	2	2	2	2	6	3	4	6.9	6.2
Dinitramine	1.0					1	1	1	2					6.6	
Napropamid	1.0	9				1	1	2	1					7.4	
Napropamid	2.0	5				1	1	1	1	1	4	1	4	7.5	7.1
Napropamid + cycloate	2.0 + 2.0									1	5	1	2		6.2
Napropamid + trifluralin	0.5 + 0.5					3	2	1	2					6.6	
Napropamid + trifluralin	1.0 + 1.0					2	1	1	1	1	6	1	2	7.6	7.4
Nitralin	1.0					1	1	2	4					7.3	
Nitralin	2.0					1	2	1	2	1	7	3	4	7.4	6.2
Trifluralin	1.0					2	3	3	3					6.4	
Trifluralin	2.0					2	4	2	1	1	6	3	3	6.4	6.2
PRE-EMERGENCE															
Nitrofen + propachlor + chlorpropham	2.0 + 3.0 + 0.5	1	2	3	1	1	2	2	2	3	7	8	5	6.4	5.7
Standard error (diff)														±0.5	±0.6

Table 3

The control of individual weed species by herbicides

(S = susceptible, R = resistant, M = moderately)

Treatment	Rate a.i. kg/ha	*Capsella bursa-pastoris*	*Fumaria officinalis*	*Galeopsis tetrahit*	*Gnaphalium uliginosum*	*Polygonum persicaria*	*Ranunculus repens*	*Sinapis arvensis*	*Spergula arvensis*	*Stellaria media*
SOIL INCORPORATED										
Cycloate	2.0	S	MR	MS	S	R	-	R	S	R
Dinitramine	0.5	MR	MR	S	MR	MR	MR	R	S	MR
Napropamid	2.0	MR	MS	MR	S	R	S	R	S	S
Napropamid + cycloate	2.0 + 2.0	S	MR	MS	S	MR	S	R	S	MS
Napropamid + trifluralin	1.0 + 1.0	MR	MS	MS	S	MR	MS	R	S	S
Nitralin	2.0	R	MS	S	R	-	R	R	S	MR
Trifluralin	2.0	R	MS	MS	R	MS	MR	R	S	MS
PRE-EMERGENCE										
Nitrofen + propachlor + chlorpropham	2.0 + 3.0 + 0.5	MR	R	S	R	S	R	R	S	MS

Proceedings 12th British Weed Control Conference (1974)

FIELD PERFORMANCE OF THE ISOPROPYLAMINE SALT OF GLYPHOSATE FOR THE CONTROL OF AGROPYRON REPENS AND OTHER WEEDS IN TOP FRUIT ORCHARDS

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Summary The results of trials carried out in 1973/4 in orchards in the United Kingdom confirmed the post-emergence activity of the isopropylamine salt of glyphosate (Mon 2139) on Agropyron repens and many other perennial and annual weeds. Excellent control of A. repens was obtained at rates of 1.44 to 2.18 kg.a.e./ha. All the annual weeds were controlled at rates of 1.09 to 1.44 kg.a.e./ha; however some perennial weeds e.g. Convolvulus arvensis required rates in excess of 2.18 kg.a.e./ha. Tank mixing Mon 2139 with residual herbicides resulted in antagonism and reduced weed control; diuron was found to be less antagonistic than simazine. Increasing the rate in the mixtures to at least 2.18 kg.a.e./ha overcame the antagonism to give acceptable weed control. Phytotoxicity due to leaf contact was observed one year after treatment in three trials where Mon 2139 was applied in the summer; it was more pronounced in pears than apples. No phytotoxicity was observed from any of the dormant and early season applications.

Résumé Les résultats d'essais effectués en 1973-74 en vergers, en Grande Bretagne, ont confirmé l'action de post-émergence du sel d'isopropylamine de glyphosate (Mon 2139) sur Agropyron repens et de nombreuses autres adventices vivaces et annuelles. Une excellente destruction de l'A. repens a été obtenue à des doses de 1.44 à 2.18 kg/ha é.a. Toutes les mauvaises herbes annuelles furent détruites à des doses de 1.09 à 1.44 kg/ha é.a. Toutefois, certaines plantes pérennes (p. ex. Convolvulus arvensis) ne peuvent être maîtrisées qu'a des doses dépassant 2.18 kg/ha é.a. Le mélange extemporané Mon 2139 avec des herbicides résiduaries s'est traduit par de l'antagonisme et une réduction de l'activité herbicide; l'antagonisme a été moindre avec le diuron qu'avec la simazine. En élevant la dose dans ces mélanges, à 2.18 kg/ha é.a., l'antagonisme a été surmonté et l'on a ontenu une action herbicide satisfaisante. Des dégâts dûs au contact foliaire ont été observés un an après le traitment, dans 3 essais où l'application Mon 2139 avait eu lieu durant l'été; ces dégâts furent plus importants sur poiriers que sur pommiers. Les applications effectuées pendant la période de dormance ou en début de saison n'ont donné lieu à aucune phytotoxicité.

INTRODUCTION

Glyphosate (N-(phosphonomethyl)glycine) and certain of its salts have been shown by Baird et al. (1971) to have a high degree of herbicidal activity when applied to the foliage of grassy and broad-leaved plants. They reported the safe application of the mono-(diethylamine) salt and related compounds to the bases of mature orchard tree crops and their inactivation by contact with the soil. However when mixed with certain residual herbicides at the time of spraying ('tank-mix'), there was antagonistic action leading to reduced weed control. When applied to perennial species glyphosate salts were readily translocated and excellent effects on Agropyron repens were reported by Baird and Begeman (1972).

Field performance in Europe and Africa reported by Evans (1972) confirmed the activity on perennial and annual weeds.

The isopropylamine salt of glyphosate was reported by Hodkinson (1972) to give good control of A. repens and other perennial weeds, with good crop safety in top fruit trials conducted in the United Kingdom.

This work in top fruit was continued during 1973/4 as part of the European Development programme. The aim of the investigations summarised in this paper was to confirm the 1972 findings and to define more clearly the factors affecting performance and crop safety in the United Kingdom.

MATERIALS AND METHODS

A total of 25 trials were conducted in commercial crops of apples, pears, plums and cherries. Experimental designs in 19 trials were randomised blocks with two, three or four replicates, with a plot size of $20m^2$. The remaining six trials were non-replicated with plot sizes ranging from 20 to $800m^2$. In 23 of the trials, treatments were applied with an Oxford Precision Sprayer using two Allman '00' nozzles, giving a spray width of 91 cm. Of the remaining trials, either a KEF knapsack sprayer with a single 'flood' jet was used or a growers' tractor mounted sprayer fitted with two 'flood' jets. Diluent was within the range 225 to 1,125 l/ha at a pressure of 1.4 kg/cm^2.

In all the trials, the isopropylamine salt of glyphosate formulated as Mon 2139 (Roundup) containing 360 gm a.e./l. water soluble concentrate and a surfactant, was used. All the rates of Mon 2139 and 2.4-D ester quoted are given in terms of a.e., and those of the other chemicals used refer to a.i. Rates of use between 0.36 and 4.4 kg.a.e./ha Mon 2139 were investigated mainly for the control of Agropyron repens. Simazine or diuron or 2.4-D ester were tank-mixed with a range of rates of Mon 2139. Growth of weeds treated with Mon 2139 was compared with that on untreated control plots and those treated with standard materials. The standard herbicides included paraquat, aminotriazole (activated), 2.4-D ester and dichlobenil, also 'tank-mixes' of paraquat + simazine or the commercial mixtures of aminotriazole with other herbicides listed in Table 3.

Single directed applications were made to the foliage of the weeds at the tree bases in strips either side of the tree rows, at various times ranging from January to July. The weed stand predominantly consisted of A. repens, at least 15 cm high and formed a complete ground cover in all the trials. In two 1973 trials two separate applications of Mon 2139 were made during the season to the same plots to evaluate a two-spray programme for weed control and crop safety. In April 1974 these two trials were re-sprayed with single applications of the same treatments to evaluate crop tolerance to repeated sprays. In all the trials care was taken to avoid contact with the leaves, but the basal bark (30 cm) of all the trees was sprayed. Assessments of effects on weeds were made visually on a 0-100 per cent scale, 0 = nil effect, 100 = complete kill. Assessments of the crop effects were made visually using a 0-5 scale, where 0 = indistinguishable from control, 5 = complete death of tree branches or entire system. Site details and application data are given in Table 1.

Table 1

Crop, cultivar, application and site details

Site		Cultivar	Age (years)	No. of reps	Herbicide Application Date	Crop Growth Stage
APPLES						
1.	Somerset.	Cox's O.P.	6	2	15/3/73	Dormant.
2.	Somerset.	Worcs. P.	25+	2	9/5/73	Pink bud.
3.	Kent.	Bramley's S.	40+	4	27/6/73	Fruitlet.
4.	Kent.	Cox's O.P. Worcs. P	10	4	27/6/73	Fruitlet.
5.	Sussex.	Cox's O.P. Golden D.	12	4	26/6/73	Fruitlet.
6.	Kent.	Egremont Rus.	6	1	26/6/73	Fruitlet.
7.	Beds.	Cox's O.P.	20	4	2/5/73	Pink bud.
8.	Beds.	Cox's O.P.	20	4	2/7/73	Fruitlet.
9.	Norfolk.	Bramley's S.	4	4	a) 13/4/73 b) 10/7/73	Green cluster. Fruitlet.
10.	Lincs.	Discovery.	2	1	12/7/73	Fruitlet.
11.	Norfolk.	Bramley's S.	5	3	15/1/74	Dormant.
12.	Norfolk.	Bramley's S.	5	1	28/3/73	Bud burst.
13.	Lincs.	Discovery.	3	1	23/4/74	Pink bud.
14.	Norfolk.	Red Delicious.	2	1	1/5/74	Pink bud.
15.	Worcs.	Bramley's S. Worcs. P.	40	3	6/5/74	Blossom.
16.	Norfolk.	Bramley's S.	5	4	30/4/74	Pink bud.
PEARS						
17.	Norfolk.	D.du Comice. Conf. William's B.C.	5	4	a) 12/4/73 b) 29/6/73	Green cluster. Fruitlet.
18.	Lincs.	Conf.	15	4	12/7/73	Fruitlet.
19.	Norfolk.	D.du Comice. Conf. William's B.C.	6	4	24/4/74	Blossom.
20.	Cambs.	Conf.	7 to 50	1	27/4/74	Blossom.
21.	Cambs.	Conf.	3	4	7/5/74	80% Petal fall.
22.	Cambs.	Conf.	2	2	13/5/74	80% Petal fall.
23.	Cambs.	Laxton Sup.	11	3	14/5/74	80% Petal fall.
PLUM						
24.	Cambs.	Czar.	15	3	12/4/73	White bud.
CHERRY						
25.	Norfolk.	Morello.	5	3	24/4/73	White bud.

RESULTS

The control of A. repens from a range of rates of Mon 2139 at intervals of up to 450 days after treatment (DAT) is given in Table 2.

Table 2

Mean % control of Agropyron repens with Mon 2139 in apples, pears, plums and cherries 1973/4

Total No. Trials	Treatment (kg/ha)		% Control (DAT) 26-60	61-200	201-450*
1	Mon 2139	0.36	50	61	
7	"	0.54	69	61	59(6)
1	"	0.72	65	83	
15	"	1.09	88	90	84(10)
6	"	1.44	98	90	
8	"	1.65	95	95	90(8)
5	"	1.80	98	94	
15	"	2.18	97	97	95(11)
2	"	3.30	100	100	99(2)
4	"	4.40	100	98	95(4)
8	Paraquat	1.10	40	27	7(5)
1	Dichlobenil	8.00	70	70	70(1)
1	Aminotriazole	4.48	46	25	10(1)

* Observations from 1973 trials only; figures in parentheses indicate number of trials

Increasing the rate of Mon 2139 resulted in a more rapid early dessication of the foliage of A. repens and also resulted in more persistent control at an acceptable level. However there did not appear to be much increase in control above 2.18 kg/ha. Excellent control was evident at 1.44 kg/ha. However below this rate the control was unacceptable. Paraquat gave a faster initial foliage kill than Mon 2139 but this did not persist beyond 25 DAT; whereas aminotriazole gave a slower foliage kill of short persistence. No crop damage was observed in any of these trials during 1973 and 1974.

The mean % control of A. repens from a range of rates of Mon 2139 mixed with simazine or diuron for the control of later germinating annual weeds is shown in Table 3; together with the comparable results for Mon 2139.

When simazine was tank-mixed with Mon 2139 antagonism occurred reducing the rate at which foliage was killed on these plots. The antagonism was more persistent in the 1974 trials than was observed in 1973. The antagonism with simazine became less pronounced when the rate of Mon 2139 was increased. The antagonism resulted in only moderate control of A. repens, up to 200 DAT, at rates below 2.18 kg/ha. In contrast, at one site where simazine was applied on its own 6 hours or 1 month after previous treatment with Mon 2139, the antagonism was completely removed; excellent persistent control resulted from rates as low as 1.09 kg/ha.

The antagonism produced by spraying a mixture of Mon 2139 and simazine on A. repens was also observed on other perennial weeds recorded in the trials, e.g. Urtica dioica and Rumex obtusifolius. However effects of the antagonism were much less pronounced on the annual weeds. When diuron was tank mixed with Mon 2139 some antagonism was observed but the short-term effect was not as pronounced as that shown with simazine (Table 3).

In spite of the antagonism with the Mon 2139 + simazine mixture, the results were superior to those from the paraquat + simazine tank mix treatment. In the short-term the aminotriazole mixtures showed good control of A. repens, however these comparative trials were only established in 1974. No crop damage was observed in any of these trials in 1973 or 1974.

Table 3

Mean % control of Agropyron repens using mixtures of Mon 2139 and residual herbicides in apples and pears 1973/4

No. of trials '73	'74	Treatment	Rate kg/ha	% Control 61-200 DAT 1973	1974	201-450 DAT 1973
1	1	Mon 2139 + simazine	0.54 + 1.68	57 (68)*	30 (50)	54 (59)
4	3	" + simazine	1.09 + 1.68	95 (96)	34 (76)	82 (84)
0	5	" + simazine	1.44 + 1.68	-	67 (90)	-
1	1	" + simazine	1.65 + 1.68	97 (99)	70 -	90 (90)
0	4	" + simazine	1.80 + 1.68	-	65 (94)	-
1	3	" + simazine	2.18 + 1.68	98 (99)	73 (95)	98 (95)
0	1	" + diuron	1.44 + 3.58	-	80 (90)	-
0	1	" + diuron	1.80 + 3.58	-	83 (94)	-
3	3	Paraquat + simazine	1.10 + 1.68	20	20	10
0	3	Aminotriazole + diuron	4.48 + 4.48	-	94	-
0	1	Aminotriazole + dalapon + diuron	3.92 + 3.92 + 4.48	-	96	-
0	1	Aminotriazole + simazine	4.48 + 1.68	-	95	-

* % control from Mon 2139 alone.

Results were also obtained from two trials on the response of A. repens to twice yearly Mon 2139 applications (Table 4).

Table 4

Mean % control of Agropyron repens and degree of crop injury following two applications of Mon 2139 in apples and pears 1973/4

Site Number	Treatment	Application rate (kg/ha) on 13.4.73		10.7.73	% control 283*	Damage Index 312*
9	Mon 2139	0.5	+	0.5	75 (20)+	1
	"	1.1	+	1.1	98 (85)	1
Apple	"	1.6	+	1.6	99 (90)	1
	"	2.2	+	2.2	99 (95)	1
	"	4.4	+	4.4	99 (95)	1
	Paraquat + simazine	1.1 1.68	+ +	1.1 1.68	20 (0)	0
		12.4.73		29.6.73	297*	331*
17 Pear	Mon 2139	1.1	+	1.1	80 (25)+	2
	"	1.6	+	1.6	96 (85)	2
	"	2.2	+	2.2	97 (90)	3
	"	4.4	+	4.4	99 (95)	3
	Aminotriazole	4.48	+	4.48	20 (10)	0

* Days after second application when assessment was made
\+ % control from the first Mon 2139 spray only.

Good control of A. repens was obtained at rates of 1.1 kg/ha and above, which also controlled the annual weeds present at the time of spraying. In both trials no perennial weeds other than A. repens were recorded and further annual weed growth took place rapidly in all the plots in the absence of the competition from A. repens. The results were superior to those of the standards. However in both trials varying degrees of phytotoxicity in the form of leaf curling and chlorosis were observed; at the highest rates complete inhibition of bud development and death of shoot tips were seen. The damage was far more severe and persistent in the pear trial than in the apple trial where the symptoms were quickly outgrown by vigorous shoot growth.

The results of three trials with Mon 2139 for the control of Convolvulus arvensis are given in Table 5.

Table 5

Mean % control of Convolvulus arvensis with Mon 2139 and 2.4-D ester in apples and pears 1973/4

No. of trials	Treatment		Rate (kg/ha)	% control (DAT)* 26-60	61-200	201-450
1	Mon 2139		0.54		42	32
1	"	+ 2.4-D	0.54 + 0.4		85	85
3	"		1.09	65	57	64
3	"	+ 2.4-D	1.09 + 0.4	91	91	85
3	"		2.18	85	68	84
3	"	+ 2.4-D	2.18 + 0.4	96	93	94
2	"		3.30	98	84	94
2	"	+ 2.4-D	3.30 + 0.4	98	95	95
3	2.4-D		0.4	72	77	79

* Days after treatment

Mon 2139 tank-mixed with 2.4-D ester gave a more rapid and persistent kill of foliage compared with the results of Mon 2139 alone. The degree of control within the trials was very variable, however 2.18 and 3.30 kg/ha + 2.4-D ester resulted in excellent persistent control. In one of these trials in pears (Site 18, Table 1) phytotoxicity symptoms were observed 350 DAT in all the Mon 2139 treated plots, the symptoms were not confined to the originally inadvertantly sprayed lower branches.

A wide range of annual and perennial weeds (other than A. repens) were encountered in the trials. All the emerged annual weeds were completely controlled by Mon 2139 at 1.44 kg/ha and generally by applications at 1.09 kg/ha. However the majority of the perennial weeds required a rate of at least 1.80 kg/ha for persistent control effectiveness depending on the amount of leaf area at the time of spraying.

DISCUSSION

The excellent herbicidal properties and the rate response characteristics of Mon 2139 for the control of A. repens, confirm the data reported by Evans (1972) and the more recent work in the U.K. prior to planting cereals (Hodkinson 1974). Good control was obtained in orchard trials with single directed sprays of 1.44 kg/ha. However the increased control from 1.80 kg/ha is desirable because in the orchard situation there is neither the additional cultivation nor crop competition found in the cereal situation. Rates below 1.44 kg/ha resulted in poor control of A. repens confirming the findings of the U.K. cereal trials.

When A. repens was removed from the orchard areas there was a rapid emergence of other weeds which grew vigorously in the absence of the previously dominant grass weeds. Simazine or diuron added to Mon 2139 to control annual weeds resulted in antagonism; this confirmed the data of Baird et al (1971). Antagonism from such mixtures has also been reported from trials in Scandinavia, Holland, Belgium and France. The antagonism was reduced by increasing the amount of Mon 2139 in the tank mix to 2.18 kg/ha again confirming the findings of Baird et al (1971). Antagonism in all the tank mix trials was more severe and more prolonged in 1974 than in 1973. This may have been due to the exceptionally dry spring, producing drought stress in the weeds with a subsequent slowing down in their growth rate. The evaluation of diuron as a residual additive was only commenced in spring 1974; the antagonism was less than with simazine at least in the short term. These results are confirmed by similar observations from trials in Belgium and Holland. There are obvious advantages of the tank mix treatments but more work remains to be done on this aspect. The antagonism was not observed with the separate applications and good results were obtained with Mon 2139 at 1.44 kg/ha followed after some hours by simazine at 1.68 kg/ha; the expected residual activity of simazine extended the clearing effect of Mon 2139. The two spray programme of early and mid-summer applications suggested by Hodkinson (1972) gave good long-term weed control at 1.09 kg/ha but not below this rate. However the later emerging perennial weeds especially C. Arvensis required at least 2.18 kg/ha for adequate control. The phytotoxicity symptoms which were observed in these trials one year after treatment were probably the result of the mid-summer applications, because at that time of the year it was extremely difficult to avoid hitting the low-lying branches with the spray. This was confirmed by the damage to pears resulting from single, summer applications to control C. arvensis. The nature of the damage was similar to that described by Clay (1972). Pears are generally regarded as being more susceptible to growth-regulator herbicide damage than apples (Davison 1973) and this also appears to be the case with Mon 2139. The phytotoxicity problem can be avoided on trees with low growing branches by confining the application to the dormant period, as a directed spray to the base of the fruit trees. Mon 2139 will perform well but slowly during the winter period provided the weed foliage is present (Evans 1972) and this could fit in well with the fruit growers' work programme.

Recommendations for the control of A. repens prior to planting cereals, suggest an optimum volume rate of 200 to 250l/ha; it has been shown by Baird and Begeman (1972) that with this weed, increasing the volume to 1000 l/ha, while retaining a fixed ratio of active ingredient to wetter decreased effectiveness. However in the 1973 orchard trials there were no differences between 225 and 562 l/ha in the long term control of A. repens. Also observations to date from the spring 1974 trials show no visual differences in foliar kill using a range of volumes (225 to 1,125 l/ha).

The trials to date have shown the occurrence of crop damage when Mon 2139 was applied as a directed spray in the early summer, but that dormant season applications offer greater safety. The application of Mon 2139 at high volumes of application and low pressures will be investigated to relate this more to commercial practice. Work is now in progress to determine any phytotoxic effects following directed applications to young (1-4 years) apple and pear trees. Continued observations will be made on the existing trials and some trials established in 1973 have been completely re-sprayed to evaluate crop tolerance to repeated Mon 2139 applications.

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THE RESPONSE OF BLACKCURRANTS, GOOSEBERRIES AND APPLES TO OVERALL OR DIRECTED APPLICATIONS OF GLYPHOSATE MADE BETWEEN OCTOBER AND MARCH

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Summary Glyphosate at 2.5 kg/ha was applied in October, December, January or March to blackcurrants at four centres; to gooseberries at one site and to eleven cultivars of apples at another. On the bush fruit, sprays were applied overall or directed to the base of the bush.

On blackcurrants and gooseberries overall applications in October generally caused severe shoot injury in spring, and a large reduction in crop. Severe damage also resulted from overall applications in March. Some injury was caused by directed sprays in October and March at two sites but applications made in December or January caused virtually no shoot damage and no crop loss. Damaged bushes were producing normal shoot growth by mid-summer.

In apples, sprays directed at branches in the middle of the tree resulted in slight injury to leaves and flowers the following spring but no loss of crop. December applications were the most injurious.

INTRODUCTION

Glyphosate (N-(phosphonomethyl)glycine) is a translocated foliage acting herbicide which gives a very useful control of both annual and perennial weeds. Early work on crop tolerance by Baird et al (1971) in America reported that applications of doses of up to 9 kg/ha to the bases of mature trees caused no adverse effects. Tolerance to overall sprays in late winter was investigated by Clay (1972) in a series of trials using container-grown blackcurrants, apples and raspberries. Blackcurrants and apples, but not raspberries were found to be sufficiently tolerant of moderate doses to suggest that glyphosate could be used in the dormant season without risk of unacceptable crop damage.

Trials reported by Hodkinson (1973) and others conducted by the West Midland and S.West Region of A.D.A.S., (Perry 1973), the Weed Research Organization and Long Ashton in 1972-73, confirmed that glyphosate could give a good control of *Agropyron repens*, *Cirsium arvense* and *Rumex* spp. growing in fruit plantations, but emphasised

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the hazard of crop damage.

To study the response of blackcurrants to glyphosate applied at different times in the dormant season in a range of climatic conditions, a collaborative experiment was carried out at the Soft Fruits Research Centre, Clonroche, Ireland (C), The Horticultural Centre, Loughgall, N.Ireland (LG), Long Ashton Research Station, Bristol (LA) and the Weed Research Organization, Oxford (WRO). A similar trial was carried out on gooseberries at Loughgall and on a range of apple cultivars at Long Ashton.

In blackcurrants and gooseberries the spray was either applied overall, or directed to the ground and basal 20 cms of bush to simulate the type of directed spray that growers might use to control overwintering weeds. In apples, spray was directed horizontally into the tree to simulate spray drift to lower branches that might arise if a grower was attempting to control tall perennial weeds growing in the tree rows.

METHOD AND MATERIALS

The herbicide formulation used in all experiments was the iso propylamine salt of glyphosate as a 36% aqueous concentrate with added wetter. Residual herbicide (simazine or chlorthiamid) and routine pesticide applications were made throughout the experimental period as necessary.

Experiment 1. Blackcurrants

Details of cultivar, bush age, plot size, replication and spray volume are given in Table 1, three cultivars being sprayed at Long Ashton. A random block design was used at all four centres. Bushes were pruned at about 1.3 m top height in early October to facilitate overall spraying; this was carried out using a multiple nozzle boom which sprayed a swath wide enough to cover the plot in a single pass. Plots were screened with polythene to prevent drift. Directed treatments were applied with a single nozzle, spraying both sides of the bushes in turn, covering the ground and stems to a height of 20 cms. Where necessary low growing shoots were tied up to ease spraying. Glyphosate was applied at 2.5 kg a.e./ha at a spraying pressure from 1-2 kg/cm^2.

Table 1

Blackcurrants: details of crop and experiment lay-out at four centres

Location	Clonroche	Loughgall	Long Ashton	WRO
Cultivar	Wellington XXX	Baldwin	Wellington XXX Baldwin Tor Cross	Baldwin
Age (years)	8	6	10	7
No. of bushes per plot	Continuous hedgerow	Continuous hedgerow	4	1
No. of replicates	3	2	6	4
Plot length (m)	5	3	4	1
Spray volume (l/ha)	260	400	500	500

The growth stage of the bushes and temperature and rainfall data are shown in Table 2. No significant rainfall (> 2 mm) was recorded for at least 12 hours after any treatment at three of the centres, but 6.5 mm and 4.9 mm fell on the 18 December and 10 January at Loughgall. Assessments of injury were made at intervals throughout the 1974 growing season according to a 0-9 scale where 0 = completely dead and 9 = indistinguishable from control. Crop weights were recorded for each bush.

Table 2

Application date, stage of blackcurrant growth and weather at time of spraying

Location	Spraying dates	Crop growth stage	Mean air temp. (°C)	Days to next rainfall
Clonroche	17.10.73	25% leaf present	5.1	2
	11.12.73	Dormant	4.9	6
	23. 1.73	Dormant	6.3	1
	13. 3.74	Bud burst	4.8	1
Loughgall	23.10.73	25% leaf present	7.6	11
	18.12.73	Dormant	3.2	0
	10. 1.73	Dormant	5.2	0
	14. 3.74	Semi-dormant	3.3	1
Long Ashton	18.10.73	10% leaf present	6.2	1
	1.12.73	Dormant	-0.2	5
	22. 1.74	Dormant	7.4	1
	5. 3.74	Bud burst	2.0	4
WRO	11.10.73	50% leaf present	7.0	3
	10.12.73	Dormant	-0.5	1
	17. 1.74	Dormant	3.4	6
	1. 3.74	Early bud burst	2.0	3

Experiment 2 Gooseberries

Eleven year old bushes of cv. Careless at Loughgall were treated with overall or directed sprays of glyphosate. Herbicide application rates and dates were the same as the blackcurrant experiment at Loughgall. Each plot consisted of 7 bushes and each treatment was duplicated in a random block design. Visual assessments of injury were made on a 0-9 scale and crop weights and berry size were recorded for each bush.

Experiment 3 Apples

The effect of glyphosate sprayed on dormant apple shoots was investigated on a block of 9 yr old trees of eleven cultivars (listed in Table 6). The trees were grown on M9 rootstock and were planted at a spacing of 4.5 m x 2.7 m and trained as small 'bush' trees 3 m high. Two trees of each cultivar were available for each treatment and were separated by guards. Two trees of each cultivar were left as unsprayed controls.

Glyphosate at 2.5 kg/ha in 500 l/ha water was applied by a tractor mounted boom fitted with three broad-pattern cone nozzles. A band of branches lying between 0.9 and 1.8 m above ground level was sprayed from both sides of the tree. Applications were made on 1 December, 22 January and 5 March 1974. Visual assessments of injury were made on a 0-9 scale and crop weights recorded for each tree.

RESULTS

Experiment 1 Blackcurrants

The overwinter treatments had no effect on the date of bud burst, which at Clonroche, Long Ashton and WRO occurred in March, but was delayed at Loughgall until early April. The March applications were made to bushes with developing buds (C, LA, WRO). Symptoms of glyphosate damage, identical to those described previously (Clay 1972), were seen on many treatments when growth commenced; the leaves failed to expand, became stunted, developing marginal and interveinal necrosis. At Long Ashton, Tor Cross, the cultivar starting growth earliest, was more severely damaged than Baldwin, the least advanced. Damage was concentrated at the top of the shoots; both apical and lateral buds were affected. Shoot tips died back progressively throughout the early summer and in the most severely damaged treatments over half of the tips were killed. The death of a large proportion of lateral buds led to a reduction in flower density and ultimately crop yield. However, even where initial effects were severe, by June vigorous healthy new shoots developed from existing shoots and from the base of the bushes. These new shoots showed no symptoms of glyphosate damage.

Table 3

Vigour of blackcurrants treated with overall (O) or directed (D) sprays of glyphosate in the dormant season (score, 0-9)

Application		Vigour at successive dates (1974)											
		Clonroche	Loughgall		Long Ashton				W.R.O.			Mean (April Scores)
Date	Method	7.4	3.4	14.5	2.4	7.5	5.6	18.7	29.4	13.6	26.7	
Oct.	D	7	7	7	9	7	7	9	8	9	8	7.8
	O	3	4	4	9	7	7	9	4	6	8	5.0
Dec.	D	9	9	9	9	9	8	9	9	9	9	9.0
	O	9	9	9	9	9	8	9	9	9	9	9.0
Jan.	D	9	9	9	9	7	9	9	9	9	9	9.0
	O	9	9	9	9	8	9	9	8	9	9	8.8
Mar.	D	9	8	8	8	6	8	9	9	9	9	8.6
	O	7	7	7	4	3	5	8	6	8	9	6.0
Control		9	9	9	9	9	9	9	9	9	9	9.0

Table 3 which presents a numerical assessment of plant vigour shows that all treatments produced at least occasional symptoms at one location or another. In general directed applications did not impair vigour nor did overall applications made in December or January. Serious damage was caused by overall applications made in October or March. At Clonroche overall applications made in October led to the death of 60% of the shoot tips the following spring. There was no injury resulting from October treatments at Long Ashton but overall March applications killed 40% of the shoot tips and 90% of shoots showed some symptoms of damage. Tor Cross with (63% of shoot tips killed) was more severely damaged than Wellington XXX (40%) or Baldwin (18%).

Data on crop yield are given in Table 4. At Clonroche and Loughgall there was not room for an unsprayed treatment (control) within the area available for the trial; comparable yields from nearby bushes of the same age and cultivar are 6.0 and 3.9 tonnes/ha respectively.

Table 4

The effect of overall (O) or directed (D) sprays of glyphosate applied on four dates on blackcurrant yield (tonnes/ha).

Spraying date		Clonroche Wellington XXX	Loughgall Baldwin	Long Ashton Tor Cross	Long Ashton Wellington XXX	Long Ashton Baldwin	Long Ashton Overall Mean	WRO Baldwin
Oct.	D	2.1	1.4	3.3	5.6	6.9	5.3	17.4
	O	1.4	0.0	4.1	7.0	7.8	6.3**	4.0***
Dec.	D	5.3	3.9	3.4	6.5	7.5	5.8	15.9
	O	5.7	3.7	3.7	6.3	5.3	5.1	17.5
Jan.	D	4.6	4.6	3.1	7.3	7.1	5.9	17.4
	O	4.0	4.1	4.7	6.7	7.9	6.4***	16.0
Mar.	D	4.5	4.0	2.2	4.7	4.5	3.8	19.1
	O	0.9	1.3	1.0	0.8	3.4	1.7***	10.1***
Control (Unsprayed)				2.6	5.2	5.6	4.5	18.1
LSD (P = 0.05)		1.1					1.1	3.1
(P = 0.01)		1.6					1.4	4.1
(P = 0.001)		2.1					1.9	5.5

* = Sig. diff. from control at P = 0.05, ** at P = 0.01 and *** at P = 0.001

Overall applications in March at all locations and in October at all except Long Ashton significantly reduced yields compared with unsprayed plots (P = 0.001), or with other treatments. Directed sprays in October at Clonroche and Loughgall and in March at Long Ashton resulted in significantly lower yields than many other treatments, but other directed treatments gave no loss of crop. When applied in March directed sprays gave very significantly higher yields than overall sprays at all locations (P = 0.001). Yields from bushes sprayed in December or January were similar to those from the unsprayed controls (Table 4).

Experiment 2 Gooseberries

The results obtained with gooseberries were very similar to those obtained with blackcurrants. Table 5 shows that overall applications did not have any adverse effect when applied in December or January, but earlier or later applications caused damage and unacceptable loss in crop. Directed applications, striking the lower shoots still caused severe damage when applied in October, but there was little shoot injury and no yield reduction following the March application.

Table 5

The response of gooseberries cv. Careless to overall and directed applications of glyphosate in the dormant season

Application		Vigour score (0-9) assessed on		Fruit yield (tonnes/ha)
Date	Method	3 April	14 May	
October	Directed	7	7	6.3
	Overall	4	4	0.0
December	Directed	9	9	23.4
	Overall	9	9	21.7
January	Directed	9	9	20.3
	Overall	9	9	23.1
March	Directed	8	8	23.8
	Overall	7	7	5.7
Control		9	9	21.0

Experiment 3 Apples

Visual assessments of injury were made at monthly intervals from March 1974. No symptoms were apparent up to the pink bud stage reached on 24 April (Table 6). However, by full bloom (8 May), developing shoots produced symptoms similar to those described for apples (Clay 1972). The leaves elongated but remained narrow because the lamina failed to expand; they were often chlorotic or distorted. Damaged shoots, or sections of shoots occurred irregularly throughout the middle and lower canopy of the tree. One-year-old extension shoots were the most severely affected and in some, the terminal and lateral buds grew out but failed to develop and eventually died. The greatest amount of damage occurred on Egremont Russet and Cox, where some 15% of shoots showed symptoms following the December application; the mean vigour score for each date of application given in table 6 suggests that taking the cultivars as a whole, more damage was caused by the December application.

Table 6

The response of 11 cultivars of apple to glyphosate applied in the dormant season assessed at three dates (A, B and C)

Vigour score (0-9)

Month of application

Cultivar	December			January			March		
	*A	B	C	A	B	C	A	B	C
Miller's Seedling	9.0	8.0	8.5	9.0	8.5	8.5	9.0	9.0	9.0
Worcester Pearmain	9.0	8.0	6.5	9.0	8.5	8.0	9.0	9.0	8.5
Early Victoria	9.0	7.5	8.0	9.0	7.0	8.5	9.0	7.0	8.0
Crispin	9.0	7.0	7.5	9.0	7.0	7.0	9.0	9.0	8.5
Egremont Russett	9.0	6.5	[illegible]	9.0	9.0	9.0	9.0	9.0	9.0
Cox's Orange Pippin	9.0	7.5	6.0	9.0	9.0	9.0	9.0	9.0	8.5
James Grieve	9.0	7.0	6.5	9.0	7.5	7.5	9.0	7.0	7.5
Golden Delicious	9.0	7.0	7.5	9.0	7.0	7.5	9.0	7.0	7.0
Laxtons' Superb	9.0	7.0	8.5	9.0	9.0	9.0	9.0	9.0	9.0
Winston	9.0	7.0	7.5	9.0	9.0	9.0	9.0	9.0	9.0
Crawley Beauty	9.0	9.0	8.5	9.0	9.0	9.0	9.0	9.0	9.0
Mean		7.74			8.56			8.63	

* Assessment dates: A = 24.4.74; B = 8.5.74; C = 7.6.74

However, by June, damaged shoots began to recover and produced progressively more normal growth from July onwards. Perry (1973) reported a similar sequence for the recovery of two-year-old Cox from stem treatments made in late October of the previous year.

In the spring, a few flowers ($< 1\%$) with reduced or defective parts were produced which failed to set fruit. At harvest, an occasional branch was observed with noticeably few fruit, but the total crop carried by the trees was not affected. Mean yields (per tree) for the eleven cultivars were, Control 23.40 kg, December application [illegible] kg, January application 25.65 kg and March application 21.95 kg.

DISCUSSION

This series of trials at four widely-different locations clearly demonstrates that glyphosate is too phytotoxic to apply as an overall spray on blackcurrants in October or in March, since it leads to an unacceptable loss of crop. Even sprays directed at the base of the bushes can cause some damage if applied at these times. However, all the bushes recover, and it is of interest that the herbicide did not appear to be translocated into the vigorous basal shoots that were produced in mid-season. This agrees with earlier results (Clay 1972) that suggested that blackcurrants possess more tolerance or ability to recover than some other fruits.

There was considerable variation between locations in the damage caused by the October applications. Damage was greatest at WRO, intermediate at Clonroche and Loughgall and absent at Long Ashton. The degree of damage appeared to be related to the proportion of leaf present at the time of spraying (Table 2). What leaf there was at Long Ashton was badly infested with leaf spot, (*Pseudopeziza ribes*) and many were brown and withered. At Clonroche, only the exposed replicates, where leaves had fallen, produced any crop. The results as a whole, therefore indicate th considerable damage is likely if glyphosate is applied before leaf-fall or after bud-burst. The experiments did not establish when overall spraying becomes unsafe in the spring, but this could be relatively early since even at Loughgall, where applications were made before bud-burst, considerable damage occurred. In general directed applications were safer than overall but with either method no damage occurred when applications were made in December or January.

Essentially similar results were obtained with gooseberry cv. Careless at Loughgall. Damage recorded following mid-October spraying appeared to be due to the fact that leaf-fall was incomplete at the date of spraying, whilst application made in early March coincided with bud-burst. Hence, glyphosate at the rates suggested for the control of perennial weeds appears to be safe to apply in blackcurrants and gooseberries after leaf-fall, but before the start of growth in the spring.

In apples the safety of glyphosate reaching the base of the apple trunks has been indicated by Baird et al (1971), Clay (1972) and Davison (1974). One of the objects of the present experiment was to investigate the likely effect of widespread glyphosate drift to dormant branches. The results show that even when a rate of glyphosate likely to be used for weed control is directed at apple branches in the dormant season only slight damage is produced in the following growing season. However, since stem or branch treatments with translocated herbicides can produce effects on shoots that do not show until a year after treatment (Davison and Clay, 1970), further observation of the trees will be made in 1975 to assess longer-term effects.

The results suggest that there should be little or no harmful effects from sprays directed at overwintering weeds reaching the trunks or branches of apple trees.

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NOTES

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TRIALS ON THE USE OF GLYPHOSATE IN SOFT FRUIT CROPS

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Summary Trials were carried out to assess the potential of glyphosate for pre-planting weed control and inter-row runner control in strawberries and as a dormant season treatment in bush and cane fruit.

When strawberries were planted at intervals into a grass sward sprayed with glyphosate severe damage occurred to runners planted one week after spraying. Damage was much less severe when the grass was removed before spraying.

When used for strawberry runner control in September, glyphosate caused very severe damage to the parent plants even when stolons were cut prior to treatment.

Glyphosate at 1 to 4 kg/ha was applied to bush and cane fruits in autumn and winter. Directed sprays to the base of raspberry canes in October resulted in some damage but not when applied in January. Overall treatment of gooseberries in October killed all bushes but application of doses up to 4 kg/ha in early February were safe. Directed applications to blackcurrants in January were safe whereas overall treatment caused damage; fruit yield was unaffected the year after treatment.

INTRODUCTION

Glyphosate is a foliar-acting herbicide which can be translocated to underground parts of weeds and is very effective for the control of many of the perennial weeds which cause severe problems in soft fruit plantations (Baird et al, 1971; Davison, 1972). Preliminary work by Clay (1972) with glyphosate on soft fruit crops indicated that glyphosate applications during the dormant season to blackcurrants were promising but applications to raspberries at the same time were more damaging. The evidence suggested that glyphosate may be useful for the control of many perennial weeds before planting and as a directed spray for control of many weeds in some fruit crops.

A series of trials were laid down at Clonroche to determine how this herbicide might be used in soft-fruit growing. The possibilities of using glyphosate as a pre-planting treatment for strawberries, and as a treatment for control of runners in strawberries were examined. Its potential use as either a directed or overall treatment in raspberries, blackcurrants and gooseberries was also investigated.

METHOD AND MATERIALS

In all the experiments the isopropyl amine salt of glyphosate was used, containing 36% a.e. glyphosate; all doses given refer to the amount of a.e. used.

Experiment 1. An observational trial was laid down to determine if strawberries could be safely planted into an unbroken sward of grass which had been sprayed with glyphosate. Glyphosate was applied on 9 October 1973, 13 December 1973 or 3 March 1974 at either 2 or 4 kg/ha in 250 l/ha of water to an established sward of predominantly *Agrostis stonolifera* and *Agropyron repens*. Plot size was 10 x 2 m, there were three replicates of each treatment and the trial was laid out as randomised blocks. Each plot was divided into four sub-plots on which strawberry runners, cv.Cambridge Vigour were planted into unbroken sward either 1 hour, 1 day, 1 week or 4 weeks after the application of glyphosate. Each sub-plot consisted of a single line of plants 5 m long with 1 m between lines and 0.5 m between plants.

Experiment 2. To determine whether the damage from glyphosate in Experiment 1 was caused by root uptake or contact between plant foliage and the sprayed grass a further trial with strawberries was laid down on an area of ground infested with *Agropyron repens* and *Agrostis stolonifera*. Cambridge Vigour runners were planted into ground which had been sprayed with glyphosate at 2.5 kg/ha in 250 l/ha of water on 24 April 1974. The runners were spaced 0.5 m apart in lines 1 m apart and each plot consisted of a single line 5 m long. Each treatment was replicated three times. The runners were planted 1 hour, 1 day or 20 days after spraying. Runners were also planted into unsprayed ground on the date of spraying. The soil surface was exposed on half the plots before spraying by removing a sod 15 cm wide and 2 cm deep along the line to be planted.

Experiment 3. A trial examining the possibility of using glyphosate in strawberries for the control of unwanted runners rooted in the alleys of fruiting plantations was laid down in September 1973. Strawberries cv.Cambridge Favourite were planted on ridges in October 1971 with 0.38 m between plants and 0.89 between ridges. Matted rows were established during 1972. The spraying treatments listed in Table 2 were applied on 7 September 1973 to a band 0.5 m wide in the centre of the alleys. The trial had a split plot design with the stolon cutting treatments as main-plots and spraying treatments as sub-plots. The trial had two replications. Sub-plots were two rows 9.14 m long with a guard row between adjacent plots. Each main plot contained six sub-plots. The spraying treatments were applied at 0.63 kg/cm^2 in 270 l/ha of water. A 20% a.c. formulation of paraquat was used and dinoseb as a 9% e.c. The stolons were severed by a tractor-driven rapidly-rotating serrated disc on 6 September 1973.

Experiment 4. In this trial the tolerance of raspberries in January to overall and directed applications of glyphosate was examined. Raspberries, cv. Glen Clova were planted in March 1971, 0.5 m apart in lines 2 m apart. The treatments listed in Table 3 were applied on 29 January 1973. The trial had a randomised design with 2 replicates. Plot size was a single line 5 m long. The directed treatments were applied to a band 0.5 m wide on each side of the cane wetting the basal 0.15 m of the cane rows. The overall treatment was applied to completely wet the canes. Both overall and directed treatments were applied in 600 l/ha of water.

Experiment 5. The tolerance of raspberries to October applications of glyphosate was examined on raspberries, cv. Malling Jewel which had been planted on 21 February 1972 in lines 2 m apart. The trial had a randomised block design with three replications and plots consisted on a single line 12.5 m long. The treatments listed in Table 4 were applied in 490 l/ha of water to a band 0.5 m wide on each side of the cane rows on 17 October 1973.

Experiment 6. The effects of January treatments of glyphosate on blackcurrants were compared on the cv. Hatton Black. Cuttings were planted in December 1968 and grown as hedges spaced 2.75 m apart. The plantation was maintained weed-free using simazine. The treatments listed in Table 6 were applied on 30 January 1973 to plots consisting of a single row 5 m long; each treatment was replicated twice. The directed treatments were applied to a band 0.5 m wide on each side of the cane row wetting the basal 15 cm of the bushes. The overall treatments were applied over the bushes using two jets to a band 1 m wide. Directed and overall treatments were applied in 610 l/ha of water.

Experiment 7. This trial was laid down to examine the effects of February applications of glyphosate on gooseberries. The gooseberries had been planted 1.37 m apart in lines 2.75 m apart. Plot size was a single line containing eight bushes and there were three replications. Glyphosate was applied using a logarithmic sprayer at rates of 5 to 0.5 kg/ha on 5 February 1973. The herbicide was applied with a single jet from over the centre of the bush row to a band 1 m wide in 660 l/ha of water.

Experiment 8. The effect of October applications of glyphosate on gooseberries was investigated on an eight year old plantation of cv. Careless. The bushes were spaced 1.37 m apart in lines 2.74 m apart. Plot size was a single row containing four bushes. The trial had a randomised block design with three replicates. Glyphosate was applied on 11 October 1973 at 1, 2 and 4 kg/ha. The treatments were applied overall using a boom with two jets to a band 1 m wide in 250 l/ha of water. An unsprayed treatment and paraquat at 1 kg/ha were included as controls.

RESULTS

Experiment 1. The October, December and March applications of glyphosate gave excellent control of the perennial grass weeds present and this control persisted until July 1974 when the trial was terminated. In April 1974 the October and December sprayed plots became badly infested with *Potentilla anserina*. The March sprayed plots were lightly infested with *P.anserina* in July 1974.

In spring and summer 1974 symptoms of severe glyphosate damage occurred on all plots and plant deaths occurred on all plots planted within one week of spraying. The damage was most noticeable from the March spraying.

Experiment 2. Planting took place during a dry period and some plants died or established poorly on most plots. Severe symptoms of glyphosate damage occurred on many plants planted into the sward 1 hour or 1 day after spraying but those planted 20 days after spraying were unaffected. Table 1 shows the percentage plants dead or nearly dead when assessed in July. The plant deaths which occurred when the sod was removed before spraying appeared to be caused by drought and insect damage rather than glyphosate.

Table 1

Effect of pre-planting glyphosate treatment with and without the sod removed on strawberries

Spraying date	Dose	Interval between spraying and planting	% plant loss (3.7.74) Sod removed	Sod not removed
24.4.74	2.5 kg/ha	1 hour	20	70
		1 day	10	70
		20 days	3	3
Control (untreated)			13	0

Experiment 3. The glyphosate treatments had a slow but severe effect on the runner plants and by mid-October all sprayed runners were dead. At this time also severe chlorosis and twisting of the newly-emerging leaves on the parent plants was also apparent. This damage became more severe during March and April 1974. Some plants on all plots recovered during May and June 1974 but at fruiting time many plants were still severely stunted. The effect of the glyphosate was less severe at the lower doses and where the stolons were severed before spraying.

Table 2 shows that the glyphosate treatments seriously reduced crop yield.

Table 2

Effect of herbicides for strawberry runner control on crop yield (tonnes/ha)

Herbicide treatment	Fruit yield Stolons cut	Stolons not cut
Dinoseb * 2 kg/ha	22.7	18.8
Paraquat 1.12 kg/ha	19.2	19.6
Glyphosate 1.12 kg/ha	11.3	5.3
Glyphosate 2.24 kg/ha	8.5	3.9
Glyphosate 4.48 kg/ha	8.5	1.9
Control (untreated)	19.5	19.3

The dinoseb treatment quickly caused severe scorching of the runner leaves present at the time of spraying. These leaves died but those produced later showed no symptoms of herbicide damage and within one month of spraying the runner plants were again growing strongly. The paraquat treatments also caused rapid scorching of the foliage but in this case the runner plants failed to recover and the treatments gave effective control of the runners. Neither the dinoseb nor paraquat treatments had any obvious effect on the growth of parent plants or on subsequent yield (Table 2). The degree of runner control and damage to parent plants were not affected by cutting the stolons before spraying.

Experiment 4. The directed glyphosate treatments had no obvious effect on the growth or cropping of the fruiting canes in 1973. A few very stunted young canes occurred in the alleys. These were often near where cut stumps of the previous years suckers had survived. Where the canes were sprayed overall bud burst was delayed about two weeks. The laminae of the leaves remained vestigial and the laterals did not elongate initially. On the plots treated with glyphosate overall at 1 kg/ha the laterals did elongate slightly during May and June and these plots produced a small quantity of fruit. Delayed emergence of suckers and stunting of all emerging suckers was caused by both overall treatments. The stunting persisted until mid-June. After this many of the suckers recovered. Measurements taken in January 1974 showed that number and quality of canes tied in were reduced by the overall treatments (Table 3).

Table 3

Effect of January applications of glyphosate on raspberries cv. Glen Clova

Dose (kg/ha)	Application method	Fruit yield (tonnes/ha) (1973)	No. canes tied in/plot (Jan.1974)	Mean cane height (m) (Jan.1974)
0.0	-	7.91	59.0	1.95
1.0	directed	7.24	76.0	2.02
2.0	directed	7.98	61.5	1.98
4.0	directed	6.72	63.0	2.03
1.0	overall	0.49	51.5	1.77
2.0	overall	0.00	29.5	1.28

Experiment 5. On plots receiving glyphosate at 4 kg/ha to the base of the canes stunting of the laterals of about 10% of the fruiting canes occurred the following spring. The leaves of these canes were pale yellow and reduced in size. The laterals at fruiting time were about half the length of those on the undamaged canes. The remainder of the canes on these plots showed no symptoms of herbicide damage. Suckers growing from close to the bases of the damaged canes also showed symptoms of herbicide damage with reduced height and leaf size. A few damaged canes occurred on the plots receiving the basal application at 2 kg/ha. The treatments had no significant effect on crop yield although there was a tendency for reduced yields from the cane base application at 4 kg/ha (Table 4).

Table 4

Effect of autumn applications of glyphosate on crop yield of raspberries

Glyphosate (kg/ha)	Cane length sprayed (m)	Fruit yield (tonnes/ha)
0	none	6.34
1	basal 0.15	6.27
2	basal 0.15	6.96
4	basal 0.15	4.87
2	none	6.92
S.E. (df = 8)		± 0.754

Experiment 6. The directed applications of glyphosate had no effect on the growth or cropping of blackcurrants in 1973 (Table 5). Bud burst was delayed about two weeks by the overall treatments with glyphosate. Almost all shoot tips died back with the damage being most severe at the 2 kg/ha rate. These plots flowered about 2 weeks late. The bushes recovered from June onwards, producing new shoots from the lower parts of the damaged shoots and from the base of the bushes; at the end of the growing season they appeared to have more young wood than those on the undamaged plots. The overall treatments severely reduced crop yield in 1973 but crop yield in 1974 did not appear to be affected.

Table 5

Effect of glyphosate applied in January 1973 on fruit yield of blackcurrants, cv. Hatton Black.

Glyphosate dose (kg/ha)	Application method	Fruit yield (tonnes/ha) 1973	1974
0	-	4.33	8.08
1	directed	3.88	7.26
2	directed	5.07	9.53
4	directed	4.04	8.91
1	overall	2.56	9.20
2	overall	1.20	10.84

Experiment 7. Bud burst was delayed for about 2 weeks on a few shoots on the first two bushes of each plot (dose 5 to 3 kg/ha). When these buds did burst they produced leaves with reduced yellow laminae but the damaged bushes recovered during May. The glyphosate treatments did not appear to affect crop yield or fruit quality although the results could have been affected by severe damage by bullfinches during the winter of 1972-1973.

Experiment 8. The glyphosate treatments had no obvious effects on the bushes in autumn 1973 but by spring 1974 all sprayed bushes were dead. The control plots cropped satisfactorily in 1974.

DISCUSSION

The planting of strawberries into a glyphosate sprayed sward resulted in severe plant damage even when planting was carried out one week after spraying. However, when the sod was removed before spraying runners could be planted safely on the day of spraying. Baird et al (1971) reported that maize and soya beans were safely sown within 17 hours of treating the soil with glyphosate. Thomas (1972) confirmed those results under Irish conditions with rape and wheat. However, in neither case did crop foliage come into contact with sprayed weed foliage. The results from Clonroche suggest that most damage occurred through contact between plant and weed foliage. The results indicate that it may not be safe to plant strawberries directly into a glyphosate sprayed sward without either removing or burying the weed trash.

When used to control runners glyphosate damage to the parent plants was severe whether or not the stolons were severed. The even damage pattern on the plots with stolons cut suggested that the damage may have been caused by drift rather than translocation through occasional uncut stolons. However, the absence of paraquat damage to the foliage of the parent plants when that herbicide was used indicated that the degree of drift was only slight. Glyphosate therefore appears to be much too toxic to strawberries to use for this purpose.

The results of the trials on raspberries and gooseberries indicated that time of application is very important. Gooseberries had a greater tolerance to overall applications during the dormant season than raspberries or blackcurrants. However, when gooseberries were sprayed overall with glyphosate in October when some leaves were still present the bushes were completely killed. With raspberries, directed applications in October caused more severe damage than in January. The results of Stott et al (1974) from a number of centres in the

British Isles showed that blackcurrants were less susceptible to glyphosate damage in December and January than in October or March. In Experiment 6 blackcurrants, although severely damaged by overall application during January, showed an ability to recover almost completely from glyphosate damage in one year. Clay (1972) also reported that blackcurrants could quickly recover from glyphosate damage.

Although more work needs to be done on the time of application the results indicate that directed applications during December and January may be useful in blackcurrants, gooseberries and raspberries for the control of weeds which have foliage present in winter.

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